2nd International Congress on Biodiesel: The Science and The Technologies

15–17 November 2009

The Westin Grand München Arabellapark
Munich, Germany

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Visit with Ibrahim Abou-Nemeh, Ph.D on Monday, November 16, 2009 during the Second International Congress on Biodiesel tradeshow at his presentation of "Biodiesel Long Term Storage, Oxidative Stability and Performance. A Pilot-Scale Study" or email adesta@novusint.com.

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Welcome!

On behalf of myself, the members of the Organizing Committee, and the American Oil Chemists' Society, welcome to the Second International Congress on Biodiesel. Throughout the multi-year period during which we planned and organized this meeting we have been keenly aware that these are tight financial times, and that your decision to spend precious funds to attend the conference placed a responsibility for a quality program on our shoulders. I believe the Organizing Committee has responded well to this challenge, and that the program assembled for this meeting could not be excelled in breadth or quality. Tight financial times mandate effective use of resources. In addition, although biodiesel and renewable fuels continue to offer the world a respite from greenhouse gas production and the tensions inherent in dependence on imported petroleum, this sector faces new technical and regulatory challenges. Given such challenges, research is a more important tool than ever to ensure success in the industry. We hope—and believe—that the research results presented in this conference will help you meet the individual professional challenges that you face daily and help you chart a path to a successful future. Again, thank you for attending, have a good meeting, and do not hesitate to contact me during the meeting if I can help increase its value for you in any way.

Best regards,
Michael J. Haas, Congress General Chair
United States Department of Agriculture, ARS, ERRC, USA

The organizing committee would like to thank the following organizations for their generous contributions to the success of the Congress.

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2nd International Congress on Biodiesel: The Science and The Technologies

Schedule-at-a-Glance

Sunday, 15 November 2009

12.00–19.00	Registration Open	Ballsaal Foyer
14.00–17.30	Opening Plenary Session	Ballsaal A
14.00–19.00	Poster Viewing	Ballsaal and Atlanta Foyers
15.30–16.00	Break	Ballsaal Foyer
17.30–19.00	Welcome Reception	Ballsaal Foyer

Monday, 16 November 2009

7.30–19.00	Registration Open	Ballsaal Foyer
7.00–19.00	Poster Viewing	Ballsaal and Atlanta Foyers
8.30–12.00	PARALLEL SESSIONS	
	Session 1: Cleaning up Biodiesel	Atlanta
	Session 2: Engine Operability and Catalyst Performance I	Ballsaal B
	Session 3: Feedstock Options—Development of Resources for Biodiesel Production	Ballsaal A
10.00–10.30	Break	Ballsaal Foyer
12.00–13.00	Luncheon	Muenchen
13.15–13.50	Keynote Presentation/Discussion	Ballsaal A
14.00–17.30	PARALLEL SESSIONS	
	Session 4: Analytical Methods and Quality Aspects	Ballsaal A
	Session 5: Engine Operability and Catalyst Performance II	Ballsaal B
	Session 6: Future and Developing Production Technologies	Atlanta
15.40–16.10	Break	Ballsaal Foyer

Tuesday, 17 November 2009

7.30–17.00	Registration Open	Ballsaal Foyer
7.30–17.00	Poster Viewing	Ballsaal and Atlanta Foyers
8.30–12.00	PARALLEL SESSIONS	
	Session 7: Alternative (i.e. not Biodiesel) Diesel Engine Fuels	Ballsaal B
	Session 8: Sustainability Aspects of Biodiesel	Atlanta
	Session 9: Biodiesel: Large Scale Transport; New Uses for Glycerol; and General Topics	Ballsaal A
10.00–10.30	Break	Ballsaal Foyer
12.00–13.00	Luncheon	Muenchen
13.00–13.30	Technology Showcase	Ballsaal B
13.30–14.00	Break	Ballsaal Foyer
14.00–16.30	Closing Plenary Session: Future Perspectives	Ballsaal A

The Organizing Committee

Michael J. Haas, Congress General Chair, USDA, ARS, ERRC, USA
Paolo Bondioli, Stazione Sperimentale Oli e Grassi, Italy
Tim Kemper, Desmet Ballestra North America, USA
Juergen Fischer, ADM Research GmbH, Germany
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Robert McCormick, National Renewable Energy Laboratory, USA
Martin Mittelbach, Karl-Franz-Universität Graz, Austria
T. (Tiger) Thiagarajan, Consultant, USA

Participating Organizations

Agricultural Research Service of the U.S. Department of Agriculture
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European Section of the AOCS
Industrial Oil Products Division of the AOCS
Malaysian Palm Oil Board
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Program Index

Congress Hotel

The Westin Grand München Arabellapark
Arabellastrasse 6
81925 Munich
Germany
Phone: + 49 89 92640
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E-Mail: westin.grand.muenchen@arabellastarwood.com

The Congress hotel rates include the breakfast buffet, the 19% VAT tax, and use of the hotel wellness area.

The Breakfast Buffet

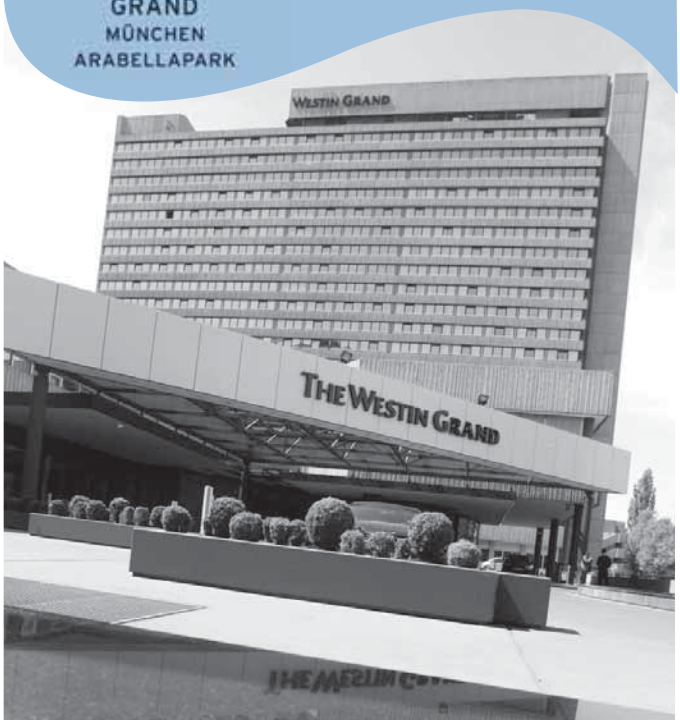
All registered guests of The Westin Grand München Arabellapark are entitled to the breakfast buffet, on a complimentary basis, served at the restaurant ZEN from 6.30–10.30. Guests will need to provide their room number and name for verification.

The Hotel Wellness Area

The AltiraSPA and the Fitness Conservatory are open Monday–Friday from 6.30–23.00, and on Saturday and Sunday from 7.30–23.00. Guests will need their room key for access.

The Business Center

The business center is open Monday–Friday from 8.00–20.00. Access to the business center is available on a 24-hour basis seven days a week for self-service. The guest room key will allow access. Guests will need their credit card to go online or to make black/white copies.



Registration Desk Hours

Sunday, 15, November 2009 . . . . . 12.00–19.00
Monday, 16 November 2009 . . . . . 7.30–17.00
Tuesday, 17 November 2009 . . . . . 7.30–17.00

Attire

Business or Business Casual Attire

Welcome Reception

Sunday, 15 November 2009
17.30–19.00
Ballsaal Ballroom Foyer

This reception, immediately following the opening plenary session, is included in the full technical registration fee. Additional tickets may be purchased at the Congress Registration Desk for €60.00.

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Technical Program

SUNDAY, 15 NOVEMBER

Plenary Session: Global Overview of the Biodiesel Industry

Room: Ballsaal A

14.00 **Opening Remarks.** M.J. Haas, USDA, ARS, ERRC, USA.

14.15 **Opening Keynote.** T. Mielke, Oilworld, Germany.

15.00 **Biodiesel Developments in Asia.** M. Basri Wahid, Malaysian Palm Oil Board, Malaysia.

15.30 **Break**

16.00 **European Perspective.** M. Mittelbach, University of Graz, Austria.

16.30 **North American Perspective.** J. Jobe, National Biodiesel Board, USA.

17.00 **Discussion**

17.30–19.00 **Welcome Reception—Ballsaal Lobby**

MONDAY, 16 NOVEMBER

MORNING PARALLEL SESSIONS

Session 1: Cleaning up Biodiesel

Room: Atlanta

Session Chairs: R. Verhé, University of Ghent, Belgium; and S. Fenwick, Archer Daniels Midland Co., USA

8.30 **Purification Methods for Biodiesel and Glycerin.** B. Harten, Westfalia Separator Process GmbH, Germany.

8.50 **Effect of Minor Components Content on Precipitate Formation in Biodiesel.** H. Tang[1,2], S.O. Salley[2], and K.Y.S. Ng[2], [1]National Biofuels Energy Laboratory, NextEnergy, USA, [2]Wayne State University, USA.

9.10 **Understanding the Low Temperature Properties of Biodiesel.** M. Brewer and R. Malpas, Shell Global Solutions, UK.

9.30 **Purification of Biodiesel Prepared from Used Frying Oils by Distillation.** R. Verhé[1], V. Van Hoed[1], C. Echim[1,2], S. Ersungur[1], N. Zyaykina[2], J. Maes[2], and W. De Greyt[2], [1]Ghent University, Faculty of Bioscience Engineering, Department of Organic Chemistry, Belgium, [2]DeSmet-Ballestra, Belgium.

9.50 **Strategies for Biodiesel Purification.** D. Masterson, Crown Iron Works, USA.

10.10 **Break**

10.40 **Factors Affecting the Cold Soak Filtration Test of Biodiesel.** N. Zyaykina[1], C. Echim[2], W. De Greyt[1], F. Soragna[1], and M. Kellens[1], [1]Desmet Ballestra Group, Belgium, [2]Ghent University, Belgium.
11.00 **Influence of Time on Cold Soak Filtration Results and Trace Component Analysis.** T. Alleman, National Renewable Energy Laboratory, USA.
11.20 **Detection and Remediation of Microbially Contaminated Petroleum and Biomass Fuels.** E. English, Fuel Quality Services, Inc., USA.
11.40 **Discussion**
12.00–13.00 **Luncheon—Muenchen Room**

Session 2: Engine Operability and Catalyst Performance I

Room: Ballsall B

Session Chairs: J. Krahl, Coburg University of Applied Sciences, Germany; and K. Oyama, Japan Petroleum Energy Center, Japan

8.30 **Evaluation of Tractor Performance Operating on 100% Biodiesel.** N.D. Rill and G.R. Cauffman, Pennsylvania State University, USA.
8.55 **Performance, Durability, and Stability of a Multi Fueled Power Generator.** K. WaduMesthrige[1,2], N. Johnson[1,2], M. Winston-Galant[1,2], S.O. Salley[2], and K.Y.S. Ng*[2], [1]National Biofuels Energy Laboratory, NextEnergy, USA, [2]Wayne State University, USA.
9.20 **A Quantitative Evaluation of an On-Highway Trucking Fleet to Compare #2ULSD and B20 Fuels and Their Impact on Overall Fleet Performance.** C. McKinley, J. Lumkes, and B. Tao*, Purdue University, USA.
9.45 **Impact Study of High-level Biodiesel Blends on Exhaust Emission with Advanced Aftertreatment Systems.** T. Kaneko, Nippon Oil Corporation, Japan.
10.10 **Break**
10.40 **Biodiesel Blend Effects on Emissions and Public Health.** O. Schröder[1], J. Krahl[2], J. Bünger[3], A. Munack[1], Y. Ruschel[1], L. Schmidt[1], and J. Schaak[1], [1]Federal Agricultural Research Center, Germany, [2]Coburg University of Applied Sciences, Germany, [3]University of Bochum, Germany.
11.05 **Characterization of Emissions from Heavy Duty Engines Operating with Varying Biodiesel Blends and Emission Control Systems.** D. Rosenblatt, G. Rideout, E. Meloche, and T. Chan, Emissions Research and Measurement Section, Air Quality Research Division, Environment Canada, Canada.
11.30 **Discussion**
12.00–13.00 **Luncheon—Muenchen Room**

Session 3: Feedstock Options—Development of Resources for Biodiesel Production

Room: Ballsall A

Session Chairs: M. Mittelbach, University of Graz, Austria; and S. Tyson, Consultant, USA

8.30 **Update of the State-of-the-Art of Marine Microalgae Production using Electric Power Plant Wastes.** A. Ben-Amotz, NBT Ltd., Eilat, & Seambiotic Ltd., Israel.
9.00 **Isolation of Phorbol Esters from Jatropha Curcas Oil and Quality of Produced Biodiesel.** R.K. Devappa[1], J. Maes[2], H.P.S. Makkar*[1], W. De Greyt[2], and K. Becker[1], [1]Institute for Animal Production in the Tropics and Subtropics, University of Hohenheim, Germany, [2]Desmet-Ballestra Group, Belgium.
9.30 **Corn Oil Extraction: Processes, Product Quality, Treatment, and Economics.** J. Hagberg, Ball Industrial Services, LCC, USA.
10.00 **Break**
10.30 **Life Cycle Energy Analysis for the Production of Biodiesel from Rendered Lipids in the U.S.** D.E. Lopez, J. Mullins, and D.A. Bruce, Clemson University, USA.
11.00 **Field Pennycress (*Thlaspi arvense* L.) Oil. A Promising Source of Biodiesel.** B.R. Moser, G. Knothe, S.F. Vaughn, and T.A. Isbell, USDA, ARS, NCAUR, USA.
11.30 **Discussion**
12.00–13.00 **Luncheon—Muenchen Room**

AFTERNOON

Keynote Presentation†

Room: Ballsaal A

13.15 **Biodiesel in Latin America: Developments, Supply, and Opportunities.** I. Azevedo, BrasPalma, Brazil.
13.45 **Discussion**

†*This presentation was originally scheduled in the Congress Closing Session but was moved to accommodate speaker travel change.*

AFTERNOON PARALLEL SESSIONS

Session 4: Analytical Methods and Quality Aspects

Room: Ballsall A

Session Chairs: F. LaCoste, ITERG, France; and B. Cahill, CEN-WG24 TF Biodiesel, European Standardization Committee, France

14.00 **ASTM - U.S. Standards and Initiatives.** J. Thaeler, National Biodiesel Board, USA
14.20 **Changes under Consideration for the EN 14214 Specification.** B. Cahill, CEN-WG24 TF Biodiesel, European Standardization Committee, France.
14.40 **Oxidation Stability of Biodiesel: Analytical Methods Assessment.** B. Lecointe, IFP France.
15.00 **Overview of World Standards on Biodiesel.** T. Klein, Global Biofuels Center, USA.
15.20 **Shelf Life Improvement of Biodiesel and Plant Oil Fuels with Synthetic Antioxidants.** A. Ingendoh, Lanxess AG, Germany.
15.40 **Break**
16.10 **Comparison of Analytical Approaches for the Determination of Steryl Glycosides in Biodiesel.** S. Schober, A. Studentschnig, and M. Mittelbach, Institute of Chemistry, University Graz, Austria.
16.30 **New Advances in the Use of Fourier Transform Infrared for the Analysis of Biodiesel.** B. Stefl, N. Wang, and C. Tseng, Cognis Corporation, USA.
16.50 **Biodiesel Long Term Storage Oxidative Stability and Performance: A Pilot-Scale Case Study.** I. Abou-Nemeh, Novus International, Inc., USA.
17.10 **Discussion**

Session 5: Engine Operability and Catalyst Performance II

Room: Ballsall B

Session Chairs: J. Krahl, Coburg University of Applied Sciences, Germany; and K. Oyama, Japan Petroleum Energy Center, Japan

14.00 **Biodiesel Performance with SCR and DPF Systems.** R.L. McCormick, A. Williams, J. Ireland, and D. Pedersen, National Renewable Energy Laboratory, U.S. Dept. of Energy, USA.

14.25 **Impacts of Biodiesel Fueling on Engine Lubricants.** S.R. Kirby[1], P.Ye[1], T. McGuire[1], Y. Zhang[1], A.L. Boehman*[1], M. Alessi[2], K. Richard[2], and S. McTavish[3], [1]Pennsylvania State University, USA, [2]Infineum USA L.P., USA, [3]Infineum UK Ltd., UK.

14.50 **An Experimental Investigation of the Origin of Increased NO_x Emissions When Fueling a Heavy-Duty Compression-Ignition Engine with Soy Biodiesel.** C.J. Mueller[1], A.L. Boehman[2], and G.C. Martin[1], [1]Sandia National Laboratories, USA, [2]Pennsulvania State University, USA.

15.15 **Biodiesel Blend NOx Emissions from Heavy Duty Diesel Engines.** J. Nuszkowski and G. Thompson, West Virginia University, Center for Alternative Fuels, Engines, and Emissions, USA.

15.40 **Break**

16.10 **Diesel Engine Emissions from Combustion of Diesel, Biodiesel and Biodiesel Blends Cause Different Mutagenicity.** J. Bünger[1], J. Krahl[2], A. Munack[3], O. Schröder[3], J. Schaak[3], M. Trißler[4], E. Hallier[4], G. Westphal[1], and T. Brüning[1], [1]BGFA, Research Institute of Occupational Medicine, German Social Accident Insurance, Ruhr-University Bochum, Germany, [2]Coburg University of Applied Sciences, Germany, [3]Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI), Germany, [4]Institute of Occupational and Social Medicine, Georg-August-University of Göttingen, Germany.

16.35 **The Effect of Animal Fat Methyl Ester Blends on the Regulated and Unregulated Emissions from a Euro Four Passenger Vehicle.** G. Karavalakis[1], D. Ampatzoglou[2], S. Stournas[1], and E. Bakeas*[2], [1]Laboratory of Fuels Technology and Lubricants, National Technical University of Athens, Greece, [2]Laboratory of Analytical Chemistry, Chemistry Department, National and Kapodistrian University of Athens, Greece.

17.00 **Discussion**

Session 6: Future and Developing Production Technologies

Room: Atlanta

Session Chairs: W. De Greyt, Desmet Ballestra, Belgium; and S. Saka, Kyoto University, Japan

14.00 **A New Process for Biodiesel Production Using Supercritical Carboxylate Esters.** S. Saka, Graduate School of Energy Science, Kyoto University, Japan.

14.20 **Immobilization of Rhizomucor Miehei Lipase on a Fibrous Support for Biodiesel Production.** G. Eylem Özarslaner[1], M. Erhan Kanişli[1], E. Öndül[1], N. Dizge[2], and N. Albayrak*[1], [1]Yüzüncü University, Turkey, [2]Gebze Yüksek Teknoloji Enstitüsü, Turkey.

14.40 **Biodiesel from Low Quality Feedstock using Alkali Metal Ion Doped Calciumoxide as Heterogeneous Catalyst.** A. Ali, D. Kumar, and V. Mutreja, School of Chemistry and Biochemistry, Thapar University, India.

15.00 **Chemical Interesterification of Vegetable Oil with Methyl Acetate: Kinetics and Thermodynamics.** A. Casas, J.R. Ruiz, M.J. Ramos, and A. Perez, Chemical Engineering Department, Institute of Chemical and Environmental Technologies, University of Castilla-La Mancha, Spain.

15.20 **Enzymatic Production of Biodiesel Fuel from Various Oil Sources in Solvent-free System.** Y. Watanabe, Osaka Municipal Technical Research Institute, Japan.

15.40 **Break**

16.10 **Enzymatic Production of Fatty Acid Ethyl Esters.** J. Brask, P.M. Nielsen, L.S. Pedersen, M.L. Damstrup, and H.C. Holm*, Novozymes A/S, Denmark.

16.30 **Use of Heterogeneous Catalysts for the Conversion of FFA into FAME.** R. Wagner, Lanxess Deutschland GmbH, Germany.

16.50 **New Generation Heterogeneous Transesterification Catalyst.** D.A. Sams[1], W.A. Turner[1], and V.S.-Y. Lin[2], [1]Catilin Inc., USA, [2]Iowa State University, USA.

17.10 **Discussion**

Biodiesel Congress Presentations

The PowerPoint presentations will be available for viewing on the Congress website in late November 2009. After the Congress, registered delegates will receive an e-mail with the specific web address and passcode needed to access these presentations. Please note that AOCS may post only the presentations from the authors who have given their consent, so not all of the presentations may be available on this website.

TUESDAY, 17 NOVEMBER

MORNING PARALLEL SESSIONS

Session 7: Alternative (i.e. not biodiesel) Diesel Engine Fuels

Room: Ballsaal B

Session Chairs: A.A. Boateng, USDA, ERRC, ARS, USA; and P.A.Z. Suarez, Universidade de Brasília, Brazil

8.30 **To Burn or Not to Burn: Distributed Pyrolysis to Refinable Crude Bio-oil and Soil-Amending, Carbon Sequestering Biochar.** A.A. Boateng, Eastern Regional Research Center, Agricultural Research Service, USDA, USA.

8.50 **Strong Genotoxic Effects of Diesel Engine Emissions from Combustion of Vegetable Oils.** J. Bünger[1], J. Krahl[2,5], J. Bünger[5], A. Munack[3], O. Schröder[3], C. Handrich[4], E. Hallier[4], T. Brüning[1], and G. Westphal[1,4], [1]BGFA - Research Institute of Occupational Medicine, German Social Accident Insurance, Ruhr-University Bochum, Germany, [2]Coburg University of Applied Sciences, Germany, [3]Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI), Germany, [4]Institute of Occupational and Social Medicine, Georg-August-University of Göttingen, Germany, [5]Steinbeis-Transfer-Center Biofuels, Germany.

9.10 **Performance of Tractors Fueled with Raw Vegetable Oil.** G.R. Cauffman and D.H. Schaufler, The Pennsylvania State University, USA.

9.30 **Bio-thermal Valorisation of Biomass: The BtVB Process**

at Hainhaus/Odenwald. A. Hornung, A. Apfelbacher, and S. Sagi, European Bioenergy Research Institute, Aston University, UK.

9.50 **The Possible Role of Fast Pyrolyis in the Production of 2nd Generation Biofuels.** W. Prins[1], M. Rosso-Vasic[2], and R.H.V. Venderbosch[3], [1]Ghent University, Belgium, [2]Albermarle Catalysts Company b.v., The Netherlands, [3]BTG Biomass Technology Group b.v., The Netherlands.

10.10 **Break**

10.40 **Continuous Process to Obtain a Diesel-like Fuel from Soybean Oil Cracking: Plant Design and Energy and Mass Balance.** J.P. Rodrigues[1], P.A.Z. Suarez*[1], J.C. Rubim[1], O.K. Iha[1], G.H.M. Aguiar[1], M.B. Ramos[1], R.S. Martins[1], I.B. Reis[1], and R.R. Lavich[2], [1]LMC-IQ-Universidade de Brasilia, Brazil, [2]Petrobás S.A., Brazil.

11.00 **Biodiesel and Renewable Diesel: A Critical Comparison.** G. Knothe, USDA, ARS, NCAUR, USA.

11.20 **Approaches to Renewable Diesel Production.** P.L. Hanks, K.Y. Cole, and W.E. Lewis, ExxonMobil Research and Engineering, USA.

11.40 **Discussion**

12.00–13.00 **Luncheon—Muenchen Room**

Session 8: Sustainability Aspects of Biodiesel

Room: Atlanta

Session Chairs: M.Q. Wang, Argonne National Laboratory, USA; and Franziska Müller-Langer, DBFZ GmbH, Germany

8.30 **Roundtable on Sustainable Biofuels (RSB): Biofuel Sustainability Protocol Development.** V. Junquera, Roundtable for Sustainable Biofuels, Switzerland.

8.50 **CEN Sustainability Standards in Support of the EC Directive's Implementation.** O. Costenoble, NEN Energy Resources, The Netherlands.

9.10 **U.S. Efforts on Biofuel GHG Regulation Development.** J. Courtis, California Air Resources Board, USA.

9.30 **GHG Emissions and Sustainability Aspects of Biodiesel.** N. Jungbluth, ESU-Services Ltd., Switzerland.

9.50 **NBB Sustainability Committee Mission and Activities.** D. Scott, National Biodiesel Board, USA.

10.10 **Break**

10.30 **Biofuel Life Cycle GHG Emissions and Land Use Change Effects.** B. Stokes[1] and Z. Haq[2], [1]Navarro Research & Engineering, Golden Field Office, USA, [2]Office of the Department of Biomass, U.S. Department of Energy, USA.

10.50 **How to Enhance the Sustainability of Palm Oil Biodiesel.** G.A. Reinhardt, S. Köppen, N. Rettenmaier, and S.O. Gärtner, Institute for Energy and Environmental Research Heidelberg, Germany.

11.10 **Biofuel Support Policies and Their Assessment.** M. Von Lampe, Organisation for Economic Co-operation and Development, France.

11.30 **Discussion**

12.00–13.00 **Luncheon—Muenchen Room**

Session 9: Biodiesel: Large Scale Transport; New Uses for Glycerol; and General Topics

Room: Ballsaal A

Session Chairs: R. Lawrence, Magellan Midstream Partners, L.P., USA; and P.M. Pagliaro, CNR, Italy

8.30 **Logistical Challenges Associated with Transporting Biodiesel Blends on Refined Products Pipelines.** R. Lawrence, Magellan Midstream Partners, L.P., USA.

8.50 **Multi-Function Catalysts for Gas Phase Glycerol Conversion.** P.C. Hulteberg and J.G.M. Brandin, Biofuel-Solution, Sweden.

9.10 **Glycerol Acetals as Fuel Additives for Gasoline and Biodiesel.** C.J.A. Mota, C.X.A da Silva, P.H.S. Ribeiro, and V.L.C. Gonçalves, Universidade Federal do Rio de Janeiro, Brazil.

9.30 **High Voltage Separation of Biodiesel from Glycerin.** G. Austic and R. Burton*, Piedmont Biofuels Industrial, USA.

9.50 **Evaluation of Soy Methyl Ester-Polystyrene Blends for Use in Concrete.** K. Coates, J. Weiss, and B. Tao*, Purdue University, USA.

10.10 **Break**

10.40 **The Use of Lewis Metal Catalysts to Produce Fatty Acid Esters from Acid Stock.** S.M. Plentz Meneghetti, Federal University of Alagoas, Brazil.

11:00 **Discussion**

12.00–13.00 **Luncheon—Muenchen Room**

AFTERNOON

13.00 **Technology Showcase Presentations**
Room: Ballsaal B

13.30–14.00 **Break**

Closing Session: Future Perspectives

Room: Ballsaal A

14.00 **Global Mandates and Projected Growth of the Biodiesel Industry.** C. Rocchietta, Biofuel Partners Srl, Italy.

14.30 **Biodiesel in India. An Insight into Feedstocks, Government Policies, Challenges and Opportunities.** K. Kapadia, Desmet Ballestra India Pvt. Ltd., India.

15.00 **Lipids as Source of Food and Fuel—Will There be Enough?** F. Gunstone, Scottish Crop Research Institute, Scotland.

15.45 **Discussion**

16.00 **Closing Comments.** M.J. Haas, USDA, ARS, ERRC, USA.

Poster Presentations

Poster Session Chairs: R.O. Dunn, USDA, ARS, NCAUR, USA; and B.R. Moser, USDA, ARS, NCAUR, USA

Poster presentations will be on display for the duration of the Congress. Visit with authors during program breaks.

Alternative Renewable Fuels

1. **Products of Natural Triacylglycerols Cracking as Components of Fuel Blends for Diesel Engines.** E. Buzetzki[1], J. Mikulec[2], and J. Cvengros*[3], [1]Technisches Buro, Slovakia, [2]Slovnaft VÚRUP, Slovakia, [3]Faculty of Chemical and Food Technology STU, Slovakia.
2. **Comparisons of Biodiesel Productivity of Different Vegetable Oils by Alkali Catalysis.** A. Sagiroglu, H.M. Ozcan, S.S. Isbilir, H. Polizar, and N.M. Toprankiran, Trakya University, Turkey.
3. **Comparisons of Biodiesel Productivity of Different Vegetable Oils by Acidic Catalysis.** A. Sagiroglu, S.S. Isbilir, H.M. Ozcan, H. Poluzar, and N.M. Toprakkiran, Trakya University, Turkey.
4. **Regulated and Non-Regulated Emissions from Animal Fat and Vegetal Biodiesel.** R. Penteado[1,2] and R. Cunha[1], [1]Lactec, Brazil, [2]P&K Consulting, Brazil.
5. **Understanding Hydrodeoxygenation of Oils and Fats.** A.T. Madsen, A. Riisager, and R. Fehrmann, Centre for Catalysis and Sustainable Chemistry, DTU Chemistry, Technical University of Denmark, Denmark.
6. **Comparison of the Mutagenic Potential of Particle Emissions of a Vegetable Oil Compatible Tractor Fueled with Rapeseed Oil and Diesel Fuel.** K. Thuneke, P. Emberger*, T. Gassner, and E. Remmele, Technologie- und Förderzentrum, Germany.
7. **Emission Characteristics of Rapeseed Oil Fueled Tractors during Three Years of Operation.** K. Thuneke, P. Emberger*, T. Gassner, and E. Remmele, Technologie- und Förderzentrum, Germany.
8. **Pre-standard DIN V 51605 for Rapeseed Oil Fuel.** E. Remmele, K. Thuneke, and P. Emberger*, Technologie- und Förderzentrum, Germany.
9. **Optimization of *Jatropha curcas* Oil-pressing for Biodiesel Production.** S. Karaj and J. Müller, University of Hohenheim, Germany.

Analytical Methods and Fuel Quality Issues

1. **Optimization of Properties of Biodiesel Formulations by Response Surface Methodology.** M.J. Pratas[1], S. Monteio[2], A. Silvestre[1], I. Marrucho[1], and J. Coutinho[1], [1]CICECO, University of Aveiro, Portugal, [2]Polytechnic Institute of Leiria, Portugal.
2. **Determination of Iodine Value of Biodiesel by 1H NMR using 1,4-dioxane as Internal Standard.** M. Oromí[1], A. Tomàs[1], G. Villorbina[1], M. Torres[2], J. Eras[1], M. Balcells[1], and R. Canela[1], [1]Chemistry Department, University of Lleida, Spain, [2]Food Technology Department, UTPV-Certa, University of Lleida, Spain.
3. **Characterization of Waste Frying Oils by NIR Spectroscopy.** A. Barranco[1], M. Uriarte[1], C. López[2], T. Travería[2], and E. Saitua*[1], [1]AZTI-Tecnalia, Spain, [2]Bionor Transformacion, S.A., Spain.
4. **Assessing Microbial Spoilage of Biodiesel Blends under Aerobic and Anaerobic Conditions.** S. Nygaard, K. Sørensen, H. Hansen, and G. Sørensen, Danish Technological Institute, Denmark.
5. **Characterization of Diesel/Biodiesel Blends by Simulated Distillation.** C. Bachler, S. Schober, S. Buchgraber, and M. Mittelbach, Karl-Franzens-University Graz, Austria.
6. **Effect of Lignin Addition on Biodiesel as Prepared by Supercritical Methanol Method.** S. Saka and J. Xin, Graduate School of Energy Science, Kyoto University, Japan.
7. **Thermodynamic Study on the Effects of Minor Constituents on Cold Weather Performance of Biodiesel.** R.O. Dunn, USDA, ARS, NCAUR, USA.
8. **Effect of Antioxidant on the Oxidative Stability of Biodiesel.** H. Tang, R.C. De Guzman, S.O. Salley, and K.Y. Simon Ng*, Wayne State University, USA.
9. **Improvement of Oxidation Stability of Biodiesel by Selective Hydrogenation Technology.** M. Toba[1], Y. Abe[1], A. Suemanotham[2], Y. Thanmongkhon[2], P. Jenvanitpanjakul[2], and Y. Yoshimura[1], [1]National Institute of Advanced Industrial Science and Technology, Japan, [2]Thailand Institute of Scientific and Technological Research, Thailand.
10. **Determination of Free and Esterified Steryl Glucosides in Vegetable Oils and Biodiesel.** F. Lacoste[1], F. De Jean[1], H. Griffon[1], and C. Rouquette[2], [1]ITERG, France, [2]IFP, France.
11. **Using HPLC to Monitor Enzymatic Biodiesel Production.** L. Spångner Christiansen[1], C.A. Godoy[2], Y. Xu[1], M. Nordblad*[1], and J.M. Woodley[1], [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, Denmark, [2]Departamento de Biocatálisis, Instituto de Catálisis y Petroleoquímica (CSIC), Spain.
12. **Pressure Drop Hysteresis Effect on Biodiesel Filtration.** K. Kim, D. Kittelson*, and D. Pui, University of Minnesota, USA.
13. **Cold Weather Limitations of Saturated Monoglyceride (SMG) Impurities.** R.W. Heiden, R.W. Heiden Associates, LLC, USA.

Cleaning up Biodiesel

1. **Purification and Winterization of Biodiesel by Micro Process Engineering.** G. Rinke and S. Kerschbaum, Karlsruhe Research Center, Institute for Micro Process Engineering, Germany.

Feedstocks for the Future

1. **Characterization of Low-Quality Feedstocks in Japan and the Possibility of their Conversion to the First- or Second-Generation Biodiesel.** H. Kuramochi[1], M. Osako[1], M. Toba[2], Y. Yoshimura[2], K. Maeda[3], K. Nakmura[4], and S. Sakai[5], [1]National Institute for Environmental Studies, Japan, [2]National Institute of Advanced Industrial Science and Technology, Japan, [3]University of Hyogo, Japan, [4]Advanced Software Technology & Mechatronics Research Institute of Kyoto, Japan, [5]Kyoto University, Japan.
2. **Algal Growth Characteristics and Oil Properties.** N.J. Abunasser[2,1], M.E.D. Garcia Perez[1], H. Tang[1], S.O. Salley[1], and K.Y.S Ng[1], [1]Wayne State University, USA, [2]MEDC, USA.

3. **Used Frying Oils as a Source for FAME Preparation.** A. Kleinova[1] and J. Cvengros*[2], [1]Faculty of Chemical and Food Technology STU, Slovakia, [2]Faculty of Chemical and Food Technology STU, Slovakia.
4. **Catalytic Transformation of Castor Oil Methylesters into High Oleic Methyesters.** N. Ravasio[1], F. Zaccheria[1], P. Bondioli[2], and L. Della Bella[2], [1]CNR ISTM, Italy, [2]SSOG, Italy.
5. **Comparison of the Biodiesel Produced from Palm Oil Raw, Degummed or Preesterified.** F.A. Avellaneda Vargas[1,2] and J. Salvadó Rovira[1], [1]Universitat Rovira i Virgili, Spain, [2]Universidad de Pamplona, Colombia.
6. **A Pretreatment Process for Waste Frying Oil as Biodiesel Feedstock: Solvent Extraction Combined with Ca-Soap Precipitation.** F.M. Tunc, H. Gurbuz*, and Z.S. Turkay, Istanbul Technical University, Chemical Engineering Department, Turkey.
7. **Extraction, Refining, and Conventional Transesterification Compared with in situ Transesterification of Jatropha Seed Oil.** C.M. Fernández, M. Solana, M.J. Ramos, A. Pérez, and J.F. Rodríguez, Institute for Chemical and Environmental Technology, University of Castilla la Mancha, Chemical Engineering Department, Spain.
8. **Characteristics and Composition of Brazilian Jatropha Curcas Seeds and Oils.** M.B. Casarini[1], A.L.M.T. Pighinelli*[2], R.A. Ferrari[1], and K.J. Park[2], [1]Institute of Food Technology, Brazil, [2]State University of Campinas, Brazil.
9. **Utilization of Brazilian Jatropha Curcas Seeds for Biodiesel and Animal Feed Production.** C.O.B. González[1], A.L.M.T. Pighinelli*[1], R.A. Ferrari[2], and K.J. Park[1], [1]State University of Campinas, Brazil, [2]Institute of Food Technology, Brazil.
10. **Improving Fatty Acid Alkyl Esters Production Yield in a Lipase-Catalyzed Process by Using Waste Frying Oils as Feedstock.** L. Azócar[1], G. Ciudad[2], H.J. Heipieper[3], R. Muñoz[4], and R. Navia[2,4], [1]Programa de Doctorado en Ciencias de Recursos Naturales, Universidad de La Frontera, Chile, [2]Núcleo Científico Tecnológico en Biorrecursos, Universidad de La Frontera, Chile, [3]Department of Environmental Biotechnology, Helmholtz Centre for Environmental Research - UFZ, Germany, [4]Departamento de Ingeniería Química, Universidad de La Frontera, Chile.
11. **Use of Oleaginous Yeasts for the Biodiesel Synthesis from Agroindustrial Residues.** A. Yousuf and D. Pirozzi, Dipartimento di Ingegneria Chimica , Università Federico II, Italy.
12. **Valorization of Side-streams of Oil Refining.** C. Echim[1], R. Verhé[1], W. De Greyt[2], and C. Stevens[1], [1]University of Ghent, Belgium, [2]Desmet Ballestra, Belgium.

Fuel and Engine Aspects of Engine Operability and Catalyst Performance

1. **Enzymatic Production of Biodiesel from Free Fatty Acids.** M. Afonso[1], M.J. Pratas*[1], S. Monteiro[2], A. Silvestre[1], M.A. Coelho[1], and João Coutinho[1], [1]CICECO - University of Aveiro, Portugal, [2]Polytechnic Institute of Leiria, Portugal.
2. **Optimization of Biodiesel and Diesel Blend Ratio for MF-399 Tractor Engine using Genetic Algorithms.** A. Zenouzi, M. Safiadin, B. Ghobadian, and T. Tavakoli Hashjin, Tarbiat Modares University, Iran.

General Topics

1. **Biodiesel Industry in Turkey.** A. Isler and F. Karaosmanoglu, Istanbul Technical University, Department of Chemical Engineering, Turkey.
2. **Application of the CPA EoS to the Modelling of Biodiesel Production.** M.B. Oliveira[1], R.R. Teles[1], S. Miguel[1], M.J. Pratas[1], A.J. Queimada[2], and J.A.P. Coutinho[1], [1]CICECO, Chemistry Department, University of Aveiro, Portugal, [2]LSRE - Laboratory of Separation and Reaction Engineering, Faculdade de Engenharia, Universidade do Porto, Portugal.
3. **Mechanical Expelling of Sunflower Oils to Produce Biodiesel.** A.L.M.T. Pighinelli[1], R.A. Ferrari[2], A.M.R. Miguel[2], and K.J. Park[1], [1]State University of Campinas, Brazil, [2]Institute of Food Technology, Brazil.
4. **Electrochemical Characterization of Biodiesel Electrolyte.** J.R. Rodrigues[1], C. Freire[2], M. Ballester[2], A.L.M.T. Pighinelli*[2], R.A. Ferrari[3], L. Martin[1], and K.J. Park[2], [1]Federal University of Maranhão, Brazil, [2]State University of Campinas, Brazil, [3]Institute of Food Technology, Brazil.
5. **Energy Balance Analysis of a One Million Gallon Biodiesel Production Facility.** R. Burton[1] and M. Hyman[2], [1]Piedmont Biofuels Industrial, USA, [2]North Carolina State University, USA.
6. **Methanol Dependence in National Programme for the Production and Use of Biodiesel (PNPB).** P. Mendes[1,2], J. Freitas[1], S. Borschiver[2], L. D'Ávila[2], and A. Barros[1,3], [1]National Agency of Oil, Gas and Biofuels, Brazil, [2]Federal University of Rio de Janeiro, Brazil, [3]Federal University of Maranhão, Brazil.
7. **Novel Two-phase Bioreactor Concept for Fatty Acid Alkyl Esters Production Using Whole Cell Catalysts.** G. Ciudad[1], I. Reyes[2], M. Jorquera[3], L. Azocar[2], R. Briones[4], L.Y. Wick[5], and R. Navia[1,6], [1]Center of Waste Management and Bioenergy, Scientifical and Technological Bioresource Nucleus, Universidad de La Frontera, Chile, [2]Programa de Doctorado en Ciencias de Recursos Naturales, Universidad de La Frontera, Chile, [3]Center of Plant, Soil Interaction and Natural Resources Biotechnology, Scientifical and Technological Bioresource Nucleus, Universidad de La Frontera, Chile, [4]Magíster en Ciencias de la Ingeniería Mención Biotecnología, Universidad de La Frontera, Chile, [5]Helmholtz Centre for Environmental Research UFZ, Department of Environmental Microbiology, Germany, [6]Departamento de Ingeniería Química, Universidad de La Frontera, Chile.
8. **Biodiesel Production in Supercritical Conditions from Non Edible Oil Feedstocks.** P. Campanelli, L. Manna, M. Bachero, and S. Sicardi, Politecnico di Torino, Department of Materials Science and Chemical Engineering, Italy.
9. **Biodiesel Obtention from Jatropha Curcas L Oil by Ethanolic Transesterification.** J. Velasquez, P. Cuartas, and A. Castillo, Universidad Pontificia Bolivariana, Colombia.
10. **Extraction with Solvent and Oil Purification from Seeds from Seeds of Jatropha curcas L.** J.Velasquez, P. Cuartas*, and H. Giraldo, Universidad Pontificia Bolivariana, Colombia.
11. **Study of Extraction of Vegetable Oil Seed Castor.** K.C. Ribeiro Martins[1], L. Galvão Viana[1], L. Santos Pereira Martins[2], L.E. Matias da Silva[1], and A.P. da Silva Mafra[1], [1]Instituto Federal de Educação, Ciência e Tecnologia do Maranhão, Brazil, [2]Universidade Estadual do Maranhão, Cidade Universitária Paulo VI, Brazil.

Glycerol

1. **Optimization of Media Composition for the Production of Biohydrogen from Waste Glycerol Obtained from Biodiesel Manufacturing.** R. Jitrwung and V. Yargeau, McGill University, Canada.
2. **Flexible Batch Pilot Plant for Glycerol Purification in the Biodiesel Production Process.** A. Zenouzi, A. Mohammadi, B. Ghobadian, and S. Minaee, Tarbiat Modares Universty, Iran.
3. **The Role of the Ion Exchange in the Purification of Glycerol from Biodiesel Production.** M. Carmona, A. de Lucas, A. Perez, and J.F. Rodriguez*, Institute of Chemical and Environmental Technology, ITQUIMA, University of Castilla-La Mancha, Spain.
4. **Glycerine-esters Used as PVC Plasticizers.** O.Y. Suárez Palacios[1,2], P.C. Narváez Rincón[1], J.-P. Corriou[2], M. Camargo Pardo[2], C. Fonteix[2], and M. Velandia[3], [1]Universidad Nacional de Colombia, Colombia, [2]Institut National Polytechnique de Lorraine, France, [3]Carboquímica, Colombia.
5. **Acetylation of Glycerol over Tungstophosphoric Acid Supported on Silica.** P. Ferreira[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Portugal.
6. **Polyester from Glycerol as Adsorbent Material for Glycerol Remotion in Biodiesel Purification.** C.A. Toro Aedo, G. Ciudad Bazaul, L. Azócar Ulloa, and R. Navia Diez, Núcleo Científico Tecnológico en Biorrecursos, Universidad de La Frontera, Chile.
7. **Hydrogen Production from Glycerol: Fermentors vs. Microbial Electrolysis Cells.** P.A. Selembo[1], J. M. Perez*[1], W.A. Lloyd[1], and B.E. Logan[2], [1]Department of Chemical Engineering, Pennsylvania State University, USA, [2]Department of Civil and Environmental Engineering, Pennsylvania State University, USA.
8. **Transesterification of Glycerol with Methyl Acetate over Sulfonic Acid-functionalized Mesostructured Silicas.** J.A. Melero, G. Vicente, G. Morales, C. Ochoa, and M. Paniagua*, Department of Chemical and Environmental Technology, Rey Juan Carlos University, Spain.

New Production Technologies

1. **Improving the Efficiency of Biodiesel Production via in situ Transesterification and Investigating the Use of the Meal Byproduct in Poultry Nutrition.** M.J. Haas[1], R.L. Stroup[2], D. Latshaw[3], and K.M. Scott[1], [1]Eastern Regional Research Center, USDA, USA, [2]R. L. Stroup Co., USA, [3]Dept. of Animal Sciences, Ohio State University, USA.
2. **Preparation of Biodiesel and Utilizing of its Side Product.** M. Hájek and F. Skopal, University of Pardubice, Faculty of Chemical Technology, Czech Republic.
3. **Testing of Lipase-producing Yeasts for Enzymatic Transesterification to Biodiesel.** A. Aurelia Chirvase[1], L. Tcacenco[2], N. Radu[1], C. Ungureanu[3], and M. Leca[4], [1]National Research & Development Institute for Chemistry and Petroleum Chemistry, ICECHIM, Romania, [2]National Research & Development Institute of Biological Sciences, Romania, [3]Politehnica University of Bucharest, Romania, [4]University of Bucharest, Romania.
4. **Supercritical Biodiesel Production using Heterogeneous Catalysts.** P. Olivares[1], J. Quesada*[1], J.A. García[2], and S. Navarro[2], [1]Department of Chemical Engineering, Faculty of Chemistry, University of Murcia, Campus of Espinardo, Spain, [2]Department of Research and Development, TAHE Group, Spain.
5. **Modeling the Kinetics of Calcium Hydroxide Catalyzed Methanolysis of Sunflower Oil.** V.B. Veljkovic[1], O.S. Stamenkovic[1], Z.B. Todorovic[1], M.L. Lazic[1], and D.U. Skala[2], [1]Faculty of Technology, University of Nis, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Serbia.
6. **Kinetics of Sunflower Oil Methanolysis Catalyzed by Barium Hydroxide.** O.S. Stamenkovic[1], V.B. Veljkovic[1], Z.B. Todorovic[1], M.L. Lazic[1], and D.U. Skala[2], [1]Faculty of Technology, University of Nis, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Serbia.
7. **Preparation of Xerogel Catalyst with ZnO as Active Component for Biodiesel Synthesis.** I. Lukic[1], A. Orlovic[1], J. Krstic[2], D. Jovanovic[2], and D. Skala[1], [1]Faculty of Technology and Metallurgy, University of Belgrade, Serbia, [2]Institute of Chemistry, Technology and Metallurgy, Department of Catalysis and Chemical Engineering, Serbia.
8. **Biodiesel Production Key. Optimizing Reactor Design for Esterification and Transesterification Processes.** G. Villorbina[1], A. Escobedo[1], A. Tomàs[1], M. Oromí[1], M. Balcells[1], J. Eras[1], N. Sala[2], and R. Canela[1], [1]Chemistry Department, University of Lleida, Spain, [2]Food Technology Department, UTPV-Certa, University of Lleida, Spain.
9. **Biodiesel Production with Calcined Limestone Functioning as Solid Base Catalyst.** M. Kouzu[1], J. Hidaka[2], T. Fujiwara[3], H. Nakano[3], and M. Yamamoto[3], [1]Research Center for Fine Particle Technology, Doshisha University, Japan, [2]Department of Chemical Engineering and Material Science, Doshisha University, Japan, [3]Jyo-nan Electric Industrial Co., Ltd., Japan.
10. **The Effect of Triacetin on the Biodiesel Quality.** M.J. Ramos, A. Casas, C.M. Fernández, and Á. Pérez, Chemical Engineering Department, Institute of Chemical and Environmental Technology, University of Castilla-La Mancha, Spain.
11. **The Production and Performance of Diesel Fuels from Renewable Sources.** J. Mikulec[1], J. Cvengros[2], L. Jorikova[1], M. Banic[1], and A. Kleinova[2], [1]Slovnaft VURUP, a.s., Slovak Republic, [2]Faculty of Chemical and Food Technology, STU, Slovak Republic.
12. **Enzymatic Esterification of Fatty Acid Distillates - a Plug-in Alternative to Sulfuric Acid Catalysis.** J. Brask[1], P.M. Nielsen[1], M.L. Damstrup[1], J. Maes[2], and W. De Greyt[2], [1]Novozymes A/S, Denmark, [2]Desmet Ballestra, Belgium.
13. **Techno-Economical Analysis of Supercritical Biodiesel Synthesis: The Weak Points and Future Production Technology.** S. Glisic and D. Skala, Faculty of Technology and Metallurgy, University of Belgrade, Serbia.
14. **Build or Revamp, Ecologically Driven Biodiesel Technology.** A. Kovacs[1,2] and D. Hayward[2], [1]KUKK K+F Ltd., Hungary, [2]QS Biodiesel Ltd., UK.
15. **Modeling and Simulation of the Continuous Biodiesel Production Process in a Countercurrent Reactor.** J. Guillermo Cadavid Estrada[1], P.C. Narváez Rincón[1], and J. Fontalvo Alzate[2], [1]Universidad Nacional de Colombia Sede Bogotá, Colombia, [2]Universidad Nacional de Colombia Sede Manizales, Colombia.
16. **Super-fast Biodiesel Synthesis using Liquefied Dimethyl Ether and Proposal of a Method for High-yield Synthesis and Reduction of Cosolvent.** H. Kuramochi[1], K. Maeda[2], M. Osako[1], K. Nakamura[3], and S. Sakai[4], [1]National Institute for Environmental Studies, Japan, [2]University of Hyogo, Japan,

[3]Advanced Software Technology & Mechatronics Research Institute of Kyoto, Japan, [4]Kyoto University, Japan.

17. **Supercritical Dimethyl Carbonate: a Novel Alternative Process for Non-Catalytic Biodiesel Production.** Z. Ilham and S. Saka, Graduate School of Energy Science, Kyoto University, Japan.
18. **Novel Dual Sites Mixed Oxide Catalysts for Simultaneous Transesterification and Esterification to Biodiesel.** S. Yan[1,2], M. Kim[1,2], S.O. Salley[2], and K.Y.S. Ng[2], [1]National Biofuels Energy Laboratory, USA, [2]Wayne State University, USA.
19. **Application of Microwave in Production of Biodiesel from Waste Frying Oils.** I. Rahmanlar[1], C. Yerlikaya[2], and S. Yucel*[1], [1]Yildiz Technical University, Bioengineering Department, Turkey, [2]Istanbul Technical University, Chemical Engineering Department, Turkey.
20. **Reaction Efficiency for Biodiesel Production Utilizing Hydro-dynamic Cavitation.** R. Burton, N. Fox, and X. Fan, Piedmont Biofuels Industrial, USA.
21. **Process Simulation of Enzymatic Biodiesel Production - At What Cost Can Biodiesel be Made with Enzymes?** L. Fjerbæk Søtoft, K.V. Christensen, B.-G. Rong, and B. Norddahl, University of Southern Denmark, Denmark.
22. **Catalytic Activity and Durability of Supported CaO-based Catalysts for Transesterification in a Continuous Flow Fixed Bed Reactor.** M. Kim[1,2], S. Yan[1,2], S.O. Salley[2], and K.Y.S. Ng[2], [1]National Biofuels Energy Laboratory, NextEnergy, USA, [2]Wayne State University, USA.
23. **Improved Conversion to Biodiesel by the Use of a Jet Reactor.** E.R. Els and A. Moolman, University of Stellenbosch, South Africa.
24. **Crosslinked Lipase Aggregate Formation of Various Lipases with Polyethylenemine.** E. Öndül[1], G.E. Özarslaner[1], M. Erhan Kanişli, N. Dizge[2], and N. Albayrak[1], [1]Yüzüncü Yıl Üniversity, Turkey, [2]Gebze Yüksek Teknoloji Enstitüsü, Turkey.
25. **Esterification of Acidic Oils over a Versatile Amorphous Solid Catalysts.** F. Zaccheria, R. Psaro, and N. Ravasio*, CNR ISTM, Italy.
26. **Esterification of Free Fatty Acids over Heteropolyacids Immobilized on Mesoporous Silica.** D. Pito[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Portugal.
27. **Continuous Transesterification of Soybean Oil Under Supercritical Alcohols.** I. Vieitez[1], C. da Silva[2], I. Alckmin[2], G.R. Borges[2], F.C. Corazza[2], J.V. Oliveira[2], M.A. Grompone[1], and I. Jachmanian*[1], [1]Laboratorio de Grasas y Aceites, Facultad de Química, Universidad de la República, Uruguay, [2]Department of Food Engineering, URI-Campus de Erechim, Brazil.
28. **Hydrolysis of Olive Oil in Submerged Membrane Bioreactor for Innovative Production Systems.** S. Chakraborty[1,2], L. Giorno[1], and E. Drioli[1,2], [1]Research Institute on Membrane Technology, Italy, [2]Dept. of Chemical and Materials Engineering, University of Calabria, Italy.
29. **Dyeing Method for Determination of Glycerol Partitioning in Biodiesel Production.** Y. Xu[1], M. Nordblad[1], P.M. Nielsen[2], J. Brask[2], and J.M. Woodley[1], [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, Denmark, [2]Novozymes A/S, Denmark.
30. **Mechanical Stability of Immobilized Lipases and the Supports in a Stirred Tank Reactor.** Y. Xu[1], C.A. Godoy[2], J.M. Guisan[2], M. Nordblad[1], P.M. Nielsen[3], J. Brask[3], and J.M. Woodley[1], [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, Denmark, [2]Departamento de Biocatálisis, Instituto de Catálisis y Petroleoquímica (CSIC), Spain, [3]Novozymes A/S, Denmark.
31. **Solvent Extraction and Processing of Microalgae Oil for Biodiesel.** R.C. Green, POS Pilot Plant Corporation, Canada.
32. **Catalysts Screening on In-situ Transesterification of Jatropha Curcas Seed.** F.H. Kasim and A.P. Harvey, Newcastle University, UK.
33. **Optimization of Reaction Conditions for Crude Palm Oil Methanolysis using Aenesulfonic Acid-Modified Mesostructured Catalysts.** J.A. Melero, L.F. Bautista, J. Iglesias, G. Morales, and R. Sanchez-Vazquez*, Department of Chemical and Environmental Technology, Rey Juan Carlos University, Spain.
34. **A Comprehensive Review of the Biodiesel Production and Purification Technologies in Iran.** B. Ghobadian, Tarbiat Modares University, Iran

Sustainability Aspects of Biodiesel

1. **Biodiesel Production from Waste Cooking Oil over Sulfonated Solid Catalysts.** C. Caetano[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Portugal.
2. **Biodiesel in the Brazilian Amazon: Mapping Initiatives, Policies, and Impacts.** R. Andrade[1] and A. Miccolis[2], [1]Universidade Católica de Brasília, Brazil, [2]ComSensos Consultoria, Brazil.

Oral Presentation Abstracts

The speakers is the first author listed or is otherwise indicated with an asterisk (*)

SUNDAY, 15 NOVEMBER

AFTERNOON

Plenary Session: Global Overview of the Biodiesel Industry

Opening Keynote Lecture. Thomas Mielke, Oilworld, Germany.

(Abstract not available)

Biodiesel Developments in Asia. Mohd Basri Wahid, Malaysian Palm Oil Board, Kajang, Selangor, Malaysia.

Countries in Asia have gone into production and use of biodiesel driven by various factors. For developed countries such as Japan and Korea, meeting emission reduction targets under the Kyoto Protocol is of primary concern. For main producers of biodiesel feedstock such as Malaysia (palm oil), Indonesia (palm oil, Jatropha) and Philippines (coconut oil), the main concerns are to support commodity prices and reduce reliance on imported diesel. Large diesel consuming countries such as India and China hope to grow their own biodiesel feedstocks to reduce reliance on fossil fuels and at the same time create local employment. In line with these objectives, policies, legislation, incentives and differential taxes have been implemented in these countries. However, global developments have affected the development of the biodiesel industries in these countries. Among these are the developments in the EU, which has introduced a Directive on Renewable Energy which imposes sustainability requirements for biofuels. This will affect exports of biodiesel from countries such as Malaysia and Indonesia. The falling prices of crude oil without the same extent of price drop in vegetable oil prices have also made biodiesel less competitive vis-a-vis diesel. This paper will cover some of the current developments, issues and challenges faced by these countries.

North American Perspective. J. Jobe, National Biodiesel Board, USA.

After ten years of often triple-digit annual percentage rate growth of biodiesel production in North America, the first half of 2009 saw approximately 30% negative growth. This contraction is related to a number of factors, primarily led by the global recession that resulted in reduced demand for diesel fuel. Other factors included high feedstock costs, constrained credit markets, reduced access to export markets, uncertain government policy support, and a well-funded public relations campaign to disparage biofuels. One of the main current challenges is the controversial theory of assessing Indirect Land Use Change (ILUC) impacts to biofuels. Landmark energy legislation commonly referred to as the Renewable Fuel Standard 2 (RFS-2), was passed by Congress in order to develop a stable domestic market for biofuels in the US. The RFS-2 required a minimum volume of biofuels including a category for biodiesel. In May 2009, EPA published a proposed draft rule for this new law that included broad and speculative assumptions on ILUC. The proposal as drafted would not only make the US biodiesel industry the first industry regulated for carbon in the US, but also accountable for carbon from other industries on other continents. The outcome of this regulatory process will have far reaching impacts on the future role of biodiesel in US energy policy.

MONDAY, 16 NOVEMBER

MORNING

Session 1: Cleaning up Biodiesel

Session Chairs: R. Verhé, University of Ghent, Belgium; and S. Fenwick, Archer Daniels Midland Co., USA

Purification Methods for Biodiesel and Glycerin. Barbara Harten, Westfalia Separator Process GmbH, Oelde, Germany.

The presentation will show how purification technology of the biodiesel and glycerin is used in different stages of the production in the biodiesel industry. Purification is necessary to achieve a product, which fulfils the different biodiesel and glycerin standards and should be optimized depending on the special requirements of the process step and should consider costs related to utilities and product losses.

Starting with a comparison of the different methods for the pre-treatment of the crude oil depending on the kind of oil and its quality, the presentation will show the purification methods in the different stages of the transesterification process to remove glycerin, catalyst, soap, water, and minor components. The different methods to remove sterol glycosides will be shown and compared. The removal of unwanted components like fatty matter, salt, water from the glycerin is an important factor to achieve a product, which fulfills the market expectations.

Effect of Minor Components Content on Precipitate Formation in Biodiesel. Haiying Tang[1,2], Steven O. Salley[2], and K.Y. Simon Ng[2], [1]National Biofuels Energy Laboratory, NextEnergy, Detroit, Michigan, USA, [2]Wayne State University, Detroit, Michigan, USA.

Filter plugging and engine failure have taken place in vehicles using biodiesel blends due to precipitate formation at low-temperatures. Precipitates were observed in biodiesel blends produced from different feedstocks after storage at 4ºC. Moreover, different rates of precipitate formation were observed for B20 versus B100. These observations suggested that the precipitate formation during cold temperature storage is dependent on the feedstock and blend concentration. The solvency effects of biodiesel blends are more pronounced at low temperature than at room temperature, leading to a higher amount of precipitates formed. The majority of these precipitates can be attributed to sterol glucosides and mono glycerins. This study investigated the effect of minor components, such as sterols, mono-, di-, tri-glycerins on the precipitate formation and cold soak filtration in biodiesel. Moreover, processing strategies to reduce sterol glucoside and mono, di-, tri-glycerins content in biodiesel were evaluated and developed.

Acknowledgements: Financial support from the Department of Energy (Grant DE-FG36-05GO85005) and Michigan's 21st Century Job Fund is gratefully acknowledged.

Understanding the Low Temperature Properties of Biodiesel. M. Brewer and R. Malpas, Shell Global Solutions, Chester, UK.

The addition of FAME to diesel fuel can have a considerable impact on the low temperature properties (cloud point and CFPP) of the fuel. Understanding this impact is one of the key aspects of ensuring fuel fitness for purpose. This paper aims to describe the various ways in which FAME can affect fuel cold properties, discuss the reason why these occur and present advice for minimizing the effects.

Methyl esters are the main components of FAME and the low temperature properties are mainly influenced by the saturated methyl ester content. The presence of impurities in FAME can also influence the cold properties. These impurities can precipitate from the fuel

mixture at temperatures above the cloud point, which can lead to blockage of fuel filters. This paper discusses two impurities that have been identified in relation to field problems, mono-glycerides and sterol-glucosides.

Purification of Biodiesel Prepared from Used Frying Oils by Distillation. Roland Verhé[1], V. Van Hoed[1], C. Echim[1,2], S. Ersungur[1], N. Zyaykina[2], J. Maes[2], and W. De Greyt[2], [1]Ghent University, Faculty of Bioscience Engineering, Department of Organic Chemistry, Belgium, [2]DeSmet-Ballestra, Zaventem, Belgium.

Alternative resources such as used cooking and frying oils are used for the production of biodiesel or biofuel. The quality of the biodiesel is largely dependent upon the quality and properties of feedstocks. Pretreatment of feedstocks and post treatment of biodiesel have been developed to meet standards. During frying of oils a number of chemical reactions such as hydrolysis, oxidation and dimerisation/polymerisation are occurring producing a biodiesel with a lower ester content, higher viscosity, higher cloud point and lower oxidative stability.

In this study, a model system with rapeseed oil was developed. The influence of time of heating on the polar content, dimerisation, viscosity, cloud point and OSI on the quality of the oil, non-distilled biodiesel and distilled biodiesel has been investigated.

The polar content of heated rapeseed oil increased from 3.4 to 33% resulting in a biodiesel with a polar content of 11%.

The viscosity of FAME increased with heating time of the feedstock due to dimerisation and was exceeding the standards.

Distillation of the biodiesel gives a biodiesel meeting the standards with the exception of oxidative stability (OSI), which was decreased to 3h at 110°C due to the absence of the tocopherols in the distilled biodiesel.

Strategies for Biodiesel Purification. Derek Masterson, Crown Iron Works, USA.

Making biodiesel is more than just a chemical reaction. A good plant will take into account all aspects of production and not concentrate on only the area of the transesterification reaction. Biodiesel purification to EN and/or ASTM standards is related to upstream factors such as the feedstock quality, downstream final purification methods such as methyl ester filtration or methyl ester distillation, and everything in between.

Factors Affecting the Cold Soak Filtration Test of Biodiesel. N. Zyaykina[1], C. Echim[2], W. De Greyt[1], F. Soragna[1], and M. Kellens[1], [1]Desmet Ballestra Group, Zaventem, Belgium, [2]Ghent University, Ghent, Belgium.

Cold Soak Filtration Test (CSFT) was recently introduced in the updated ASTM B100 (D6751-08) specifications as a means to assess the performance of biodiesel in respect of filter plugging under cold weather conditions. It appeared that this new mandatory specification can become an issue to comply with for biodiesel produced from soft oils, animal fats, or palm oil and its fractions. A specific melting behavior of biodiesel containing a large fraction of saturated FAME, combined with rather poor precision of the analytical method, makes the CSFT not a user friendly method. CSFT was applied on a large number of industrially produced biodiesel samples from different origin with the objective to get a better understanding of the factors affecting cold soak filterability. Correlations between CSFT outcome and classical biodiesel quality parameters (moisture, free and bound glycerine, steryl glucosides, total contamination, etc.) were established. Effect of varying technological options (cold filtration, clarification, distillation, etc.) on CSFT was studied in order to select the most suitable process for the consistent production of good quality biodiesel meeting the CSFT.

Influence of Time on Cold Soak Filtration Results and Trace Component Analysis. Teresa Alleman, National Renewable Energy Laboratory, USA.

The cold soak filtration test (CSFT) has recently been added to B100 to ensure cold weather operability of blended biodiesels. The D6751 specification includes a maximum filtration time for B100. Previous work has shown the CSFT returns bimodal results, with fuels either easily passing or grossly failing the test. In this study, two B100s were selected that initially failed the CSFT. These fuels were retested over several weeks to determine the influence of time on CSFT results. In addition, the solids collected during filtration were analyzed.

Detection and Remediation of Microbially Contaminated Petroleum and Biomass Fuels. E. English, Fuel Quality Services, Inc., Flowery Branch, GA 30542, USA.

Since the 1950s, petroleum related industries have recognized the impact microorganisms can have on petroleum fuel product quality, power system reliability, and causing breaches in fuel system integrity resulting in release of fuel product to the environment.

Generally, petroleum fuel products will be transported great distances from the refinery to the consumer where numerous opportunities exit to inoculate fuel and downstream fuel systems with microbial contamination.

With the introduction of ultra-low sulfur diesel, biodiesel and biodiesel blends the risks are greater and the time frames are possibly much shorter. It is as important as ever to realize the potential impact microorganisms may have to fuels that are distributed, stored, and dispensed to the retail market.

This presentation will discuss and elucidate the potential impact that microbial contamination may have to biodiesel fuels and elated systems as well as current methods for detection and remediation.

Session 2: Engine Operability and Catalyst Performance I

Session Chairs: J. Krahl, Coburg University of Applied Sciences, Germany; and K. Oyama, Japan Petroleum Energy Center, Japan

Evaluation of Tractor Performance Operating on 100% Biodiesel. N.D. Rill and G.R. Cauffman, Pennsylvania State University, University Park, PA USA.

The Farm Operations Unit at the Pennsylvania State University began exploring the use of biodiesel blends in 2002. By 2004, the entire Penn State Farm Operation's fleet of 40+ vehicles and tractors was successfully running on a 20% blend of biodiesel. The success of using a 20% blend generated curiosity as to what tractor performance would be operating on 100% biodiesel. In 2005, The Penn State Farm Operations Unit in collaboration with machinery manufacturer New Holland began a project to evaluate the performance of several tractors using 100% biodiesel as the sole fuel source. These units were standard production tractors without modification of any sort ranging from 28 hp to 150 hp. The tractors have function well performing routine farm tasks throughout the year including the winter months. The success of this project has been instrumental in New Holland supporting the use of 100% biodiesel in much of their diesel-powered machinery.

Performance, Durability, and Stability of a Multi Fueled Power Generator. Kapila WaduMesthrige[1,2], Nickolas Johnson[1,2], Mark Winston-Galant[1,2], Steven O. Salley[2], and K.Y. Simon Ng*[2], [1]National Biofuels Energy Laboratory, NextEnergy, Detroit, Michigan, USA, [2]Wayne State University, Detroit, Michigan, USA.

The long term performance, durability, stability and, exhaust emissions of a power generator equipped with a CI engine using

a commercial B20 blend were investigated under cold weather conditions, following military specifications. The brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), frequency, and power of the generator using B20 were compared with baseline fuel ULSD, synthetic aviation fuel (S-8), and military grade jet fuel (JP-8) under identical engine and weather conditions. Both ULSD and B20 showed the highest stability in the generator in terms of frequency and power, while S-8 with lower density and viscosity and higher volatility had unstable frequency and power. B20 tends to form a density gradient (phase separation) at low temperatures in which unsaturated FAMEs such as C16:0 and C18:0 crystallized and deposited at the bottom of the fuel tank. This crystallization process was reversible and did not show any adverse effects on engine performance, such as fuel filter plugging. Exhaust emission data showed increased NOx levels and decreased levels of CO and unburned HC for B20 compared to ULSD.

Acknowledgements: Financial support from the Department of Energy (Grant DE-FG36-05GO85005) and Michigan's 21st Century Job Fund is gratefully acknowledged.

A Quantitative Evaluation of an On-Highway Trucking Fleet to Compare #2ULSD and B20 Fuels and Their Impact on Overall Fleet Performance. C. McKinley, J. Lumkes, and B. Tao*, Purdue, West Lafayette, IN, USA.

This presentation describes the results of a study comparing commercial performance of twenty Class-8 trucks paired by make, model, mileage, and drive cycles using #2 ultra low sulfur diesel fuel (ULSD) and a 20% soy methyl ester blend (B20). Each fleet accumulated over 2.4 million km (1.5 million miles) during the 2007 calendar year. All trucks were equipped with data collection units that monitored engine information including fuel consumption, idle time, truck speed, engine load, and engine speed. Data collection occurred over a continuous span of twelve months. In addition to operating data, laboratory-based fuel and engine oil testing was performed to quantify the analytical differences between the two fuel types. Cetane number, energy content, density, kinematic viscosity, and lubricity were measured for both fuels; at every oil service interval engine oil samples were evaluated based on fuel dilution, soot content, wear metals, contaminant metals, viscosity, oxidation, and acid/base number. Operational and maintenance issues such as cold start reliability, fuel filter service intervals, and general engine maintenance was also analyzed for each fleet. Statistical analysis was performed to determine significant differences in the performance of engines on these #2ULSD and B20 fuels.

Acknowledgements: Frito-Lay Co. and Indiana Soybean Alliance.

Impact Study of High-level Biodiesel Blends on Exhaust Emission with Advanced Aftertreatment Systems. Takashi Kaneko, Nippon Oil Corporation, Japan.

Effects of high biomass blends into diesel fuel on diesel emissions were investigated under the Japan Auto-Oil Program (JATOP). The wide variety of biomass blendstock, which includes not only some kinds of fatty acid methyl esters (FAME) but also hydrofined biodiesel and Fischer Tropsch diesel fuel, were selected to evaluate. The main blend levels evaluated were 5, 10, and 20% and the higher blend level over 20% was also evaluated in some tests. The main advanced technologies for exhaust aftertreatment systems were DPF, Urea-SCR and the combination of DPF and NSR. It was revealed that the catalyst-out CO, HC, NOx and PM levels were very low until 20% of biomass blends regardless of the types of biomass blendstock. It was also revealed that NOx emissions increased a little by 20% FAME blends. Moreover, NOx emissions remarkably increased by more than 20% of FAME blends. The impacts of high biodiesel blends on performance of DPF regeneration control were also investigated. The study results showed that concern was raised about high FAME blends in active regeneration control of DPF.

Biodiesel Blend Effects on Emissions and Public Health. O. Schröder[1], J. Krahl[2], J. Bünger[3], A. Munack[1], Y. Ruschel[1], L. Schmidt[1], and J. Schaak[1], [1]Federal Agricultural Research Center (FAL), 38116 Braunschweig, Germany, [2]Coburg University of Applied Sciences, D-96406 Coburg, Germany, [3]University of Bochum, D-44789 Bochum, Germany.

Biodiesel can be used alone (B100) or blended with petroleum diesel in any proportion. The most popular biodiesel blend in the U.S.A. is B20 (20% biodiesel, 80% diesel fuel), which can be used for Energy Policy Act of 1992 (EPAct) compliance. In the European Union, the use of biofuel blends is recommended and was introduced by federal regulations in several countries. In Germany, biodiesel is currently blended as B7 (7% biodiesel) to common diesel fuel.

To investigate the influence of blends on the emissions and possible health effects, we performed a series of studies with several engines (Euro 0, 3 and 4) measuring regulated and non-regulated exhaust compounds and determining their mutagenic effects.

Emissions of blends showed an approximate linear dependence on the blend composition, in particular when regulated emissions are considered. However, a negative effect of blends was observed with respect to mutagenicity of the exhaust gas emissions. In detail, a maximum of the mutagenic potency was found in the range of B20. From this point of view, B20 must be considered as a critical blend, in case diesel fuel and biodiesel are used as binary mixtures.

Characterization of Emissions from Heavy Duty Engines Operating with Varying Biodiesel Blends and Emission Control Systems. D. Rosenblatt, G. Rideout, E. Meloche, and T. Chan, Emissions Research and Measurement Section, Air Quality Research Division, Environment Canada, Ottawa, Ontario, Canada.

This presentation details the characterization of emissions from two on-road heavy-duty engines, model year 2004 Cummins ISM and Caterpillar C11, operating on B20 FAMEs blended from different feedstocks (canola, soy, tallow/yellow grease). These tests were conducted with varying emission controls including DOC, passively regenerating catalyzed DPF, and prototype urea based SCR technologies. Selected tests were also performed with Canadian oilsands derived fuel and B20 canola blended with oilsands. In addition, exhaust emission rates from heavy-duty highway trucks were characterized while operating with biodiesel blends at 24°C and -15°C and selected tests with SCR

Extensive chemical analysis of emissions, including aldehydes, air toxics, N2O, PAH, SO2, particle phase sulphates and particle size distribution measurements will be presented in addition to CO, CO_2, NO_X, HC, and total gravimetric PM. In general, the use of biodiesel blends in heavy-duty diesel engines compared to commercially available Canadian ULSD (<15ppm S) has shown reductions in TPM and associated particulate speciation, CO, and HC species with varying impacts on NOX. In these studies, the emissions reductions noted with different emission control technologies were demonstrated with both B20 blends and ULSD.

Session 3: Feedstock Options—Development of Resources for Biodiesel Production

Session Chairs: M. Mittelbach, University of Graz, Austria; and S. Tyson, Consultant, USA

Update of the State-of-the-Art of Marine Microalgae Production using Electric Power Plant Wastes. Ami Ben-Amotz, NBT Ltd., Eilat, & Seambiotic Ltd., Ashke, Israel.

The fluctuation in the price of fuel in the last two years has

succeeded to convince government authorities and firms around the world to search for alternative sources of energy. The Israeli Electric Company (IEC) together with Seambiotic Ltd., Israel present new green bio-fuel technology of production of oil-rich marine microalgae on wastes of electric power plant. The technology is based on cultivation of certain microalgae on coal burning smokestack sulfur scrubbed gas as emitted by many power plants. This technology allows low cost industrial production of mass quantities of marine unicellular algae using flue gas and cooling turbine seawater. Coal burning flue gas passes through special scrubbing wet process which reduces the toxic sulfur content and yields gas/moisture composition that is safe to algae and allows selection of certain marine microalgae at higher productivity compared to pure carbon dioxide. The second waste of the power plant, turbine cooling chlorinated sea is available to culture most of the common marine microalgae at reduced cost. Seambiotic Ltd established algae production ponds in close vicinity to the power plant smokestack for large scale production of marine microalgae on electric power plant wastes in attempt to test the technology and reduce the cost of production. Cultivation for the last 5 years showed selection of a few marine species with variable but manipulated content of the cellular content of carbohydrates, lipids and protein, possible sources of bio-ethanol and bio-diesel and essential amino acids, respectively. The yearly productivity attained high rates of about 20 grams dry algal biomass per m2 per day which turns to be about 5 times higher than most terrestrial plants. The algae were harvested, dried and the bioconversion efficiency of the biomass to bio-diesel and bio-ethanol was assayed in collaboration with downstream professional companies. High conversion efficiency to bio-diesel and bio-ethanol with surprising high quality of bio-fuel specifications was observed. The results show that marine unicellular algae grown on wastes of electric power plants can be feasible source to bio-fuels, the most attractive alternative to terrestrial higher plants like sugarcane and corn while considering the issues of global warming by carbon dioxide reduction and non-agricultural land use.

Isolation of Phorbol Esters from Jatropha Curcas Oil and Quality of Produced Biodiesel. Rakshit K. Devappa[1], Jeroen Maes[2], Harinder P.S. Makkar*[1], Wim De Greyt[2], and Klaus Becker[1], [1]Institute for Animal Production in the Tropics and Subtropics, (480b), University of Hohenheim, Stuttgart, Germany, [2]Desmet-Ballestra Group, Corporate Village, Da Vincilaan 2, 1935 Zaventem, Belgium.

Jatropha curcas seeds are rich in oil (28-32%), which can be converted to high quality biodiesel. Phorbol esters (PE) present in oil (3.15 mg/g) can be used as biopesticides and antimicrobial agents. This study aims to assess effect of treatments for PE isolation on quality of biodiesel. Two methods (I and II), having an effective treatment time of 2 and 5 minutes, were optimized for isolation of PE. Both methods yielded 77.8-80.0% PE in the isolated fraction. The methods reduced oil free fatty acid content from 2.9 to 1.3%, and phosphorus content from 133 to less than 40 ppm. Fatty acid composition did not change. Biodiesel prepared from PE-isolated oils met EN-14214 specifications, although oxidative stability decreased with increased time of the treatment. The results suggest that PE could be isolated for various applications by any of the two methods with high yield, only slightly affecting the biodiesel quality.

Acknowledgements: The authors are grateful to the Bundesministerium für Bildung und Forschung (BMBF), Berlin, Germany.

Corn Oil Extraction: Processes, Product Quality, Treatment, and Economics. J. Hagberg, Ball Industrial Services, LCC, Des Moines, Iowa, USA.

Well-documented economic challenges have driven the need to find alternative biodiesel feedstocks. Many biodiesel plants have been constructed in the US's Upper Midwest, home to much of the corn ethanol industry. With corn containing approximately 3% oil (w/w) and that oil playing no integral part in the ethanol process, extracting it is economically attractive to ethanol plant owners.

Expensive corn fractionation and associated oil extraction result in a valuable edible oil product which does not benefit biodiesel plants. For a fraction of the cost, a substantial amount of corn oil can be removed from corn stillage. Once treated, this corn stillage oil (CSO) can provide biodiesel plants with an economically attractive feedstock.

This presentation focuses on extracting oil from corn stillage; enhanced oil recovery methods; quality issues, including the impact on distiller grains; and, the pre-treatment required for using CSO as a feedstock for biodiesel production. Included are quality and economic analyses of the systems.

Life Cycle Energy Analysis for the Production of Biodiesel from Rendered Lipids in the U.S. D.E. Lopez, J. Mullins, and D.A. Bruce, Clemson University, Clemson, SC, USA.

This study examines the energy life cycle of biodiesel synthesized from rendered lipids in the U.S. In particular, the fossil energy required in the production of biodiesel from beef tallow, poultry fat, and waste vegetable oil were investigated. In an effort to enable comparison with bio-energy crop systems, similar metrics were employed in the life cycle energy assessment (LCEA). Nevertheless, a critical differentiation between the vegetable oil and rendered lipid feedstock lies on the fact that the latter one is unintentionally generated during the production of animal protein. Therefore, three different scenarios were found eligible for analysis: I. conversion to biodiesel, II. rendering and conversion, and III. farming, rendering, and conversion. The energy required in the conversion and farming were reviewed from the literature. The thermal energy and electricity requirements at the rendering process stage were calculated from the data provided by 26 different U.S. rendering facilities. The outcome of the LCEA greatly depended on the selection of system boundaries. For animal fats, scenario III resulted in a net energy ratio (NER) < 1. In contrast, the NERs for scenarios I and II were both found to be greater than one. For scenario I, the NER was found to be > 3.6 which is larger than the one typically reported soybean oil biodiesel.

Acknowledgements: Animal Co-product Research and Education Center.

Field Pennycress (*Thlaspi arvense* L.) Oil. A Promising Source of Biodiesel. B.R. Moser, G. Knothe, S.F. Vaughn, and T.A. Isbell, USDA, ARS, NCAUR, Peoria, IL, USA.

Field pennycress (*Thlaspi arvense* L., FP) is a winter annual species of the mustard family (Brassicaceae) that is widely distributed throughout temperate North America which can serve in a winter rotational cycle with conventional crops, thus not displacing existing agricultural production or negatively impacting the food supply. The oil from FP seeds, obtained in 36 weight percent yield, was high in erucic acid, with linoleic, linolenic, oleic, and gondoic acids also present in significant quantities. The corresponding methyl esters (FPME) displayed a high cetane number, excellent cold flow properties, comparable oxidative stability, and relatively high kinematic viscosity versus soybean oil methyl esters (SME). Comparison to ASTM D6751 revealed that FPME was satisfactory with respect to all parameters measured here. Kinematic viscosity and oxidative stability did not meet the stated requirements in EN 14214, but blending or treatment with antioxidants are likely to ameliorate these deficiencies. In conclusion, field pennycress has excellent potential as an alternative feedstock for biodiesel production.

AFTERNOON

Keynote Presentation

Biodiesel in Latin America: Developments, Supply, and Opportunities. Iderlon Azevedo, BrasPalma, Brazil.

(Abstract not available)

Session 4: Analytical Methods and Quality Aspects

Session Chairs: F. LaCoste, ITERG, France; and B. Cahill, CEN-WG24 TF Biodiesel, European Standardization Committee, France

ASTM - U.S. Standards and Initiatives. J. Thaeler, Nation Biodiesel Board, USA.

ASTM International is the industry consensus standards setting body used in the United States and in many other countries around the world for fuels and lubricants. The Biodiesel Task Force within ASTM has been active since 1993. ASTM standards for pure biodiesel as a blend stock with petrodiesel, ASTM D6751, were first approved in 2001. Standards for finished blends of biodiesel and petrodiesel for blends containing 5% or less biodiesel were approved and published by ASTM in 2008 for on/off road use (ASTM D975) and for home heating and boiler operations (ASTM D396). Standards for on/off road use for blends containing 6 to 20% biodiesel (ASTM D7467) were also approved in 2008. As with all ASTM standards, the biodiesel standards continue to be improved and fine tuned. This presentation will summarize the current status of the biodiesel standards at ASTM and provide an overview of ongoing improvement activities on biodiesel standards and test methods at ASTM.

Changes under Consideration for the EN 14214 Specification. Barry Cahill, CEN-WG24 TF Biodiesel, European Standardization Committee, France.

The Comité de Normalisation Européen (CEN) is responsible for the definition of European standards for automotive fuels. Many of these standards are incorporated into national regulations and must reflect the industrial reality and regulatory constraints of the European Union. Thus the standards are constantly under review to ensure their pertinence.

The Fatty Acid Methyl Ester standard EN 14214 is known world-wide as the standard defining biodiesel for the biggest market of first generation biodiesel. The standard was first issued in 2003, and a modest revision was made in 2008, principally to incorporate changes related to more modern test methods. The presentation concerns a more ambitious revision that is now under way in order to update the standard based on lessons learned from market experience and to reinforce the standard in view of moves to higher biodiesel blend levels. The draft revision, which will be voted in 2010, contains among others changes to oxidation stability, phosphorus level reduction, definition of arctic grades and many modifications to test methods. Recommendations are made for good practices in handling the fuel and indications are given on changes that are under study for further revisions of the standard.

Oxidation Stability of Biodiesel: Analytical Methods Assessment. Bertrand Lecointe, IFP, France.

(Abstract not available)

Overview of World Standards on Biodiesel. T. Klein, Global Biofuels Center, USA.

This presentation will focus on biodiesel standards that have been set around the world and will include a look at blend limits, mandates, usage and supply and demand through the 2015 timeframe. It will also feature a short overview of biodiesel standard harmonization efforts and what it could mean for the global biodiesel market. The presentation will also focus on a key issue affecting biofuels around the world: sustainability criteria setting, suggesting that such efforts can only be effective and successful with international cooperation and organization.

Shelf Life Improvement of Biodiesel and Plant Oil Fuels with Synthetic Antioxidants. Axel Ingendoh, Lanxess AG, Leverkusen, Germany.

Natural stability is not a sufficient guarantee of high-quality biodiesel fuel for the automotive industry. Biodiesel is subject to ageing upon exposure to air. Unlike fossil fuels, it is a "living product". Biodiesel's ageing can be prevented with synthetic antioxidants.

BHT marketed under the Lanxess brand Baynox® is the most suitable antioxidant from the family of hindered phenols for RME/canola and other biodiesels produced from oils with low unsaturation.

On the contrary, biodiesels produced from soy bean oils contain high levels of multiple unsaturated fatty acid esters making them prone to faster aging upon exposure to air. Bisphenol AO 2 marketed under the brand Baynox® plus is the most effective hindered phenol and is ideally suited for this type of biodiesel.

Plant oils as diesel fuels for tractors are increasingly used in Europe. Their shelf life and performance in the tractor engine depends on oxidations stability just as biodiesel. Improvement can be obtained by treating the plant oil fuel form rape seed oil with Bisphenol AO2.

The low oxidation stability of biodiesel leads to the risk of engine damage that can now be avoided with the use of suitable antioxidants. The concept of extending shelf-life with Baynox® and Baynox® plus antioxidants helps improve biodiesel quality and its increasing acceptance in a rapidly growing market.

Comparison of Analytical Approaches for the Determination of Steryl Glycosides in Biodiesel. S. Schober, A. Studentschnig, and M. Mittelbach, Institute of Chemistry, University Graz, Graz, Styria, Austria.

Insolubles formation in biodiesel can lead to engine failures filter blocking and deposit formation. Steryl glucosides and their derivatives have been identified as most critical species in this context, found especially in soy and palm based biodiesel. Different analytical approaches have been investigated to analyze the content of such products. The here presented work will give a critical comparison of these methods which mostly are based on SPE extraction techniques followed by TLC or GC/FID detection. Recovery rates will be discussed together with sample preparation, separation techniques, compound identification as well as determination limits. Quantification is carried out via suitable internal standard (cholesteryl-Î²-D-glucopyranoside) which has been synthesized especially for this application.

New Advances in the Use of Fourier Transform Infrared for the Analysis of Biodiesel. Barbara Stefl, Nan Wang, and Ching-hui Tseng, Cognis Corporation, Cincinnati, OH, USA.

Fourier Transform Infrared Spectroscopy is a useful tool for measuring a variety of components and properties of biodiesel quickly and easily. Previous work demonstrated the effectiveness of a networked FT-IR system correlated to ASTM and EN methods for a variety of biodiesel specifications, including both component analyses and physico-chemical properties. Recent work investigates correlating FT-IR spectra to oxidative stability and cold soak filtration, and specification analysis of biodiesel blends.

Biodiesel Long Term Storage Oxidative Stability and Performance: A Pilot-Scale Case Study. Ibrahim Abou-Nemeh, Novus International, Inc., St. Charles, MO, USA.

The demand for energy is increasing with each passing day. Consequently, green house gases (GHG) emission is on the rise causing irreversible global climatic and eco-system changes. As a result, the quest for a "greener" fuel source has been intensified. Biodiesel (FAME) possesses numerous technical and environmental advantages, however, it suffers from some quality drawbacks such as cold flow properties, long term thermal and oxidative stability. The latter issue becomes significant particularly when the biodiesel is exposed to air, heat, light or trace metals. As a result, different polymers, peroxides, acids, aldehydes etc. are formed which have far reaching consequences on fuel pump components, combustion profile and overall engine performance. In this study, the long term storage and oxidative stability of biodiesel feedstocks, i.e., RME, SME and TME have been evaluated. Numerous analytical techniques to assessing biodiesel quality such as peroxide values by ASTM D-3307, induction period Rancimat EN 14112, level of insolubles ASTM D-2274 and gum formation, acid value ASTM D-664, viscosity ASTM D-445 etc. under normal storage conditions have been investigated. A correlation between the biodiesel peroxides value versus the induction period has been proposed.

Acknowledgements: I would like to thank Mr. M. Fischer and Mr. L. Pandey for their technical support during the execution of this project.

Session 5: Engine Operability and Catalyst Performance II

Session Chairs: J. Krahl, Coburg University of Applied Sciences, Germany; and K. Oyama, Japan Petroleum Energy Center, Japan

Biodiesel Performance with SCR and DPF Systems. R.L. McCormick, A. Williams, J. Ireland, and D. Pedersen, National Renewable Energy Laboratory, U.S. Dept. of Energy, Golden, Colorado, USA.

In recent years there has been concern about the compatibility of biodiesel with exhaust emission control components; especially selective catalytic NOx reduction (SCR) and diesel particle filter (DPF) systems. Some types of SCR catalysts can be severely inhibited at low exhaust temperatures by strong adsorption of exhaust hydrocarbons. We have investigated this phenomenon using a zeolite-based catalyst known to have some susceptibility to this problem. Our results show that biodiesel, even tested at B100, produces no greater inhibition than does ULSD. Several research groups, including ours, have shown that PM derived from biodiesel is more reactive (burns at a lower temperature) during regeneration of a DPF. We have examined the impact of a long-chain alcohol and of sodium (a common biodiesel contaminant) on PM reactivity. The alcohol functionality increased PM reactivity even more than observed for methyl ester at equivalent fuel oxygen content. Sodium, a well known carbon gasification catalyst, did not increase PM reactivity. Biodiesel can contain ash forming impurities including Na, K, Mg, Ca, and P. Current ASTM or EN specification limits for these elements may not be adequate to protect DPF systems from performance degradation. The results of an accelerated DPF aging relevant to this question will be described.

Impacts of Biodiesel Fueling on Engine Lubricants. Stephen R. Kirby[1], Peng Ye[1], Thomas McGuire[1], Yu Zhang[1], André L. Boehman*[1], Michael Alessi[2], Katherine Richard[2], and Stuart McTavish[3], [1]Pennsylvania State University, University Park, PA, USA, [2]Infineum USA L.P., Linden, NJ, USA, [3]Infineum UK Ltd., Oxfordshire, UK.

The quality control of biodiesel production and the variability of its composition present challenges for engine manufacturers, fuel suppliers and lubricant suppliers. Adverse interactions between fuel and lube have been observed in the past with methanol and other alternative fuels (see extensive work by J.M. Perez and co-workers). This problem is potentially compounded by the relatively poor oxidative stability of biodiesel, which may further degrade the lubricant through interaction with peroxides within the fuel. Thus, it is essential to understand the mechanisms by which biodiesel fueling can affect lubricant performance, and to determine if there are thresholds of biodiesel concentration in the fuel where these problems are not observed. In this research, the objective is to determine the magnitude of impacts on the engine lubricants from fueling a diesel engine on biodiesel fuel from various feedstocks, from fueling a diesel engine on biodiesel of degraded quality and from interaction between diesel soot that is recirculated to the intake air via exhaust gas recirculation (EGR). The use of EGR in modern diesel engines to reduce engine-out emissions of nitrogen oxides can lead to loading of diesel soot in the lubricating oil. As has been shown by Boehman and co-workers[1], the use of biodiesel can have significant effects on the nanostructure and reactivity of diesel soot. When biodiesel-derived soot becomes mixed with engine lubricant in the crankcase, this impact on the structure and surface chemistry of soot may alter the influence of the lubricant additives. This presentation will provide a progress update on impacts observed to date from these ongoing experiments.

[1]*Combustion and Flame*146 (2006) 589-604

An Experimental Investigation of the Origin of Increased NO_x Emissions When Fueling a Heavy-Duty Compression-Ignition Engine with Soy Biodiesel. Charles J. Mueller[1], Andre L. Boehman[2], and Glen C. Martin[1], [1]Sandia National Laboratories, Livermore, CA, USA, [2]Pennsulvania State University, University Park, PA, USA.

It is generally accepted that emissions of nitrogen oxides (NO_x) increase as the volume fraction of biodiesel increases in blends with conventional diesel fuel. While many mechanisms based on biodiesel effects on in-cylinder processes have been proposed to explain this observation, a clear understanding of the relative importance of each has remained elusive.

To gain further insight into the cause(s) of the biodiesel NO_x increase, experiments were conducted in a single-cylinder version of a heavy-duty diesel engine with extensive optical access to the combustion chamber. The engine was operated using two biodiesel fuels and two hydrocarbon reference fuels, over a wide range of loads, and using undiluted air as well as air diluted with simulated exhaust gas recirculation. Measurements were made of cylinder pressure, spatially integrated natural luminosity (a measure of radiative heat transfer), engine-out emissions of NO_x and smoke, flame lift-off length, actual start of injection, ignition delay, and efficiency. Adiabatic flame temperatures for the test fuels and a surrogate #2 diesel fuel also were computed at representative diesel-engine conditions.

Results suggest that the biodiesel NO_x increase is not quantitatively determined by a change in a single fuel property, but rather is the result of a number of coupled mechanisms whose effects may tend to reinforce or cancel one another under different conditions, depending on specific combustion and fuel characteristics. Nevertheless, charge-gas mixtures that are closer to stoichiometric at ignition and in the standing premixed autoignition zone near the flame lift-off length appear to be key factors in helping to explain the biodiesel NO_x increase under all conditions. These differences are expected to lead to higher local and average in-cylinder temperatures, lower radiative heat losses, and a shorter, more-advanced combustion event, all of which would be expected to increase thermal NO_x emissions. Differences in prompt NO formation and species concentrations resulting from fuel and jet-structure changes also may play important roles.

Biodiesel Blend NOx Emissions from Heavy Duty Diesel Engines. John Nuszkowski and Gregory Thompson, West Virginia University, Center for Alternative Fuels, Engines, and Emissions (CAFEE), Morgantown, WV, USA.

While biodiesel blended with petroleum diesel fuel provide decreased carbon monoxide (CO), total hydrocarbons (THC), and particulate matter (PM) emissions relative to petroleum diesel, research continues to study the influence on oxides of nitrogen (NOx) emissions. Depending on the research, biodiesel blends have been shown to decrease, increase, or provide no significant difference in NOx emissions relative to petroleum diesel. Studies were conducted on a 1992 DDC Series 60, 1999 Cummins ISM, and 2004 Cummins ISM engines to represent actual in-use diesel engines during steady state and transient operation. The 1992 DDC engine and 2004 Cummins engine were instrumented with in-cylinder pressure. When adding cetane improvers DTBP and 2-EHN to B20 Soy, a NOx decrease of 0.6-2.5%, relative to the B20 fuel, was noticed on the 1999 and 2004 Cummins engines. The varying results in previous research for biodiesel blend NOx emissions were found to be due to engine load and neat petroleum diesel fuel properties. At low load, a cetane or ignition delay effect occurred creating a maximum decrease of 4% in NOx emissions with a B20 blend (20% biodiesel and 80% neat petroleum diesel, by volume) compared to the neat petroleum diesel. At high load, a high correlation was found between the degree of unsaturation of the fuel and the increase in NOx emissions (up to 9%), suggesting an increased flame temperature due to an increase in the number of double bonds.

Diesel Engine Emissions from Combustion of Diesel, Biodiesel and Biodiesel Blends Cause Different Mutagenicity. Jürgen Bünger[1], Jürgen Krahl[2], Axel Munack[3], Olaf Schröder[3], Jens Schaak[3], Markus Trißler[4], Ernst Hallier[4], Götz Westphal[1], and Thomas Brüning[1], [1]BGFA, Research Institute of Occupational Medicine, German Social Accident Insurance, Ruhr-University Bochum, 44789 Bochum, Germany, [2]Coburg University of Applied Sciences, D-96406 Coburg, Germany, [3]Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI), 38116 Braunschweig, Germany, [4]Institute of Occupational and Social Medicine, Georg-August-University of Göttingen, 37073 Göttingen, Germany.

Several governments have defined policies to reduce GHG by blending diesel fuel with up to 20% biodiesel, among others the EU and the USA. To investigate the influence of blends on the regulated and non-regulated emissions and estimate possible health effects, we performed a series of studies with blends of common diesel fuel (DF) and rapeseed methyl esters (RME, biodiesel) measuring regulated and non-regulated exhaust compounds and determining the mutagenic effects of the particulate matter and the gas phase.

The emissions of DF, RME, and several blends up to 50% RME content were investigated running the standard European cycles ESC and ETC on three different diesel engines. The particles of DEE were trapped on PTFE-coated glass fiber filters and the gaseous phase was cooled and sampled as condensate according to the VDI-Guideline 3872 part 1. Regulated emissions were measured with standard equipment. The mutagenic effects of the particle extracts and condensates were determined using the Salmonella *typhimurium* / mammalian microsome assay (OECD guideline 471) with tester strains TA98 and TA100.

The regulated emissions of blends showed an approximate linear dependency on the blend composition and did not differ significantly from the neat fuels. However, a negative effect of blends was observed with respect to mutagenicity of the exhaust gas emissions. For the particle extracts a maximum of the mutagenic potency was found in the range of B20 exceeding the mutagenicity when pure DF or RME was combusted. This effect occurred with each of the three engines. However, these unexpected results were not consistently observed in assays with the condensates.

In the view of these results, B20 must be considered as a critical blend, at least if DF and biodiesel are used as binary mixtures. It was not possible to predict the higher mutagenicity of the blends from the measurements of regulated emissions. Despite preliminary results point towards a possible role of oligomerization in the blends for the increased mutagenicity, a systematic research on not federally regulated emissions is urgently needed to elucidate effects of fuel combustion on possible health hazards for exposed humans.

The Effect of Animal Fat Methyl Ester Blends on the Regulated and Unregulated Emissions from a Euro Four Passenger Vehicle. George Karavalakis[1], Dimitrios Ampatzoglou[2], Stamoulis Stournas[1], and Evangelos Bakeas*[2], [1]Laboratory of Fuels Technology and Lubricants, National Technical University of Athens, 9 Iroon Polytechniou Str., Zografou Campus, 15780 Athens, Greece, [2]Laboratory of Analytical Chemistry, Chemistry Department, National and Kapodistrian University of Athens, Greece.

Diesel vehicles are an important source of emissions of air pollutants, particularly NO_x and PM, as well as, toxic compounds with potential health impacts including volatile organic compounds, aldehydes, and polycyclic aromatic hydrocarbons (PAHs). Currently, emission regulations do not include any restrictions for the several hundred organic compounds, such as those of aldehydes and ketones and others that may be associated with particulate matter, such as those of PAHs. However, developments in engine manufacture and fuel type and quality, are expected to reduce these types of pollutants in the future. Moreover, the use of fatty acid methyl esters (FAMEs), commonly known as biodiesel, will play a key role on the formation of those micro-contaminants.

In this study, a Euro 4 compliant diesel passenger vehicle equipped with a 1.1 litre common-rail turbocharged direct injection engine and an oxidation catalyst was fuelled with an ultra low sulphur diesel and animal fat methyl ester blends at proportions of 10, 20 and 30% v/v respectively. The measurements were conducted on a chassis dynamometer with constant volume sampling (CVS) according to the European regulated technique. Emissions and fuel consumption evaluation were performed using the certification New European Driving Cycle (NEDC) and the real traffic-based Artemis driving cycles (Urban, Road, and Motorway). Regulated emissions of NO_x, PM, CO, and HC were measured and compared over the different driving conditions. CO_2 and fuel consumption were also evaluated for the different fuel/cycle combinations. The unregulated pollutants were characterized by determining 12 PAH, 4 nitro-PAH, and 6 oxy-PAH compounds in the particle phase, some of which were identified to be highly toxic, mutagenic and/or carcinogenic. Moreover, 13 carbonyl compounds (aldehydes and ketones) were determined and quantified in the exhaust. PM speciation analysis was also performed in order to identify alkane species ranged from C_{13} to C_{35} present to the exhaust emissions of the diesel engine operated with diesel fuel and the biodiesel blends over several driving conditions.

Session 6: Future and Developing Production Technologies

Session Chairs: W. De Greyt, Desmet Ballestra, Belgium; and S. Saka, Kyoto University, Japan

A New Process for Biodiesel Production Using Supercritical Carboxylate Esters. Shiro Saka, Graduate School of Energy Science, Kyoto University, Japan.

Production of glycerol is unavoidable in the conventional

processes for biodiesel fuel (BDF) production. In this research, therefore, we investigated conversion of rapeseed oil to fatty acid alkyl esters (FAAE) and triacin by processing of supercritical carboxylate esters. As a result, it was discovered that the transesterification reaction of triglycerides with carboxylate esters can proceed without catalyst under supercritical conditions, generating FAAE and triacin. In order to study the effect of the triacin addition to FAAE, its effect was investigated on various fuel characteristics. It was, consequently, discovered that there were no adverse effects on the main fuel characteristics when the molar ratio of FAAE to triacin was 3:1, corresponding to the theoretically derived mole ratio from the transesterification reaction of rapeseed oil with carboxylate esters. Moreover, the addition of triacin to FAAE improved the pour point and triacin has high oxidation stability. Therefore, by defining BDF as a mixture of FAAE with triacin, we can obtain an improved yield over 100% of BDF, theoretically up to 125% by the supercritical carboxylate esters, in excess of the yield of the conventional process.

Immobilization of Rhizomucor Miehei Lipase on a Fibrous Support for Biodiesel Production. G. Eylem Özarslaner[1], Mehmet Erhan Kanişli[1], Eda Öndül[1], Nadir Dizge[2], and Nedim Albayrak*[1], [1]Yüzüncü University, Van, Turkey, [2]Gebze Yüksek Teknoloji Enstitüsü, Kocaeli, Turkey.

Lipase form Rhizomucor miehei was immobilized on a fibrous type support. Enzyme immobilization involved electrostatic complex formation between lipase and polyethylenemine (PEI) polymer, and crosslinking of the complexes with glutaraldehyde (GA). The method yielded multilayer lipase complex formation and spontaneously deposition of the complexes on the fibrils of fibrous support. At the optimum PEI to enzyme ratio, nearly all lipase in solution were complexed in solution or may be deposited on the support. Interestingly, PEI-lipase aggregates in solution at the optimum ratio lead to 160% increase in lipase activity. The stability of PEI immobilized lipase against various denaturing conditions were increased. Upon 2 h incubation at 60°C soluble enzyme lost nearly 90% of initial activity while immobilized enzyme kept full activity. Compared with free enzyme, immobilized lipase on fibrous support showed an extension of optimum pH range and increase in pH stabilities of at all pHs tested. Apparent Vmax values of PEI-lipase complexes were increased 10 fold compared to soluble enzyme. An evaluation of the performance of fibrous support immobilized enzyme in plug-flow type reactor for biodiesel production is in progress.

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Biodiesel from Low Quality Feedstock using Alkali Metal Ion Doped Calciumoxide as Heterogeneous Catalyst. Amjad Ali, Dinesh Kumar, and Vishal Mutreja, School of Chemistry and Biochemistry, Thapar University, Patiala, Punjab, India.

The limited and fast diminishing resources of mineral oil, increasing prices of crude oil and environmental concerns have been the diverse reasons for exploring the use of triglycerides as alternative fuels. Fatty acid methyl esters (FAME) commonly known as biodiesel can be prepared from transesterification reaction of vegetable oils and fats with alcohols in the presence of an acid, base or enzyme catalyst. Biodiesel can be produced easily even at industrial scale by homogenous base-catalyzed process but it suffers several limitations viz., only moisture and free fatty acids (FFAs) and moisture can be used and yielded the biodiesel and glycerol contaminated with alkali.

Present work investigated the use alkali metal ion doped CaO as heterogeneous catalysts for the transesterification of used cottonseed oil to overcome the drawbacks associated with homogenous alkali catalyst. The variables used for the transesterification were catalyst concentration, methanol concentration, percentage of alkali metal ion doping, alkali metal ions, reaction temperature (30°C to 65°C) and reaction time (0.1- 8hrs). Maximum yield in 10 minutes of reaction period were obtained with Li+ doped CaO catalyst at 65 °C of reaction temperature. Catalyst was found to be effective for the transesterification of cotton seed oil even when 35% of water and 1.5% FFAs were present in the reaction mixture.

Chemical Interesterification of Vegetable Oil with Methyl Acetate: Kinetics and Thermodynamics. A. Casas, J.R. Ruiz, M.J. Ramos, and A. Perez, Chemical Engineering Department, Institute of Chemical and Environmental Technologies, University of Castilla-La Mancha, Ciudad Real, Spain.

Biodiesel production using transesterification of vegetable oils with methanol implies the obtaining of glycerol, a by-product whose market is saturated. Chemical interesterification of oils with methyl acetate provides a promising alternative because of triacetin is formed instead of glycerol. Triacetin is used as a plasticizer and gelatinizing agent in polymers and explosives.

In this research, the chemical interesterification of oil with methyl acetate using methanolic potassium methoxide as catalyst has been studied. Reactions at 50 °C have been carried out using a range of 12:1 to 100:1 of methyl acetate to oil molar ratio (MA/O) and 0.1:1 to 0.5:1 of catalyst to oil molar ratio (C/O). Excess methyl acetate shifts the equilibrium to the formation of products but it is necessary to recover it. Catalyst amount improves the speed of the reaction. However, the presence of methanol in the catalyst reduces the yield of triacetin (forming diacetin, monoacetin, and glycerol). A compromise between the products yield, the reaction kinetics and the methyl acetate recovering is found with the conditions 48:1 MA/O and 0.1:1 C/O.

At these conditions, the equilibrium is reached within the first 30 minutes. The composition obtained was 76.5 wt% of FAME, 19.4 wt% of triacetin (impurified with diacetin and monoacetin) and 4.1 wt% of the intermediate diacetinmonoglyceride.

Enzymatic Production of Biodiesel Fuel from Various Oil Sources in Solvent-free System. Yomi Watanabe, Osaka Municipal Technical Research Institute, 1-6-50 Morinomiya, Jotoku, 536-8553 Osaka, Japan.

The solvent-free BDF production system using immobilized *Candida antarctica* lipase that has been developed in our institute has the following advantages; 1) high conversion (>95%) can be reached at 30°C, 2) the amount of methanol is the smallest among other methods including chemical and supercritical liquid methods, 3) the production cost can be reduced to be competitive to the chemical methods by continuously using the immobilized lipase for over than 3 months, 4) it is free from waste water containing alkali or salts, 5) organic solvent free, and thus 6) pre and post processing can be minimized, 7) glycerol can easily be reused.

By stepwise addition of methanol, vegetable oil (from soy bean, rapeseed, and corn), crude oil, used frying oil were converted to >95% FAMEs without any pretreatments. Palm oil was also converted to BDF continually at high degree of conversion. In order to convert materials containing large amount of FFAs in addition to acylglycerols, such as acid oil, to FAMEs, two step conversion system is effective; the first step is the esterification of FFAs to FAMEs and the second step is the transesterification of acylglycerols to FAMEs. These systems were successfully scaled up to 30 L, and thus were considered to be applicable for industrial production of BDF from various oils. In addition, conversion of acid oil by a novel two-step system consisted of hydrolysis of acylglycerols and esterification of FFAs successfully reduced the enzyme dosage and the remaining acylglycerols in the final products.

Enzymatic Production of Fatty Acid Ethyl Esters. J. Brask, P.M. Nielsen, L.S. Pedersen, M.L. Damstrup, and H.C. Holm*, Novozymes A/S, Bagsvaerd, Denmark.

Substituting methanol with bioethanol in production of biodiesel will allow for a totally renewable "green-green" fuel with a very low carbon footprint. Fatty acid ethyl ester (FAEE) has similar fuel properties compared to FAME, including somewhat improved low-temperature properties. Our research indicates that enzymatic synthesis of FAEE can be based on 96% ethanol, whereas the traditional alkaline catalyzed processes require anhydrous conditions. Further, the higher molecular weight of ethanol results in a higher mass yield of FAEE compared to FAME, which more than balances an added cost of ethanol compared to methanol. Hence, in this paper we argue that enzymatically produced FAEE could be the future's sustainable biofuel.

Use of Heterogeneous Catalysts for the Conversion of FFA into FAME. Rudolf Wagner, LANXESS Deutschland GmbH, Leverkusen, Germany.

With the reorientation of the market, especially within the last 12 months and increasing triglyceride sourcing problems, the biodiesel industry is requiring additional versatility in its ability to process feedstocks. Many of these contain free fatty acid concentrations substantially above those typically contained in refined oils obtained from traditional sources. Lanxess resin technology has successfully been developed to address these new challenges and is already being implemented on a large industrial scale.

New Generation Heterogeneous Transesterification Catalyst. David A. Sams[1], Wayne A. Turner[1], and Victor S.-Y. Lin[2], [1]Catilin Inc., Ames, Iowa, USA, [2]Iowa State University, Ames, Iowa, USA.

Catilin, Inc. has developed a unique heterogeneous transesterification catalyst that is effective at standard operating conditions of 65-70C and atmospheric pressure. The catalyst, called T300, has been tested with a wide range of feedstocks including soybean oil, rapeseed, tallow, WVO and palm oil. Bench scale tests have been successfully completed with FFA levels of up to 1%. Results from a 1,000 tonne per year pilot plant indicate conversions greater than 98.5%wt are readily achievable with glycerin purities greater than 98%wt. The Catilin process eliminates several steps in traditional biodiesel production reducing operating costs while capital expenses are greatly reduced for new plant construction. The catalyst is a granular solid that is designed for use in a continuous stirred tank reactor for easy retrofit into existing plants. The design also allows for catalyst replacement during normal operation to maintain targeted catalyst activity. The catalyst does not contain noble or transition metals and is non-hazardous and non-toxic for low cost disposal.

TUESDAY, 17 NOVEMBER

MORNING

Session 7: Alternative (i.e. not biodiesel) Diesel Engine Fuels

Session Chairs: A.A. Boateng, USDA, ERRC, ARS, USA; and P.A.Z. Suarez, Universidade de Brasília, Brazil

To Burn or Not to Burn: Distributed Pyrolysis to Refinable Crude Bio-oil and Soil-Amending, Carbon Sequestering Biochar. A.A. Boateng, Eastern Regional Research Center, Agricultural Research Service, USDA, Wyndmoor, PA, USA.

The proposed U.S. renewable fuels initiative requires increasing the domestic supply of alternative fuels to 36 billion gallons by 2022. This includes 15 billion gallons from corn-based ethanol and 21 billion gallons from advanced biofuels, such as ethanol from lignocellolosic biomass. For the latter, we must use biochemical and thermochemical conversion technologies to utilize vast lignocellulosic biomass resources that could be sustainably harvested from US fields and forests. While biochemical conversion methodologies proposed for lignocelluloses await cost effective technologies, thermochemical conversion technologies that are proven for coal can be economically adopted for biomass. Research has shown that the distributed approach, whereby energy-dense pyrolysis liquids are produced at remote areas and shipped to a centralized processing station, can be cost effective at the farm-scale when the oil is used as a gasification feedstock to produce Fischer-Tropsch liquids. The presentation will focus on the thermochemical conversion research at ARS/USDA's Eastern Regional Research Center, in Wyndmoor, PA, which responds to the ARS action plan in bioenergy with a subcomponent on pyrolysis. This program addresses research on integrated pyrolysis systems that produce bio-crude oil at distributed locations, which is subsequently refined at a centralized location, leaving biochars that build soil quality and increase crop productivity so food and bioenergy crops can be sustainably harvested.

Strong Genotoxic Effects of Diesel Engine Emissions from Combustion of Vegetable Oils. Jürgen Bünger[1], Jürgen Krahl[2,5], Jörn Bünger[5], Axel Munack[3], Olaf Schröder[3], Claudia Handrich[4], Ernst Hallier[4], Thomas Brüning[1], and Götz Westphal[1,4], [1]BGFA - Research Institute of Occupational Medicine, German Social Accident Insurance, Ruhr-University Bochum, Bochum, Germany, [2]Coburg University of Applied Sciences, Coburg, Germany, [3]Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI), Braunschweig, Germany, [4]Institute of Occupational and Social Medicine, Georg-August-University of Göttingen, Göttingen, Germany, [5]Steinbeis-Transfer-Center Biofuels, Coburg, Germany.

In Germany the use of vegetable oils is increasing as a substitute for biodiesel and petrol diesel. Aim of this study was the comparison of mutagenic effects of diesel engine emissions (DEE) from combustion of diesel fuel (DF) and biodiesel (rapeseed methyl ester, RME) with different vegetable oils.

Genotoxicity of DEE was investigated after the combustion of three different vegetable oils (palm oil, rapeseed oil; linseed oil), RME, and DF in a light duty truck diesel engine. DEE were sampled on particle filters (solid phase) and as condensates (gas phase) according to the VDI-Guideline 3872 part 1. The mutagenic effects of the emissions were determined using the Salmonella typhimurium/mammalian microsome assay (OECD guideline 471) with tester strains TA98 and TA100.

While federally regulated emissions of DF and vegetable oils differed only in acceptable margins, unexpected strong mutagenic effects were observed in extracts of particle emissions and condensates of the gaseous phases. The mutagenic effects of the particle extracts were up to 15fold stronger compared to DF and RME. The mutagenicity of the condensates increased up to 4fold. Blends of 20% and 50% rapeseed oil with DF resulted in a smaller but also significant increase of the mutagenicity compared to 100% DF.

Performance of Tractors Fueled with Raw Vegetable Oil. Glen R. Cauffman and Douglas H. Schaufler, The Pennsylvania State University, State College, PA, USA.

This research investigates in cooperation with a major international machinery manufacturer, the long term sustainability of agricultural tractor engines retrofitted with modifications to use

straight vegetable oil (SVO). Vegetable oil is typically changed through transesterification into biodiesel, and it has been recommended practice in the US and Europe to use only "biodiesel" fuels. Advocates of locally produced renewable fuel or a fuel self sufficient food system are interested in fueling with SVO in order to avoid the glycerol glut and reduce the risk of personal injury and environmental contamination relative to the use of hazardous chemicals in the production of biodiesel. However, SVO's tend to form carbon deposits more readily than transesterified fuels and they create less optimal injector spray pattern resulting in shortened engine life. Recent reports by Krahl and co-workers (Bunger et. al., 2007(a) and Bunger et. al., 2007(b)) have shown that the mutagenicity of the particulate matter emitted by vehicles operating on raw rapeseed oil is higher than if that same vehicle operates on No. 2 diesel fuel. Two agricultural machinery companies introduced tractors in Europe in 2007 that run on either petrodiesel or SVO. Because of their on-going relationship, Penn State and New Holland are testing the use of SVO. This will move forward only if it can be shown that the use of SVO does not result in early engine component failure.

Bio-thermal Valorisation of Biomass: The BtVB Process at Hainhaus/Odenwald. A. Hornung, A. Apfelbacher, and S. Sagi, European Bioenergy Research Institute, Aston University, Birmingham, UK.

Aston University recently applied for a new patent for the BtVB process - Biothermal Valorisation of (ash rich) Biomass, that is able to process all kinds of biomass and biogenic residues, highly flexible for different feed sizes and moisture contents. The BtVB process is coupling residues and effluents of a biogas unit to a thermal line consisting of a pyroformer (pyrolysis reactor) and gasifier as well as an algae production to generate new feedstock. Finally the minerals present in the charcoal from pyrolysis, is used for carbon sequestration and refertilisation of soils. The CO_2 negative (by sequestration of char) and high integrated approach at a small to medium scale for power generation, from ash rich biomass with high electric power output and integrated fertilizer recycling, is a "first" in the global market. Also important to note is that this concept does not require the adaption of biomass based intermediates i.e. pyrolysis oil, gases and char, slag, effluents or biogenic residues to existing refinery concepts because it integrates all those in a new holistic approach via the coupling of pyroformer to a Güssing type gasifier.

The pyrolysis vapours with no filtration or condensation pass directly to a gasifier for gasification. The pyrolysis char, rich in ash is used in a different ways, and the gasified gases are used to power a gas or dual fuel engine. The ash remains in the char, which can used as such for fertilization or even combustion. If the remaining pyrolysis char is used to fertilize fields, which produces something commonly known as "Black Earth", a high added value based on the fertilizer content and the carbon sequestrated can be achieved. This utilization of char is the only way to convert CO_2 via plants to stable carbon and furthermore, to remove it from the atmosphere. Alternatively the char can even be used for combustion in biomass power plants. A very efficient fertilizer cycle can be achieved by introducing algae cultivation into the process and using lignin rich residues from biogas processes. The fertilizer as well as the heat and the CO_2 required are delivered by the different process stages (biogas, gasifier, engines) and thereby cutting the costs of algae production. Based on this knowledge Aston University and the Odenwald district in Germany will realise a 10 MW power plant based on energy grass, residue wood and algae with combined production of biochar for application.

The Possible Role of Fast Pyrolyis in the Production of 2nd Generation Biofuels. W. Prins[1], M. Rosso-Vasic[2], and R.H.V. Venderbosch[3], [1]Ghent University, Belgium, [2]Albermarle Catalysts Company b.v., Amersfoort, The Netherlands, [3]BTG Biomass Technology Group b.v., Enschede, The Netherlands.

Fast pyrolysis of biomass is the process of thermal decomposition, in absence of oxygen at atmospheric conditions, with the aim to produce a high quantity of liquid product (bio-oil) that can be easily stored, transported and further processed. The technology has developed to a level of large scale demonstration and, could be commercialized within the next five years. Potential applications of bio oil are manifold but, apart from direct combustion or co-combustion, up to now insufficiently developed. There are however a number of drivers that create an increasing interest in the technology.

One of the reasons that food/ feed industries, refinery companies and catalyst companies show a distinct interest these days, is the need for second generation biofuels. Fast pyrolysis is, to a large extent, a non-selective biomass conversion technique that accepts a wide variety of lignocellulosic feedstock materials such as forestry, agricultural or plantation residues, and industrial waste streams from e.g. from food/feed, bio-ethanol or bio-diesel production. On the other hand, this fairly simple liquefaction technique offers significant logistic advantages, allowing shipping to central sites (refineries, chemical plants, power stations) for large scale conversion to final products. In fact, fast pyrolysis has the potential to become a key process in various biorefinery concepts.

It has been recognized already in the early days of fast pyrolysis R&D [1], that the application of catalysis could be of major importance in controlling the oil quality and its chemical composition. Without any catalyst involvement, the bio-oil derived from fast pyrolysis is a mixture of hundreds different, highly oxygenated chemical compounds. This chemical "soup" also has some unfavorable properties like a high acidity, an insufficient chemical stability and a low combustion value. Besides, none of the compounds is present in the oil in quantities above a few weight percent.

Catalysis could be applied for a number of reasons, and at a number of different positions in the process. Lower pyrolysis temperatures, a higher chemical and physical stability, high yields of target components, and an improved miscibility with refinery streams, are all goals strived for. Catalyst materials could be impregnated in the biomass feed, mixed into the pyrolysis reactor, built in the process after the reactor for upgrading of the primary pyrolyse vapors, or be used to modify the condensed liquids.

This contribution is meant to review all opportunities and challenges in headlines, and discuss the consequences for process design.

Continuous Process to Obtain a Diesel-like Fuel from Soybean Oil Cracking: Plant Design and Energy and Mass Balance. J.P. Rodrigues[1], P.A.Z. Suarez*[1], J.C. Rubim[1], O.K. Iha[1], G.H.M. Aguiar[1], M.B. Ramos[1], R.S. Martins[1], I.B. Reis[1], and R.R. Lavich[2], [1]LMC-IQ-Universidade de Brasilia, Brazil, [2]Petrobás S.A., Brazil.

Fermentation, transesterification, and pyrolysis of biomass, industrial, and domestic wastes, have been proposed as alternative solutions for the increasing of energy demand and environmental awareness. Among these different approaches, pyrolysis of fatty materials seems to be a simple and efficient method for hydrocarbons production. In the last years, our research group has been focus in a project to provide the substitution of petroleum derived diesel in isolated communities of Brazilian Savannah and Amazonian rainforest regions, which are strongly dependent on diesel fuel for economical production, transport, and electricity. We have studied the pyrolysis of different fatty materials in bench scale in the absence or presence of

Lewis acid catalysts and build up a pilot plant to crack oils and fats and distillate the products in order to obtain a diesel-like fuel suitable to be directly used in diesel engines.

Acknowledgements: CNPq, MDA, and MCT.

Biodiesel and Renewable Diesel: A Critical Comparison. G. Knothe, USDA, ARS, NCAUR, Peoria, IL, USA.

Several types of fuels can be obtained from lipid feedstocks. These include biodiesel and what is termed renewable diesel. While biodiesel retains the ester moiety occurring in triacylglycerols in converted form as mono-alkyl esters, the composition of renewable diesel, hydrocarbons, emulates that of petrodiesel. Accordingly, the properties of these two fuels show similarities and differences closely resembling the similarities and differences between biodiesel and conventional, petroleum-derived diesel fuels. However, one of the most significant difference between biodiesel and renewable diesel is the production process, including the energy balance. While it is known that the energy balance of biodiesel is positive by a ratio of about 3:1, little to no information is available about the energy balance of renewable diesel, however, it appears to be a more energy-intensive process. A summary of factors affecting the energy balance of these fuels, including glycerol, will be given and a comparison of these fuels should focus on fuel properties and production-related aspects.

Approaches to Renewable Diesel Production. P.L. Hanks, K.Y. Cole, and W.E. Lewis, ExxonMobil Research and Engineering, Annandale, NJ, USA.

Governmental policies throughout the world are mandating the use of biofuels as a complement to traditional petroleum based fuels. Biofuels processing and associated handling of oxygenated compounds in refineries accustomed to handling primarily hydrocarbon streams requires innovation and novel solutions. In addition to being capable of handling a wide array of new bio-feedstocks, solutions must address challenges including: catalyst selection, product cold flow properties, heat release, CO management, and corrosion concerns. In addition, regulatory provisions are needed for a broader range of hydroprocessing solutions, such as FCC pretreatment hydrotreaters.

Session 8: Sustainability Aspects of Biodiesel

Session Chairs: M.Q. Wang, Argonne National Laboratory, USA; and Franziska Müller-Langer, DBFZ GmbH, Germany

Roundtable on Sustainable Biofuels (RSB): Biofuel Sustainability Protocol Development. V. Junquera, Roundtable for Sustainable Biofuels, Switzerland.

The Roundtable on Sustainable Biofuels (RSB) is an international multi-stakeholder initiative drafting standards for sustainable biofuels production through an open and consultative process. RSB plans to release in early 2010 its "Version One" of a global sustainability standard for biofuels.

In March 2009, RSB concluded a 7 month public consultation period for "Version Zero" of the RSB standard, during which RSB held numerous regional consultations across the globe with around 900 participants from more than 15 countries. Version Zero was the result of twelve months of stakeholder consultation via the Bioenergy Wiki, teleconferences, and in-person regional meetings.

In January 2009, the Roundtable on Sustainable Biofuels adopted a governance structure with open membership divided into 11 Chambers representing the different actors along the biofuels supply chain, as well as different types of civil society and government groups. This structure is intended to ensure a balance amongst different actors affected by biofuels. Each Chamber elects two members to the RSB Steering Board (usually one from the global South and one from the global North), who makes consensus-based decisions regarding the RSB strategy, changes to the standards, and options for certification.

Through its certification scheme, RSB hopes to encouraging positive and mitigate negative impacts of biofuels on society and the environment.

CEN Sustainability Standards in Support of the EC Directive's Implementation. Ortwin Costenoble, NEN Energy Resources, The Netherlands.

On the initiation of the Netherlands, the European Standardization Organization, CEN, started work on sustainability criteria for biomass for energy applications in 2008. CEN Technical Committee 383 addressed the broad field of biofuels, bioheat and bio-electricity. On request of the European Commission pre-standards to support national implementation plans are to be finalized at the end of this year. This lecture will provide an update and an outlook on these standards that are of importance for the biodiesel industry in- and outside Europe.

During 2008 CEN/TC 383 working groups started on principles and indicators related to GHG-calculations, environment and biodiversity, socio-economy and indirect effects. The verification and auditing of these aspects, including the chain-of-custody were tackled. Over 150 experts of different countries, origins and organizations work on technical documents. Links with RSPO, RSB, RTFO, IUCN, WWF, EBB, ASTM and many non-European countries have been (in) formally established to guarantee maximum input and consensus.

With the finalization of the EC Renewable Energy Directive at the end of 2008, the question became opportune if CEN standards could support the market in implementing the legal requirements. Halfway 2009, the EC and CEN agreed that standards on the following items would prevail:

1. Chain of custody (according to the mass balance system)
2. Verification and auditing
3. Provision of evidence that the production of raw material meets the environmental requirements

CEN/TC 383 agreed to focus on these aspects in order to be able to have pre-standards available for the EC to refer to in its Paper to the EU Members States on the RED implementation. In addition, CEN works on a document on challenges for the practical application of the GHG methodology as laid down in the RED.

In the week before the congress, CEN/TC 383 will meet on the final texts and the next steps with regards to all other principles (such as socio-economic aspects and indirect effects). The speaker is the Secretary of CEN/TC 383 and will be able to present the most recent conclusions, next to some basic explanation on the relationship of the EC, CEN and the RED with regards to biodiesel.

U.S. Efforts on Biofuel GHG Regulation Development. John Courtis, California Air Resources Board, USA.

(Abstract not available)

GHG Emissions and Sustainability Aspects of Biodiesel. N. Jungbluth, ESU-services Ltd., Uster, ZH, Switzerland.

The use of biofuels is promoted for reducing the climate change impact and the use of non-renewable resources. The implementation of biofuel production processes helps to achieve these goals. But, after some years of enthusiasm other environmental impacts came to the focus of the public debate. Life cycle assessment (LCA) has proved to be a powerful tool for the full environmental assessment of products. The production of fuels like ethanol, rape seed methyl ether, biogas, etc. was investigated in a way consistent with the existing ecoinvent datasets and made publicly available via the website www.ecoinvent.org. The consistent and coherent LCI datasets for basic

processes make it easier to perform LCA studies, and increase the credibility and acceptance of the life cycle results. Results from the study, comparing and analysing a range of different biofuel production chains, are presented. The study uses two methods for the evaluation of the overall environmental impacts, namely the Eco-indicator 99 (H,A) and the Swiss ecological scarcity 2006 method. It showed that many biofuels cause higher environmental impacts than fossil fuels. For such assessment knowledge about production patterns of the biomass resources, the production processes as well as the type of fuel are important. This is why general statements about single types of biofuels fail to give convincing answers on chances and challenges in the biofuel sector.

NBB Sustainability Committee Mission and Activities. D. Scott, National Biodiesel Board, USA.

Sustainability, at its simplest level, means conservation of resources. Key resources include energy, water, and land. Biodiesel does a good job at capturing and storing solar energy in a usable form. It takes energy to treat and transport water for most human uses. So, if we are making smart choices about energy, we are making smart choices to protect our water security. Like water, land is required to grow crops. Much attention is being placed on the availability of land to grow crops for food and fuel. Much of the rhetoric against biofuels betrays the fact that using undervalued or underutilized coproducts of food production enhances food security. These uses do not compete as much as they complement each other. There is interest to certify that biofuels live up to these standards. Caution must be taken than certification requirements do not burden and stunt new innovations by small businesses emerging in a competitive and established market. Those developing certification criteria must also understand the intricacies of farming and how inputs and practices interact among various regions and crops.

Biofuel Life Cycle GHG Emissions and Land Use Change Effects. B. Stokes[1] and Z. Haq[2], [1]Navarro Research & Engineering, Golden Field Office, USA, [2]Office of the Department of Biomass, U.S. Department of Energy, Washington, DC, USA.

In recent years there have been great advances in the development of life cycle inventory and analysis methods, models, and applications. Most recently there has been a focus in understanding and modeling the life cycle greenhouse gas emissions for biofuels. A primary driver was the need to ensure sustainability and assess the environmental value of alternative, renewable fuels, especially the net-energy ratios and reduced emissions as compared with fossil fuels. Much of the effort has focused on "well-to-wheels" analyses of liquid transportation fuels. The scope has broadened and become more complex as improvements have been made to the data, technology processes, and the models. The analyses includes land use change, mostly direct, but lately adding the indirect land use change effects. This presentation will discuss activities and efforts in the U.S. to address GHG emissions and land use effects of biofuels.

Unfortunately, the U.S. is proposing to use life cycle assessments as criteria for policy in the selection among feedstocks and accessibility to emerging markets. Understanding and accurately depicting the life cycle emissions of biofuels has become a critical issue going beyond the scientific and technical realms. The analysis has become more complicated by the inclusion of indirect land use change effects. The current technical and policy arenas will be discussed with some insights into the issues that are driving U.S. developments with ramifications to the sustainability of biodiesel and other biofuels.

How to Enhance the Sustainability of Palm Oil Biodiesel. Guido A. Reinhardt, Susanne Köppen, Nils Rettenmaier, and Sven O. Gärtner, Institute for Energy and Environmental Research Heidelberg, Wilckensstr. 3, 69120 Heidelberg, Germany.

In recent years, concern has been raised regarding the sustainability of palm oil in general. While trying to tackle these issues by establishing the Round Table on Sustainable Palm Oil (RSPO), the palm oil industry was overrun by numerous reports on tremendous greenhouse gas emissions, severe biodiversity loss, and displacement of indigenous people due to clearing of tropical rainforests for the establishment of new oil palm plantations.

In order to shed more light on the scientific background, IFEU has conducted several studies on the environmental impacts of palm oil biodiesel (Reinhardt et al. 2007a,b; Rettenmaier et al. 2007), mainly by means of life cycle assessment (LCA). This presentation highlights the importance of certain life cycle steps, of which direct and indirect land-use change (LUC) is the most decisive in terms of greenhouse gas emissions and biodiversity loss. Therefore, both types of LUC have to be adequately addressed in LCAs.

Furthermore, significant environmental optimization potentials along the entire life cycle are pointed out, among others by

1. Avoiding the irreversible loss of biological diversity and of tremendous carbon stocks by establishing new oil palm plantations on degraded land instead of clearing tropical rainforests for this purpose
2. Improving plantation management by adopting or ensuring best practice methods and by reinforcing measures to sustain biodiversity on the oil palm plantations
3. Lowering the environmental impacts of biomass conversion by capturing and using methane from POME, by using all co-products entirely in optimized ways, and by significantly reducing the emissions of airborne pollutants

The authors conclude that palm oil cannot be declared sustainable unless the issues listed above as well as social issues such as land tenure and displacement are satisfactorily addressed. For this, the current legislation in the field of biofuels and certification systems such as RSPO are a good starting point, but still need significant improvements.

Biofuel Support Policies and Their Assessment. Martin Von Lampe, Organisation for Economic Co-operation and Development (OECD), Paris, France.

(Abstract not available)

Session 9: Biodiesel: Large Scale Transport; New Uses for Glycerol; and General Topics

Session Chairs: R. Lawrence, Magellan Midstream Partners, L.P., USA; and P.M. Pagliaro, CNR, Italy

Logistical Challenges Associated with Transporting Biodiesel Blends on Refined Products Pipelines. Rod Lawrence, Magellan Midstream Partners, L.P., USA.

(Abstract not available)

Multi-Function Catalysts for Gas Phase Glycerol Conversion. P.C. Hulteberg and J.G.M. Brandin, Biofuel-Solution, Limhamn, Scania, Sweden.

During the last three years Biofuel-Solution, a privately held Swedish entity, has developed an IP-portfolio around gas phase glycerol conversion into medium-value chemicals. The targeted chemicals have large to very large markets, to allow for use by more than a fraction of the glycerol available today without impacting the cost of the product.

In the course of this work, several end-products have been targeted. These include plastic monomers, mono-alcohols and energy gases; using acrolein as a common starting point. To produce chemicals with high purity and efficiency, selective and active catalysts are required.

By developing multi-function catalysts which perform more than one task simultaneously, synergies can be reached that cannot be achieved with traditional catalysts. For instance, by combining catalyst functionalities, reactions that are both endothermic and exothermic can be performed simultaneously. This means lower inlet reactor temperatures (in this particular case) and a more even temperature distribution.

Glycerol Acetals as Fuel Additives for Gasoline and Biodiesel. Claudio J.A. Mota, Carolina X.A da Silva, Paulo H. S. Ribeiro, and Valter L. C. Gonçalves, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

Glycerol is a byproduct of biodiesel production from trans-esterification of vegetable oils and animal fat. For each 90 m3 of biodiesel produced, about 10 m3 of glycerol is obtained. Thus, the economic feasibility of the biodiesel transesterification process involves the utilization of glycerol not only in soaps, cosmetics and pharmaceuticals, as regularly used, but in other high demand industrial sectors.

We wish to show that glycerol acetals and ketals, produced in reactions of glycerol with acetone, formaldehyde, butanal, pentanal and other carbonylated compounds, can be used as fuel additives. In gasoline, they improve the octane number and reduce gum formation. In biodiesel they are particularly useful for improving the cold flow properties. We will also show how to explore the use of heterogeneous acid catalysts to improve acetal formation, without using hazardous solvents to shift equilibrium.

Acknowledgements: RepsolYPF, FINEP, CNPq, FAPERJ.

High Voltage Separation of Biodiesel from Glycerin. Greg Austic and Rachel Burton*, Piedmont Biofuels Industrial, Pittsboro, NC USA.

As biodiesel production technology changes, all aspects of the process are being tested and refined for faster, easier, and more efficient production. One such piece of the production process is separating crude biodiesel glycerin from biodiesel. Using gravity settling is the most often used method for separating glycerin and biodiesel. Effective and easy, using gravity is not a good solution for production facilities looking to move to a continuous flow setup. Centrifuges are faster than gravity, and can be used in a continuous flow design. However, centrifuges are expensive both upfront and in the power they consume to run and maintain. Ultimately, other methods need to be found to make separation easy, fast, and less time consuming. In this study, a high voltage, low current charge was used to greatly enhance the speed of separation. Information is collected and compared between a batch and continuous production design.

Acknowledgements: Graham Laming, UK.

Evaluation of Soy Methyl Ester-Polystyrene Blends for Use in Concrete. K. Coates, J. Weiss, and B. Tao*, Purdue University, West Lafayette, IN, USA.

The concrete industry uses commercial admixtures and topically applied products as evaporation retardants, curing compounds, and penetrating sealants to reduce cracking, spalling, freeze-thaw damage, sulfate attack, and chloride ion penetration. This presentation will describe results from a study using fatty acid methyl esters (FAME) as an effective, economical sealant for concrete. The effects of the FAME on cementitious materials properties will be presented, including compressive strength, shrinkage, viscosity, setting and hydration time, air content, evaporation rate, FAME penetration, water absorption, and chloride penetration.

The results demonstrate that FAMEs applied to concrete are highly effective without significantly affecting concrete properties. Results from sorption tests show that samples with FAME-PS blends admixed reduce water absorption by 74-94%. In topical applications, reductions of 85-93% were obtained. Testing performed to examine chloride ion ingress showed reductions of up to 77% in chloride penetration depth. These reductions in absorption have direct positive implications on the durability of the concrete, and demonstrate the ability of FAME-PS to reduce transport within cementitious systems without significantly impacting their basic mechanical properties.

Acknowledgements: Indiana Soybean Alliance.

The Use of Lewis Metal Catalysts to Produce Fatty Acid Esters from Acid Stock. S.M. Plentz Meneghetti, Federal University of Alagoas, Maceió, Brazil.

Esterification of fatty acids is an important transformation for biodiesel obtention. This reaction can be autocatalytic, but without the presence of suitable catalysts the reaction yields are low. One strategy to obtain new catalytic systems for that reaction is based on the development of compounds exhibiting Lewis acid character. For this purpose, a series of Ti(IV) and Zr(IV) complexes, exhibiting general formula $M(n\text{-butoxide})_{4-x}(maltolate)_x$, where M = Ti or Zr and x = 0 to 4, were studied as catalyst for esterification, in order to obtain methyl esters. The compounds containing different ratios of maltolate and n-butoxide ligands were synthesized from the reaction of maltol (3-hydroxy-2-methyl-4-pyrone) and n-butoxide metal precursors. All complexes, containing maltolate as ligand, were very efficient as catalyst in esterification, mainly those based in zirconium.

AFTERNOON
Closing Session: Future Perspectives

Global Mandates and Projected Growth of the Biodiesel Industry. Claudio Rocchietta, Biofuel Partners Srl, Italy.

Current overcapacity in biodiesel production worldwide, more stringent quality specifications required by the petroleum industry, unfair international competition with consequent market distortions and uncertainty over environmental and Energy policy have all resulted in poor margins and financial stress for the present biodiesel players.

While the focus of the biodiesel industry is, in the short term, in survival mode, on the other side the imminent implementation of sustainability criteria-- the forecasted increases in mandatory targets at country levels to meet the objective for climate change mitigation outlined in the EU Renewable Energy Directive-- are stimulating challenges to the industry to produce higher product quality coupled with the capability to process alternative and cheaper feedstocks.

The presentation will analyze the current legislation on biofuels in the EU countries and the threats and opportunities, short and medium term, trying to outline a perspective for the biodiesel sector, in the frame of overall political targets.

Biodiesel in India. An Insight into Feedstocks, Government Policies, Challenges and Opportunities. K. Kapadia, Desmet Ballestra India Pvt. Ltd., India.

India is one of the fastest growing economies in the world today, and one of the largest and fastest growing energy consumers. India imports around 70 percent of its petroleum, and its transport sector's energy demand is expected to grow by 6-8 percent per annum. India's carbon emissions are also growing, making it one of the top five global contributors to carbon emissions.

Key factors driving the development of biodiesel as an alternative,

renewable source of energy in India are: efforts towards energy self reliance; reducing the environmental impact; supporting farmers via alternative crops; tax incentives; mandates; and excise duty exemptions.

In April 2003, the GOI launched a National Mission on Biodiesel that identified *Jatropha curcus* as the most suitable tree-borne oilseed for the production of biodiesel, and focused on promoting plantations of Jatropha on wastelands. The GOI's Planning Commission set an ambitious target of 11.2 million hectares to be planted with *Jatropha* by 2012, in order to produce sufficient biodiesel to create a B20 blend.

India's mission for biodiesel is to achieve 60 million metric tons per year (B20 blend) inclusion in petroleum diesel by 2030. To enable this target, the goals are 30 MMT/year by 2020 and 6 MMT/year by 2012. Today, India has a capacity for biodiesel production that is approximately 1.3 MMT/year. Due to economic and policy reasons this installed base is presently operating at approximately 10 percent of capacity.

The biodiesel producers are presently optimistic about the India's prospects following a recent $3 million shipment from Kakinada port facility to European customers.

Lipids as Source of Food and Fuel—Will There be Enough? Frank Gunstone, Scottish Crop Research Institute, Scotland.

The following topics will be addressed:

- Changes since the Vienna Biodiesel Conference two years ago.
- Biodiesel is part of the larger issue of energy supply.
- Food demand increases with population and with income.
- The non-food use of vegetable oils is increasing and shows up in USDA statistics.
- Non-conventional sources of biodiesel feedstock are essential.

NOTES

Poster Presentation Abstracts

Poster Session Chairs: R.O. Dunn, USDA, ARS, NCAUR, USA; and B.R. Moser, USDA, ARS, NCAUR, USA

Poster presentations will be on display for the duration of the Congress. Visit with authors during program breaks.

Alternative Renewable Fuels

1. **Products of Natural Triacylglycerols Cracking as Components of Fuel Blends for Diesel Engines.** Eduard Buzetzki[1], Jozef Mikulec[2], and Jan Cvengros*[3], [1]Technisches Buro, Novackeho 4, Bratislava, Slovakia, [2]Slovnaft VÚRUP, Vlčie hrdlo, Bratislava, Slovakia, [3]Faculty of Chemical and Food Technology STU, Radlinského 9, Bratislava, Slovakia.

Results of the study of catalytic cracking of some vegetable oils and animal fats are presented. The cracking procedure takes place in a batch at the temperature up to 440°C during 20 to 50 min with 2 to 10% of zeolite catalyst NaY. The obtained liquid condensate represents up to 90%, gaseous fraction about 5% and bituminous residue about 5%. Modified liquid condensate after removal of light ends up to 10% at 190°C has similar properties as fossil diesel. It contains mainly the unsaturated hydrocarbons and oxygenates as aldehydes, ketones, alcohols and acids. Its heating value is about 40 MJ/kg and oxygen content up to 15% wt. The blends of the modified liquid cracking condensates from rapeseed and sunflower oils at the portion of 3 and 6% vol. with fossil diesel meet the diesel fuel standard EN 590 in all criteria.

Acknowledgements: This work was supported by the Slovak Research and Development Agency under the contract No. APVV-20-037105.

2. **Comparisons of Biodiesel Productivity of Different Vegetable Oils by Alkali Catalysis.** Ayten Sagiroglu, Hakki Mevlut Ozcan, Sebnem Selen Isbilir, Hatice Polizar, and Neslihan Mert Toprankiran, Trakya University, Edirne, Turkey.

The main advantages of biodiesel are its biodegradability, renewable, improved nontoxic exhaust emissions and unnecessary alteration of normally diesel engines. Today, the biodiesel is produced by catalysis of inorganic acids, alkali and free-immobilized lipases with vegetable oil and short chain alcohols. Alkali and acidic catalyst is the most using catalyst for production of biodiesel because of higher reaction yield and rate. In recent years the use of free or particularly immobilized lipases as catalysis for alcoholysis of oils has been widely investigated. But enzymes used as catalysts are limited to biodiesel production, because of the enzymes are expensive and have lower yield than the inorganic catalysts to biodiesel process.

In this study, we have comprised biodiesel productivity of different vegetable oils like sunflower, safflower, canola, soy, olive oils and waste sunflower oils by alkali catalysis.

3. **Comparisons of Biodiesel Productivity of Different Vegetable Oils by Acidic Catalysis.** Ayten Sagiroglu, Sebnem Selen Isbilir, Hakki Mevlut Ozcan, Hatice Poluzar, and Neslihan Mert Toprakkiran, Trakya University, Edirne, Turkey.

Triglycerides (TG) of vegetable oils and fats are becoming increasingly important as alternatively fuels for diesel engines due to the diminishing petroleum reserves. However, their high viscosities and low volatilities do not permit their direct use or in oil/petrol blends in any diesel engine type. Addition the vegetable oil fuels were not acceptable because they more expensive than petroleum fuels.

Nowadays the main process developed to overcome this drawback is the methanolysis reaction to produce biodiesel, a biodegradable, non-toxic diesel fuel substitute that can be used in unmodified diesel engines. It has a significant added value compared to petro-diesel because of its higher lubricity, which extends engine life and reduces maintenance costs and environmental benefits as well as contribution to fuel economy. Recently, that can be found on the production of biodiesel involving other chemical or enzymatic protocols as greener alternatives.

Here, we reported the comparison of biodiesel productivity using five vegetable oil and roasted sunflower oil with methanolysis reaction by an acidic catalysis protocol as an economically viable vegetable oil for the production of biodiesel.

4. **Regulated and Non-Regulated Emissions from Animal Fat and Vegetal Biodiesel.** Renato Penteado[1,2] and Ricardo Cunha[1], [1]Lactec, Curitiba, PR, Brazil, [2]P&K Consulting, Curitiba, Pr, Brazil.

A Diesel engine for electricity generation use has been tested in one updated emissions laboratory. Performance and emissions have been analyzed. Different kinds of fuels have been applied, such as Diesel, biodiesel from soybean, biodiesel from palm oil (oleaginous from Brazilian Amazon) and biodiesel from chicken fat.

Performance for each fuel was measured and torque, power, and fuel consumption are presented. Regulated emissions, such as CO, HC, NOx, and PM were measured.

Based on FTIR technique, regulated and non-regulated (aldehydes) emissions were also measured and results are presented. A comparison between both analytical and FTIR measuring techniques is presented.

Results are show by multiple graphs. Conclusions and recommendations are pointed out.

Acknowledgements: Authors acknowledges the Institute for Technological Development (Lactec), Petrobras and Eletronorte Brazil, for research financial support.

5. **Understanding Hydrodeoxygenation of Oils and Fats.** A.T. Madsen, A. Riisager, and R. Fehrmann, Centre for Catalysis and Sustainable Chemistry, DTU Chemistry, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark.

Production of diesel fuels from renewable feedstock is increasing. One auspicious route could be by hydrodeoxygenating waste fats and oils to result long-chain alkanes, a process well suited for existing fuel infrastructure. This was studied over metal oxide-supported platinum-group metals in a batch reactor.

Oleic acid and tripalmitin in n-tetradecane as a solvent and n-dodecane as internal standard was added to an autoclave and mixed with catalyst and charged with 0-50 bar hydrogen at 250-375°C. This model feed closely resembles waste fats and allows relating the products directly to reactants and reaction routes.

Supported Pt and Pd almost exclusively yielded long-chain alkanes via decarboxylation, while complete hydrogenation was suppressed despite high pressures of H_2. Deoxygenation without hydrogen was possible as well, although catalysts are prone to faster deactivation. Supported Ni was less active and also consumed more H_2 for complete hydrogenation. CH_4 was found to be the major component in the gas phase resulting from methanation of H_2 and CO or CO_2 from decarboxylation. This protocol may be advantageous for studying production of renewable diesel.

Acknowledgements: ATM is grateful for support of his Ph.D. stipend from the Danish Research and Innovation Agency through the "Waste-to-value" consortium.

6. **Comparison of the Mutagenic Potential of Particle Emissions of a Vegetable Oil Compatible Tractor Fueled with Rapeseed Oil and Diesel Fuel.** Klaus Thuneke, Peter

Emberger*, Thomas Gassner, and Edgar Remmele, Technologie- und Förderzentrum, Straubing, Bavaria, Germany.

Aim of the research project was to investigate the mutagenic potential of exhaust gas particles of a vegetable oil compatible tractor to enlarge data basis for valuation of health risks. The results show that the mutagenic potential of the exhaust gas particles for the sum of eight operating modes according to ISO 8178 is 10 to 60% lower during rapeseed oil fuel operation in comparison to diesel fuel operation. During idle the mutagenic potential of the particles is even 50 to 80% lower. In general the mutagenic effects of all samples – with the exception of diesel fuel under no load condition – are on a very low level. The research proved that the risk of particle emissions causing cancer or damage to genetic material is lower when the vegetable oil compatible engine is fuelled with standard conform rapeseed oil fuel rather than with diesel fuel.

Acknowledgements: The authors would like to thank the Bavarian State Ministry for Food, Agriculture and Forestry, Munich, Germany for financing the study and the Bifa Environmental Institute, Augsburg, Germany for excellent co-operation.

7. **Emission Characteristics of Rapeseed Oil Fueled Tractors During Three Years of Operation.** Klaus Thuneke, Peter Emberger*, Thomas Gassner, and Edgar Remmele, Technologie- und Förderzentrum, Straubing, Bavaria, Germany.

Rapeseed oil fueled tractors gain more and more importance in Germany. Besides environmental benefits, a reduction of costs can be achieved in many cases. The adaptation of the tractors is usually conducted by retrofitting workshops. Shortly, series produced vegetable oil compatible engines are available for agricultural machinery. However, the emission characteristics during rapeseed oil fuel operation are widely unknown. Thus, it was the aim of the research project finished 2009 to monitor exhaust gas emissions of rapeseed oil fueled tractors by recurrent measurement since the year 2006. The operation of the tested vegetable oil compatible tractors with standard conform rapeseed oil fuel leads to equal or lower limited exhaust gas emissions apart from NOx. With increasing operating hours no significant change in emission concentrations was observed. Although present exhaust gas regulations can be fulfilled widely, efforts have to be undertaken to fulfill limiting values with both diesel and rapeseed oil fuel, due to ongoing stricter emission regulations.

Acknowledgements: The authors would like to thank greatly the Bavarian State Ministry for Food, Agriculture and Forestry for financing this research project.

8. **Pre-standard DIN V 51605 for Rapeseed Oil Fuel.** Edgar Remmele, Klaus Thuneke, and Peter Emberger*, Technologie- und Förderzentrum, Straubing, Bavaria, Germany.

A reliable and environmentally low impact operation of combustion engines is only possible, when relevant fuel properties are defined and range within specified limits. Standardised fuel quality is an important pre-condition for the assessment of operational and emission characteristics, engine development as well as a basis for fuel trading. The demands on rape seed oil fuel quality were first laid down in the "Quality Standard for Rapeseed Oil as a Fuel (05/2000)." Based on this "RK-Quality Standard" national standardization was initiated. On July 1st, 2006 the pre-standard DIN V 51605 "fuels for vegetable oil compatible combustion engines – fuel from rapeseed oil – requirements and test methods" was published. It was decided to develop the DIN V 51605 to a definite standard. Therefore further research work such as round robin analyses tests and engine test runs with graduated rapeseed oil fuel qualities need to be performed.

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9. **Optimization of *Jatropha curcas* Oil-pressing for Biodiesel Production.** Shkelqim Karaj and Joachim Müller, University of Hohenheim, Stuttgart, Baden, Württemberg, Germany.

Jatropha curcas might be used as alternative fuel and since it is a non edible vegetable oil it has a very significant function because of the demand for edible oils as food. The objective of this study was the optimization of oil-pressing with respect to oil quality for biodiesel production. For this study, dried J. curcas seeds (mc. 9 % db.) were imported from India. The experiments were carried out with a mechanical screw press type (Komet D85-1G). The screw press was modified and sensors were installed for measuring parameters such as oil recovery, temperature, pressure, energy requirement, torque and angular velocity. The data were collected with a data acquisition unit (hp 34970A) and then transferred as Excel files, for further statistical analyses with OriginLab-8 software. Chemical properties such as: density, kinematic viscosity, calorific value, and iodine value, melting point, flashing point, water content, carbon impurities, phosphor content, calcium and magnesium content, total contamination, acid value, fatty acid and free fatty acid were analysed according German Standard protocols (DIN) and results were compared with European standard for biodiesel production (EN 14214).

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Analytical Methods and Fuel Quality Issues

1. **Optimization of Properties of Biodiesel Formulations by Response Surface Methodology.** Maria Jorge Pratas[1], Silvia Monteio[2], Armando Silvestre[1], Isabel Marrucho[1], and João Coutinho[1], [1]CICECO - University of Aveiro, Aveiro, Portugal, [2]Polytechnic Institute of Leiria, Leiria, Portugal.

The growing interest in vegetable oil and their derivatives as renewable fuels for diesel engines has been motivated by the predictable dwindling of fossil resources as well as by the environmental concerns associated with fossil CO_2 emissions. Europe aims to replace 20% of fossil fuels for alternative fuels such as biofuels, natural gas or hydrogen until 2020. In Portugal, the current goal is the replacement of 10% of fossil fuels by alternative fuels until 2010.

Envisaging the necessity of more knowledge on the use of vegetal oil mixtures for the production of biodiesel in order to minimize product costs while still conforming to specifications, the transesterification of mixtures of soybean, jatropha, rapeseed and palm oil have been studied.

The goal of this work is to find the ranges of composition where the properties of biodiesel produced from those oil mixtures conform to the biodiesel national specifications. Response surface methodology (RSM) was used to evaluate methyl esters yield, iodine index, oxidation stability, cloud point and properties such as density and viscosity.

Acknowledgements: Maria Jorge Pratas acknowledge the financial support from Fundação para a Ciência e a Tecnologia through her PhD (SFRH/BD/28258/2006) scholarship.

2. **Determination of Iodine Value of Biodiesel by 1H NMR using 1,4-dioxane as Internal Standard.** M. Oromí[1],

A. Tomàs[1], G. Villorbina[1], M. Torres[2], J. Eras[1], M. Balcells[1], and R. Canela[1], [1]Chemistry Department, University of Lleida, Lleida, Spain, [2]Food Technology Department, UTPV-Certa, University of Lleida, Lleida, Spain.

Two procedures for the determination of iodine value (IV) in biodiesel are provided by EN 14214. These methods not only involve several steps, but also use several solvents and reactants, sample can't be recovered and both analysis are time consuming. 1H NMR has been found to be an effective tool for the direct, rapid, and automated determination of IV in vegetable oils. This value is calculated considering the number of double-bonded protons and the average molecular weight both derived directly from the spectrum. In the present study, the IV of various biodiesel samples from different origins is determined by 1H NMR using 1,4-dioxane as internal standard. Results are compared with the IV obtained by the wet method and 1H NMR spectrum without internal standard. The use of one internal standard allows to determinate the IV directly comparing the area of olefinic and 1,4-dioxane hydrogen signals. Besides, this new method provides more accurate IV measures when mixtures of diverse fatty acid esters are present.

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3. **Characterization of Waste Frying Oils by NIR Spectroscopy.** A. Barranco[1], M. Uriarte[1], C. López[2], T. Travería[2], and E. Saitua*[1], [1]AZTI-Tecnalia, Derio, Bizkaia, Spain, [2]Bionor Transformacion, S.A., Zamudio, Bizkaia, Spain.

Waste frying oils (WFO) are an interesting source of raw material for biodiesel production. They are collected in large quantities in most developing countries and its utilization serves the environmental cause. These WFO have a different chemical composition, compared to fresh oils, due to several degradation processes and hence, may affect the transesterification reaction.

During this work the quality of WFO collected in Spain has been assessed. Different properties of these materials have been analysed and their influence on the quality of the final biodiesel has been studied. Many parameters have been found to be greatly important such as acidity and the content of polar compounds. In order to improved the speed in the characterization of raw materials Near Infra-Red (NIR) spectroscopy has been employed. Different models have been optimized and validated for the determination of the most important parameters.

Acknowledgements: This work was performed within the research project PIIBE. The financing by the Spanish Ministry of Science and Innovation is gratefully acknowledged.

4. **Assessing Microbial Spoilage of Biodiesel Blends under Aerobic and Anaerobic Conditions.** S. Nygaard, K. Sørensen, H. Hansen, and G. Sørensen, Danish Technological Institute, Aarhus, Jylland, Denmark.

Micro organisms are known to grow in fuel tanks where they may affect both fuel quality and the integrity of storage facilities. Mixing with biodiesel is suspected to increase these problems, but the underlying, microbiological mechanisms remain poorly understood. In this study, five different biodiesel mixtures were incubated with microbially contaminated water under anaerobic and aerobic conditions for 51 and 29 days, respectively, and changes in chemical properties of the fuel as well as in the microbial communities were monitored. The results indicate that rapid microbial growth occurred in all mixtures. Anaerobic mixtures contained mainly fermentative bacteria, and methane-producers were less abundant (<1% of the population). Methanogens are thought to increase rates of corrosion in oil installations by maintaining a low hydrogen concentration. Aerobic mixtures contained large amounts of fungi, and both growth and diversity of bacteria was limited, possibly as a consequence of bacteriocides excreted by the fungi.

Acknowledgements: The authors would like to acknowledge The Danish Ministry of Technology and Innovation for financial support to the project Waste-2-Value.

5. **Characterization of Diesel/Biodiesel Blends by Simulated Distillation.** C. Bachler, S. Schober, S. Buchgraber, and M. Mittelbach, Karl-Franzens-University Graz, Graz, Styria, Austria.

Simulated Distillation is a GC based method commonly used in petroleum industry for determination of petroleum fraction according to their boiling point distribution. In contrast to physical distillation analysis time is shorter, sample amounts are considerably smaller and sample preparation is quite easy. Due to the fact that biodiesel made of rapeseed lacks lower boiling point constituents in contrast to fossil diesel the boiling point distribution of biodiesel is quite different and does not meet EN 590. In the course of our investigations different blends of fossil diesel with traditional biodiesel samples e.g. RME were analysed. Furthermore novel biodiesel samples e.g. castor oil methyl ester, fish oil ethyl ester and coco oil methyl ester were tested in blending experiments. Generally it can be shown that Simulated Distillation is an efficient tool for the determination of boiling point distributions of different types of fuel.

6. **Effect of Lignin Addition on Biodiesel as Prepared by Supercritical Methanol Method.** Shiro Saka and Jiayu Xin, Graduate School of Energy Science, Kyoto University, Japan.

Effect of lignin addition on biodiesel prepared by supercritical methanol (270°C/12MPa-300°C/20MPa) with molar ratio between rapeseed oil and methanol of 1:42 was studied. It was consequently found that lignin could be decomposed to low molecular compounds that have the free radical trapping effect after supercritical methanol treatment. Behave of lignin decomposition during supercritical methanol treatment and various lignin-derived compounds were studied by FT-IR and GC-MS. The rapeseed biodiesel prepared by supercritical methanol method at 300°C/20MPa for 20min with a small amount of lignin addition had the induction period longer than 6h at 110°C in Rancimat test. In addition, it was also found that lignin-derived compound has a catalytic effect in biodiesel production by supercritical methanol method without significantly affecting other fuel properties of prepared biodiesel. Therefore, it is possible to produce biodiesel at 270°C/12MPa within 30min by supercritical methanol method with lignin addition.

7. **Thermodynamic Study on the Effects of Minor Constituents on Cold Weather Performance of Biodiesel.** R.O. Dunn, USDA, ARS, NCAUR, Peoria, IL, USA.

Biodiesel is an alternative diesel fuel made from vegetable oils, animal fats and other lipid feedstocks. Fuel properties and performance of biodiesel during cold weather are influenced by factors related to its feedstock, namely fatty acid composition and trace concentrations of monoacylglycerols, steryl glucosides and other minor constituents may be present after conversion. This study applies thermodynamic models to determine the effects of small variations in fatty acid methyl ester (FAME) concentration and very small concentrations of minor constituents on crystallization onset temperature and cloud point (CP). Differential scanning calorimetry (DSC) curves are analyzed to determine melting point (MP) and enthalpy of fusion of various FAME components, monostearin, monopalmitin, β-sitorsteryl glucoside, free fatty acids, sodium and potassium salts of fatty acids (soaps), α-tocopherol, glycerol and

water. Data calculated from thermodynamic models are compared with direct experimental measurement of CP of corresponding mixtures of FAME and constituents. Effects of interactions between types of minor constituents are also evaluated.

8. **Effect of Antioxidant on the Oxidative Stability of Biodiesel.** Haiying Tang, Rhet C. De Guzman, Steven O. Salley, and K.Y. Simon Ng*, Wayne State University, Detroit, Michigan, USA.

A significant problem associated with the commercial acceptance of biodiesel is poor oxidative stability. This study investigated the effectiveness of individual and binary antioxidants to improve the oxidative stability of different types of biodiesel and distilled biodiesel. Results indicate that different types of biodiesel have different levels of oxidative stability, and that natural antioxidants and FAME composition play significant roles in determining oxidative stability. Synthetic antioxidants can enhance the oxidative stability of different types of biodiesel, and antioxidant activity increases as a function of its concentration. However, the effective activity level of antioxidant is dependent on biodiesel feedstock. Binary antioxidant formulations (TBHQ, PY, and BHA) have a synergistic effect on oxidative stability of biodiesel. After long-term indoor and outdoor storage, the oxidative stability of untreated SBO-based biodiesel significantly decreases as a function of time, while the addition of the antioxidant TBHQ can improve and maintain oxidative stability of biodiesel over a 24-month period.

Acknowledgements: Financial support from the Department of Energy (Grant DE-FG36-05GO85005) and Michigan's 21st Century Job Fund is gratefully acknowledged.

9. **Improvement of Oxidation Stability of Biodiesel by Selective Hydrogenation Technology.** M. Toba[1], Y. Abe[1], A. Suemanotham[2], Y. Thanmongkhon[2], P. Jenvanitpanjakul[2], and Y. Yoshimura[1], [1]National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan, [2]Thailand Institute of Scientific and Technological Research, Bangkok, Thailand.

On account of the demand of increasing the mixing rate of the biodiesel blended in petroleum diesel and the stricter limitation of oxidation stability specified by new proposed standards such as Worldwide Fuel Charter, the technology of producing biodiesel with high oxidation stability is desired. Unsaturated fatty acid methyl esters with more than two C=C bonds in biodiesel are easily oxidized and form acids and other oxidized products. To improve the oxidation stability of biodiesel, we examined selective hydrogenation of polyunsaturated fatty acid methyl esters in biodiesel over noble metal catalysts under mild condition. Polyunsaturated fatty acid methyl esters were selectively hydrogenated to monounsaturated and saturated ones. Induction time in Rancimat test of hydrogenated rapeseed FAME is 17.8 hours and its oxidation stability is almost equal to that of rapeseed FAME mixed with 8200ppm of BHT. Incremental acid value and pour point of B5-B20 hydrogenated rapeseed FAME/petroleum diesel mixture could meet Japanese mandatory law and JIS standard, respectively.

10. **Determination of Free and Esterified Steryl Glucosides in Vegetable Oils and Biodiesel.** F. Lacoste[1], F. De Jean[1], H. Griffon[1], and C. Rouquette[2], [1]ITERG, Pessac, France, [2]IFP, Vernaison, France.

Steryl glucosides (SG) are minor components that dramatically modify the low temperature performance of fatty acid methyl esters (FAME) used as biodiesel. SG are naturally present in vegetable oils but they may also be the result of the transesterification of esterified steryl glucosides (ESG). These are present in vegetable oils at a few hundred of mg/kg level, depending on the nature of the feedstock.

An analytical method was developed in order to quantify SG and ESG in vegetable oils and in FAME. The purification of SG and ESG was performed by liquid chromatography on silica gel, and the analysis of the trimethylsilyl derivatives was achieved by gas chromatography and flame ionization detection.

The filterability of biodiesel is affected when the SG content is higher than 20 mg/kg. Therefore, the sensitivity of this new method is adapted to the purpose, since the quantification limit is 10 mg/kg of SG and ESG.

The recoveries are acceptable, between 75% and 90% depending on the species and content, and the reproducibility relative standard deviation, evaluated at 10%, is comparable to other studies.

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11. **Using HPLC to Monitor Enzymatic Biodiesel Production.** L. Spångner Christiansen[1], C.A. Godoy[2], Y. Xu[1], M. Nordblad*[1], J.M. Woodley[1]; [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, DK-2800 Lyngby, Denmark, [2]Departamento de Biocatálisis, Instituto de Catálisis y Petroleoquímica (CSIC), 28049 Madrid, Spain.

The use of enzyme-based catalysts to produce biodiesel shows great promise from an environmental and technical point of view[1]. However, enzymatic conversion involves complicated kinetics with significant differences between one catalyst and another, making accurate and comprehensive analytical methods highly important[2]. The presented method uses normal-phase HPLC and ELS detection to separate and quantify each of the major lipid classes involved in biodiesel production, i.e. tri-, di- and mono-glycerides, free fatty acids and biodiesel with a reduced sample-to-sample time (18 min). An extended program (30 min) has additionally been used to quantify glycerol. The method has been used to monitor the conversion of crude rapeseed oil and ethanol into fatty acid ethyl esters (FAEE) and shows clear differences between the tested catalysts with respect to substrate selectivity.

[1] Nielsen, P.M. *et al.*, 2008. *Eur. J. Lipid Sci. Technol.*, 110, 692.
[2] Foglia, T.A., Jones, K.C., 1997. *J. Liq. Chromatog. Rel. Technol.*, 20, 1829.

12. **Pressure Drop Hysteresis Effect on Biodiesel Filtration.** K. Kim, D. Kittelson*, and D. Pui, University of Minnesota, Minneapolis, Minnesota, USA

Filter plugging is a common problem associated with the use of biodiesel blends in cold climates. A screening test is being developed to predict filter plugging based on pressure drop measurements across a test filter. The fuel is pumped through a test filter under controlled temperature and flow conditions and the pressure drop is measured. As temperature is reduced at constant flowrate, the pressure drop increases and the rate of increase increases sharply as a plugging condition is approached. Biodiesel blends in general exhibit higher pressure drops than ULSD and the pressure drop increases with the biodiesel fraction. When fuels are cooled to -30°C and then reheated, the pressure drop at each temperature is higher than that measured when the fuels are being cooled. The difference between the cooling and heating curves decreases as the fuel is heated but is still present at 20°C. Both ULSD and biodiesel blends exhibit this hysteresis effect but the effect is much larger with biodiesel blends. It is evident that exposure of biodiesel blends to low temperatures predisposes them to filter plugging even if they are dispensed and used at higher temperatures.

Acknowledgements: This work was sponsored by the University of Minnesota Center for Filtration Research. We thank Metro Transit for advice and fuel samples.

13. **Cold Weather Limitations of Saturated Monoglyceride (SMG) Impurities.** Richard W. Heiden,

R.W. Heiden Associates, LLC, 1026 New Holland Avenue, Lancaster, PA 17601, USA.

The formation of precipitates that block fuel filters above the cloud point represents an important challenge to the cold weather operability of biodiesel fueled vehicles. Normally, cold weather limitations of biodiesel fuels are predicted by standard cloud point/ pour point, and cold soak filtration (CSFT), but these tests fail to predict the impact of the temperature on the solubility of some important impurities. Saturated monoglycerides (SMG's) are identified in previously reported work[1] as the prime factors in incidents of fuel filter blockages that struck fleets of maintenance vehicles using B-20 in the eastern part of the U.S. in 2006. Our initial studies of the temperature dependence of the solubilities of monopalmitin and monostearin in B100 and various blends are reported there. Now, two years later SMG's on filters are a major concern to the biodiesel industry and the solubility of SMG's has come to the forefront.

We present here data that defines the magnitude of the SMG challenge. We have systematically studied the effects of various conditions that determine the SMG solubility in B-100 and various blends. The results of these studies are discussed.

[1]Richard W. Heiden, Ph.D. "Impurities in B20 That Cause Fuel Filter Plugging during Cold Weather", International Congress on Biodiesel, Vienna, 2007.

Cleaning up Biodiesel

1. **Purification and Winterization of Biodiesel by Micro Process Engineering.** G. Rinke and S. Kerschbaum, Karlsruhe Research Center, Institute for Micro Process Engineering, Karlsruhe, Germany.

A new pure physical method for winterization of biodiesel based on waste cooking oil is demonstrated using micro heat exchangers with 7500 micro channels, each with a hydraulic diameter of 135 μm. These micro heat exchangers allow a rapid and effective cooling. Biodiesel is pumped from a vessel through a micro heat exchanger in such a way, that pure seed crystals of saturated fatty acid methyl esters are produced at the outlet of the micro channels and injected back into the biodiesel vessel. In contrast to other crystallization methods these seed crystals are no clusters containing unsaturated fatty acid methyl esters.

The change in chemical composition of the biodiesel within the vessel was measured by gas chromatography, which allows the determination of important saturated fatty acid methyl esters as palmitic acid methyl esters, stearic acid methyl esters and unsaturated methyl esters as Oleic acid methyl esters and Linoleic acid methyl esters. Thus micro process engineering allows the reduction of the sum of saturated fatty acid methyl esters within biodiesel based on waste cooking oil from 21.3% to 9.6%. This corresponds to a reduction in the CFPP value of 11 K.

Feedstocks for the Future

1. **Characterization of Low-Quality Feedstocks in Japan and the Possibility of their Conversion to the First- or Second-Generation Biodiesel.** Hidetoshi Kuramochi[1], Masahiro Osako[1], Makoto Toba[2], Yuji Yoshimura[2], Kouji Maeda[3], Kazuo Nakmura[4], and Shin-ichi Sakai[5], [1]National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan, [2]National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan, [3]University of Hyogo, Himeji, Hyogo, Japan, [4]Advanced Software Technology & Mechatronics Research Institute of Kyoto, Shimogyo-ku, Kyoto, Japan, [5]Kyoto University, Sakyo-ku, Kyoto, Japan.

In Japan, edible vegetable oils cannot be used for biodiesel production because most of oil crops are imported from foreign countries. Therefore, waste cooking oils and greases must be used for the domestic biodiesel production. Although used flying oil is converted to fatty acid methyl esters, namely, the first-generation biodiesel, other low-quality waste oils and greases are not used for the biodiesel production. In this work, we examined the abundance of them in Japan, and then characterized them in terms of not only the content of major components such as glycerides and fatty acids but also that of minor impurities such as water and alkali metals. Furthermore, we investigated the possibility of converting the low-quality feedstocks to the first-generation biodiesel by two-step acid-base esterification with homogeneous catalysts, and also the possibility to the second-generation biodiesel (a hydrocarbon-based biodiesel) by hydrodeoxygenation with a hydrotreating catalyst.

2. **Algal Growth Characteristics and Oil Properties.** N.J. Abunasser[2,1], M.E.D. Garcia Perez[1], H. Tang[1], S.O. Salley[1], and K.Y.S Ng[1], [1]Wayne State University, Detroit, MI, USA, [2]MEDC, Lansing, MI, USA.

With the increasing cost of oil feedstock world-wide and the raging food-vs-fuel debate, there is a growing need for an alternative non-food based feedstock. Algal oil is a promising alternative to the traditional feedstock options. However, for algae to become a viable option there need to be comprehensive studies on growth systems, growth parameters and oil characteristics. A novel, adaptively controlled, external loop photobioreactor utilizing submersible illumination was developed. Experiments were run to measure the growth rate and productivity using a variety of light sources. Parameters such as pH, dissolved oxygen, light intensity, nutrient concentrations and cell count were monitored and recorded automatically via data acquisition software. Additionally, a mathematical model of the system, based on the photosynthetic factories model, is being developed to aid in the optimization of the growth rates. Separate experiments were run to determine the effect of varying light intensities and CO_2 concentrations on the growth of two microalgae, Dunaliella Tertiolecta, UTEX LB 999 in Erdschreiber's medium, and Chlorella Minutissma, UTEX 2219, in Modified bold 3N medium. The microalgae from all experiments were harvested in the stationary phase and the oil extracted via different solvent based methods. The efficiencies of the extraction methods were compared and the properties of the algae oil were measured.

3. **Used Frying Oils as a Source for FAME Preparation.** Andrea Kleinova[1] and Jan Cvengros*[2], [1]Faculty of Chemical and Food Technology STU, Bratislava, Slovakia, [2]Faculty of Chemical and Food Technology STU, Bratislava, Slovakia.

FAME are used as alternative diesel fuel made from renewable sources. The attention is oriented to the materials that do not compete with food and feed production. Significant potential as an alternative low-cost biodiesel feedstock present used frying oils (UFO). The chemical changes which take place during frying can be extensive and the properties of the product should not meet all requirements of the standard EN 14 214. The possibilities of determination of the degree of deterioration of frying oils, and of evaluation of suitability of UFO for FAME production are evaluated as well as the relations between selected UFO properties and the parameters of future FAME. The methods of UFO treatment so that the treated UFO will yield standard FAME as well as the methods of FAME treatment prepared from untreated UFO in order to meet the requirements of the EN 14 214 are also discussed.

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4. **Catalytic Transformation of Castor Oil Methylesters into High Oleic Methyesters.** Nicoletta Ravasio[1], Federica Zaccheria[1], Paolo Bondioli[2], and Laura Della Bella[2], [1]CNR ISTM, Milano, Italy, [2]SSOG, Milano, Italy.

In several southern countries the use of castor oil as fuel is being discussed. However, the extremely high viscosity and high water content complicate the use of straight castor oil as a fuel for internal combustion engines. A better perspective may be possible by transesterification, but also in this case viscosity is far from meeting the European specifications requiring viscosity at 40°C between 3,50 and 5,00 mm2/s.

The extremely high viscosity of castor oil and castor oil ME is due to the presence of the hydroxyl group [1], therefore a treatment allowing one to remove this group would result in an improvement of castor oil physical properties.

We recently reported that Cu/SiO2 catalysts is able to selectively reduce the conjugated and unconjugated dienic component of tall oil [2]. Here we wish to report that by using a similar catalyst supported on a much more acidic material, a bifunctional process can be set up, involving dehydration of ricinoleic acid to C18:2 and selective hydrogenation to oleic acid isomers. Preliminary tests show that after 6h at 200°C under 6 bar H2 over a Cu/SiO2Al2O3 catalyst, ricinoleic methylesters were completely converted into a mixture containing 70% C18:1 isomers.

1) V.Scholz, J.Nogueira da Siva, Biomass&Bioenergy 32 (2008) 95.
2) P.F. Bondioli, M.N. Ravasio, F. Zaccheria, PCT/IT2006/000258 WO2006/111997 A1; EP Appl. 06745284.7 (2007).

5. **Comparison of the Biodiesel Produced from Palm Oil Raw, Degummed or Preesterified.** F.A. Avellaneda Vargas[1,2] and J. Salvadó Rovira[1], [1]Universitat Rovira i Virgili, Tarragona, Tarragona, Spain, [2]Universidad de Pamplona, Pamplona, Norte de Santander, Colombia.

The use of palm oil for biodiesel production still presents some difficulties because of its high acid index. The work presented here was carried out with the final objective of compare and optimize the biodiesel production by transesterification of palm oil using methanol and NaOH as catalyst. The experiments were carried out varying the molar ratio methanol:oil, the amount of catalyst used, and the pretreatment applied to the oil, using it raw, degummed, or preesterified (by acid catalysis with phosphoric acid). The parameters that were measured and compared were the yield (in g of biodiesel produced/g oil used) and its FAME percentage according to the quality standard UNE 14103. The best biodiesel produced was analyzed according to standard norm UNE 14214 to evaluate its global quality. The results obtained showed that the biodiesel produced from degummed oil or pretreated oil presented the highest FAME percentage, but lowest yields.

6. **A Pretreatment Process for Waste Frying Oil as Biodiesel Feedstock: Solvent Extraction Combined with Ca-Soap Precipitation.** F.M. Tunc, H. Gurbuz*, and Z.S. Turkay, Istanbul Technical University, Chemical Engineering Department, Istanbul, Maslak, Turkey.

Waste frying oils (WFOs) are promising alternative feedstocks for biodiesel production. Since alkali transesterification is complicated if WFOs contain free fatty acids (FFA) higher than 0.5% w/w, WFOs with high FFA should be refined before using as biodiesel feedstock. Methanol extraction has some clear advantages in comparison to conventional refining processes for high acidity oils. Although distillation is the principle method for solvent recovery in conventional application of solvent extraction, the contribution of the steam and cooling water consumption to the operating cost is high. To maintain the economic advantage of solvent extraction process, it could be necessary to use other solvent recovery methods. In this work an alternative solvent recovery method based on the precipitation of FFAs in the methanol phase as calcium soaps by using $Ca(OH)_2$ as precipitating agent was studied. The effects of FFA content of extract phase, reaction temperature, $Ca(OH)_2$/FFA ratio, and stirring rate on the precipitation kinetics were determined experimentally. Additionally, both the effect of this pretreatment method on the quality of biodiesel and the possibility of using the precipitated calcium soaps as heterogenous catalysts in transesterification were also evaluated.

7. **Extraction, Refining, and Conventional Transesterification Compared with in situ Transesterification of Jatropha Seed Oil.** C.M. Fernández, M. Solana, M.J. Ramos, A. Pérez, and J.F. Rodríguez, Institute for Chemical and Environmental Technology, University of Castilla la Mancha. Chemical Engineering Department, Avd. Camilo Jose Cela, Ciudad Real, Spain.

Jatropha Curcas L. has attained significant economic importance being a very promising source of non-edible oil that can be used as feedstock for production of biodiesel. The aim of this work was to optimize the method of oil extraction for jatropha seed and to find an economical process to produce biodiesel with a good quality. The literature has reported that jatropha seeds contain around 20-40% oil. The oil extraction yield obtained for hulled seeds with solvent extraction was 38 wt% using n-hexane in 2 hour. The Jatropha oil contained about 11% of free fatty acid (FFA), which is far beyond the limit of 1% FFA level that can be converted into biodiesel by transesterification using an alkaline catalyst. Oil contents, physicochemical properties and fatty acid composition of Jatropha oil were investigated.

In situ transesterification differs from the conventional reaction in that the oil-bearing material contacts with alkalized alcohol directly instead of reacting with pre-extracted oil and alcohol. That is, extraction and transesterification proceed in one step. In situ transesterification process achieved an oil extraction yield higher than 30 wt% and with a methyl ester conversion higher than 90 wt%. Therefore, in situ transesterification is a competitive and economical process to produce biodiesel.

8. **Characteristics and Composition of Brazilian Jatropha Curcas Seeds and Oils.** M.B. Casarini[1], A.L.M.T. Pighinelli*[2], R.A. Ferrari[1], and K.J. Park[2], [1]Institute of Food Technology, Campinas, Sao Paulo, Brazil, [2]State University of Campinas, Campinas, Sao Paulo, Brazil.

The interest in using Jatropha curcas L. as a feedstock for biodiesel production is rapidly growing in Brazil. Therefore, twenty seven samples of seeds, from different Brazilian regions, were analyzed for their composition. The seed oils were analyzed for fatty acids and physicochemical characteristics. The results revealed that the average seed weight varied from 0.52 to 0.78g and the percentage of kernel, shell, crude protein, lipid, ash and moisture content were 59.10%, 40.59%, 17.19%, 31.51%, 4,54% and 7.56% respectively. The lipid content in the seeds ranged from 11.29% to 39.70%, and the oil showed 20.27% saturated and 79.66% unsaturated fatty acids with oleic and linoleic acids as predominating. The iodine and saponification value were 98.40 mg I2 /g and 193.34 mg KOH/g. The molecular mass of fatty acids was 277.47. Physicochemical analysis of the seed oils showed that they could be classified as semi drying oils and could be found applicable in biodiesel production.

Acknowledgements: FAPESP, CNPq, ITAL

9. **Utilization of Brazilian Jatropha Curcas Seeds for Biodiesel and Animal Feed Production.** C.O.B. González[1], A.L.M.T. Pighinelli*[1], R.A. Ferrari[2], and K.J. Park[1], [1]State University

of Campinas, Campinas, Sao Paulo, Brazil, [2]Institute of Food Technology, Campinas, Sao Paulo, Brazil.

An alternative to minimize the biodiesel production costs is to choose alternative and no-edible raw materials. Jatropha Curcas L. is a crop that is rapidly growing in Brazil. This project intends to use Jatropha as biodiesel and animal feed. The present work is organized as follow: 1) establishment of the best conditions for oil extraction by expelling and solvent (ethanol and hexane); 2) establishment of the best transesterification conditions of Jatropha oil in laboratory scale; 3) elimination of the main toxins (phorbol esthers, lectin, trypsin inhibitors) from the cake obtained by both methods; 4) transesterification reactions in a pilot scale with optimization of the process. At last, a technical-economic analysis of the involved steps will be conducted. The experimental steps will be developed according to the experimental factorial design 2k methodology, followed by optimization, by means of answer surface response, to obtain the regression models that describe the process behavior.

Acknowledgements: FAPESP, CNPq, ITAL, FEAGRI.

10. **Improving Fatty Acid Alkyl Esters Production Yield in a Lipase-Catalyzed Process by Using Waste Frying Oils as Feedstock.** Laura Azócar[1], Gustavo Ciudad[2], Hermann J. Heipieper[3], Robinson Muñoz[4], and Rodrigo Navia[2,4], [1]Programa de Doctorado en Ciencias de Recursos Naturales, Universidad de La Frontera, Temuco, Región de La Araucanía, Chile, [2]Núcleo Científico Tecnológico en Biorrecursos, Universidad de La Frontera, Temuco, Región de La Araucanía, Chile, [3]Department of Environmental Biotechnology, Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany, [4]Departamento de Ingeniería Química, Universidad de La Frontera, Temuco, Región de La Araucanía, Chile.

The effect of waste frying oil (WFO) incorporation as feedstock mixed with rapeseed oil in a lipase-catalyzed process for fatty acid alkyl ester (FAAE) production was investigated. Response surface methodology was used to optimize the interaction of four variables reaching a 96% FAAE yield when applying 75 wt% WFO in mixed feedstock, methanol to oil ratio of 3.75:1 mol/mol, 12 wt% Novozyme 435 and 40°C at 12 hours of reaction time and 200 rpm. The addition of WFO increased the FAAE production yield. Major reason for this is the fact that in comparison to rapeseed oil WFO contains more monoacylglycerols, diacylglycerols and free fatty acids that seem to be more available substrates for the enzymatic catalysis. Therefore, a partial replacement of rapeseed oil by WFO in process catalyzed by Novozyme 435 could help to diminish the production costs for biodiesel by using a less expensive feedstock, increases the production yield and could be a potential alternative to FAAE production at industrial scale.

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11. **Use of Oleaginous Yeasts for the Biodiesel Synthesis from Agroindustrial Residues.** Abu Yousuf and Domenico Pirozzi, Dipartimento di Ingegneria Chimica , Università Federico II, Napoli-80125, NA, Italy.

Due to the higher cost of the traditional feedstock used for biodiesel (i.e. vegetable oils), this research is focused on the use of valueless waste materials, obtained from various sources like agriculture and agro-industries, as alternative feedstock. Oleaginous yeasts can use different kinds of residues as nutrients. Their biomass contains a significant fraction (>20%) of lipids, that can be used as feedstock for biodiesel synthesis.

Lipomyces starkeyi were able to survive and proliferate in the presence of olive mill wastewaters (OMW), without external organic supplement, in spite of the antimicrobial activity of their phenolic components. A momentous increase in lipid concentration was observed in Lipomyces starkeyi in the course of the OMW treatment at preliminary diluted.

Lignocellulosic biomass was also taken as a source of nutrients for the microorganisms. Tomato seeds and peels were first subjected to a hydrolysis treatment to obtain simple sugars from cellulosic material. The growth of the Lipomyces starkeyi was monitored in these sugars.

Subsequently, we started processing more robust plants, i.e. Giant reed and Sorghum. In this case, the extraction of fermentable sugars required a more complex pretreatment (acid hydrolysis). The lipids extracted from biomass have been evaluated as regards their fatty acids composition, as well as their potential for the synthesis of biodiesel.

12. **Valorization of Side-streams of Oil Refining.** C. Echim[1], R. Verhé[1], W. De Greyt[2], C. Stevens[1]; [1]University of Ghent, Ghent, Belgium, [2]Desmet Ballestra, Zaventem, Belgium.

In the transition from a fossil fuel based to a bio-based economy, it is of crucial importance that the biological feedstocks (mainly plant material) will be valorized in an integral way. Too many times in the past, the biological material was used for a very low value application or discarded as waste after the valorization of one component. Also the synergy between food, feed and fuel production is a crucial aspect. After refining the oil, several important side-streams can be characterized and these can be transformed into biodiesel using different procedures. The valorization of the side-streams helps to reduce the waste, to minimize the foot print of the technology and to add value through the production of biodiesel as an energy carrier.

Alternative resources such as side-streams of refining can partially replace the traditional feedstocks for the production of biodiesel, but require application of new technologies and/or additional purification steps.

Fuel and Engine Aspects of Engine Operability and Catalyst Performance

1. **Enzymatic Production of Biodiesel from Free Fatty Acids.** Marise Afonso[1], Maria Jorge Pratas*[1], Sílvia Monteiro[2], Armando Silvestre[1], Maria Alice Coelho[1], and João Coutinho[1], [1]CICECO - University of Aveiro, Aveiro, Portugal, [2]Polytechnic Institute of Leiria, Leiria, Portugal.

Biodiesel is one of the biomass based renewable fuels which has attracted much attention during the last decades, as an answer to replace traditional fossil fuels, motivated by environmental issues and by the dwindling of fossil resources.

For conventional oils the basic homogeneous catalysis is by far the most efficient technology, however, this approach is not suitable for acidic oils or for free fatty acids. In this case, the enzymatic heterogeneous catalysts can be an attractive alternative in the production of biodiesel as enzymes can be easily separated from the reaction media and easily recycled, generating less waste, and consuming less energy.

In this work the esterification of oleic acid with methanol and ethanol was carried out with lipase Novozyme®435 as catalyst. Using a factorial planning with five factors and three levels (the temperature, enzyme/oil ratio and alcohol/oil ratio) conversion conditions were optimized by Response Surface Methodology (RSM) and the yields compared for both alcohols.

The aim of this work was to optimize the enzymatic production

of oleic acid methyl and ethyl esters and to compare the activity of Novozyme®435 with other commercially available enzymes.

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2. **Optimization of Biodiesel and Diesel Blend Ratio for MF-399 Tractor Engine using Genetic Algorithms.** Ali Zenouzi, Mohammad Safiadin, Barat Ghobadian, and Teymur Tavakoli Hashjin, Tarbiat Modares University, Tehran, Iran.

In this research work, biodiesel was initially produced from waste vegetable oil by transesterification reaction. The main properties of the produced fuel were compared with ASTM D-6751 standard. After that, the MF-399 tractor engine performance was evaluated using B_0 up to B_{25} biodiesel and diesel blends. Finally the experimental data fitted to surfaces using Genetic Algorithms and optimum values of biodiesel and diesel blend ratio were determined.

General Topics

1. **Biodiesel Industry in Turkey.** Asli Isler and Filiz Karaosmanoglu, Istanbul Technical University, Department of Chemical Engineering, Maslak, Istanbul, Turkey.

The idea about using vegetable oils as fuels is more than hundred years old. There are some technologies to overcome obstacles and produce fuels which approximate the properties and performance of fossil fuels. Biodiesel is obtained by the transesterification technology as a clean alternative to the fossil fuels which is a form of renewable energy produced from biomass.

Biodiesel has been popular in Turkey after 2000. There are 58 plants with processing license, eight of them have biodiesel processing license with recycling waste vegetable oils, but a limited number of these plants continue their production and energy agriculture. Regulations for energy, renewable energy and biofuels are made in Turkey according to the consistence period to European Union and revision and secondary legislation studies continue currently in Turkey. Biodiesel has been defined as the third engine biofuel and it is subject to all same legal regulations as for gasoline and diesel. Biodiesel can be blended maximum 5 percent with diesel fuel and domestic resources originated biodiesel blended up to 2 percent has zero special consumption tax. It is expected that use and production will be increased in the future.

In this study, current situation and the future of biodiesel market in Turkey are presented and things that must be organized in this area are investigated for Turkey.

2. **Application of the CPA EoS to the Modeling of Biodiesel Production.** M.B. Oliveira[1], R.R. Teles[1], S. Miguel[1], M.J. Pratas[1], A.J. Queimada[2], and J.A.P. Coutinho[1], [1]CICECO, Chemistry Department, University of Aveiro, Aveiro, Portugal, [2]LSRE - Laboratory of Separation and Reaction Engineering, Faculdade de Engenharia, Universidade do Porto, Porto, Portugal.

Biodiesel is nowadays in Europe the most used biofuel for road transportation.

During its production, different separation and purification processes are required for the glycerol rich streams. The adequate design of these processes involves the knowledge about the VLE data for water + glycerol and alcohol + glycerol systems that are surprisingly scarce. To overcome this lack of information, several experimental measurements were performed. These data were used to evaluate the capability of the Cubic plus Association equation of state (CPA EoS), with a new association scheme proposed for the glycerol molecule, for modeling these systems. A single, temperature independent, binary interaction parameter was enough to provide an excellent correlation of the VLE data measured.

The good predictive performance of the CPA EoS for the description of multicomponent systems that are present in the transesterification reaction will also be shown, as well as new experimental data for these systems.

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3. **Mechanical Expelling of Sunflower Oils to Produce Biodiesel.** A.L.M.T. Pighinelli[1], R.A. Ferrari[2], A.M.R. Miguel[2], and K.J. Park[1], [1]State University of Campinas, Campinas, Sao Paulo, Brazil, [2]Institute of Food Technology, Campinas, Sao Paulo, Brazil.

The limiting factors of biodiesel production are the high cost of raw material and reaction conditions. The objective of this work was to study the transesterification of crude sunflower oil with ethanol. The oil was obtained through mechanical expelling equipment. The expelling and transesterification reactions were carried out by an adequate experimental design. The factors studied were screw speed (53–70 Hz) and temperature (60–110°C), for the expelling process; alcohol (3–15 mols) and catalyst concentrations (1–5% of oil mass), for transesterification reaction. The highest oil yield was 68.4%, and the response surface showed that for lower levels of both factors, oil yield would increase, in the range evaluated. The highest ester yield obtained was 88.0%, and for the range studied it was possible to say that lower amounts of ethanol and high concentrations of catalyst, esters yield would be higher.

Acknowledgements: FAPESP, CNPq, FEAGRI.

4. **Electrochemical Characterization of Biodiesel Electrolyte.** J.R. Rodrigues[1], C. Freire[2], M. Ballester[2], A.L.M.T. Pighinelli*[2], R.A. Ferrari[3], L. Martin[1], K.J. Park[2]; [1]Federal University of Maranhão, São Luís, Maranhão, Brazil, [2]State University of Campinas, Campinas, São Paulo, Brazil, [3]Institute of Food Technology, Campinas, São Paulo, Brazil.

Biodiesel is an attractive and eco-friendly alternative to petrodiesel due to its biodegradable, renewable, and non-toxic attributes. In addition, biodiesel contributes to improved lubricity, higher flash point, similar viscosity, and a reduction in most exhaust emissions when compared to conventional diesel fuel (CDF). The development of biodiesel may also reduce the dependence on fuels derived from imported petroleum, which continue to decrease in availability and affordability. The biodiesel is also hygroscopic, i.e. it has a natural ability to absorb moisture. Studies show a 30 times higher capacity of absorption of water in relation to the common diesel, which enhances its natural tendency to oxidation and thus increases its corrosion potentiality. On the other hand the presence of free water introduces a series of degradation processes such as corrosion of automotive components and tanks. Corrosion problems have been detected in field tests performed by automotive industries and improvements are needed to overcome them. The aim of the present work was to investigate the corrosion behavior of cupper exposed to various biodiesels at different stages of the washing process. The electrochemical characterization to determine the corrosiveness tendency of the produced biodiesel was accomplished by electrochemical impedance spectroscopy (EIS).

5. **Energy Balance Analysis of a One Million Gallon Biodiesel Production Facility.** Rachel Burton[1] and Michael Hyman[2], [1]Piedmont Biofuels Industrial, Pittsboro, NC, USA, [2]North Carolina State University, Raleigh, NC, USA.

In the U.S. Biodiesel industry, energy balance data currently relies on research by the Department of Energy, National Renewable Energy Laboratory, and the University of Idaho. This work has evaluated only soybean-based biodiesel. Under the EISA Renewable Fuels Standard (RFS2), the understanding of energy inputs versus outputs in addition to production impact on greenhouse gas (GHG) emissions is critical. This research will examine Piedmont Biofuels Industrial's multi-feedstock biodiesel production facility in the southeastern United States. In 2005, Piedmont's energy balance research began with Australia's Murdoch University on a pilot production facility utilizing yellow grease as a feedstock. In 2009, this life cycle analysis of regional poultry fat based biodiesel production will be the primary platform. This work intends to carry out the energy analysis of this commercial scale production and show the differences between the current data on soybean based biodiesel and previous work on waste grease biodiesel production.

Acknowledgements: Scott Hoover, Southern Energy Management.

6. **Methanol Dependence in National Programme for the Production and Use of Biodiesel (PNPB).** P. Mendes[1,2], J. Freitas[1], S. Borschiver[2], L. D'Ávila[2], and A. Barros[1,3], [1]National Agency of Oil, Gas and Biofuels, Rio de Janeiro, RJ, Brazil, [2]Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil, [3]Federal University of Maranhão, São Luiz, MA, Brazil.

The objective of this poster is to analyze the methanol dependence in National Programme for the Production and Use of Biodiesel (PNPB). PNPB was created to reduce external dependency of petrodiesel; promoting social exclusion; guarantee competitive prices, quality and supply; and produce biodiesel from different oleaginous plants in diverse regions. In the years 2007-2008, 96% of biodiesel was produced utilizing methanol, according to database of National Agency of Oil, Gas and Biofuels (ANP) that regulates the sector. In addiction, Brazilian import of methanol was increased in 372%. Brazil has imported 95% of methanol from Chile. However, Chile needs to import natural gas (NG) for producing methanol from Argentina. Argentina is not self-sufficient in NG and it needs to import too from Bolivia. This study recommends investments in the production of methanol to reach energy security taking account the political instability of Latin America.

Acknowledgements: The National Agency of Oil, Gas and Biofuels provided support for this work.

7. **Novel Two-phase Bioreactor Concept for Fatty Acid Alkyl Esters Production Using Whole Cell Catalysts.** Gustavo Ciudad[1], Isaac Reyes[2], Milko Jorquera[3], Laura Azocar[2], Reinaldo Briones[4], Lukas Y. Wick[5], and Rodrigo Navia[1,6], [1]Center of Waste Management and Bioenergy, Scientifical and Technological Bioresource Nucleus, Universidad de La Frontera, Temuco, Chile, [2]Programa de Doctorado en Ciencias de Recursos Naturales, Universidad de La Frontera, Temuco, Chile, [3]Center of Plant, Soil Interaction and Natural Resources Biotechnology, Scientifical and Technological Bioresource Nucleus, Universidad de La Frontera, Temuco, Chile, [4]Magíster en Ciencias de la Ingeniería Mención Biotecnología, Universidad de La Frontera, Temuco, Chile, [5]Helmholtz Centre for Environmental Research UFZ, Department of Environmental Microbiology, Leipzig, Germany, [6]Departamento de Ingeniería Química, Universidad de La Frontera, Temuco, Chile.

A novel two-phase bioreactor using gas-phase methanol and rapeseed oil (gas-liquid bioreactor) with immersed microorganisms overlying a nutrient agar phase is proposed. This novel bioreactor concept was thought to increase oil bioavailability and decrease methanol toxicity for effective microbial growth and biodiesel production. Specific Serrratia sp., Arthrobacter sp., and R. oryzae characteristics and physico-chemical cell surface properties were investigated. Conversion yields using Serratia sp. reached 10% for FAAE and 23% for free fatty acids at 160 h of reaction time and room temperature. Higher production yields of over 50% and 21% for biodiesel and free fatty acids were observed for R. oryzae. The same experiments were carried out in a two-phase liquid-liquid (methanol-rapeseed oil) bioreactor, showing microbial growth but no biodiesel formation. The data suggest that the application of gas-phase methanol coupled with microorganisms as immobilized whole cell catalysts may be a potential alternative for biodiesel production.

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8. **Biodiesel Production in Supercritical Conditions from Non Edible Oil Feedstocks.** P. Campanelli, L. Manna, M. Bachero, S. Sicardi; Politecnico di Torino - Department of Materials Science and Chemical Engineering, Torino, Italy.

Renewable energy sources are a vital tool in the sustainable development of our society, nowadays a lot of attention has been focused on biodiesel.

Biodiesel produced by transesterification with alcohols of vegetable oils presents glycerol as the major side-product. Due to the growing production rate of biodiesel, the availability of glycerol has also been rapidly increasing in recent years. Because the high costs due to its purification, glycerol from biodiesel is not economically suitable.

The aim of our project is the production of biodiesel in supercritical conditions, according to the international standards, using non edible oils and different acyl acceptors in order to reduce or eliminate glycerol production. All experiments were carried out batchwise in a 100 ml supercritical reactor. The sampling system was designed to monitor the reaction at various times. A GC-FID system was used to measure the fatty acid methyl esters composition of the produced biodiesel.

9. **Biodiesel Obtention from Jatropha Curcas L Oil by Ethanolic Transesterification.** J. Velasquez, P. Cuartas, and A. Castillo, Universidad Pontificia Bolivariana, Medellin, Antioquia, Colombia.

The depletion of fossil fuels, triggered the development of extensive studies worldwide focused on obtaining alternative and renewable sources of energy. An alternative is to get biodiesel from plants rich in fatty acids such as sunflower, soybeans, and among others African palm oil. Since many of these seeds are human and/or animal consumption, and to avoid the increase in prices in foodstuffs, alternatives have sought to produce biodiesel from not supplies plants such as the higuerilla and Jatropha curcas L. The production of biodiesel from extracted Jatropha seed oil, is made by transesterification using ethanol in the presence of a catalyst type alkaline hydroxide.

This project is to establish conditions optimum to perform the ethanolic transesterification from Jatropha oil curcas L and set the kinetics for transesterification by fatty acids contained in Jatropha oil curcas L. The project is done in laboratory where the contents of fatty acids oil and physico-chemical properties of this and obtained biodiesel will be characterised to identify whether meets quality standards required for biofuels.

10. **Extraction with Solvent and Oil Purification from Seeds from Seeds of Jatropha curcas L.** J. Velasquez, P. Cuartas*, and H. Giraldo, Universidad Pontificia Bolivariana, Medellin, Antioquia, Colombia.

The oil extraction from seeds of Jatropha curcas is made basically by means of mechanical and chemical extraction, where the mechanical extraction presents/displays problems in the recovery of the oil and its purity. The extraction with reliable on the contrary, presents/displays a recovery near 99% with an oil of high quality and purity. For the Extraction with reliable of oil from seeds of Jatropha curcas L. an optimization of the process is made that allows to find best the solvent, the size of particle of greater efficiency of extraction and the optimal time for the oil extraction; also a mud curve is made and critical parameters are evaluated as the age of the seed and the influence of the rind in the oil extraction. The project is developed to laboratory level, where the dry seeds of Jatropha curcas L. they are put under a process of chemical extraction in a Soxhlet equipment using hexane, acetone, benzene, toluene, ethanol and ether of petroleum like solvent. The obtained oil is purified by means of a simple distillation; soon to be characterized by means of gas chromatography. The results demonstrate that reliable the optimal one for the oil extraction is the hexane with a yield of extraction of 99% for a size of particle of 0,5 mm.

Acknowledgements: Universidad Pontificia Bolivariana, Grupo de Pulpa y Papel.

11. **Study of Extraction of Vegetable Oil Seed Castor.** K.C. Ribeiro Martins[1], L. Galvão Viana[1], L. Santos Pereira Martins[2], L.E. Matias da Silva[1], and A.P. da Silva Mafra[1], [1]Instituto Federal de Educação, Ciência e Tecnologia do Maranhão, Av. Getúlio Vargas, nº 04 - Monte Castelo - São Luís-MA - CEP 65030-005, Brazil, [2]Universidade Estadual do Maranhão, Cidade Universitária Paulo VI, CaixaPostal 09, São Luís-MA, Brazil.

This research deals mechanical equipment for the extraction of vegetable oils, especially oils of high viscosity, such as castor oil. For a more detailed study on the stability of oil, it is necessary that after extracting it retains its original integrity. The need for equipment to handle and low cost manufacturing in the extraction of vegetable oils, both in research laboratories and in encouraging the family farm, raised the need to develop this research. Were designed and built two mechanisms pressing. The first equipment is an axial press activated by a hydraulic press of 60 tons. The second consists of an extrusion press enabled by electric motor and drive pulley. The content of oil extracted from castor seed and the operating parameters and performance data in each case were analyzed and compared with each other aiming at the development of these mechanisms.

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Glycerol

1. **Optimization of Media Composition for the Production of Biohydrogen from Waste Glycerol Obtained from Biodiesel Manufacturing.** R. Jitrwung and V. Yargeau, McGill University, Montreal, Quebec, Canada.

Glycerol is a by-product of biodiesel production. Enterobacter Aerogenes (E.A.) have a known ability to convert glycerol to yield hydrogen and ethanol. E.A. were cultured in aerobic conditions, transferred into anaerobic conditions, then cultured in a Minimum Mineral Synthetic Media (MMSM) solution containing glycerol. The biohydrogen was monitored by gas chromatography, glycerol, ethanol, and organic acids were monitored by high-pressure liquid chromatography and the changes in concentration of ions were monitored by inductively coupled plasma spectrometry as well as ion chromatography. Results indicated that the production of biohydrogen is sensitive to the concentration in oxygen and salts. The Response Surface Design was used to optimize the MMSM composition (SO_4^{2-}, NO_3^-, and PO_4^{3-} obtained from Fe_2SO_4, NH_4NO_3, and Na_2HPO_4), the amount of oxygen and the inoculums volume. This optimization resulted in an increase from 95 to 99% for glycerol conversion and a 77% decrease in cost of salts compared to previous studies. Results were also validated using crude glycerol. The effect of other constituents such as ethylene diamine tetra acetate, thionine, yeast extract and tryptone is currently under investigation.

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2. **Flexible Batch Pilot Plant for Glycerol Purification in the Biodiesel Production Process.** Ali Zenouzi, Abas Mohammadi, Barat Ghobadian, and Saied Minaee, Tarbiat Modares University, Tehran, Iran.

Glycerol as a secondary product from the biodiesel manufacturing processes is more valuable than biodiesel. So, purification of this product can significantly increases economic potential of the process. In the present research work, a highly flexible and multipurpose batch pilot plant has been presented for maximum recovery of this important byproduct and alcohol. The glycerol effluent of the biodiesel process contains water, an alcohol component, biodiesel as well as unconverted triglycerides from renewable lipid feedstocks. Biodiesel has a lower boiling point than triglycerides. So in this study, it has been identified that it is most promising method to convert this compound to triglycerides. This change leads to a minimization of energy consumption as well as maximization of glycerol purification (more than 99 weight percent). Also as a main result of this investigation, it can be seen that present improved process has a more feedstock flexibility than conventional design.

3. **The Role of the Ion Exchange in the Purification of Glycerol from Biodiesel Production.** M. Carmona, A. de Lucas, A. Perez, and J.F. Rodriguez*, Institute of Chemical and Environmental Technology, ITQUIMA, University of Castilla-La Mancha, Ciudad Real, Spain.

Glycerol is obtained by transesterification of vegetable oils and animal fats with methanol or another alcohol in presence of a catalyst to produce alkyl esters. This product is separated containing methanol, catalyst and soaps, impurities that depressed its price. Ion exchange can be used to remove the cationic and anionic compounds contained in this stream. The equilibrium of ion exchange for the systems H+/Na+ and OH-/Cl- at different temperatures using the ion exchangers Amberlite 252 and Amberlite IRA-420, respectively, has been determined. Results indicate that the resin capacity is completely available for ion exchange in both cases in this glycerol-aqueous media. Beside, resins exhibit a higher selectivity by the entering ion when the temperature increases. The selectivity of the cationic resins towards the K+ or Na+ increases as the water content of the glycerine decreases. To avoid the further water elimination, the system H+/Na+ is being studied in methanol media instead of water.

4. **Glycerine-esters Used as PVC Plasticizers.** O.Y. Suárez Palacios[1,2], P.C. Narváez Rincón[1], J.-P. Corriou[2], M. Camargo Pardo[2], C. Fonteix[2], and M. Velandia[3], [1]Universidad Nacional de Colombia, Bogotá D.C., Colombia, [2]Institut National

Polytechnique de Lorraine, Nancy, France, [3]Carboquímica, Bogotá D.C., Colombia.

The World glycerin overproduction, by the growing of the use of biodiesel as fuel, and the tendency to replace oil derived products in chemical industries, were the driving forces to study the plasticization of PVC with glycerol-esters of carboxylic acids. In this study the esterification of glycerol with some carboxylic acids was investigated to determine the effect of temperature, molar ratio and catalyst percentage on the conversion and the quality of the product. Likewise, the plasticization performance of some of the esters produced was established, measuring the usual performance properties of plasticizers. Nine of the esters produced showed compatibility and three showed good performance as plasticizers.

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5. **Acetylation of Glycerol over Tungstophosphoric Acid Supported on Silica.** P. Ferreira[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Caparica, Portugal.

Glycerol is the by-product of the biodiesel production by transesterification of triglycerides with methanol or ethanol. Due to the increase of biodiesel demanding, an increase of glycerol production and a price decline have been observed, becoming the glycerol an attractive molecule for the synthesis of other value chemical products.

The products of glycerol acetylation are monoacetin, diacetin and triacetin. The monoacetin and diacetin have applications in cryogenics and as raw material for the production of biodegradable polyesters while the triacetin has applications going from cosmetics to fuel additive.

Traditionally, the esterification of glycerol with acetic acid is carried out over mineral acids as catalysts. However, the effluent disposal leads to environmental problems and economical inconveniences. These problems can be overcome by the use of heterogeneous catalysts. Zeolites, mesoporous silica with sulfonic acid groups, Starbon and heteropolyacids encaged in the USY zeolite have been used as solid catalyst in the acetylation of glycerol. In this work, we study the esterification of glycerol with acetic acid over dodecatungstophosphoric acid supported on silica. Good selectivity to diacetin was observed.

6. **Polyester from Glycerol as Adsorbent Material for Glycerol Remotion in Biodiesel Purification.** Claudio Andrés Toro Aedo, Gustavo Ciudad Bazaul, Laura Azócar Ulloa, and Rodrigo Navia Diez, Núcleo Científico Tecnológico en Biorrecursos, Universidad de La Frontera, Temuco, Chile.

Crude biodiesel can contain several impurities as: free-glycerol, soap, metals, methanol, free fatty acid (FFA), catalyst, water and glycerides. These components should be removed in order to fulfill strict standards. The main objective of this research has been to develop polyesters from glycerol and adipic acid (PGA) to use it as an adsorbent material in biodiesel purification. Polyesters were synthesized from glycerol through polycondensation reaction and the biodiesel purification was carried out. PGA was able to refine biodiesel due to the presence of a huge number of carboxylic and hydroxide functional groups on these materials and their gel type structure, removing 50% of the glycerol content in the biodiesel samples. Moreover, we have reported readiness of these materials to remove sodium from crude biodiesel. This demonstrates the potential of crude glycerol to develop adsorbent materials for biodiesel refining.

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7. **Hydrogen Production from Glycerol: Fermentors vs. Microbial Electrolysis Cells.** P.A. Selembo[1], J.M. Perez*[1], W.A. Lloyd[1], and B.E. Logan[2], [1]Department of Chemical Engineering, Pennsylvania State University, University Park, Pennsylvania, USA, [2]Department of Civil and Environmental Engineering, Pennsylvania State University, University Park, Pennsylvania, USA.

The use of glycerol for hydrogen gas production was examined via anaerobic fermentation with heat-treated mixed cultures and via electrohydrogenesis using microbial electrolysis cells (MECs). A hydrogen yield of 3.9 mol-H2/mol was obtained using glycerol via electrohydrogenesis, which is higher than that obtained via fermentation (0.28 mol-H2/mol-glycerol). Hydrogen was also produced using the untreated glycerol byproduct of biodiesel fuel production (70% glycerol content) via electrogenesis at a yield of 1.8 mol-H2/mol-glycerol, which was again much higher than that obtained via fermentation (0.31 mol-H2/mol-glycerol). The higher yields obtained via MECs are because the bacteria in MECs can use carbohydrates to make hydrogen, including end fermentation products. These results demonstrate that electrohydrogenesis is an effective method for producing hydrogen from either pure glycerol or the glycerol byproduct of biodiesel fuel production and that biodiesel production can be combined with hydrogen production for maximum utilization of resources and minimization of waste.

8. **Transesterification of Glycerol with Methyl Acetate over Sulfonic Acid-functionalized Mesostructured Silicas.** J.A. Melero, G. Vicente, G. Morales, C. Ochoa, and M. Paniagua*, Department of Chemical and Environmental Technology, Rey Juan Carlos University, Mostoles, Madrid, Spain.

Glycerol is the main byproduct obtained in the biodiesel production. The current energy legislation implemented in Europe has promoted a glut of this compound over the last years, and hence decreasing its market price. For that, new applications of glycerol must be explored. An appealing alternative is to transform glycerol into oxygenated compounds that can be suitable for being incorporated as fuel additives. In this work, the transesterification of glycerol with methyl acetate over sulfonic acid-functionalized mesostructured silicas to yield acetylated derivates has been deeply studied. Diacetylglycerols (DAG) and triacetylglycerol (TAG, also called triacetin) have been shown to be valuable petrol fuel additives leading to enhanced cold and viscosity properties when blended with diesel-fuel. Under optimized reaction conditions, these mesostructured catalysts yield an almost complete glycerol conversion with a combined selectivity towards DAG and TAG up to ca. 80% after 4 hour of reaction and 170°C. At such high temperature, conventional sulfonic acid resins are not appropriate due to their low thermal stability.

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New Production Technologies

1. **Improving the Efficiency of Biodiesel Production via in situ Transesterification and Investigating the Use of the Meal Byproduct in Poultry Nutrition.** M.J. Haas[1], R.L. Stroup[2], D. Latshaw[3], and K.M. Scott[1], [1]Eastern Regional Research Center, USDA, Wyndmoor, PA, USA, [2]R. L. Stroup Co., Troy, OH, USA, [3]Dept. of Animal Sciences, Ohio State University, Columbus, OH, USA.

We have previously shown that biodiesel can be produced

directly from the lipids resident in biological materials by incubating them in alkaline alcohol solutions. High levels of transesterification are achieved in relatively short reaction times at mild temperatures and ambient pressure. This approach eliminates the need for lipid isolation by solvent extraction or expelling, eliminates the use of extracting solvents, could reduce process steps and costs, and considerably expands potential biodiesel production by allowing the use of new lipid-bearing materials as feedstocks. This presentation will describe efforts to reduce alcohol use and thus improve the economics of the process as applied to distillers dried grains with solubles, a byproduct of the fermentation of corn to produce ethanol. The results of an investigation of the suitability of post-transesterification soy meal as a component of poultry diets will also be presented.

2. **Preparation of Biodiesel and Utilizing of its Side Product.** Martin Hájek and Frantisek Skopal, University of Pardubice, Faculty of Chemical Technology, Pardubice, Czech Republic.

This paper is introducing a complete biodiesel preparation process, including treatment and utilization of side product. Biodiesel is prepared in a emulgation reactor. The optimum reaction condition has been found. After the transesterification, the catalyst is neutralized by a gas carbon dioxide dosage into the reaction mixture. Then the excess of methanol is distilled off from the reaction mixture. For better separation of biodiesel from other materials, water is added to the reaction mixture. Addition of water improves and fastens sedimentation process. After separation, gained biodiesel fulfils the EN 14:214 and the side product – glycerol phase contents: glycerol: 58 wt-%; soaps: 17 wt-%; potash: 2 wt-%; water 11 wt-%; methanol 2 wt-% and the rest is ester.

The side product is treated in the next process. Firstly, the glycerol phase is diluted by methanol and hypophosphoric acid is added to glycerol phase. Thus the soaps are formed to fatty acid, carbonates neutralized to carbon dioxide and the formed precipitate of potassium phosphate is filtered off. After the evaporation of excess methanol, two phases arise (organic and refined glycerol phase). The compassion of organic phase is: higher fatty acid and esters in weight rate 1:1, and refined glycerol phase: 89% glycerol, 9% water, 2% potassium phosphate.

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3. **Testing of Lipase-producing Yeasts for Enzymatic Transesterification to Biodiesel.** Ana Aurelia Chirvase[1], Luminita Tcacenco[2], Nicoleta Radu[1], Camelia Ungureanu[3], and Minodora Leca[4], [1]National Research & Development Institute for Chemistry and Petroleum Chemistry, ICECHIM, Bucharest, Romania, [2]National Research & Development Institute of Biological Sciences, Bucharest, Romania, [3]Politehnica University of Bucharest, Bucharest, Romania, [4]University of Bucharest, Bucharest, Romania.

Lipase-catalyzed biodiesel transesterification could eliminate separation difficulties characteristic to chemical catalysis on condition to use cheap enzyme preparation.

The paper presents the results of testing several yeasts strains as transesterification lipase producers. The research methodology comprises: design of cultivation medium and bioprocessing conditions; determination of yeast specific growth rate (μ) and lipase activity; isolation of extracellular lipase by centrifugation and ammonium sulfate precipitation; crude enzyme testing in transesterification process. Isolation of lipases was done with high yields for Yarrowia lipolytica ATCC 8661 (95%) and Candida rugosa DSM 70761 (62%).

These results were in agreement with the cultivation characteristics (Yarrowia lipolytica: μ of 0,16 h^{-1} and enzymatic activity of 142,6 UAE/mL; Candida rugosa: μ of 0,11 h^{-1} and final enzymatic activity 221,9 UAE/mL). The transesterification preliminary results obtained by thin layer chromatography demonstrated the lipases from Candida rugosa DSM 70761 and from Yarrowia lipolytica ATCC 8661 have high enough catalysis activities.

Acknowledgements: Romanian National Research & Development Programme PNCD 2 "Partnership", domain Biotechnology.

4. **Supercritical Biodiesel Production using Heterogeneous Catalysts.** P. Olivares[1], J. Quesada*[1], J.A. García[2], and S. Navarro[2], [1]Department of Chemical Engineering, Faculty of Chemistry, University of Murcia, Campus of Espinardo, 30071 Murcia, Spain, [2]Department of Research and Development, TAHE Group, C/ Riquelme 17, bajo B, 30005 Murcia, Spain.

The present work deals with the supercritical methanol transesterification of cooking and crude oils for biodiesel production. The main drawback of waste vegetable oils is their high free fatty acid and water content, which complicates the conventional production of biodiesel. However, this disadvantage disappears when the reaction is carried out in supercritical conditions. Furthermore, purification of the reaction products is simpler than in the alkali catalyzed process and non-polluting effluents are generated. The study will be carried out using heterogeneous catalysts to enable in a search for milder reaction conditions.

The research is structured in two parts. The first part entails production of biodiesel in batch stirred tank reactor without catalysts, to investigate the influence of the main process variables: reaction temperature, working pressure, methanol-to-oil molar ratio, stirring speed and treatment time. Once the optimal reaction conditions have been obtained, the effect of free fatty acid and water contents in the oil on the reaction yield will be studied. When the different heterogeneous catalysts are used, two types of reactor will be used: a) A batch stirred tank reactor with catalyst particles suspended in the medium and b) A stirred tank reactor with a recirculation loop, in which structured supports (monoliths), impregnated with the active phase of the catalyst, will be placed.

5. **Modeling the Kinetics of Calcium Hydroxide Catalyzed Methanolysis of Sunflower Oil.** V.B. Veljkovic[1], O.S. Stamenkovic[1], Z.B. Todorovic[1], M.L. Lazic[1], and D.U. Skala[2], [1]Faculty of Technology, University of Nis, Leskovac, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia.

The calcium hydroxide catalyzed methanolysis of sunflower oil was studied at 60°C and under the atmospheric pressure in a batch mechanically stirrer reactor. The catalyst amount was in the range from 1 to 10% based on the oil weight and the methanol to oil molar ratio was 6:1 in all experiments. The aim of the work was to model the methanolysis reaction kinetic. The methanolysis reaction was assumed to occur between methanol and glyceride molecules adsorbed on the surface catalyst active sites. The sigmoidal kinetics of the process was explained by triglyceride (TG) mass transfer limitations in the initial period followed by the chemical reaction controlled region in the latter reaction period. The overall chemical reaction followed the pseudo-first order reaction kinetics. The kinetic model agreed quite well with the experimental data during the reaction, except in the middle reaction period when the fatty acid methyl esters formation rate rapidly increased.

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6. **Kinetics of Sunflower Oil Methanolysis Catalyzed by Barium Hydroxide.** O.S. Stamenkovic[1], V.B. Veljkovic[1], Z.B. Todorovic[1], M.L. Lazic[1], and D.U. Skala[2], [1]Faculty of Technology, University of Nis, Leskovac, Serbia, [2]Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia.

The sunflower oil methanolysis in the presence of barium hydroxide as a catalyst was studied in a batch reactor at 20°C and under the atmospheric pressure. The catalyst was prepared by dehydration of the $Ba(OH)_2 \cdot 8H_2O$ at 200ºC under the vacuum for 10 hours. The methanol to oil molar ratio was 6:1 in all experiments. The catalyst amount was in the range from 1 to 10% based on the oil weight. The goal of the work was to model the methanolysis reaction kinetics using a simple model which did not require complex computations. Barium hydroxide catalyzed methanolysis reaction was shown to be both homogeneous and heterogeneous due to a considerable solubility of barium hydroxide in methanol. The homogeneously catalyzed methanolysis of triglycerides was the irreversible pseudo second-order reaction followed by the reversible second-order reaction. The kinetics of homogenous-heterogeneously catalyzed methanolysis reaction followed the pseudo-first order reaction kinetic. The simulation of the methanolysis process confirmed a good agreement between the model and the experimental data.

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7. **Preparation of Xerogel Catalyst with ZnO as Active Component for Biodiesel Synthesis.** I. Lukic*[1], A. Orlovic[1], J. Krstic[2], D. Jovanovic[2], and D. Skala[1], [1]Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade, Serbia, [2]Institute of Chemistry, Technology and Metallurgy, Department of Catalysis and Chemical Engineering, Njegoseva 12, Belgrade, Serbia.

The utilization of a successful heterogeneous catalyst will cope with most of the economical and environmental drawbacks of a classical and to-day mainly applied in industry homogeneous process.

In this study a new type of heterogeneous catalyst with zinc-oxide as active component on different supports (alumina/silica, pure alumina and pure silica) was synthesized using sol-gel method. Obtained wet gel was treated at atmospheric pressure and elevated temperature to obtain corresponding xerogel. Prepared catalysts were characterized with XRD, FTIR and N_2 physisorption at 77 K and tested in the methanolysis of sunflower oil. Xerogel catalysts with zinc-oxide as active component on alumina/silica exhibited good activity in the methanolysis of sunflower oil, with the yield of fatty acid methyl esters (FAME) of 92% after 4 h of reaction at 200°C and 3.7 MPa.

A test of deactivation is of great importance in order to prove the industrial application of heterogeneous catalyst. The possibility to reuse the catalyst was checked by using the catalyst without any further purification and activation. The results showed that conversion did not drop significantly after two cycles.

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8. **Biodiesel Production Key. Optimizing Reactor Design for Esterification and Transesterification Processes.** G. Villorbina[1], A. Escobedo[1], A. Tomàs[1], M. Oromí[1], M. Balcells[1], J. Eras[1], N. Sala[2], and R. Canela[1], [1]Chemistry Department, University of Lleida, Lleida, Spain, [2]Food Technology Department, UTPV-Certa, University of Lleida, Lleida, Spain.

The aim of this work was to investigate the biodiesel production from soy oil and chicken fat to find out the optimal process for high yield production of methyl ester and short process time with low energy input. Reaction parameters such as temperature, molar ratio of oil to methanol and amount of catalyst were optimized as a previous step to reaction with different reactors. Then, the optimal reactor was selected considering the best production yield, the minor reaction time and the faster glycerol separation. Conversion of oil and fat to methyl ester was examined using GC-HT (gas chromatography high temperature) applying the EN14105 FAME standard. A new and fast RMN method to determine iodine value was also developed.

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9. **Biodiesel Production with Calcined Limestone Functioning as Solid Base Catalyst.** Masato Kouzu[1], Jyu-suke Hidaka[2], Terumasa Fujiwara[3], Haruhiko Nakano[3], and Mitsuyo Yamamoto[3], [1]Research Center for Fine Particle Technology, Doshisha University, Kyoto, Japan, [2]Department of Chemical Engineering and Material Science, Doshisha University, Japan, [3]Jyo-nan Electric Industrial Co., Ltd, Japan.

As a precursor of the practical catalyst to utilize solid base catalysis of calcium oxide for biodiesel production, crushed lime stone whose size ranged from 1.0-1.7 mm was used in this study. The precursor was turned into the practical catalyst by only calcination at 1173 K. At 333 K under atmospheric pressure, rapeseed oil was transesterified with methanol in the presence of the practical catalyst, on a laboratory scale pilot plant characterized by batch unit consisting of a circulating stream passing through the column reactor. In the early trial, the yield of fatty acid methyl esters (FAME) produced after 2 h was only 60%. Moreover, the column reactor was blocked up due to serious agglomeration of the practical catalyst when the reaction time was extended by an extra hour. These drawbacks were hurdled by improving the reacting condition. As a result, the yield of FAME reached 96.5% at 2 h of the reaction time, and the good reaction efficiency went on for the successive 10 operations, without exchanging the catalyst.

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10. **The Effect of Triacetin on the Biodiesel Quality.** M.J. Ramos, A. Casas, C.M. Fernández, and Á. Pérez, Chemical Engineering Department, Institute of Chemical and Environmental Technology, University of Castilla-La Mancha, Ciudad Real, Spain.

Triacetylglycerol (triacetin) is an important product with a great number of industrial applications similar to that for glycerol and whose global market is not so saturated. Triacetin can be synthesized from glycerol (by esterification with acetic acid) or it can be a by-product obtained of the reaction between triglycerides and methyl acetate (interesterification). The final product would contain triacetin and biodiesel in only one phase. The aim of this work was to test the performance of the biodiesel quality standards when triacetin is present in different concentrations in the biodiesel.

Properties like density, cinematic viscosity at 40ºC, absolute viscosity at low temperature, cloud point, pour point, cold filter plugging point and cetane number have been measured for mixtures triacetin-biodiesel from 0 to 20 wt% of triacetin, and using different biodiesel (rapeseed, palm, sunflower, high oleic sunflower and soybean biodiesel) and some blends.

In general, the addition of triacetin (0-20 wt%) did not get worse the low temperature properties of the different biodiesel. In order to

take the rest of the parameters meeting the standard specification, a maximum triacetin content of 8-12 wt% is allowed, depending on the raw material nature (vegetable oil). Although triacetin increased the viscosity of the mixtures, it provided with fluidity to biodiesel at low temperature, due to the decrease in the biodiesel pour point.

12. **The Production and Performance of Diesel Fuels from Renewable Sources.** Jozef Mikulec[1], Jan Cvengros[2], Ludmila Jorikova[1], Marek Banic[1], and Andrea Kleinova[2], [1]Slovnaft VURUP, a.s., Bratislava, Slovak Republic, [2]Faculty of Chemical and Food Technology, STU, Bratislava, Slovak Republic.

To the advantages of the process, the utilization of hydrorefining catalysts and excellent emission profile of the products can be included. As a disadvantage of TAG hydrodeoxygenation, high unit investment costs should be mentioned. Such disadvantages may be eliminated via connecting the process of hydrogenation desulphurisation of gas oil with TAG hydrodeoxygenation by means of technology modification and relatively simple adjustment of the corresponding equipment. The study is devoted to the issue of direct transformation of vegetable oils and/or animal fats to liquid fuels applying a commercially available NiMo and NiW-based hydrorefining catalysts combined with undesulphurised gas oil. Tests of TAG conversion to fuel components were performed and the basic qualitative indicators were evaluated. During the final stage, a long-term stability test of the catalyst was carried out and a larger amount of the sample for application tests was prepared. Performance and emission measurements were made using a VW Touareg vehicle. The tests documented that even 5% (wt.) concentration of the second generation biocomponents reduces the controlled and uncontrolled emissions.

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12. **Enzymatic Esterification of Fatty Acid Distillates - a Plug-in Alternative to Sulfuric Acid Catalysis.** J. Brask[1], P.M. Nielsen[1], M.L. Damstrup[1], J. Maes[2], and W. De Greyt[2], [1]Novozymes A/S, Bagsvaerd, Denmark, [2]Desmet Ballestra, Zaventem, Belgium.

Biodiesel feedstocks with more than a few percent FFA are in today's biodiesel production units typically deodorized to lower the FFA content and thereby avoid soap-formation in the alkaline catalyzed transesterification reaction. The fatty acid distillate (FAD) is typically converted to FAME with sulfuric acid catalysis, a process with many disadvantages. In this paper we present our work on an enzymatic process to convert FAD to FAME. With FFA being lowered to less than 5%, the deacidified FAD stream can be joined with the deodorized oil and enter conventional alkaline transesterification. The enzymatic unit is hence a plug-in solution for biodiesel producers looking for an alternative to the sulfuric acid process, requiring only few changes in the production units.

13. **Techno-Economical Analysis of Supercritical Biodiesel Synthesis: The Weak Points and Future Production Technology.** Sandra Glisic* and Dejan Skala, Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade, Serbia.

The preliminary economic analysis based on previously determined supercritical process of biodiesel synthesis (SCA) was performed. A total annual production cost and installed cost of biodiesel plant showed that the price of utilities (energy) did not play an important role on total product cost and that the price of biodiesel mainly depends on raw material (oil) cost. Performed analysis indicates that capital cost is also very important. On the basis of techno-economical analysis and specifically the analysis of oil cost and utilities influence it was shown that non-catalytic biodiesel production (SCA) represents the competitive technology to the today widely used homogeneous alkali catalysed alcoholysis (HACA). Namely, this analysis indicated that lower price of biodiesel could be produced by SCA unit with a larger capacity. An important conclusion based on this analysis is that the HACA process requires the higher capital investment while the amount of consumed energy is equal to the energy consumed by SCA if feedstock contains a larger amount of free fatty acids (5%). In this case the price of biodiesel produced by HACA is higher for 11% compared to price of biodiesel produced using SCA.

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14. **Build or Revamp, Ecologically Driven Biodiesel Technology.** A. Kovacs[1,2] and D. Hayward[2], [1]KUKK K+F Ltd., Budapest, Hungary, [2]QS Biodiesel Ltd., London, UK.

We prefer using the term of ecologically driven instead of generation hierarchies. The concept asks for: feedstock not competing with food supply; reducing carbon footprint and resource exploitation; exploration of existing infrastructure and knowledge; byproducts are converted into valuable products.

Basis: shifting reversible trans-esterification toward completion in a single step in fraction of time of known cases.

Food supply independence: flexible adoption to pretreatment or pre-esterification in the same continuous technology.

Carbon print: Better product yield, quality reliability controlled by strict and responsive truly continuous technology, lesser and smaller vessels, lower operational expenses.

Existing units can be revamped without excessive cost to multiple the capacity. Lessons of petroleum refinery technology orient in fine tuning for eco-efficiently.

Byproducts handling and conversion must fit to the scale of the unit, must guarantee as complete and economic recycle as possible. New findings in feeding mono-gastric animals treated biodiesel byproducts component feeds and related results of public health tests will also be presented.

These constitute the frame of agro-industrial-ecology approach with revisiting heterogeneous catalytic techniques and technologies and systems.

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15. **Modeling and Simulation of the Continuous Biodiesel Production Process in a Countercurrent Reactor.** Juan Guillermo Cadavid Estrada[1], Paulo César Narváez Rincón[1], and Javier Fontalvo Alzate[2], [1]Universidad Nacional de Colombia Sede Bogotá, Bogotá D.C., Cundinamarca, Colombia, [2]Universidad Nacional de Colombia Sede Manizales, Manizales, Caldas, Colombia.

This study presents the modeling and simulation of the continuous palm oil methanolysis in a reactor operated in countercurrent. In this equipment reaction and extraction occurs simultaneously, which enhances the conversion because equilibrium is shifted towards products, and the two phases separator downstream the reactor in the conventional process is not necessary. The effects of the methanol feeding point, mole fraction of glycerol in the feeding and methanol to oil molar ratio over palm oil conversion, yield to methyl esters and productivity of the equipment were analyzed. According to the results, there are: an optimum point for methanol feeding, an optimum glycerol molar fraction in the methanol feeding, and it is possible to reduce the methanol excess to the process. Finally, the performance of the reactor for some specific operation conditions was compared with a reactor operated in parallel, showing that conversion, yield and

productivity in the countercurrent operation are higher than those in the co-current one.

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16. **Super-fast Biodiesel Synthesis using Liquefied Dimethyl Ether and Proposal of a Method for High-yield Synthesis and Reduction of Cosolvent.** Hidetoshi Kuramochi[1], Kouji Maeda[2], Masahiro Osako[1], Kazuo Nakamura[3], and Shin-ichi Sakai[4], [1]National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan, [2]University of Hyogo, Himeji, Hyogo, Japan, [3]Advanced Software Technology & Mechatronics Research Institute of Kyoto, Shimogyo-ku, Kyoto, Japan, [4]Kyoto University, Sakyo-ku, Kyoto, Japan.

Super-fast biodiesel synthesis from triolein (a biodiesel feedstock model) was achieved in the presence of liquefied dimethyl ether (L-DME) using the cosolvent effect and low viscosity. This method was faster than the other conventional colsovent method using tetrahydrofuran. Unfortunately, the super-fast reaction could not be maintained for about 10s because a heterogeneous phase was formed by the by-product glycerin. In this study, a method for higher ester yield, in which methanol was additionally introduced into the reaction system immediately before the beginning of phase separation due to by-product glycerin to maintain the reaction system in a homogenous state, was suggested. This method resulted in super-fast and high-yield BDF synthesis with a yield exceeding 96% at 3 min. In order to reduce the amount of L-DME and methanol required for the super-fast reaction with high yield, furthermore, we estimated the liquid-liquid equilibrium of the reaction system using the LLE-UNIFAC model, and then proposed a two-step reaction method. We experimentally examined how the two-step method reduced the amount of L-DME and methanol added for the same super-fast reaction rate and high yield.

17. **Supercritical Dimethyl Carbonate: a Novel Alternative Process for Non-Catalytic Biodiesel Production.** Zul Ilham and Shiro Saka, Graduate School of Energy Science, Kyoto University, Japan.

This paper will discuss the potential of non-catalytic supercritical dimethyl carbonate process for production of biodiesel. Special focus is oriented towards the superiority of this process in producing higher value by-products, than the glycerol produced in the conventional process without tolerating the ability to produce high yield of fatty acid methyl ester. In this study, it was demonstrated that, the supercritical dimethyl carbonate process successfully converted triglycerides to fatty acid methyl esters with glycerol carbonate and citramalic acid as by-products, while free fatty acids were converted to fatty acid methyl esters with glyoxal. These by-products from this process possess higher value in applications than the abundantly available glycerol. In addition, the yield of the fatty acid methyl esters as biodiesel from supercritical dimethyl carbonate process was almost at par with supercritical methanol method. Therefore, supercritical dimethyl carbonate process can be a good candidate as a non-catalytic process for biodiesel production.

18. **Novel Dual Sites Mixed Oxide Catalysts for Simultaneous Transesterification and Esterification to Biodiesel.** Shuli Yan[1,2], Manhoe Kim[1,2], Steven O. Salley[2], and K.Y. Simon Ng[2], [1]National Biofuels Energy Laboratory, Detroit, Michigan, USA, [2]Wayne State University, Detroit, Michigan, USA.

Using waste or unrefined oils as feedstock can greatly decrease the production cost of biodiesel. In this study, novel dual sites mixed oxide catalysts were developed which can transesterify triglycerides and esterify free fatty acid (FFA) simultaneously. Effects of catalyst structure, metal oxide molar ratio, FFA and water contents in feedstock, reaction temperature and oil concentration on the yield of FAME were investigated. A number of high FFA content feedstock, such as crude soybean oil, crude coconut oil, crude palm oil, waste cooking oil, and the well-refined soybean oil with 3% water and 5% oleic acid, was studied. In a batch reactor, with 12:1 molar ratio of methanol to oil, 2.3 (wt)% catalyst, and an agitation rate of 400 rpm, a high yield (95%) of biodiesel was obtained within 3 hours. In a continuous reactor, with 40:1 molar ratio of methanol to oil, 200°C, and 150 ~ 450 psi, the yield of FAME maintained in the range of 72 ~ 92% for 32.5 days. This class of mixed oxides catalysts is very promising to lower the overall production cost of biodiesel.

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19. **Application of Microwave in Production of Biodiesel from Waste Frying Oils.** Isa Rahmanlar[1], Cemile Yerlikaya[2], and Sevil Yucel*[1], [1]Yildiz Technical University, Bioengineering Department, Istanbul, Turkey, [2]Istanbul Technical University, Chemical Engineering Department, Istanbul, Turkey.

Waste frying oils contains significant amounts of degradation products because of polymerization, oxidation and hydrolysis reactions. Frying oils which is unusable because of increasing in degradation product content causes vital environmental problems. Very little amount of waste frying oil which is collected from household and industrial sources is used for industrial purposes such as animal feed and fatty acid production.

In this study, biodiesel from waste frying oil by using microwave method by means of alchoholysis reaction was investigated. In recent years, it is aimed to use this method which is used in organic synthesis reactions in biodiesel production thanks to providing advantages such as short reaction time and decreasing in formation of by-products. The parameters such as alkaline catalyst amount, methanol/oil molar ratio, reaction time which influence the alchoholysis reaction were analyzed. Experiments have been performed to determine the optimum conditions for this alcoholysis process by response surface method.

20. **Reaction Efficiency for Biodiesel Production Utilizing Hydro-dynamic Cavitation.** Rachel Burton, Nick Fox, and Xiaohu Fan, Piedmont Biofuels Industrial, Pittsboro, NC, USA.

Continuous hydro-dynamic cavitational mixing offers a highly efficient biodiesel processing system. Cavitation describes the formation, growth, and implosive collapse of gas or vapor-filled bubbles in a liquid. The rapid collapse of vapor bubbles is a violent process that creates highly localized, large amplitude shock waves. These shock waves generate intense micro-streaming, which in turn can accelerate chemical reactions such as the reaction of oil and alcohol. The following work will demonstrate how one methodology of hydro-dynamic cavitation will reduce the need for high incoming reaction temperatures and improve production yield on low quality feedstocks in comparison to batch base-catalyzed biodiesel process in a commercial production setting.

21. **Process Simulation of Enzymatic Biodiesel Production - At What Cost Can Biodiesel be Made with Enzymes?** L. Fjerbæk Søtoft, K.V. Christensen, B.-G. Rong, and B. Norddahl, University of Southern Denmark, Odense, Funen, Denmark.

The industrial production of biodiesel has had a very turbulent lifetime due to drastic changes in prices of raw materials and fossil fuels as well as regulatory changes and produced amounts of biodiesel.

Biodiesel production is carried out by various forms of catalysts, but industrially only chemical homogenous catalysts are used on large scale.

Smaller pilot plants with enzymatic catalyzed production are reported, but not to a very large extent. In order to evaluate the potential and remaining obstacles of introducing enzymes as the preferred industrial catalyst, analysis of economical as well as environmental impacts of the alternative process must be evaluated towards the conventional process.

With process simulation tools, an evaluation will be carried out looking at what it will cost to produce biodiesel with enzymes. Different scenarios will be taken into account with variations in raw material prices, process designs and enzyme cost and performance.

Acknowledgements: The work was supported by The Danish Council for Strategic Research.

22. **Catalytic Activity and Durability of Supported CaO-based Catalysts for Transesterification in a Continuous Flow Fixed Bed Reactor.** Manhoe Kim[1,2], Shuli Yan[1,2], Steven O. Salley[2], and K.Y. Simon Ng[2], [1]National Biofuels Energy Laboratory, NextEnergy, Detroit, Michigan, USA, [2]Wayne State University, Detroit, Michigan, USA.

Supported CaO-based mixed oxide catalysts for the transesterification of soybean oil with methanol and ethanol were tested in a continuous flow fixed bed reactor. Although CaO based catalysts show high catalytic activity, leaching of active species from the CaO based catalysts prevents its use as industrial catalysts. In order to stabilize Ca species while maintaining catalytic activity, supported CaO-mixed oxide catalysts with different compositions were prepared and tested in a continuous flow fixed bed reactor. Reactant mixture of oil and methanol (oil:methanol=1:15 in molar ratio) was fed at a feed rate of 0.1~0.2 mL/min. The reactor temperature was maintained at 80ºC. The yield of methylesters was maintained as high as 98% for more than 5 days. Ca concentrations in the products steeply decreased from 1400 ppm at the first day to 5 ppm at the 5th day. High durability was observed from these support CaO-based mixed oxide catalysts.

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23. **Improved Conversion to Biodiesel by the Use of a Jet Reactor.** E.R. Els and A. Moolman, University of Stellenbosch, Stellenbosch, South Africa.

A custom designed jet reactor for biodiesel manufacture will be tested on pilot scale. The increase in conversion to biodiesel due to improved mass transfer obtained with the jet reactor will be presented. Results will include optimised process operating conditions for the use of the jet reactor.

Acknowledgements: University of Stellenbosch Biofuelson.

24. **Crosslinked Lipase Aggregate Formation of Various Lipases with Polyethylenemine.** Eda Öndül[1], Gülçin Eylem Özarslaner[1], Mehmet Erhan Kanişli, Nadir Dizge[2], and Nedim Albayrak[1], [1]Yüzüncü Yıl Üniversity, Van, Turkey, [2]Gebze Yüksek Teknoloji Enstitüsü, Kocaeli, Turkey.

Crosslinked Lipase Aggregate (CLA) formation of various lipases with branched polyethylenemine (PEI) polymer and crosslinking with glutaraldehyde (GA) was investigated for development of stable enzyme particles. Lipases from Rhizomucor miehei (Rm), Thermomyces lanuginosas (Tl), Candida rugose (Cr), Pseudomonas fluorescens (Pf), Burkholderia capecia (Bc), Candida antarctica lipase A (Cal-A) and lipase B (Cal-B) were screened for complex formation in solution and precipitation upon centrifugation. Lipase activities were not affected by PEI. A strong degree of turbidity was observed with Rm, Tl, Cal-A and Bc while weak or no turbidity were obtained with Cal-B, Cr and Pf. At PEI to lipase ratios of 1:50, 1:45 and 1:25 with Rm, Tl, and Cal-A were lead to highest degrees of precipitation yields as 100, 80 and 75% of the activities in solution, respectively. Although Bc formed very turbid mixture, the complexes were unable to precipitate upon centrifugation. The other lipases were neither able to form complex with PEI nor precipitate. GA did not affect association of the PEI-lipase mixture nor the activity thereof except too high concentrations. In addition to increased enzyme stabilities, some overactivation up to 60% was also observed upon CLA formation. An evaluation of the performance of CLA lipases for biodiesel production is in progress.

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25. **Esterification of Acidic Oils over a Versatile Amorphous Solid Catalysts.** F. Zaccheria, R. Psaro, and N. Ravasio*, CNR ISTM, Milano, Italy.

A further increase in the production of biodiesel will only be possible by making available new feedstocks apart from rapeseed, soybean and palm oil. A possible way is to use raw materials that are not compatible with the actual process, such as highly acidic oils.

The actual technology for the transesterification reaction does not allow the use of oils having >0.5% FFA by weight. Thus, these materials react with the homogeneous basic catalyst to form soaps by-products. An acid catalysed pre-treatment is necessary to use these feedstock, sulphuric acid and sulphonic resins being the most popular ones. This treatment converts FFA into FAME while TG are then processed under basic homogeneous conditions.

Here we report that a commercial silica zirconia catalyst is able to reduce the acidity of oils with up to nearly 20% FFA to values that makes them suitable for the homogeneous transesterification reaction. Secondary raw materials with very high acidity, such as olive oil fatty acids or Tall Oil, are successfully esterified over this catalyst showing its resistance to the water formed.

Moreover the catalyst is active also in the transesterification of tryglycerides.

Thus, a sample of rapeseed oil containing 5% by weight of oleic acid is converted in 1 h at 180°C in a mixture containing 0.3% FA, 46.6% FAME, 2.2 MG, 9.5 DG, 41.3 TG.

26. **Esterification of Free Fatty Acids over Heteropolyacids Immobilized on Mesoporous Silica.** D. Pito[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Caparica, Portugal.

Biodiesel is generally synthesized by the transesterification of natural oils, or fat of vegetable or animal origin, which is carried out by acid or base catalysis. However, some of the natural oils or fats contain considerable amount of free fatty acids, which interfere with transesterification process and must be converted into their corresponding esters before reaction. Thus, esterification forms an essential step in the production of biodiesel.

The heteropolyacids have higher Brönsted acidity than the conventional solids acids. The heteropolyacid supported on solids have advantages over homogenous catalysts, such as their easy separation from liquid products. This work reports the esterification of palmitic acid, oleic acid and stearic acid with methanol over heteropolyacids (PW, SiW, PMo) immobilized on SBA-15. It was observed that the PW-SBA-15 catalyst has the highest catalytic activity of the three catalysts for palmitic acid esterification. It was also obtained a similar catalytic activity of PW-SBA-15 when different fatty acids were used.

27. **Continuous Transesterification of Soybean Oil Under Supercritical Alcohols.** I. Vieitez[1], C. da Silva[2], I. Alckmin[2], G.R. Borges[2], F.C. Corazza[2], J.V. Oliveira[2], M.A. Grompone[1], and I. Jachmanian*[1], [1]Laboratorio de Grasas y Aceites, Facultad de Química, Universidad de la República, Montevideo, Uruguay, [2]Department of Food Engineering, URI-Campus de Erechim, Erechim, RS 99700-000, Brazil.

This work compares the reaction efficiency of soybean oil transesterification under supercritical methanol and ethanol, in a continuous catalyst-free process. Experiments were performed in a tubular reactor, at 20 MPa, with oil to alcohol ratio of 1:40, varying the temperature in the range from 250°C to 350°C, and at two levels of water concentrations, 0 and 10 wt%. Results showed that yields obtained by methanolysis were always higher than that corresponded to ethanolysis. Water addition had a positive effect on the conversion obtained with both alcohols, corroborated by the higher ester content and TAG depletion when 10 wt% water was used compared with anhydrous conditions. Temperature was the main factor affecting efficiency, even it increase favoured the yields, temperatures above 300ºC increased the percentage of fatty acid degradation, a phenomenon responsible for the low ester contents obtained at the highest temperatures and lowest flow rates studied.

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28. **Hydrolysis of Olive Oil in Submerged Membrane Bioreactor for Innovative Production Systems.** Sudip Chakraborty[1,2], Lidietta Giorno[1], and Enrico Drioli[1,2], [1]Research Institute on Membrane Technology, Italy. [2]Dept. of Chemical and Materials Engineering, University of Calabria, Italy.

Continuous hydrolysis of olive oil by Candida rugosa (CRL) lipase was studied in a two configuration of microporous hydrophilic membrane bioreactor. Membranes are used in bioreactor exclusively as a matrix for immobilization of the enzyme, without any separation intentions. Membrane acts as a support for the interface between two distinct liquid phases. Upon this retention, the enzyme becomes confined to a defined region of the membrane reactor, where reaction with the substrate occurs. The enzyme was immobilized on the shell side of the membrane and is usually entrapped inside the pores or membrane matrix. Olive oil and buffer solution, fed continuously through two compartments partitioned by membrane, caused reaction at the interface of lipase-adsorbed membrane and buffer solution. The hydraulic pressure in the oil phase was enough to maintain phase separation, an accurate pressure control was not necessary. Fatty acid was obtained in a single phase without being mixed with components of other phases. The products resulting from reaction with contact with the substrate should permeate through the membrane pores, either by diffusion or convection. In this way a continuous removal of products from the reaction media is attained.

Acknowledgements: The work is being carrying out at ITM-CNR in collaboration with UNICAL, Italy.

29. **Dyeing Method for Determination of Glycerol Partitioning in Biodiesel Production.** Y. Xu[1], M. Nordblad[1], P.M. Nielsen[2], J. Brask[2], J.M. Woodley[1]; [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, DK-2800 Lyngby, Denmark, [2]Novozymes A/S, Krogshøjvej 36, DK-2880 Bagsværd, Denmark.

Lipase-catalyzed biodiesel production has the potential to be highly efficient and selective, compared to conventional base-catalysed production[1]. In both routes, the major byproduct of biodiesel production is glycerol. However, for enzyme-catalysed reactions it has been reported that this leads to enzyme deactivation by blocking the access of hydrophobic substrates to the active site[2]. Since glycerol is colorless, a dyeing method has been introduced to study the distribution of glycerol in such systems. In this paper we report data on the partitioning of glycerol between immobilized enzyme and the surrounding solution, in order to improve understanding of the effect glycerol has on enzyme deactivation. Glycerol has great affinity for hydrophilic enzyme supports (such as silica) and to a lesser extent for some hydrophobic supports (such as polystyrene). We also observed that the immobilization of enzyme on the support influenced glycerol partitioning.

[1] Nielsen, P.M. *et al.*, 2008. *Eur. J. Lipid Sci. Technol.*, 110, 692.
[2] Dossat, V. *et al.*, 1999. *Enzyme Microb. Technol.*, 25, 194.

30. **Mechanical Stability of Immobilized Lipases and the Supports in a Stirred Tank Reactor.** Y. Xu[1], C.A. Godoy[2], J.M. Guisan[2], M. Nordblad[1], P.M. Nielsen[3], J. Brask[3], J.M. Woodley[1]; [1]Department of Chemical and Biochemical Engineering, Technical University of Denmark, DK-2800 Lyngby, Denmark, [2]Departamento de Biocatálisis, Instituto de Catálisis y Petroleoquímica (CSIC), 28049 Madrid, Spain, [3]Novozymes A/S, Krogshøjvej 36, DK-2880 Bagsværd, Denmark

Lipase-catalyzed biodiesel production is attracting considerable interest as an alternative to conventional base-catalysed biodiesel production. The use of enzyme technology is attractive for a number of reasons, including the potential of improved sustainability. As other enzyme-based processes, effective use of the lipase will demand reuse via for example immobilization of the enzyme on a porous support[1]. In such cases, the mechanical stability of the immobilized lipases and supports will be a crucial factor for the large-scale application of the immobilized lipase-catalyzed biodiesel process[2]. In the work reported here, the mechanical stabilities of several immobilized lipases (including Novozyme 435 and Lipozyme TL IM) and several supports (including both silica and hydrophobic polymeric materials) have been assessed in a scaled-down stirred reactor which mimics industrial operation. The particle properties and loading ratio were investigated for their effects on the mechanical stability.

[1] Nielsen, P.M. *et al.*, 2008. *Eur. J. Lipid Sci. Technol.*, 110, 692.
[2] Martins dos Santos, V.A. P. *et al.*, 1997. *Biotech. Bioeng.*, 56, 517.

31. **Solvent Extraction and Processing of Microalgae Oil for Biodiesel.** R.C. Green; POS Pilot Plant Corporation, Saskatoon, Saskatchewan, Canada.

Oil extraction from dried microalgae involves pre-grinding the biomass, solvent extraction, followed by refining and bleaching of the extracted oil. Extraction of the crude oil is carried out by suspending the microalgae in an organic solvent and disrupting the cells by passing the mixture through a bead mill. The miscella is recovered by centrifugation and the solvent is removed by vacuum evaporation. The resulting crude oil can be purified by solvent winterization, degumming, refining and bleaching with adsorbent clay. Critical control parameters for effective extraction include solvent:solid ratio, bead load and residence time in the mill. Typical yields and process parameters for pilot scale extraction of microalgae oil for biodiesel will be presented.

32. **Catalysts Screening on In-situ Transesterification of Jatropha Curcas Seed.** F.H. Kasim and A.P. Harvey, Newcastle University, Newcastle upon Tyne, United Kingdom.

Jatropha curcas (J.curcas) is being recognize as a new potential feedstock for biodiesel production. In the present, the seed was mechanically or chemically extracted to gain its oil, and subsequently treated for biodiesel production. This paper however will look at the alternative way of producing biodiesel, known as in-siti

transesterification. In this process, no mechanical or even chemical extraction of oil from the seed was needed. The seed was directly treated with alcohol and catalyst to produce biodiesel. Three types of catalysts will be used in this screening process, namely sodium hydroxide, sodium methoxide and sulfuric acid. The performance of the catalysts were compared in term of methyl ester yield.

33. **Optimization of Reaction Conditions for Crude Palm Oil Methanolysis using Aenesulfonic Acid-Modified Mesostructured Catalysts.** J.A. Melero, L.F. Bautista, J. Iglesias, G. Morales, and R. Sanchez-Vazquez*, Department of Chemical and Environmental Technology. Rey Juan Carlos University, Mostoles, Madrid, Spain.

Organosulfonic acid-functionalized mesostructured silicas – showing good textural properties and relatively high concentration of strong acid sites – simultaneously drive the esterification of FFA and transesterification of triglycerides, making possible the single-step production of biodiesel from FFA-containing feedstock. Within the scope of this work, we present the use of surface response methodology for optimizing the transesterificaction reaction conditions of crude palm oil with methanol (temperature, catalyst loading and alcohol to oil molar ratio) using arenesulfonic-containing SBA-15 materials as catalysts. The statistical analysis evidences strong interaction between operating variables, especially for methanol to oil ratio and temperature, indicating several processes, such as mass transfer between different phases, underlie the transesterification reaction affecting catalytic results. Under de range of study, the optimal conditions are: temperature 160ºC, catalyst loading 5.1 wt% (depending on amount of crude palm oil) and methanol to oil molar ratio 30. Thus, 90% of the starting oil is converted to FAME in just 2 hours.

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34. **A Comprehensive Review of the Biodiesel Production and Purification Technologies in Iran.** Barat Ghobadian, Tarbiat Modares University, Tehran, Iran.

In this paper, the biodiesel production and purification technologies for both SVO and VWO from the rise of biodiesel research activities in Iran is presented. Biodiesel production research work started initially at laboratory level to determine the biodiesel processors design parameters. The design was aimed at the laboratory biodiesel processors to biodiesel refineries, producing biodiesel with ASTM D6751quality. A 3 liters biodiesel processor called multifunction processor was designed and developed. This fully automated processor helped to develop the larger biodiesel processors called the first generation biodiesel processors. A batch type biodiesel processor called BDI-80, is an example of this type and a sample of this generation. The second generation was a semi-continuous type with a number of novel characteristics. This generation was still a semi-industrial type. Based on this generation type, the family type and the rural type processors are the well known examples. The third generation biodiesel production technology is biodiesel refinery. The design of this type is completed and its construction is still underway. These research activities resulted in patenting a new hybrid fuel called diesterol.

Sustainability Aspects of Biodiesel

1. **Biodiesel Production from Waste Cooking Oil over Sulfonated Solid Catalysts.** C. Caetano[1], I. Fonseca[2], A. Ramos[2], J. Vital[2], and J. Castanheiro*[1], [1]Centro de Química de Évora, Departamento de Química, Universidade de Évora, Évora, Portugal, [2]Requimte, CQFB, FCT, Universidade Nova de Lisboa, Caparica, Portugal.

Biodiesel, which is recognized as "green fuel," is an alternative to petroleum diesel due to the lower dependence on foreign crude oil and lower combustion emission profile. It is made from renewable biological sources, such as vegetable oils and animal fats, it is biodegradable, non-toxic and so it is beneficial environmental. Biodiesel can be synthesized by the transesterification of vegetable oils with short chain alcohol (methanol or ethanol), which is carried out by acid or base catalysis. Traditionally, strong homogeneous acid or base catalysts have been used in the biodiesel. However, solid catalysts have many advantages over liquid acids. They do less harm to the environment, are reusable and easy to be separated from liquid products. In this work, we study the biodiesel production from waste cooking oil over sulfonated solid catalysts. Mesoporous silica (SBA-15 and MCM-41) and polymers with sulfonic acid groups were the catalysts chosen. It was observed that the catalysts exhibit a good catalytic activity.

2. **Biodiesel in the Brazilian Amazon: Mapping Initiatives, Policies, and Impacts.** R. Andrade[1] and A. Miccolis[2]; [1]Universidade Católica de Brasília, SGAN 916 Sala A222 Brasília DF, [2]ComSensos Consultoria , CLN 215 B 213 Brasília DF.

While biodiesel production in Brazil has relied heavily on soybeans, recent initiatives and policies for the Amazon have focused on oil palm (Elaeis guineensis), touting it as a promising new crop for increasing Brazil's energy independence, recovering degraded lands and creating jobs. Based on an extensive literature review, this paper examines the extent to which these initiatives are considered sustainable with regard to social and environmental impacts. We show that oil palm is emerging as a promising crop for producing biodiesel in the Amazon due to its phenomenal yields, high potential for energy production in isolated communities and vast expanses of suitable lands. Some recent studies, however, are questioning the social and environmental sustainability of the oil palm production model currently being adopted in the Amazon, suggesting that the expansion of large-scale palm oil monocultures may increase deforestation and land concentration, while also potentially undermining food security and local livelihoods

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Speaker Biographies

Ibrahim Abou-Nemeh, Ph.D., is currently the Director of the R&D Product Discovery at Novus International. His research areas: Biofuels, eco-biocides, micronutrients, microalgae, nano-systems and biodegradable materials. Prior to joining Novus, he was the manager of pharmaceutical, oral care and industrial research at Roquette America, USA from 1998-2004. He earned his MS and PhD degrees in Chemical Engineering from the Wroclaw University of Technology, Poland and the University of Ghent, Belgium respectively. Dr. Abou-Nemeh held several academic positions at the Technical University of Graz, Austria, University of Ghent and the New Jersey Institute of Technology, USA. He published and presented more than 50 peer-reviewed papers and presentations and authored more than 20 patents some are pending. He is member of ACS, AICHE, AAAS, ASTM, and AOCS.

Nedim Albayrak was born in Ankara Turkey. Having completed his food science education at Ankara University, he earned master and doctorate degrees at The Ohio State University, USA. At OSU he worked on biotechnology and biochemical engineering. Some of his findings at OSU which was related to the development of a novel enzyme immobilization method were patented. After finishing his degrees in the US, he returned to his home country where he became an assistant professor in Food Science department at Yuzuncu Yil University. He teaches biotechnology, biochemistry related courses and his group works on enzyme related eco-friendly solutions for food industry.

Amjad Ali completed a M.Sc. in chemistry from Indian Institute of Technology Roorkee, in the year 2000. He joined Indian Institute of Technology Bombay for Ph.D. in the same year with Prof. C.P. Rao in chemistry department and worked on lower rim substitute calix[4]arene derivative, their metal complexes and study of catecholase activity of prepared complexes. After completing Ph.D., he joined Bharat Petroleum Corporation Limited (R&D, center) as postdoc fellow and worked there for about one year on biodiesel quantification and diesel fuel additive synthesis from vegetable oils. At present, he is working in Thapar University, Patiala (India) as assistant professor in school of chemistry and biochemistry and apart from teaching coordination and bioinorganic chemistry to M.Sc. students, actively involved in developing the heterogeneous catalyst for biodiesel production from low quality feedstock.

Teresa Alleman is a senior chemist with the Fuels Performance Group at the National Renewable Energy Laboratory. She has been with the Fuels Performance Group for 9 years working on reducing technical barriers to increase utilization of alternative and advanced fuels. Currently, Teresa's research focus is in biodiesel and ethanol issues, particularly fuel quality, test methodology, and trace contaminant analysis. Teresa has provided critical input and data to support new ASTM methods and specifications in recent years. She is an active member of ASTM International, ACS, and AOCS.

Evangelos Bakeas is Lecturer of Analytical Chemistry and Environmental Analysis at the National and Kapodistrian University of Athens. He received B.S. and Ph.D. degrees from the University of Athens. His research interests include all aspects of air pollution (development of new analytical methods, monitoring of organic pollutants, emissions etc.). He has over 30 publications covering a variety of topics on air pollution.

Ami Ben-Amotz is presently Emeritus Professor of Marine Phycology. Ami Ben-Amotz received his PhD at Weitzman Institute of Science (WIS), Israel, on studies with the alga *Dunaliella*. After post doctorate studies at Brandeis University, USA, on hydrogen production by marine algae he returned to Israel and initiated research academic activity at the National Institute of Oceanography (NIO) and at the WIS to study the biology, physiology, biochemistry and biotechnology of marine microalgae with emphasis on *the* halotolerant alga *Dunaliella*. The fruitful cooperation led the way to establishment of the commercial *Dunaliella* production plant in Eilat, known today as Nature Beta Technologies Ltd., (NBT) Israel, a subsidiary of Nikken Sohonsha Co., Japan. Prof. Ben-Amotz served as Head of the Department of Marine Biology at the NIO and Head of the *Dunaliella* Section at the WIS, Chief Scientist of NBT and recently as Chief Scientist of Nikken Sohonsha Co., Japan. Prof. Ben-Amotz served as President of the 8th International Marine Biotechnology Conference which was held in Eilat, Israel in March 2007. Upon his retirement of NIO Prof. Ben-Amotz founded Seambiotic Ltd., a company devoted to the cultivation of marine microalgae on wastes of electric power plants for the production of feasible bio-fuels and high value products. Prof. Ben-Amotz has more than 150 publications and supervised dozens of students mostly on aspects related to marine algae, *Dunaliella* and natural products.

A.A. Boateng is a senior research chemical engineer with the Agricultural Research Service (ARS) of the USDA. He started the ARS thermochemical conversion research 6 years ago and is the Lead Scientist on their On-farm Distributed Pyrolysis project. Prior to joining USDA Kwesi held engineering faculty positions at 2 liberal arts universities and spent 10 years in industry with increasing responsibilities rising to chief process engineer. He has authored about 60 publications, 45 of which are refereed. He is the author of the industry acclaimed book, "Rotary Kilns - Transport Phenomena & Transport Processes," a Butterworth-Heinemann publication. Kwesi is a former Fulbright Scholar, AIChE senior member and ASME Fellow. He holds a PhD from the University of British Columbia.

André Boehman is a Professor of Fuel Science and Materials Science and Engineering in the Department of Energy & Mineral Engineering in the College of Earth and Mineral Sciences at the Pennsylvania State University, where he has taught courses on Energy, Fuels, Combustion and the Environment since 1994. He holds a BS in Mechanical Engineering from the University of Dayton (1986) and an MS (1987) and PhD (1993) in Mechanical Engineering from Stanford University. Prof. Boehman's research interests are in alternative and reformulated fuels, combustion and pollution control. He serves as the Editor of the journal *Fuel Processing Technology* and has held executive positions with the ACS Division of Fuel Chemistry and with the International DME Association.

Mark Brewer is currently Fuels Scientist at Shell Global Solutions, based in the UK at the Shell Technology Center (Thornton). His current position at Shell includes responsibility for purpose issues with implementation of Biofuels, as well as development of performance packages of automotive fuels. In the past he has been worked in customer technical service for a fatty acid manufacturer, in addition to working on fuel additive development for a major additive supplier. He received a BSc (Hons) from the University of Nottingham UK.

Jürgen Bünger is currently the Chair for Experimental Occupational Medicine at Ruhr-University of Bochum. The focus of his research are exposures from engine exhaust and their health impacts on humans, mainly diesel engine emissions, especially the influence of petroleum and plant oil derived fuels on mutagenicity and genotoxicity. The two other principal investigators of the working group are Prof. J. Krahl, Coburg (chemistry) and Prof.-Ing. A. Munack, Braunschweig (engineering). They have performed together about 25 projects on the influence of fuel properties on regulated and unregulated diesel engine emissions since 1993. Prior to joining Ruhr-University of Bochum, Bünger was Consultant and deputy director at the Institute of Occupational Medicine, University of Göttingen. Prof. Dr. Bünger received his medical degree at the University of Göttingen, Germany in 1986. Between 1986 and 1993, he held residencies in Surgery, Pathology, and Internal Medicine at different hospitals. He completed his thesis at the University of Münster, Germany in 1989; and in 2002 his "Habilitation" at the University of Göttingen. Since 2005, he had held the position of vice director and head of the Medical Center of Competence at BGFA, Research Institute of Occupational Medicine, Ruhr-University of Bochum. He has published numerous research papers.

Rachel Burton is Vice-President and Research Director at Piedmont Biofuels Industrial in Pittsboro, North Carolina. She also founded the Biofuels Program at Central Carolina College, where she is currently an instructor. She received her bachelor and applied science degrees in sustainable agriculture and automotive technology at University of North Carolina at Chapel Hill. In 2005, she received Sustainable North Carolina's Clean Technology award. In 2006 and 2007, she was the recipient of NC State Energy Alternative Fuels Leadership awards. Rachel currently sits on the National Biodiesel Board's Sustainability Taskforce for a second term. She has also served as coordinator of the National Sustainable Biodiesel Summit for both 2007 and 2008. Rachel developed the first two-year degree curriculum in biofuels technology accredited in the U.S. She has participated in biofuels research through the University of North Carolina, North Carolina State University, and other private industry stakeholders. Her collaborative work has been published in Inform magazine, Lipid Technology, The Journal of Physical Chemistry and Alternatives Journal.

Barry Cahill joined the Rootes Group, manufacturers of automobiles in Coventry, England in 1964, having graduated from University College Dublin. His initial duties concerned component testing in the mechanical laboratory and vehicle safety testing to ensure compliance with emerging regulations. A period in the International Engineering sector of the Company preceded a two-year secondment to Tehran for Chrysler International / Iran National Industrial Manufacturing in 1977. A brief period in Quality Engineering in Chrysler UK was followed by a transfer to Talbot in France, working on overseas contracts. He joined the Diesel Engineering department of PSA in 1982, with responsibility for emission regulations, particulate filters and fuel quality. He was part of the Fuels Engineering department of PSA for many years until retirement in 2008. He is now working independently and is chairman of the CEN sub-committees for biodiesel and bioethanol specifications.

Abraham Casas was born in Puertollano (Spain) in 1982. He is Chemical Engineering from 2006 and received his Master's Degree in Environmental Engineering and Management in 2007. He expects to complete his Ph.D. in Chemical, Environmental and Materials Engineering from Universidad de Castilla-La Mancha in 2010. He has worked with the development of new technologies in the reaction and purification stages in the biodiesel production and improvement of the biodiesel properties.

Glen Cauffman oversees the operation of the College of Agriculture University Farm Operation. As such he has been instrumental in forming a relationship between agricultural industries and Penn State to showcase the use of biomass derived alternative fuels. The university now uses B20 fuel in all diesel powered equipment across campus. Additionally, B100 is used in three current New Holland agricultural tractors and Straight Vegetable Oil is being evaluated long term in two New Holland tractors used daily on the university farm. Mr. Cauffman has been a champion of the use of farmer grown fuels and green lubricants and has been recognized for his efforts throughout the state and the country.

Ortwin Costenoble is senior standardization consultant at NEN, the Netherlands Standardization Institute. He is the specialist in international standardization work in the (bio)fuels field. He is international secretary of many standardization groups, a.o. CEN/TC 19 and CEN/TC 383. Besides this he acts as project manager of (pre-normative) research work in biofuels, biobased products and hydrogen.

Edward English is Fuel Quality Services Technical Director. He is also secretary for ASTM D02.14 Stability and Cleanliness of Liquid Fuels, co-chairs ASTM's Task Force on Fuel Corrosivity, is a member of ASTM Task Force on Microbial Contamination, is a member of IASH and served on Underwriters Laboratory E85 Task Force. He has made presentations discussing microbial contamination of fuels, alternative fuels and materials compatibility to the USEPA, FAA, California Cooperative Unified Program Agency (CALCUPA), New England Interstate Water Pollution Control Commission (NEIWPCC), Petroleum Equipment Institute (PEI), National Institute of Storage Tank Maintenance (NISTM), National Biodiesel Board (NBB), DuPont, Society of Automotive Engineers.

Frank Gunstone has been interested lipids for over 65 years to the time when he started postgraduate studies

concerned with seed oil fatty acid composition and with autoxidation. Since then as a university teacher (1946-1989) and since retirement, he has conducted research, published papers, trained students some of whom have become independent workers in the field, edited and written books, and collected some prizes. Gunstone states: "I do not claim to be conducting original research any more but I continue to read, think, talk, and write lipid science".

Patrick Hanks is a Senior Researcher at ExxonMobil Process Research Labs based in Clinton, NJ. He has a PhD in Chemical Engineering from the University of Texas at Austin. He has a Bachelors of Chemical Engineering from Auburn University. Upon completion of his PhD, he went to work for ExxonMobil performing hydroprocessing research. His main research area is upgrading biologically derived molecules to transportation fuels.

Barbara Harten studied dairy technology at the University of Hannover, Germany. After completing studies at the university, she worked for one year at the institute of dairy technology of the Technical University Munich / Weihenstephan as a technical assistant, with a scientific focus on foam stabilization and improvement of whey-based products. In 1989, she became employed by Westfalia Separator in the dairy department, responsible for testing of new machines in the field and after-sales service. In 1994, she began working in the business unit Oils and Fats Processing inside Westfalia Separator, main focus on Biodiesel and Oleochemistry applications. This year, the name of the department changed to Renewable Resources; Barbara's current position is product manager for Biodiesel.

Hans Christian Holm was born in Roskilde, Denmark in 1963. He studied at Roskilde Kathedral Skole (Mat-Fys), then went on to get his degree in Civil Engineer Chemistry (Master of Chemical Engineering) from DTU. In 1989, he received his Bachelor of Business/Foreign Trade from HD-U. Since 1986, he has been employed at Novozymes, where he is currently senior manager, working on the global marketing of oils and fats. Hans is the recipient of the 2008 Euro Fed Lipid Technology Award and co-recipient of the 2005 US President Green Chemistry award.

Andreas Hornung is currently an instructor at Aston University. He is also head of the European Bioenergy Research Institute (EBRI) and Chair in Chemical Engineering and Applied Chemistry. He is director of EBRI UK Ltd, and head of the Chemical Engineering and Applied Chemistry Group. The EBRI Institute is a platform for the development and implementation of bioenergy systems in local, national and European contexts. Professor Hornung's group researches advanced pyrolysis/gasification and pyrolysis/combustion systems for combined heat and power production. Professor Hornung did his studies as engineer in Chemistry at the Technical University in Darmstadt, Germany, then went on to receive his PhD from the Technical University of Kaiserslautern, Germany. After having spent another four years at the Technical University of Karlsruhe, he went to Industry to develop the prototypes for his research. He worked in Austria and Italy and got a post-doc offer in 2001 to take over the position as head of the pyrolysis/gas treatment division at the Forschungszentrum Karlsruhe in Germany.

Christian Hulteberg studied chemical engineering at Lund Institute of Technology, graduating with a Master of Science in chemical engineering in 2002. He continued his studies which resulted in a Ph. D. in chemical engineering and catalysis in 2007 and an MBA in 2006. After finishing his Ph.D. on hydrogen energy related topics Dr Hulteberg went on to form his own company working with problems related to the production of green chemicals and renewable energy. The company currently employs 5 people and is working with in the fields of hydrogen energy, catalysis and environmental engineering. Through its subsidiary it is also performing research on the production of high-value products from glycerol, where energy gases are one of the focus areas.

Axel Ingendoh has an education in pharmaceutical chemistry and a PhD in chemistry from Marburg University. He trained in natural product synthesis at Geneva University and joined Chemical Research at Bayer Leverkusen in 1980. Since then he worked in process development and as a plant manager of an ion exchange resins production plant. He joined the antioxidants marketing group of Bayer Rubber Chemicals in 1996 and moved to the Bayer spinoff company Lanxess AG in Leverkusen. He began the development of biodiesel Antioxidants in 2000 and holds patents on the uses of BHT in Biodiesel. Presently he is the global Baynox (BHT) technical manager for Biodiesel.

Joe Jobe is the CEO for the National Biodiesel Board (NBB). NBB is the national trade association representing the biodiesel industry as the coordinating body for biodiesel research and development in the US. Its members include biodiesel producers and marketers, feedstock producers and processors, soybean commodity boards, biodiesel suppliers, and other stakeholders in the US and Canada. Joe has served as the CEO for over 10 years. Prior to working for the NBB, Joe was a fraud investigator for the Missouri Attorney General's Office. Prior to that, he worked as a certified public accountant.

Niels Jungbluth studied environmental engineering at the Technical University of Berlin. He prepared a life cycle inventory for cooking fuels in India for his diploma thesis during a six month stay at the TATA Energy Research Institute in New Delhi. Between 1996 and 2000 he worked on a Ph.D. Project at the Swiss Federal Institute of Technology (ETH) in Zurich at the chair of Natural and Social Science Interface. His thesis on the environmental consequences of food consumption has been awarded with the Greenhirn Price 2000 by the German Öko-Insitut. In this thesis he investigated food consumption patterns by means of life cycle assessment. Since 2000 he works at ESU-services Ltd. as a managing partner with emphasis on energy systems, consumption patterns and food production. He is in the editorial board and peer reviews for the "Int. Journal of LCA". Presently he is responsible for the LCA work within the update and extension of photovoltaics for ecoinvent data v2.0, RENEW and the LCI bioenergy project.

Victoria Junquera is the Scientific Coordinator at the Roundtable for Sustainable Biofuels (RSB). In her capacity, she advises RSB on technical and policy issues related to biofuel sustainability, with a particular emphasis on greenhouse gas emissions. Ms. Junquera has 7 years of experience in the areas

of biofuels, climate change, and Life Cycle Assessments (LCA). She was a Process Engineer at a mid-sized biodiesel plant in California. She has participated as a working group member of the California Low Carbon Fuel Standard and is very familiar with international low carbon policy. Ms. Junquera has a Masters in Chemical Engineering from The University of Texas at Austin and is a Certified Professional Engineer in California. She lives in Lausanne, Switzerland.

Tammy Klein is Executive Director of the Global Biofuels Center (GBC), a service of Hart Energy Consulting (HEC) that advises the world's leading biofuel producers, oil companies, automobile manufacturers, governments and other stakeholders on market, policy and technology issues. Klein is an internationally recognized expert on biofuels and is a senior analyst for HEC. Klein advises HEC clients and the GBC membership, governments and NGOs biofuels policy issues. She holds a J.D. from the Georgetown University Law Center. She was a board member of the Georgetown International Environmental Law Review. She holds a B.S. in Journalism from the University of Florida.

Gerhard Knothe, chief editor of *The Biodiesel Handbook,* is a Research Chemist at the National Center for Agricultural Utilization Research of the U.S. Department of Agriculture in Peoria, IL. He received his PhD in organic polymer chemistry from the University of Bremen, (West) Germany. From 1988-1989, he did postdoc work at the University of Kentucky. His current research at the NCAUR is focused on vegetable oil-based diesel fuels (biodiesel) and oleochemistry. He is the author or co-author of more than 90 publications and recipient of the 2006 Industrial Uses of Soybean Award.

Bertrand Lecointe joined IFP in 1999 after graduated from IFP School. He began as Research Engineer involved in combustion process analysis in the Engine Technology Department. He has been in charge of several studies concerning two stroke engines, GDI turbocharged engines or new combustion processes (CAI™ or HCCI). In 2004, he joined the Fuel, Lubricant and Emission Department to be in charge of the research studies in the field of engine and fuel suitability mainly regarding biofuels.

Dora Lopez received her B.S. in Chemical Engineering from the Central American University in 2002. She was awarded a DAAD scholarship to carry out her BS thesis in Germany. She received her Ph.D. in Chemical Engineering from Clemson University, USA in 2007. During her PhD, she investigated the use of solid catalysts for the production of biodiesel. She has published numerous biodiesel-related journal articles. Dr. Lopez post-doctoral research focused on the assessment of the energy life cycle for the production of biodiesel. She recently joined Logos Technologies where she investigates the synthesis of jet fuel from biomass.

Harinder P.S. Makkar is presently International Project Coordinator of a Sino-German Project on 'Fuel and Feed for Tomorrow'. The aim of this project is to enhance economic viability and sustainability of Jatropha-based biofuel production systems by introducing innovative industrial and livestock production systems. He has been conducting research on Jatropha for the last 15 years. He obtained PhD Degree in Agricultural Biochemistry from University of Nottingham, U.K. He has been recipient of Commonwealth and Alexander von Humboldt Fellowships, and was awarded Mercator Professorship in 2006. He has acted as expert consultant for FAO, IAEA and other international organizations. He has published over 200 research papers and 7 books, spread in the area of natural plant products and bioactive compounds and their interactions with livestock, soil, plant and environment.

Derek Masterson is a Product Sales Manager in the Biodiesel Division at Crown Iron Works and has been with Crown for over 14 years. Derek is Crown's representative on the National Biodiesel Board, the trade organization that represents the biodiesel industry in the United States. Derek attended the University of Minnesota and received a Bachelor of Science in Chemical Engineering.

Robert McCormick is a Principal Engineer in the Fuels Performance R&D Group at the National Renewable Energy Laboratory. He holds a doctorate in chemical engineering and has worked in fuel processing, catalysis, and fuel utilization R&D for more than 20 years in industrial, academic, and government environments. He has been engaged in R&D on biodiesel utilization since 1994. Research areas include fuel and blending component quality and quality specifications, stability, compatibility with modern engines and infrastructure, pollutant emissions effects, and impact on engine and emission control system durability. Bob is a recipient of numerous awards, including the MRI National Biodiesel Board's Eye on Biodiesel Innovation Award (2006).

Bryan Moser received his PhD in organic chemistry in 2004 from Arizona State University and is currently employed as a research chemist at the USDA ARS National Center for Agricultural Utilization Research (Peoria, IL, USA). The emphasis of his work is on evaluation of alternative feedstocks for biodiesel production and the development of bio-based additives that address the low temperature operability issue of biodiesel. Other research interests include naturally occurring compounds as oxidative stability additives, along with the influence of chemical structure on fuel properties of biodiesel.

Claudio J.A. Mota was born in Rio de Janeiro, Brazil. He studied Chemical Engineering at the Federal University of Rio de Janeiro, where he also obtained his doctoral degree in Chemistry. He worked in the Petrobras Research Center for 11 years carrying out researches on cracking chemistry and acidity of solid acids. In 1997 he moved to the Institute of Chemistry of the Federal University of Rio de Janeiro, where he is presently an associated professor. He has been as invited professor in the University of Strasbourg, France, where he has a long-term collaboration in hydrocarbon chemistry. He also has collaborations with research groups in Argentina and Mexico. Together with the Mexican partner, he won in 2000 the Third World Academy of Science (TWAS) Award, sponsored by the Mexican Academy of Science. In 2007 he received the Technology Award of the Brazilian Chemical Industry Association (ABIQUIM) for his work in biomass transformation.

He is member of national and international scientific societies, as well as research fellow of the National Research Council (CNPq) and the Rio de Janeiro Research Foundation (FAPERJ). He participates in the Brazilian Biodiesel Technology Network of the Ministry of the Science and Technology, as one of the coordinators of the co-product area, mostly related with glycerin conversion. He is author and co-author of over 70 scientific articles and 9 patents. His present research interests are focused on catalytic processes of oil refining, natural gas conversion and biomass transformation, with emphasis on the molecular aspects and innovative solutions.

Chuck Mueller is a Principal Member of the Technical Staff in the Engine Combustion Department at Sandia National Laboratories' Combustion Research Facility in Livermore, California, where he has been employed since 1996. Mueller received B.S. degrees in Aeronautics and Engineering Physics from Miami University in 1991, and M.S.E. and Ph.D. degrees in Aerospace Engineering from the University of Michigan in 1993 and 1996, respectively. His research interests include employing laser, imaging, and other advanced diagnostics in an optical engine, to better understand the effects of bio-derived and other emerging fuels on in-cylinder combustion processes.

K. Y. Simon Ng received his BSE, MSE, and PhD in chemical engineering from the University of Michigan, Ann Arbor. He is currently a Professor of Chemical Engineering and Materials Science of Wayne State University (WSU), a Gershenson Distinguished Faculty Fellow, the founding director of WSU's Graduate Programs in Alternative Energy Technology, and the director of the WSU/NextEnergy National Biofuels Energy Laboratory. He has published and presented over 250 research papers in energy and materials research area. Dr. Ng is a member of Council of Energy Research and Education Leaders, American Institute of Chemical Engineers, American Oil Chemists Society, North American Catalysis Society, and ASTM International. Recently, he served as a special advisor to the Michigan Renewable Fuel Commission.

John Nuszkowski performs research in heavy-duty vehicle performance and emissions as a research assistant professor for the internationally recognized Center for Alternative Fuels, Engines and Emissions (CAFEE) at West Virginia University (WVU). After completing his B.S. in mechanical engineering at the Rochester Institute of Technology (RIT), Dr. Nuszkowski went to WVU for the diesel engines research program and earned his M.S. and Ph.D. He is a member of the Society of Automotive Engineers (SAE) and American Society of Mechanical Engineers (ASME) with the publication of three journal papers and six conference papers.

Simoni M. Plentz Meneghetti obtained her PhD in physico-chemistry of macromolecules at the Louis Pasteur University (Strasbourg I) France, in 2000. She has almost 15 years of experience in chemical and petrochemical industry. After a postdoctoral position at Federal University of Alagoas (Maceió – Brazil), she became a Professor of Inorganic Chemistry at same University (2006). Her research interests are centered in catalysis and oleochemistry and she is carrying out several research projects concerning the development of catalysts to obtain alternative fuels derived from vegetable oils and substitute crops to obtain biofuels.

Wolter Prins obtained his master degree in Chemical Engineering from the University of Groningen in The Netherlands, and his doctor degree from the University of Twente in Enschede, The Netherlands. In 1984, he was as an assistant professor in Professor Van Swaaij's Reaction Engineering Group at the Department of Chemical Technology. In 1992, he started the R&D group of BTG Biomass Technology Group bv in Enschede (www.btgworld.com) and stayed there as R&D leader in a 0.6 part-time position until 2008. In 2004, he became shareholder and director of BTG's shareholder company. In his other (0.4) part-time position as an associate professor at the University of Twente, he developed from 2000 to 2008 a new biomass research group together with his colleague dr. S.R.A. Kersten. (tccb.tnw.utwente.nl). Recently, the University of Ghent in Belgium offered him a position as a full professor in Bioresources Processing (appointment per May 1, 2008 in the faculty of Bioscience Engineering) with the mandate to start, once again, a research group in thermochemical biomass conversion. Wolter Prins has published around a hundred papers in the area of novel gas-solid reactors, heat and mass transfer in fluidized beds, and thermochemical conversion of biomass. He was closely involved in the development of the so-called rotating cone technology for fast pyrolysis of biomass which was demonstrated in the past few years in Malaysia for bio-oil production from empty palm fruit bunches.

Guido Reinhardt took his PhD in natural sciences at the University of Heidelberg. He is member of the scientific board of IFEU and scientific director of the department "Sustainability of renewable energies and biobased systems". Since he joined IFEU in 1991, he has been working in the fields of life cycle assessment (LCA), transport and environment as well as environmental assessments of food, energy, industrial crops, and biobased materials. Guido Reinhardt is a consultant for national and international institutions like the European Commission, the IEA as well as German federal ministries and a member of several advisory panels, e.g. at the Ministry of Agriculture in Lower-Saxony.

Claudio Rocchietta has more than 30 years of international operational/general management experience in agribusiness, with the last 15 years specifically in biofuels. In July 2005, he founded BFP. Currently, he is CEO of OXEM, the largest biodiesel plant in Italy (under construction), as well as the CEO of BIM (a new co. for the construction of a crushing/biodiesel plant in Romania). Furthermore, Claudio currently holds various board directorships which include: Greenergy Biofuels Ltd (London), WEC (World Energy Council). Previously (1992-2005) he was CEO of NOVAOL (a pioneer in the biodiesel development – as of 2001 part of BUNGE Group) which grew to become one of the European leaders in biodiesel production, with activities in Italy, France, Austria and Germany. During the same period, he was General Manager of ERIDANIA, Italy (sugar, oilseeds and agribusiness). In the early 1990s, he was responsible for "green chemistry" strategy for Ferruzzi – Montedison Group, which ended up with the foundation of NOVAOL. Prior to this he spent four years as M&A director for Ferruzzi Group's

Oilseed division, where he led acquisitions in US, France and Spain and became a Board Member in Central Soya (USA), Lesieur (France), Koipe (Spain) and Calgene (USA). Early on in his career, Claudio worked in specialty chemicals and in agribusiness in various commercial and management functions with W.R.GRACE and CARGILL (1970-1987).

Debbie Rosenblatt is an emissions inventory analyst with the Canadian Federal Government of Canada. For more than 13 years she has worked at Environment Canada's Emissions Research and Measurement Section. During this time, Ms. Rosenblatt has managed research studies and programs on alternative and reformulated fuels, propulsion systems, off road mobile sources, and emission control technologies. Along with managing projects, Ms. Rosenblatt is continually developing collaborative programs with other government departments, industry, academia, and international governments and agencies. She received a Bachelor of Science from the University of Guelph in Canada.

Shiro Saka earned a Ph.D. in Wood Science from North Carolina State University in 1980. In 1996, he became a Professor in the Graduate School of Energy Science, Kyoto University, mainly working on supercritical science and technology of the biomass conversions to biofuels such as biodiesel, bioethanol and biomethane etc. He is the former President of Biomass Division, Japan Institute of Energy, and currently the Editor-in-Chief of the Journals of Wood Science and Mokuzai Gakkaishi, The Japan Wood Research Society, and Guest Editor in Bioresource Technology, Elsevier.

Dave Sams serves as the Vice President for Business Development at Catilin, Inc, a technology company focused on the development of catalytic solutions to today's renewable energy problems. Prior to joining Catilin, Dave served as the VP - Business Development for ORYXE Energy and has also held various technical and management positions with W.R. Grace & Co. and Shell Oil Company. Dave earned his PhD and Master's degrees in Chemical Engineering from the University of Arizona where he studied potassium catalyzed coal gasification and a bachelor's degree in Chemical Engineering from the University of Minnesota.

Sigurd Schober was born in 1971 in Graz. After studying chemistry at the University of Graz (MSc on polymer characterization by NMR), he joined the Department of Organic and Bio-organic Chemistry for his PhD. During his PhD thesis (topic stability of fatty acid derivatives), he engaged in several National and European funded projects dealing with biodiesel issues. After completing his PhD (2006), he has worked as post doc; since 2008 he has worked as research scientist within the Working Group for Renewable Resources at the Institute of Chemistry/University of Graz. His main working field concerns analytical developments for fat/oil as well as biodiesel characterization inclusive trainings on analytical techniques. He has engaged in different EU funded projects on analytical issues as well as improvement of biodiesel properties and alternative use. In addition, he is the author of several papers on biodiesel stability and analytical topics.

Olaf Schröder is scientist in the Institute of Agricultural Technology and Biosystems Engineering, Johann Heinrich von Thünen-Institut since 1996. His fields of work are regulated and non regulated compounds in exhaust gas of diesel engine running with biogenic fuels. He studied chemistry at the Technical University of Braunschweig and finished with diploma in 1996.

Don Scott serves as Director of Sustainability for the National Biodiesel Board. Don's program areas build science and awareness to ensure that biodiesel production meets today's needs for environmental stewardship, economic prosperity, and quality of life without compromising future generations' ability to meet these needs for themselves. Don is a licensed Professional Engineer with a civil engineering degree from the University of Missouri–Columbia. Prior to joining the National Biodiesel Board, Don was an Environmental Engineer for the Missouri Department of Natural Resources. His work there focused on protecting clean, plentiful drinking water. Don enjoys driving and working on diesel engines, and joined the NBB team to help the biodiesel industry grow as a sustainable alternative to traditional transportation fuels.

Barbara Stefl is a chemical engineer by training, and attended the University of Notre Dame and Texas A&M University for her B.S. and M.S., respectively. After working for Union Carbide Corporation in research & development for 12 years, she received her MBA from Marshall University and joined Cognis Corporation, working in sales & marketing for agricultural products. Currently, she is the Global Business Director for Cognis' QTA Business, which uses a networked system of infrared spectrometers to analyze biodiesel, in addition to many other chemical, food and agricultural products.

Bryce J. Stokes is a Senior Advisor with Navarro Research and Engineering, Inc., U.S. DOE Golden Field Office, Golden, CO, after recently retiring from the U.S. Forest Service. He is providing support to the DOE feedstocks program. He received his BS and MS from Mississippi State University in Engineering and PhD from Auburn University in Forestry. He worked as a Forest Engineer for Weyerhaeuser Company prior to joining the USDA Forest Service in Auburn, Alabama as a Research Engineer. He later served as Project Leader for the Engineering Unit at Auburn and then served as National Program Leader for Forest Operations Research as part of the Resource Use Sciences Staff in the R&D Washington Office. His 30 years of research focused on harvesting machine and system design and management; biomass recovery and utilization; reducing forest operations environmental impacts; and specialty systems for pine thinning and wet area harvesting. During his career he also had staff co-responsibility for biomass, carbon sequestration, climate change, and sustainability with his Agency, Department, and in federal interagency working groups. He had co-responsibilities in industrial partnerships for forest productivity and life-cycle analyses. He previously served in a support role for the USDA Energy Council and is Past Chair of the USDA Biobased Products and Bioenergy Coordination Council and the Federal Working Group on Woody Biomass Utilization. He is active in the Council on Forest Engineering, Forest Products Society, and the American Society of Agricultural and Biological Engineers. He served as

a U.S. representative to International Energy Agency tasks on conventional forestry and short-rotation crops for energy 10 years. He has over 140 scientific and technical publications.

Paulo Anselmo Ziani Suarez was educated at the Federal University of Rio Grande do Sul (Porto Alegre, RS, Brazil), where received Bachelor of Chemical Engineering (1993), Master in Chemistry (1996) and Doctor in Materials Sciences (2000) degrees. In 1998 spent one-year term at the Université Louis Pasteur (Strasburg, France) as part of his PhD studies. Professor at the Institute of Chemistry at the University of Brasilia since 2001 and Researcher of the National Council for Scientific and Technological Development (CNPq, a foundation linked to the Ministry of Science and Technology of Brazil) since 2003. Was Visiting Scientist at the USDA/ARS/NCAUR lab in Peoria, Il-EUA, four times in the last years. Received the Prize *MERCOSUL of Science and Technology – 2004*, Energy, from UNESCO, in August, 2005; the Prize *Petrobras of Technology* – 2006, from Petrobrás, in October, 2006; and the Prize *Scientist in Catalysis – 2007*, from the Brazilian Society of Catalysis, 2007. Authored up to 58 scientific papers, 3 book chapters and 1 book and holds 6 patents. According to ISI/Web of Science was cited 3,600 times (H index 18).

Haiying Tang received her MSE and PhD in chemical engineering from Wayne State University (WSU) in Detroit, Michigan. She is currently an assistant professor (research) of National Biofuels Energy Laboratory (NBEL) of Wayne State University & NextEnergy. She has extensive research experience in alternative energy technologies, biomedical devices, nanostructures, thin films, and engineering experience in petrochemical industries. Her research interests at NBEL include investigating the precipitate formation for biofuels and its blends at low temperature; strengthening biodiesel fuel specifications and standards; evaluating the effect of antioxidants on oxidation stability of fuel; the development of the non-food crop based feedstock for biodiesel. Dr. Tang has coauthored over 20 publications and 40 presentations.

Jordan Thaeler is the Technical Projects Manager for the National Biodiesel Board. Jordan joined the NBB in 2008 and holds degrees in biological engineering and finance from the University of Arkansas. Before coming to the NBB Jordan maintained an analyst position with Merrill Lynch.

Roland Verhé is Director of the Department of Organic Chemistry, Ghent University. He obtained his PhD at Ghent University in 1972. His research interests involve organic synthesis and the chemistry and technology of lipids for food and non-food applications. Research topics are dealing with determination of minor compounds in oils, the quality of specialty oils and the use of various lipid resources for biodiesel and biofuels. He is the coordinator of various international educational programmes in the field of food sciences and renewable resources.

Rudolf Wagner obtained a PhD degree in Chemistry in the University of Adelaide (Australia). After working for several years at Hoechst (near Augsburg in Bavaria) he joined Bayer AG. He spent several years in the Central Research Division and as plant manager in the Plastics Manufacturing Division before changing to the Lewatti ion exchange resins group, where he has been responsible for the global technical marketing of resins in specialty applications.

Mohd. Basri Wahid is currently the Director-General of Malaysian Palm Oil Board (MPOB). Entomologist by training, Dr. Basri holds an Executive MBA degree from Asian Institute of Management; Ph.D from University of Guelph, Canada and M.Sc. and B.Sc. from Lincoln College, New Zealand. He began his career at the then Palm Oil Research Institute of Malaysia (PORIM) in early 1982 as a research officer in the Biology Division. From 1990 onwards he has quickly moved up the management hierarchy to become the Director-General; a position he holds since January 2006. Dr. Basri holds several patents and is a life member of Malaysian Plant Protection Society, a member of Entomology of Malaysia, MARS, AIM Club and alumni member of Lincoln University. He is also a Fellow of the Malaysian Academy of Science.

Yomi Watanabe currently works as Chief Research Scientist at the Lipid Engineering Laboratory of Osaka Municipal Technical Research Institute (Osaka, Japan), researching novel enzymatic methodologies in oil processing. She received her BA in Chemistry and PhD in Agriculture from Kyoto University (Kyoto, Japan).

Nadya Zyaykina joined the R&D division of Desmet Ballestra in 2006, where she is currently involved in biodiesel related research projects. She graduated as chemical engineer from Mendeleev University of Chemical Technology of Russia in 1999. In 2001, she obtained Master in Human Ecology from Free University of Brussels. Nadya holds a degree of Doctor in Applied Sciences (again from Free University of Brussels, 2005) for research in the field of dioxins and related chloroaromatic compounds.

Antitrust Policy

The American Oil Chemists' Society (the "Society") intends to strictly comply with the antitrust laws of the United States, all state governments, and any other relevant governing authority (the "Antitrust Laws"), and in furtherance of this intention, proclaims the following Antitrust Policy:

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