

### AFTERNOON

#### PRO 1: New Technology

---

Chair(s): D. Litle, Süd-Chemie Inc, USA; and R. Nyachoto, California Oils Corp., USA

**Innovation - An Instrumental Initiative in Palm Processing.** Rajan Skhariya, Mecpro Heavy Engineering Ltd., New Delhi, India

Palm Kernels are important by-products for oil palm mills. They constitute about 45-48% (by weight) of the palm nut of the oil palm. On a wet basis, the kernel contains about 47-50% (by weight) of oil, whose properties and characteristics are quite different from Palm Oil. At present, the prevalent practice is Mechanical Extraction of oil, using screw press besides prepressing followed by Solvent extraction. MECPRO, has recently been able to develop innovative state of the art process technology of direct Solvent Extraction of Palm Kernel using Expander, wherein, production costs are reduced significantly. In this process the oil recovery is more, besides, the energy consumption is substantially reduced. Major breakthrough, has also been achieved in the extraction of oil from Empty Fruit Bunch & Palm Fibre by using flammable and or non-flammable solvent, which is a revolutionary technology for the Palm Oil Industry, not only to make it energy efficient and environment friendly, but also to have value addition from the downstream project. A virtuous cycle of growth of Palm Oil Milling & Refining sector that is already underway is likely to continue, driven by the robust performances through the technological innovations, which are truly indispensable. To achieve better recovery of oil from the Palm Oil Mill, several technological innovations have been developed which will enhance the OER up to 1% of FFB processed, besides, significant reduction in effluent and oil content in the effluent. The specially designed solvent extraction plant using five patented technologies will not only be safe but environment friendly, as well. The oil extracted from palm fibre will be rich in Beta Carotene having more than 3000 PPM, which can be further extracted. The oil extracted can be used for Carotene extraction, poultry feed, soap manufacturing or bio-diesel. Since the capital investment can be recovered within the span of two years in the proposed technology, it makes economically viable option for Palm Oil Mills to invest in this downstream project. The utility required for the project is the exhaust steam from the mill turbine. With our patented technologies, the consumption of flammable or non-flammable solvent used for extraction will significantly be reduced to less than 2.5 liter/mt. The process is fully continuous, PLC controlled, consume 19 kW/mt of power and can be accommodated in existing mill complex.

**Nano Neutralization™?The Next Generation in Chemical Refining.** Eric Svenson, Desmet Ballestra North America, Marietta, GA, USA

Refiners of vegetable oil are constantly making adjustments to their process that positively impact quality, efficiency and sustainability. Nano Neutralization™ is a new tool that is proven to improve efficiency and sustainability while maintaining quality. Nano Neutralization™ uses intense hydrodynamic cavitation technology to physically break the weak metal bonds of the non-hydratable phospholipids in milliseconds. Vegetable oil is pumped through scientifically designed geometries, dramatically dropping pressure at multiple stages. Water in the oil vaporizes and recompresses to liquid at each stage, creating shockwaves that break the weak metal bonds of the non-hydratable phospholipids to make them hydratable. Nano Neutralization™ has been found to drastically reduce chemical consumption. Phosphoric acid that was previously used to chemically cleave the metals from the non-hydratable phospholipids is nearly eliminated. With no need to neutralize excess phosphoric acid, and the outstanding mixing in the reactor, the quantity of caustic soda required approaches the stoichiometric amount necessary to neutralize the FFA, which is also a significant reduction. By reducing excess caustic, there is less saponification of oil into soap and a much cleaner

separation in the centrifugal separator. This results in a valuable increase in oil yield as less oil passes with the soapstock. The cleaner separation also results in less soap remaining in the oil. Less soap in the oil reduces the amount of silica or water wash needed to remove the soaps prior to bleaching. Nano Neutralization™ is putting modern science behind caustic refining technology.

#### **Emulsification-free Degumming of Oil.** G. Chou, Sunho Biodiesel Corporation, Taipei, Taiwan, R.O.C.

Conventional enzymatic degumming processes involve emulsification, which poses many disadvantages. For example, a high shear mixer, an expensive instrument, is required to effect emulsification. Consumption of lipase, whether it is a free lipase or an immobilized lipase, contributes to significant cost. Furthermore, oil loss due to emulsification is unavoidable and a centrifuge for effective separation of oil and gum is required. For these reasons, the enzymatic degumming process becomes non-cost-effective. In this presentation, the conventional understanding of the requisites of emulsification with regard to enzymatic degumming will be shown to be incorrect. It will be proven that enzymatic degumming can be carried out without emulsification. It follows that all of the disadvantages addressed above can be overcome through a suitable process design. This makes the enzymatic degumming process not only a cost-effective process but also a completely environmentally friendly (total green) one.

#### **Nutritive Shortenings Produced from Regioselective Hardening of Soybean Oil with Pt Containing Zeolites.** A. Philippaerts<sup>1</sup>, S. Paulussen<sup>1</sup>, S. Turner<sup>2</sup>, O.I. Lebedev<sup>2</sup>, G Van Tendeloo<sup>2</sup>, P. Jacobs<sup>1</sup>, B Sels<sup>1</sup>, <sup>1</sup>KU Leuven, Heverlee, Belgium, <sup>2</sup>University of Antwerp, Antwerp, Belgium

Catalytic hydrogenation of vegetable oils is a well-known process in food industry to make the oil more resistant against air autoxidation and to obtain fats with a certain melting profile. Unfortunately, hydrogenated edible oils have negative health impact, due to the cis/trans isomerization of the double bond, occurring in parallel with hydrogenation. Despite the known low trans fat products, Pt catalysts usually suffer from a low hydrogenation selectivity, i.e. they lead to high levels of trisaturates, which are associated with a sandy mouth feeling. In contrast, shape-selective Pt/ZSM-5 catalysts are capable of hydrogenating common soybean oils into stable (devoid of C18:3), essentially trans-free fats with extraordinary plasticity, very useful for high-nutritive bakery shortenings. Thorough analysis of the Pt/ZSM-5 hydrogenated triglyceride fraction showed a unique fat composition, highly enriched in OSO, resulting from a higher hydrogenation activity of the central (sn-2) fatty acids compared to the outer (sn-1/3) fatty acids of the triglycerides. We can thus conclude that the improved selectivity obtained with the Pt/ZSM-5 catalyst results from a unique regioselectivity, which hinders the formation of fully trisaturates. This unique regioselectivity was further evidenced with the hydrogenation of pure triglycerides.

#### **Design of Ru-zeolites for the Hydrogen-free Production of Conjugated Linoleic Acids and Conjugated Oils.** A. Philippaerts<sup>1</sup>, J. Van Aelst<sup>1</sup>, S. Goossens<sup>1</sup>, M. Tromp<sup>2</sup>, S. Turner<sup>3</sup>, G. Van Tendeloo<sup>3</sup>, P. Jacobs<sup>1</sup>, B. Sels<sup>1</sup>, <sup>1</sup>KU Leuven, Heverlee, Belgium, <sup>2</sup>Technische Universitat Munchen, Garching, Germany, <sup>3</sup>University of Antwerp, Antwerp, Belgium

Conjugated linoleic acids (CLAs) and conjugated vegetable oils are interesting compounds in the coatings, paints and polymer industries as well as in the food industry. While the isomer distribution is not important for the industrial applications, the type of CLA isomer is crucial for their beneficial effects on physiological properties. This contribution presents the direct production of CLAs over Ru supported on zeolites. Ru/Cs-USY was identified as the most active and selective catalyst for isomerisation of methyl linoleate to CLA at 165°C. Interestingly, no hydrogen pre-treatment of the catalyst or addition of H-donors is required to achieve industrially relevant isomerisation productivities. Moreover, the biologically most active CLA isomers, viz. c9,t11, t10,c12 and t9,t11, were the main products. The Ru/USY(40) catalyst was also tested in the isomerization of vegetable oils. Because of the particular synthesis procedure, extra mesopores are created in the USY support facilitating transport of the bulky triglyceride molecules to the active centers of the catalyst. As an example, the isomerization of safflower oil at 180°C under N<sub>2</sub>, yielded after 2 hours 75 mg CLA/g oil with a very high specific yield, viz. 377 g(CLA)/(g(metal).h). Moreover, only very low amounts of undersirable C18:1 trans were analyzed.

#### **Improving the Efficiency of Lipases in Interesterification by Neutralization of Mineral Acidity.** W.D. Cowan<sup>1</sup>,

H.S. Yee<sup>2</sup>, H.C. Holm<sup>3</sup>, <sup>1</sup>Novozymes UK, Chesham, Bucks, UK, <sup>2</sup>Novozymes malaysia, Kuala Lumpur, Malaysia, <sup>3</sup>Novozymes A/S, Bagsvaerd, Denmark

Enzymatic Interesterification is now widely used for the production of modified fats for margarines and shortenings. Mineral acids coming from bleaching earths or as residues from phosphoric acid degumming have been shown to have a negative effect on enzyme performance. To maximise the conversion efficiency and obtain the longest working life for the catalyst these acids need to be removed. Simple neutralisation with alkali has been investigated but the reaction was not specific for mineral acids. This paper reports on investigations made into different techniques that could be used to remove the acidity without having other negative effects such as column blocking or difficulty in application. A simple method to remove mineral acids will be described as well as results from its practical application.

**Mitigation of 3-MCPD and G Esters in Refined Palm Oils.** Frank Pudel<sup>1</sup>, Bertrand Matthäus<sup>2</sup>, Anne Freudenstein<sup>2</sup>, Tim Rudolph<sup>1</sup>, <sup>1</sup>Pilot Pflanzenöltechnologie Magdeburg e.V., Magdeburg, Germany, <sup>2</sup>Max-Rubner-Institute, Detmold, Germany

Although fatty acid esters of 3-chloropropane-1,2-diol (3-MCPD) and glycidol (G) were found in any type of refined vegetable oil, refined palm oil is the most critical source of these contaminations. Additionally, it has the world leading position in usage for food purposes. There are two ways to mitigate the formation of 3-MCPD and G esters in refined palm oils: a) by changing the refining process and b) by selection of appropriate palm fruits respectively crude palm oils. The presentation will show the final results of a joint research project initiated by the German food industry and supported by the Research Association of the German Food Industry (FEI) regarding to point a and b of the mitigation strategies (AiF-project No. BG 16004). E.g., chemical refining (degumming, neutralization, bleaching) as well as a single additional washing step, the use of citric acid or diacetin during deodorization, the application of a two temperature deodorization regime or of short path distillation for gentle ffa removal are suitable means leading to lower amounts of 3-MCPD and/or G esters. Furthermore, some indications to raw material treatment before processing will be given.

**In situ Destruction of MCPD and Glycidyl Esters During Triglyceride Production.** J. Rongione, J. Heydinger Galante, Stepan Company, Maywood, NJ, USA

Monochloropropanediol (MCPDs) and glycidyl esters have become the focus of increased regulatory, academic and industry attention. Their presence in vegetable oils has been linked to deodorization. Our data indicates these species can also be formed during the esterification of glycerol. Several processes have been developed to reduce the level of MCPDs in oil streams. These methods do decrease MCPD levels but depend on physical removal of the species. We wish to reveal a process which involves the in situ destruction of MCPD and glycidyl esters via reaction with carboxylate salts. This chemistry effectively reduces levels of MCPD and glycidyl esters below detectable limits during the esterification reaction and/or in the treatment of previously formed oil streams. Introduction of carboxylate salts into the oil production process or treatment of oils streams after deodorization effectively removes these species from the oil stream. The carboxylate ion can be chosen to preserve the fatty acid distribution of the treated oil stream or to facilitate removal after MCPD destruction. Stoichiometries, anion choice and reaction parameters will be discussed.

**Best Practices and Opportunities for Optimization and Conservation in Hydrogenation of Fats and Oils.** Walter Farr<sup>1</sup>, Nancy Easterbrook<sup>2</sup>, <sup>1</sup>Walter E. Farr and Associates, Memphis, TN, USA, <sup>2</sup>Air Products & Chemicals, Allentown, PA, 18195

"The Reports of My Death Have Been Greatly Exaggerated" Mark Twain. This same thought holds true for the unit operation of hydrogenation within the edible oils industry. In spite of the migration to low trans products, hydrogenation still continues to be an important production step. The hydrogenation process offers significant opportunities for manufacturers interested in reducing costs, improving efficiency, and improving their plant's sustainability profile. Engineers may obtain these benefits by turning their attention to two basic areas: the supply of hydrogen gas, and the hydrogenation reaction process. This paper will describe advances in the field of gaseous

hydrogen supply in which modern compact steam methane reformers better fit the smaller hydrogen requirements of today's refinery. In addition, the hydrogenation process step will be reviewed with particular emphasis on best practices which result in the conservation of energy and/or hydrogen. While hydrogenation is a mature operation in a mature industry, this paper will demonstrate that there is still considerable room for improvement in the hydrogenation plant.

## TUESDAY

## MORNING

### **PRO 2: Plant Operations and Safety**

---

Chair(s): J. Willits, Desmet Ballestra North America Inc., USA; and M. Snow, Bunge North America Inc., USA

**Pinch Technology in Practice Today.** B. Pretty, Andrew McMullan, KBC Advanced Technologies Inc., 13873 Park Center Rd., Virginia, USA

Pinch Technology, also known as Process Integration techniques, have now been actively employed in the manufacturing industries as an energy efficiency tool for over 25 years. Born in the hey-day of the 1980's energy crisis, Pinch methods and tools are now seeing a resurgence of interest in the face of energy price uncertainties, global climate change concerns, and regulatory pressures for greenhouse gas emissions reductions. This presentation will cover the Pinch basics for identifying energy savings potential in any energy system through targeting techniques and the underlying design techniques that turn a target into a real energy savings opportunity. While most effective if employed during the design stage of new plant or process unit developments, Pinch has been, and continues to be successfully utilized in existing plant retrofit situations. The importance of understanding the relationship between the way energy is recovered within processes and the way it is delivered to those processes - known as the process/utility interface - will also be discussed

**Crystallization and Processing Technology.** Klaus Funch Hoeyer, SPX Flow Technology, Soeborg, Denmark

SPX (previously Gerstenberg Schröder A/S) is one of the main suppliers of processing equipment for the oil and fat industry worldwide. The purpose of this presentation is to share the knowledge and experience in processing of fat products. The optimal processing line for margarine, including the general processing parameters which significantly affect the efficiency of the processing line and the quality of the final products, will be covered. Important parameters for margarine production, such as choice of fat blend, configuration of the line, capacity of the line, cooling intensities, pin rotor machine volume and resting tube volume will be covered. Furthermore, the processing benefits of using CO<sub>2</sub> as refrigerant will be presented. The new scraped surface heat exchanger named Nexus from SPX is based on this technology.

**Plant Safety, a New Dimension – Food Safety Modernization Act Impact on Food Safety and Security in Plant Operations.** D. Strayer, Bunge North America, St. Louis, MO, USA

Traditionally, a new employee or visitor to a processing plant is given personal safety equipment and reviews the plant's personnel safety requirements before entering a production area. That individual is then charged with following and obeying all company and OSHA safety regulations while they are on the property. With the new Food Safety Modernization Act (FSMA), passed by Congress in 2010, the responsibility of that individual expands beyond just personal safety practices to include the safety and security of the products produced within that plant. FSMA mandates that all employees and visitors in a processing facility are responsible for insuring that the quality and wholesomeness

of the final product meets both the company's standards and complies with FDA requirements. This new FSMA law gives the FDA new responsibility and authority as well as directing them to write and implement fifty new regulations and guidances covering many aspect of the manufacturing process. This paper will review those new laws and directives, and then examine their impact on the individual, the company, and the consumer.

**Ammonia Refrigeration, Safe Design and Operation.** D. Sweet, Synergy, Kennesaw, GA, USA

The ammonia refrigeration industry is subject to numerous government regulations throughout the world. Some of the standards and regulations a typical refrigeration system in the United States may will be discussed. Even the most skeptical among us must admit that these standards and regulations have been valuable in encouraging facilities to design and operate safer ammonia refrigeration systems. For example, years ago most facilities were relatively unaware of the amount of ammonia losses from their refrigeration system. Now a typical facility will measure, control and minimize the ammonia losses from its refrigeration system. So it is fair to say that these standards and regulations have raised the bar for ammonia safety. In general, these standards and regulations have the following objectives in mind: - Identify and assess the hazards associated with releases of potential hazardous chemicals; - Design a safe facility to prevent these releases; - Operate a safe facility and train facility personnel to prevent releases; - Minimize the consequence of releases that occur.

**Application of Chlorophyllase Enzymes in Oil Processing.** J. B. Soe, R. Mikkelsen, H. Vestergaard, T. Jorgensen, K. Carlson, L. Lauridsen, DuPont Industrial Biosciences, Brabrand, Denmark

Vegetable oils derived from oilseeds such as Soybean and Rape Seed (Canola) typically contain some chlorophyll components which have to be removed in the final oil. This is because chlorophyll imparts an undesirable green color and can induce photo oxidation of oil during storage, leading to a deterioration of the oil. The enzyme chlorophyllase can be applied in oil processing to degrade chlorophyll pigments and generate good quality oils. We have conducted small pilot scale trials with experimental chlorophyllases and will present data from these trials, process optimization and various oil quality parameters.

## AFTERNOON

**PRO 3/EXH 2: Processing Exhibitors' Session**

---

Chair(s): T. Neuman, GEA Westfalia Separator Inc., USA

**Oilseed Preheating Heat Recovery Optimization.** Farah Sköld<sup>1</sup>, Etienne Le Clef<sup>2</sup>, <sup>1</sup>Solex Thermal Science Inc, Calgary, AB, Canada, <sup>2</sup>Desmet Ballestra Group, Zaventem, Belgium

The use of waste heat from various sources within a crush plant can result in substantial savings on overall energy consumption. The use of waste heat in from of hot water can lower or in some cases eliminate the steam consumption during pre-heating/conditioning step in the preparation plant. The optimized heat recovery loop is based on low maintenance equipment that provides optimal thermal performance. The design offers operational flexibility to enable operator to handle varying feed input conditions. Moreover the system allows the use of different heat sources, hot water and steam. With changes in availability of recovered energy during normal or plant upset conditions the system can be adjusted to provide desired outlet seed properties.

**Setting New Benchmarks for Efficiency and Productivity.** Pablo Garcia, Siemens Industry, Inc., Spring House, PA, USA

The world of oils and fats is rapidly changing. Soaring prices for raw materials, energy and increasingly stringent regulations are forcing companies to look for efficient solutions to remain competitive while ensuring consistent product quality. To enable successful edible oil production, Siemens offers a range of products, solutions and services tailored to your unique requirements. Modern automation systems not only provide efficient operation, but also focus on transparency, energy conservation, reliability and availability. Transparency helps to better understand a company's own production and identify new optimization potential. Material and Tank Management tools provide real time data on storage location content, properties and operational status, and provide the necessary information to help make correct decisions and avoid potential operational errors. Material transports can be planned, controlled, monitored and diagnosed while each movement is recorded and stored via an Archive Manager, providing tracking and tracing capabilities. Energy conservation is accomplished with energy-efficient drives and smart motor control centers providing the necessary information for intelligent power management. Diagnostic capable products support preventive maintenance, lower maintenance costs and increase reliability. The result: an automation system that controls, manages the energy and monitors the condition of plant assets.

**New Innovations in Oil Seed Preparation.** Charles Brockmeyer, Buhler Inc., Plymouth, MN, USA

**BASF: Catalyst and Adsorbent Supplier to the Oleochemical and Biorenewable Industries.** Doug Okonek<sup>1</sup>, Thorsten von Fehren<sup>2</sup>, <sup>1</sup>BASF Corporation, Beachwood, Ohio USA, <sup>2</sup>BASF SE, Ludwigshafen, Germany

**Purification of Glycerin from Biodiesel Plants.** Perry Alasti, Artisan Industries Inc., Waltham, MA, USA

With the expected growth of biodiesel production in North America thanks to the passing of RFS-2, coupled with the global political turmoil causing oil prices to reach \$100/barrel and higher, we can expect a glut of crude glycerin in the coming years, as more biodiesel plants come on stream and existing plants will begin to ramp up production. Refining glycerin to various purities will be instrumental in insuring profitability regardless of feedstock and energy costs. We will present Artisan's refining process and compare it with two alternate processes currently available in the market.

**Design Aspects of a Modern Pressing Plant.** H.C. Boeck, HF Press+LipidTech, Hamburg, Germany

## WEDNESDAY

## MORNING

### **PRO 4: General Processing**

---

Chair(s): J. Mulholland, N. Hunt Moore & Assoc Inc., USA; and B. Cooke, Dallas Group, USA

**Efficient Recovery of Sterols and Tocopherols in Deodorizer Distillates : Myths and Facts.** W. De Greyt<sup>1</sup>, J. Willits<sup>2</sup>, B. Schols<sup>1</sup>, M. Kellens<sup>1</sup>, <sup>1</sup>Desmet Ballestra Group, Zaventem, Belgium, <sup>2</sup>Desmet Ballestra North America, Marietta, GA, USA

Deodorizer distillate (DOD) is one of the side streams of the refining process with a high valorisation potential. In case of physical refining (like for palm oil), DOD is valorized as a source of FFA. Improvements in the deodorizer design are aiming to increase FFA levels in the DOD to > 90%. DOD from chemical refining mainly consists of FFA, neutral oil and unsaponifiable matter (mostly tocopherols and sterols). High concentrations can be reached (only) when oils rich in tocopherols/ sterols (soybean oil, corn oil, ...) are deodorized under the right process conditions and with a properly designed deodorizer allowing maximum stripping and recovery in the distillate. An overview of the potential of different vegetable oils for tocopherol/sterol stripping will be given and factors affecting the stripping of tocopherols and sterols will be discussed. Optimized deodorizer design for the production of high value DOD rich in tocopherols and sterols will be presented.

### **Formation of 3-MCPD/Glycidyl Esters During Processing of Edible Oil; Current State of Knowledge.** K.

Hrncirik, A. Ermacora, Unilever R&D, Vlaardingen, The Netherlands

Two classes of processing contaminants formed during refining of edible oils and fats – the fatty acid esters of 3-monochloropropan-1,2-diol (3 MCPD) and glycidol – received significant attention within the last few years. Since refined oils are used in a wide range of food products (either as ingredients or as a medium during processing), there is a great interest in understanding the mechanism of 3 MCPD/glycidyl ester formation and developing an effective mitigation strategy. The large variation in the levels of 3-MCPD/glycidyl esters observed amongst oils of different origin suggests that they are dependent on minor intrinsic compositional changes of oils and/or different processing conditions. Recent studies showed that over the course of oil refining the formation of 3 MCPD/glycidyl esters occurs mainly during the deodorisation step. Several pathways of heat-induced formation of 3 MCPD/glycidyl esters have previously been proposed, but the reaction mechanism and the nature of the precursors still remains to be completely elucidated. In this speech summarizes the current knowledge on the factors crucial for the formation of the esters (covering mainly refining conditions) and addresses the major knowledge gaps.

### **Supercritical Carbon Dioxide Extraction of Corn Dried Distillers Grains with Solubles.** J. Calderon, O. N. Ciftci,

F. Temelli, University of Alberta, Edmonton, Alberta, Canada

Corn distiller's dried grains with solubles (DDGS) is a by-product of ethanol industry that needs attention due to its valuable composition. Separation of high value lipid components from corn DDGS using a 'green' process can add value to corn DDGS, and contribute to sustainability of ethanol plants. In this study, corn DDGS was extracted using supercritical carbon dioxide (SC-CO<sub>2</sub>) at 50-70°C, 34.5-49.6 MPa, and constant CO<sub>2</sub> flow rate of 1 L/min. The highest yield of total lipids (9.2%) was obtained at 49.6 MPa and 70°C. The extract contained 108 mg/kg of carotenoids at 49.6 MPa and 60 °C, 1538 mg/kg of tocochromanols and 15904 mg/kg of phytosterols at 49.6 MPa and 70°C. Sovova's model was successfully used to model the extraction of total lipids, and Chrastil's and a modified Chrastil's models were used to model the solubility of total and minor lipids. The study revealed that DDGS is a good cheap source of lipids and valuable minor lipid components, and SC-CO<sub>2</sub> extraction can be used as a 'green' process to add value to corn DDGS by producing oil and high value minor lipids.

### **Oil Extraction from Microalgae *Nannochloropsis* spp. with Isopropyl Alcohol.** L. Yao, J.A. Gerde, T. Wang,

Department of Food Science and Human Nutrition, Iowa State University, Ames, IA, USA

An environmentally friendly extraction of microalgal oil and non-lipid biomass was investigated. Hot isopropanol (IPA) was used to extract oil from *Nannochloropsis* spp., leaving the majority of non-lipid biomass in a cake fraction. Extraction procedures with or without a dewatering step (DW) were compared. Effects of dewatering condition, IPA concentration, and sonication pretreatment on the oil and biomass yield were studied. The dewatering condition with a high water-to-alcohol ratio (2:1) and mild mixing (1-min gentle shaking) had less oil loss in the DW fraction than that with a low water-to-alcohol ratio (1:1) and vigorous mixing (30-min and 300 rpm shaking). When sonicated algae were used, the difference in oil loss between the above two dewatering conditions was greater. Without dewatering, a 70% (w/w) IPA solvent extracted 87 (one-time extraction) or 97% (two-time extraction) of the total oil in the intact algae cells, similar to the yields obtained from 87 or 95% IPA solvents, but required the least amount of IPA. With sonicated algae cells, the 70% IPA solvent extracted slightly less oil than 87 or 97% IPA. About 66% non-lipid biomass was recovered in the cake fraction.

**Comparison of Alcohol Extraction of Oil from Oil-bearing Products with Different Lipid Compositions.** L. Yao, S.-L. Lee, J.A. Gerde, T. Wang, Department of Food Science and Human Nutrition, Iowa State University, Ames, IA, USA

With an increasing interest in using microalgae as a source for biofuel, complete extraction of oil from algae is desirable. Various extraction methods were applied to extract oil from the cells, among which alcohols were attractive alternative solvents to hexane and other petroleum-based organic solvents. A procedure using isopropanol to extract algae oil was previously developed in our laboratory and it was found that the sonication pretreatment and the algae lipid composition might be major factors that influenced the extraction efficiency. In this study, isopropanol extraction efficiency of oil from *Scenedesmus* spp. and *Schizochytrium limacinum* was compared with that from *Nannochloropsis* spp. and full fat soy flour. Effects of sonication pretreatment and isopropanol concentration were examined. The neutral and polar lipid distribution in each alcohol extraction fraction was determined by HPLC analysis. Using sonicated algae cells, 87 and 95% aqueous IPA extracted greater than 90% of total oil, significantly higher than 70 and 50% IPA did. The yield of 70% IPA extraction varied with the type of starting materials.

**Minimal Refining Canola Oil: Maximizing Phytosterols and Tocopherols Contents and Removing Pesticides.**

Saeed Mirzaee Ghazani<sup>1</sup>, Alejandro G. G Marangoni<sup>1</sup>, Guadalupe García-Llatas<sup>2</sup>, <sup>1</sup>Food Science Department, University of Guelph, Guelph, Ontario, Canada, <sup>2</sup>Nutrition and Food Science Area, University of Valencia, València, Spain

Canola oil contains a relatively low amount of saturated fatty acids, a high amount of free and esterified sterols, and is a good source of tocopherols compared to common vegetable oils. Clinical studies have shown that sterols lead to a reduction in bad cholesterol (LDL-C) and tocopherols act as natural antioxidants. Traditional refining leads to the removal of about 35-45% of phytosterols and tocopherols found in canola oil. A Minimal Refining for Health method (MRH) refers to the removal of undesirable components with the lowest impact on nutrients such as phytosterols and tocopherols. In the MRH method developed in our laboratory, sodium hydroxide is replaced, after super degumming, with calcium hydroxide, sodium silicate or magnesium oxide to minimize degradation of tocopherols and phytosterols during deacidification. Clays such as diatomaceous earth, Magnesol® and Trisyl® are used for soap removal before wet bleaching at lower temperatures using lower acidified clay concentration. This MRH method omits the deodorization step, allowing for a future assessment of using different oligosaccharides and polysaccharides to bind and remove pesticides from the oil with obvious nutritional and sensory benefits.

**Dehulling of Canola in a Fluid Bed Application.** Matthias Börner<sup>1</sup>, Mirko Peglow<sup>1</sup>, Matthias Ihlow<sup>2</sup>, Thomas Piofczyk<sup>3</sup>, <sup>1</sup>NaWiTec, Thermal Process Engineering, Otto-von-Guericke University, Magdeburg, Germany, <sup>2</sup>AVA, Magdeburg, Germany, <sup>3</sup>OEHMI Engineering GmbH, Magdeburg, Germany

In recent times the dehulling of canola / rapeseed becomes more and more of particular interest. By the additional dehulling step undesired contents from the hulls (dye, glucosinolates, fiber) can be reduced significantly in the final product. The attained canola meal has higher applicability for animal feed and enables a better protein extraction. Moreover, the detached hulls can be further used for the production of base chemicals, like e.g. phenol or lignin, or for energy production by gasification or burning. The challenges in canola dehulling are based in the way of processing. To dehull non-size-classified canola a fluid bed process was adapted. By applying a smart product flow within the fluid bed the initial hull content of approximately 20 m% in the raw material can be reduced below 5 m% in the final product. Additionally a gentle drying and preheating can be combined during dehulling to improve the later oil yield. In the first analysis of product, an improved PDI of about 50 % was verified. The process development will be further continued to achieve higher product qualities and to make a multi-feedstock possible. So, within the same fluid bed soybeans or sunflower shall be treated as well.

**Mechanical Downstream Processing of Single Cell Oils for Biofuel Production.** M. De Coninck<sup>1,2</sup>, R. Van Hecke<sup>1</sup>, K. Deprez<sup>1</sup>, I. Foubert<sup>2</sup>, J. De Baerdemaeker<sup>2</sup>, <sup>1</sup>KAHO Sint-Lieven, association KULeuven, Department of Mechanical Engineering, Gebr. De Smetstraat 1, B-9000 Ghent, Belgium, <sup>2</sup>Katholieke Universiteit Leuven, Division

of Mechatronics, Biostatistics & sensors, Kasteelpark Arenberg 30, B-3001 Heverlee, Belgium

Nowadays, harvesting and recovery of interesting products from microalgae is one of the most problematic areas of algal biofuel production technology. The traditional downstream process runs up to more than 50% of the total production cost of Single Cell Oils (SCO). This research is focused on the development of a simple and economical feasible mechanical downstream process set up for the commercial production of SCO. An efficient yield technique to extract the biomass from its growing medium and the disruption of the harvested cells are the main focuses. Two algae model organisms were selected: *Phaeodactylum tricornutum* and *Nannochloropsis* sp. In this study crossflow (micro)filtration is investigated as an alternative for the concentration of microalgae. Due to its low shear forces it's a more gentle technique than centrifugation which can damage the cells. Tests at lab-/pilot scale were performed with a 0,1m<sup>2</sup> 0,45µm membrane. As a result of these tests crossflow filtration seems to be a suitable technology to concentrate algae suspensions. Also research is done to optimize the cleaning of the membranes to extend the life time and reduce the operating costs. The major costs of this technique are the energy consumption of the pumps as well as the membrane replacement.

**Adsorbent Treatment of Biodiesel Feedstock with Synthetic Magnesium Silicate.** G.E. Hicks, B.S. Cooke, Dallas Group, Jeffersonville, IN, USA

Fats and oils used as feedstock for biodiesel can contain a wide variety of impurities that must be removed in order to properly react to produce biodiesel. A number of these impurities have been known to cause problems during the transesterification reaction, including sterol glucosides, soaps, phosphorus and other metals. In this study, synthetic magnesium silicate was used to treat a crude Soybean oil to remove these impurities and produce finished oil with high quality. This process helps to ensure that the resulting biodiesel produced meets certain specifications and can also yield higher overall plant efficiencies. Treatment of the crude Soybean oil with synthetic magnesium silicate resulted in: Soap reduction? 83-92% Water reduction? 40-61% Phosphorus reduction? 85-94% Sterol Glucoside reduction? 56-84% Ca reduction? 50-80% Mg reduction? 50-80% Na reduction? 80% K reduction

**Lipase-catalyzed Transesterification of Carbon Dioxide-expanded Canola Oil and Fully-hydrogenated Canola Oil.** E. Jenab, F. Temelli, J. Curtis, Y. Y. Zhao, University of Alberta, Edmonton, AB, Canada

A mixture of lipid reactants in contact with high pressure CO<sub>2</sub> expands as CO<sub>2</sub> dissolves in the liquid phase, causing viscosity to decrease and reaction rate to increase. However, performance and stability of enzymes may be affected negatively. The performance and reusability of Lipozyme RM IM and TL IM for transesterification of canola oil and fully-hydrogenated canola oil in high pressure CO<sub>2</sub> media were studied using a batch stirred reactor at 17.5 MPa and 65°C. The influences of exposure time and pressurization/depressurization on enzyme activity were investigated by assessing conversion rate using LC-MS and structural changes using SEM, FTIR and XPS. There was no significant difference in the performance of these enzymes, reaching equilibrium conversion of about 26% after 2 h. Although SEM images illustrated some morphological changes after 4x7h of reuse, similar conversion rates were achieved after first, second, third and fourth cycles. FTIR and XPS results showed no significant changes in the secondary structure of enzymes reused for 4 times and exposed to high pressure CO<sub>2</sub> for 12 h at 17.5 MPa/65°C. Findings enhance our understanding of enzymatic conversions of lipids under high pressure CO<sub>2</sub>, targeting production of base-stock for zero-trans margarines.

**High Voltage Electrostatic Destabilization of Water-oil Emulsion for the Extraction of Lipids in Wastewater Bacteria for Biofuel Production.** Emmanuel Revellame<sup>1</sup>, William Holmes<sup>1</sup>, Lader Lerma<sup>2</sup>, Rafael Hernandez<sup>1</sup>, L. Antonio Estevez<sup>2</sup>, W. Todd French<sup>1</sup>, <sup>1</sup>Dave C. Swalm School of Chemical Engineering, Mississippi State University, Mississippi State, MS, USA, <sup>2</sup>University of Puerto Rico, Mayaguez, PR, USA

The destabilization of emulsions by application of electric field is important in the petroleum industry for removal of water from crude oil. This process involves application of high voltage (~13-20 kV) to break emulsion drops and could be used to separate lipids in microbial consortia in the presence of water. This study shows the application of high-voltage electrostatic coalescence in the de-emulsification of water-in-oil emulsions present in the organic phase of the

system water-lipid-decane. Lipids, particularly phospholipids, were used as surrogate of microbial cell membrane. Water separation was evaluated with solution that contained alkane and lipids at different concentrations. Application of different voltages (10-15 kV) was performed. Initial results showed 70% water removal in 100s.

**UV Curable High Performance Pressure Sensitive Adhesives from Acrylated Epoxidized Soybean Oil.** Kollbe Ahn<sup>1,2</sup>, Susan Sun<sup>1</sup>, <sup>1</sup>Kansas State University, Manhattan, KS, USA, <sup>2</sup>University of California Davis, Davis, CA, USA

Several oleo-based pressure-sensitive adhesives (PSA) were studied to substitute current petro-based PSAs. However, the PSAs derived from plant oils have unsolved challenges for practical uses, such as complex processes using petrochemicals, slow emulsifying, and drying, which interrupts boosting the lipid-based PSAs as a renewable substitution. Here we showed transparent PSAs derived from pure acrylated epoxidized soybean oil (AESO) via fast and simple UV free-radical polymerization. In this study, we controlled the degree of free radical polymerization by the amount of UV irradiation in order to obtain the optimum balance of cohesion/adhesion strength for PSA applications. This AESO PSA resulted in better peel and overwhelming shear strength on glass surfaces compared to a commercial PSA tapes, which corresponded to dynamic rheological properties analysis and the adhesion/cohesion behavior analysis investigated using the Johnson-Kendall-Roberts (JKR) technique. In addition, using a photo initiator and tackifier, we accomplished excellent commercial values for PSA tapes.

## AFTERNOON

### PRO 5: Biodiesel

---

Chair(s): H.C. Holm, Novozymes A/S, Denmark; and R. Burton, Piedmont Biofuels, USA

**Lipase Esterification for Commercial Biodiesel Production.** R. Burton, G. Austic, P. Eudy, X. Fan, Piedmont Biofuels Industrial, Pittsboro, NC, USA

In commercial biodiesel production, the ability to process a wide range of feedstock grades provides favorable economics. Often cost-effective or low- quality feedstocks contain high levels of free fatty acids (FFA). These low quality feedstocks like yellow grease and brown grease are difficult to process due to these high FFA levels. Traditional chemical means of processing require sulfuric acid, high proportions of methanol to fatty acid, and the infrastructure rectify sidestreams from such process. It is now proven that the immobilized or liquid phase enzymes such as *Candida Antarctica Lipase B* (CALB) and *Thermomyces Lanuginosus*, can be utilized for the production of biodiesel. The use of these enzymes in the processing of fatty acid esters can reduce waste alcohol streams, increase production yield, and enhance the co-product quality of glycerol. Together with Novozymes, Piedmont has developed an enzyme based esterification process utilized in a commercial setting. This paper will evaluate these experiences of enzymatic esterification in a biodiesel production facility.

**Biodiesel Produced with Liquid Lipase Formulation.** P.M. Nielsen, R.M. Anders, Novozymes A/S, Bagsvaerd, Denmark

Biodiesel produced with lipase as catalyst has been the subject of intensive research for 10 years. Results from this research points towards the use of immobilized lipase in order to be able have a high yield of fatty acid alkyl esters, and to facilitate the re-use of enzyme. Our latest results have shown that the esterification/transesterification can be performed in a cost effective process with lipase in a liquid formulation instead of using immobilization. The lipase is catalyzing the reaction of free fatty acids as well as glycerides to achieve full conversion with bound glycerin within the specifications of biodiesel standards. The new process will enable the biodiesel producers to utilize raw materials

with any content of free fatty acids and delivers a glycerol of very high purity. In the presentation we will discuss the important parameters in the process and the advantages of using the liquid formulations of lipase instead of immobilized enzyme.

**A Robust Multi-enzyme Preparation for Industrial Production of Biodiesel.** S. Basheer, TransBiodiesel Ltd., Shfar-am, Israel

The use of free or immobilized lipases for transesterification/esterification of oil feedstocks with short-chain alcohols to form fatty acid alkyl esters (biodiesel) has been intensively studied during the last decade and unfortunately yielded unsatisfactory results with respect to activity and stability of the enzyme. Therefore, the cost-effectiveness of the biocatalysts at industrial quantities is still prohibited. Furthermore, it has been reported that all currently available lipases in either their free or immobilized forms are incapable of reaching near to complete conversions, preferably above 99%, for oil triglycerides to fatty acid alkyl esters at reasonable reaction time. The presented work relates to the preparation of an immobilized multi-enzyme system for transesterification and esterification of oil glycerides and fatty acids with short-chain alcohols, to form fatty acid short-chain alkyl esters to be used as biodiesel. The newly developed enzymatic biodiesel production process allows the use of different low-grade oil feedstocks including crude plant oils, yellow and brown greases, animal fat and other acid oils. The design and use of one-step or multi-step industrial scale processes integrated with a robust multi-enzyme immobilized system for the production of biodiesel will also be presented.

**Effect of Water Content on Liquid Lipase-mediated Alcoholysis for Biodiesel Production in an Oil/water Biphasic System.** Liangliang Lv, Guoling Zhang, Wei Du, Dehua Liu, Department of Chemical Engineering, Tsinghua University, Beijing, 100084, P.R. China

Biodiesel production catalyzed by free lipase has been drawing attention for its lower cost and faster reaction rate compared to immobilized lipase. It has been found that free lipase NS81006 could efficiently catalyze the methanolysis and ethanolysis of renewable oils for biodiesel production in a biphasic water/oil system and a certain amount of water is demonstrated to be necessary for the catalytic process. However, there was no research on what the influence of water content on the catalytic process. In this paper, the effect of water content on liquid lipase NS81006-mediated methanolysis and ethanolysis for biodiesel production was explored respectively for the first time. The results showed that with water content ranging from 3% to 10% (based on oil weight), there was no significant difference in the final biodiesel yield either in NS81006-mediated methanolysis or ethanolysis process. While in both cases, the quality of biodiesel varied obviously. The acid value as well as the contents of monoglyceride and diglyceride was found to be much lower in the lower water-containing system. The reusability of the free lipase was further studied in different water-containing systems and it was found that lipase could maintain rather good catalytic performance in the biphasic water-oil system. The gradual reduction in biodiesel yield in the repeated uses resulted from the accumulation of by-product glycerol in the water phase.

**Toward Continuous Enzyme-catalysed Processes for the Production of Biodiesel.** Mathias Nordblad, Anders Kristian Pedersen, Lene Have Meyland, Yuan Xu, John M. Woodley, Department of Chemical and Biochemical Engineering, Technical University of Denmark, Lyngby, Denmark

The application of lipases in the production of biodiesel can find several roles: in pretreating high FFA oils via esterification, transesterification for converting oil to biodiesel and polishing via esterification to ensure the product is within specification. In all these cases the potential size of the process plants, suggest that continuous operation would be highly beneficial due to the economies of scale. To investigate this, we have examined both oil pretreatment via esterification and biodiesel production via transesterification in batch stirred tank reactors (BSTRs), continuous stirred tank reactors (CSTRs) and continuous packed bed reactors (CPBRs). In addition comparisons have been made between the use of liquid enzyme (in CSTR and BSTR) and immobilized enzyme (in BSTR, CSTR and CPBR) in transesterification reactions. In this presentation an evaluation will be given of the alternative modes of operation based on experimental and modeled data from laboratory scale studies. Implications for scale-up will be discussed, together with guidelines for the implementation of continuous processes for enzymatic reactions.

**Improving Sustainability in Oils Processing by Fatty Acid Recovery.** W.D. Cowan , H.C. Holm , H.S. Yee ,  
<sup>1</sup>Novozymes UK, Chesham, Bucks, UK, <sup>2</sup>Novozymes A/S, Bagsvaerd, Denmark, <sup>3</sup>Novozymes Malaysia, Kuala Lumpur, Malaysia

All vegetable and animal sourced oils contain free fatty acids which are normally generated by lipase activity during harvesting or processing. Often these fatty acids will be removed by sodium hydroxide neutralization. The formed soaps are a yield loss but as they also entrain neutral oil the overall loss is much higher. This paper reports on investigations into using lipase condensation reactions between these fatty acids and partial glycerides and/or glycerol to recover lipids that normally would be lost as soaps or deodorizer distillates. The sustainability of oil processing can therefore be improved and a simple LCA calculation method will be demonstrated.

**Production of Biodiesel from Waste Frying Oils.** I. Vieitez, N. Callejas, B. Irigaray, Y. Pinchak, N. Merlinski, M. Pardo, M.A. Grompone, I. Jachmanián, Laboratorio de Grasas y Aceites, Departamento de Ciencia y Tecnología de los Alimentos, Facultad de Química, Universidad de la República. Av. Gral Flores 2124. 11800, Montevideo, Uruguay.

Transesterification of waste frying oils (WFO) was studied with the purpose of achieving the best conditions for biodiesel production. Transesterification reactions were carried out during 90 minutes, using WFO from different sources (high oleic sunflower oil, rice bran oil and sunflower oil), methanol, and different basic catalysts. In order to determine the best conditions for the biodiesel production, different catalysts, and different methanol/WFO and catalyst/WFO molar ratios were tested. As WFO from restaurants and food services shown a wide variety of qualities, different analyses were performed to evaluate the raw materials. The following ranges were found: acidity between 0.2-7.6%, polar compounds content between 14.9-35.9% and polymeric compounds content between 3.6-19.7%. Transesterification process was performed with fresh oils heated at 180°C during 15, 30 and 45 hours as well as with several commercial WFO. The steps for the biodiesel elaboration were the following: filtration, centrifugation, drying, transesterification and purification. For oils with acidity below 2%, the best conditions for maximizing the ester content were a methanol/WFO ratio of 6:1 and 2% of potassium hydroxide respect to WFO. Under these conditions, results show that the yield of methyl esters was higher than 94% in some of these oils, depending on their quality.

**Biodiesel Process Development for Industrial Applications: Alternative Bio-Feedstocks, Quality Challenges, and Emerging Green Technologies.** A. Baig, F.T.T. Ng, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada

The development of energy-efficient biodiesel production technologies aiming at reducing the feedstock costs and increasing the production efficiency are urgently needed to reduce energy consumption and to increase the process economics. Due to the high cost of refined vegetable oil, currently, biodiesel industry has moved towards using alternative inexpensive bio-feedstocks with high free fatty acids. However, using traditional homogeneous base-catalyzed industrial process could result in higher acid number, yield losses, higher post-cleaning processes, lower quality of glycerin, product and process inconsistency. Therefore, many industrial processes were shifted toward using green heterogeneous catalysts as they are generally preferred for chemical transformations in industrial processes because they can potentially be regenerated, and they are environmentally benign because they can be reused and safe for industrial operations. Because of these advantages, innovative green heterogeneous-catalyzed processes are gaining attraction for the production of biodiesel. An overview of biodiesel process development for industrial-scale production of biodiesel will be discussed including new alternative bio-feedstocks, emerging green technologies, and challenges for meeting the quality standards.

---

## Processing Posters

Chair(s): F. Eller, USDA, ARS, NCAUR, USA; ; and F. Karaosmanoglu, Istanbul Technical University, Turkey

**Effect of Packing Material for Enhanced Resolution and Loading Capacity when Purifying EPA.**  
Eun-Kyung Lee, Bong-Soo Lee, AK Biotech Co., Ltd., Nam-gu, Ulsan, Korea

EPA have ability to prevent and treat hypertension, arthritis, inflammatory and autoimmune disorders as well as cancer. So EPA purification process is very important for EPA medicine. One of the EPA purification process, HPLC is very expensive process. None of the worthless condition which are yield, resolution, loading capacity for EPA purification by HPLC. We expected to increase productivity by optimization of packing material. Hybrid packing material enhanced yield, resolution and loading capacity when we purified EPA by HPLC.

### **Ultrasonic-based Treatment of Low Grade Palm Oil Using a Heterogeneous Catalyst.**

Adeeb Hayyan<sup>1,2</sup>, Farouq S. Mjalli<sup>1</sup>, Talal Al-Wahaibi<sup>1</sup>, Yahya M. Al-Wahaibi<sup>1</sup>, Mohd Ali Hashim<sup>2</sup>, Maan Hayyan<sup>2</sup>,

<sup>1</sup>Petroleum and Chemical Engineering Department, Sultan Qaboos University, Muscat 123, Sultanate of Oman,

<sup>2</sup>Department of Chemical Engineering, Centre for Ionic Liquids (UMCiL), University of Malaya, Kuala Lumpur 50603, Malaysia

Low grade crude palm oil (LGCPO) produced from industrial palm oil mills was considered as a promising feedstock for biodiesel production. The high content LGCPO acid value of 20 mg KOH/g oil increased the challenge of performing the biodiesel transesterification reaction. Ferric sulphate (FS) was used as a heterogeneous recyclable catalyst. The esterification of LGCPO was carried out by applying ultrasonic energy to replace conventional mechanical stirring and convert free fatty acid (FFA) to fatty acid methyl ester (FAME) via esterification reaction in presence of FS as solid acid catalyst. The lab-scale investigation involved different parameters such as: FS to LGCPO dosage, methanol to ACPO molar ratio, reaction temperature, reaction time and stirrer speed. Using optimum esterification reaction conditions the acid value was reduced from 20 mg KOH/g oil to less than 2% at a yield of 96%. The biodiesel produced met the EN14214 and ASTM D6751 standards specifications. FS catalyst was recycled for three times without noticeable loss in its activity. The produced biodiesel from a two-stage process has an acid value of 0.11 mg KOH/g oil .

### **Influence of the Process Parameters on the Efficiency of Steam Deacidification of Palm Oil.**

R. Verhe<sup>1</sup>, V. Van Hoed<sup>1</sup>, W. De Greyt<sup>2</sup>, K. Sampaio<sup>1,3</sup>, A. Meirelles<sup>3</sup>, <sup>1</sup>Ghent University, Gent, Belgium, <sup>2</sup>DeSmet Ballestra, Zaventem, Belgium, <sup>3</sup>University of Campinas, Campinas, Brazil

The quality of palm oil is mainly dependent on the process conditions during physical refining and especially the steam deacidification. Crude palm oil was submitted to a pretreatment step followed by deodorisation. The influence of two operative conditions ; temperature (200-260°C) and steam percentage (0.5-3.5%); together with a third parameter ; the initial FFA content (2-6%); was studied for the final FFA content, tocopherol, sterol and carotene retention and neutral oil loss using a central component design. The results revealed that the initial FFA is an important parameter in order to obtain acceptable values for the final FFA content. Reducing the oil acidity to low values implies higher temperatures or longer residence times. The result is an decrease in concentration of minor components in the refined oil. It was also observed that higher steam flows associated with higher temperatures also increases the hydrolysis of neutral oil during refining. The conclusion is that the initial oil acidity is a relevant parameter for the nutraceutical quality of the final refined palm oil

### **A New Technique for the Concentration of Gallic Acid Extracts from Defatted Mango Kernel Meal by Membrane Separation.**

Narayana Amarnath<sup>1</sup>, S. Abhishek Rao<sup>2</sup>, Pradosh Prasad Chakrabarti<sup>1</sup>, <sup>1</sup>Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad - 500007, India, <sup>2</sup>Birla Institute of Technology & Science, Pilani, Goa Campus, Zuarinagar, Goa - 403726, India

Antioxidants are generally extracted from natural resources by using different solvents and then concentrated by evaporation. The evaporation step makes the process energy intensive and prolonged heating during evaporation reduces the antioxidant properties. Defatted mango kernel meal, a by-product of mango kernel fat industry was never utilized as a source of natural antioxidants like gallic acid, ellagic acid and other phenolic compounds. In the present study, attempts were made to isolate the antioxidants (predominantly gallic acid) from defatted mango kernel meal (DMKM) and then to concentrate the gallic acid rich extract by using membrane separation technique. Gallic acid and

other antioxidants were first extracted from DMKM using different solvents. It was observed that 50:50 mixtures of water and ethanol showed significantly high amount of extractability for gallic acid. Few commercially available polymeric reverse osmosis membranes were then screened for their compatibility with the chosen solvent system. The crude extract was then passed through different solvent resistant membranes. A thin film composite membrane (SW30-HR) showed maximum rejection properties and at volume concentration ratio 10, more than 90% of the gallic acids could be concentrated using this membrane.

### **Study the Oxidative Stability of PLA1 Enzymatic Degumming Oil.**

Wan Jianchun, Cong Yanxia, Jiang Bo, Hu Peng, Yu Jianguo, Wilmar (Shanghai) Biotechnology Research & Development Center Co., Ltd, Shanghai, China

The stability of PLA1 enzymatic degumming oil was studied and compared with that of chemical refining oil. The effects of washing, additional of citric acid and bleaching earth on the stability of enzymatic degumming oil were discussed. The result showed enzymatic degumming could effectively decreased the phosphorus content that could meet the physical refining requirement. Oxidative stability index (OSI) value and schall oven test suggested that adding 0.1% activated carbon in the process of bleaching could greatly improve the oxidative stability of PLA1 enzymatic degumming oil, which is comparable to that of chemical refining oil.

### **Flocculation Induced by High pH to Harvest Microalgae for Low Value Products.**

D. Vandamme, I. Fraeye, K. Muylaert, I. Foubert, K.U. Leuven Kulak: Molecular and Microbial Systems, Lab Aquatic Biology, Kortrijk, Belgium

Microalgae are generally assumed to achieve much higher areal productivities than agricultural crops. Therefore, they are considered to be an attractive source of biomass. So far, however, the production cost of microalgae is still high and production is only economically feasible for high-value applications such as food supplements, natural pigments or PUFA's. To be able to use microalgae for low-value applications such as feed or fuel production or wastewater, the production cost has to be reduced by at least an order of magnitude. A significant reduction in the cost of microalgal biomass production will require cost-efficient methods for harvesting microalgae. We studied flocculation induced by high pH to preconcentrate microalgae, both freshwater (*Chlorella vulgaris*, *Scenedesmus obliquus*) and marine species (*Phaeodactylum tricornutum*, *Nannochloropsis salina*). In this presentation, the mechanism will be explained in detail. Moreover, it will be shown that there is a significant effect of growth phase and medium salinity. Practical implications such as medium recycling, contamination and its potential consequence for biofuel production will be discussed. Finally, this technique will be compared to other techniques (electro-coagulation-flocculation and usage of biopolymers) in terms of mechanism, efficiency and implementation possibilities.

### **Influence of Environmental Stress on Physicochemical Properties of Cold-pressed Rice Bran Oil Nanoemulsion Stabilized by Glycerol Monostearate (GMS).**

A. Thanonkaew<sup>1</sup>, S. Wongyai<sup>2</sup>, E. Decker<sup>3</sup>, D. McClements<sup>3</sup>, <sup>1</sup>Research Unit of Local Southern Thai Foods, Department of Food Science and Technology, Faculty of Technology and Community Development, Thaksin University, Phapayom, Phatthalung, Thailand, 93110, <sup>2</sup>Medicinal Products Department, Faculty of Oriental Medicine, Rangsit University, Paholyotin Road, Muang Aek, Patumtani Thailand, 12000, <sup>3</sup>Department of Food Science, University of Massachusetts, Amherst, Massachusetts, 01003, USA

Emulsion-based delivery systems have shown to be particularly suitable for encapsulating lipophilic components. The relatively high levels of functional and nutraceutical components present within cold-pressed rice bran oil (CPRBO) may mean that it behaves differently in nanoemulsions than other edible oils. Therefore, the overall objective of this study was to examine the influence of pH (2-9), ionic strength (0-400 mM NaCl) and thermal processing (30-90 °C) on the physicochemical properties of nanoemulsion. Oil-in-water nanoemulsions (30% CPRBO, 10 mM phosphate buffer) stabilized by GMS (3%) were prepared using high-pressure homogenization. The nanoemulsions were unstable at low pH (pH 6-2), high salt concentration (75-400 mM) and high temperature (60-90° C). Increase of yellowness ( $b^*$ ) and viscosity were found when increase of salt concentration and decreases of pH. However, the thermal processing had no influence on the yellowness and viscosity of nanoemulsion. These results have important implications for the formulation and production of CPRBO emulsion-based products using GMS as an emulsifier.

### **Effect of Photoirradiation Time on Soy Oil Conjugated Linoleic Acid Yields.**

Reddy Yettella V. Ramesh, Brooke Henbest, Andrew Proctor, University of Arkansas, Fayetteville, AR, USA

Photoirradiation has been used to synthesize 20% conjugated linoleic acid (CLA) in soy oil with an iodine catalyst. CLA yields are affected by irradiation time, adsorbent treatment, iodine concentration and mixed tocopherols. However, the effect of these factors the number and length of photoperiods on CLA yields is not determined. The objective of this study was to determine the effect of irradiation time, Magnesol, mixed tocopherols (MT) and iodine concentration on soy oil CLA yields and oxidative stability. Soy oil was initially treated with 5% Magnesol. Iodine at 0%, 0.35% or 0.175% and 1400 MT was mixed with Magnesol treated soy oil and irradiated for either 6 or 12 hours. The irradiated oil was again treated with Magnesol, mixed with 0%, 0.35% or 0.175% iodine; 1400 MT and irradiated for either 6 or 12 more hours. CLA content in soy oil was determined by conventional GC-FID. The oxidative stability of the oil was determined by measuring peroxide value. All determinations were made in triplicate. Increasing photoirradiation time increased CLA yields and lowered PV. However, two 6 hour photoperiod treatments produced more CLA and reduced PV than a single 12 hours photoperiod. This may be due to Magnesol treatment between photoperiods.

### **Two-Part Process Optimization for Conversion of Macro Algae into Biofuels.**

S. C. Ndelela, N. O. Olson, Iowa State University-Iowa Energy Center-BECON Facility, Ames, Iowa, USA

The use of algae as a feedstock for biofuel production is a fast growing research area. Recent advances have been made in the conversion of a variety of microalgae with high lipid contents into biodiesel. Conversely, the study of marine (macro) algae with high phenol and carbohydrate content but lower protein and lipid content compared to their micro counterparts has not been explored extensively as a biofuel feedstock. The first part of this project is being performed to optimize hydrolysis of sugar from macro algae that could potentially be fed into a laboratory scale fermentation reactor. To enhance hydrolysis of the sugar/carbohydrate fraction from macro algae, CO<sub>2</sub> and water under sub- and supercritical conditions are employed. Secondly, the remaining biomass meal including lignin will be converted into chemicals and fuel derivatives by a variety of organic solvents under high temperature and pressure conditions. Analytical results from HPLC, GCMS, and LCMS for the two-part process will be the basis of the discussion.

### **Obtention of High Micro-nutrients Content Oils.**

X. Pages<sup>1,2</sup>, M. Gaud<sup>1,2</sup>, B. Gadenne<sup>1,2</sup>, P. Carre<sup>2,1</sup>, <sup>1</sup>ITERG, French Institute for Fats and Oils F3360 Pessac, France, <sup>2</sup>CREOL, Pessac, France

This work has been done by ITERG and CREOL in the framework of the European collective research program : OPTIMOILS: Valorization of Healthy lipidic Micro-Nutrients by Optimizing Food Processing of edible oils and fats. Rapeseed and sunflower oils contain micro-nutrients such as sterols, tocopherols, phospholipids, phenols and co enzymes (Q9 and Q10) which are of great interest for food application. New processing ways of production (mild cooking and pressing; extrusion,...) and mild refining of rapeseed oil have been studied. It has been found that dehulling and mild cooking (80°C, 30 mn) prior to pressing is a better way than traditional pressing or cold pressing. Mild deodorization has been done at low temperature (150/160°C) during a short duration. Mild-refining oils with high content of these micro-nutrients have been obtained and studied in a nutritional point of view. The specification of the oil is in conformity with Codex Alimentarius. The process is environmentally friendly: no use of solvent extraction, no production of waste water and less energy consumption.

### **Toward the Development of a Continuous Crystallization Process for the Concentration of Omega-3 Fatty Acids from Mackerel Oil.**

Prerna Sinha<sup>1</sup>, Paul Angers<sup>2</sup>, Joseph Arul<sup>2</sup>, <sup>1</sup>Department of Chemical Engineering, Universite Laval, Quebec, Quebec, Canada, <sup>2</sup>Department of Food Science and Nutrition, Universite Laval, Quebec, Quebec, Canada

Urea adduct crystallization was used for the concentration of omega-3 PUFA from mackerel oil. Urea can selectively form complexes with only straight chain saturated fatty acids. In this process, the crystallization time and temperature,

and fatty acid to urea ratio were optimized. Mackerel oil was first converted to free fatty acids using hydrolysis, and then subjected to urea adduct crystallization. The fatty acid composition was analyzed using GC. Previously, very long residence times in the crystallizer have been used for this process, usually being more than twelve hours. We were able to achieve 84% concentration of omega-3 PUFAs by using two step urea adduct crystallization in thirty minutes crystallization time for each step. The optimum fatty acid to urea to solvent ratio was found to be in the range of 1:2:10 to 1:3:10 at a crystallization temperature of -15°C. The next objective will be to proceed towards making the process a continuous one by using kinetic data from the batch crystallizer to design a continuous crystallizer.

### **Production of Renewable Fuel from Activated Sludge through a Fluidized-Bed Catalytic Cracking (FCC) Process.**

Emmanuel Revellame, William Holmes, Rafael Hernandez, William French, Robert Callahan II, Dave C. Swalm  
School of Chemical Engineering, Mississippi State University, Mississippi State, MS, USA

Annual production of activated sludges in the United States ranges from 7 - 8 million tons. Currently, disposal technologies of these sludges include incineration and landfilling, both of which are heavily regulated and could create adverse environmental impacts. A fraction of the activated sludges can be used as fertilizer once it complies with regulations for Class A biosolids. Activated sludges contain microbial consortia known to produce lipidic materials and many other organic compounds, which could be used to produce biofuels and specialty chemicals. Several studies showed that reasonable yields (3 - 6% weight) of biodiesel could be produced from activated sludge. At these yields however, activated sludge biodiesel is less economical than petroleum diesel. This study describes the production of renewable fuel from activated sludge using Fluidized Catalytic Cracking (FCC). This process could convert most of the compounds present in sludge into fuel, and thus, increase fuel yields and reduce cost. Several catalysts, sludge to catalyst ratios, sludge moisture content and temperatures were tested. Initial results using ZSM5 at 500°C with air showed considerable production of hydrocarbons, from methane to methylnaphthalene.

### **Fatty Acid Composition and Oil Yield from Different Genotypes of Macauba (*Acrocomia aculeata*).**

R. Antoniassi<sup>1</sup>, A.F. Faria-Machado<sup>1</sup>, H.R. Bizzo<sup>1</sup>, N.T.V. Junqueira<sup>2</sup>, <sup>1</sup>Embrapa Food Technology, Rio de Janeiro, RJ, Brazil, <sup>2</sup>Embrapa Cerrados, Planaltina, DF, Brazil

Macauba (*Acrocomia aculeata*) is a palm tree distributed throughout tropical and subtropical Americas. Since this palm shows high productivity in bunches and oil, Embrapa has been selecting genotypes for biodiesel production. Macauba fruits have a moist pulp, rich in oil and carotenoids, and their kernels are similar to those from *Elaeis guineensis*. In this study, fruits from 120 different genotypes of macauba were collected from three different Brazilian States (Minas Gerais, Mato Grosso, Goiás). These genotypes, which include edible (sweet macauba) and non-edible (common macauba) fruits, showed certain variability for pulp yield, oil and carotenoids contents, and fatty acid composition. The fruits weight ranged from 28 to 56g, with 29-56% of pulp and 3-10% of kernel. Pulp and kernel showed, respectively, 7-44% and 21-55% of oil. The major fatty acids from pulp oil were C18:1 (35-71%), C18:2 (6-35%) and C16:0 (8-29%), whereas the highest levels of C18:3 were 3% and 8% for common and sweet macauba, respectively. The kernel oil from all evaluated genotypes was rich in lauric acid. The highest carotenoids content in the pulp oil was 370ppm. Results showed that some genotypes are very promising since the oil yield of the whole fruit varied from 3 to 20%.

### **Assessment of Extrusion-Pressing and Cooking-Pressing Processes for Production of Partly Defatted Soybean Meal with Low Residual Antitrypsic Activity.**

A. Quinsac<sup>1</sup>, P. Carré<sup>2</sup>, F. Fine<sup>1</sup>, F. Labalette<sup>3</sup>, M. Janowski<sup>4</sup>, <sup>1</sup>CETIOM, Pessac, France, <sup>2</sup>CREOL, Pessac, France, <sup>3</sup>ONIDOL, Paris, France, <sup>4</sup>La Mécanique Moderne, Arras, France

In order to study the feasibility of an identity preserved production of soybean meal for feedstuff, two processes based on a thermal treatment (extrusion or cooking) associated to pressing were compared for oil extraction yield, meal quality and economics. The effects of cooking on antitrypsic factors (ATF) inactivation and protein solubility were modeled with a bench-cooker and scaled up with a 75 kg batch cooker. Convenient conditions were tested in a continuous flow 2 stages cooker at 150 kg/h. The effects of single-screw extrusion at 150°C with similar flow rate and without steam injection were also measured. Cooked and extruded seeds were then pressed at 150 kg/h and the quality

of the oil and meal was determined. Results indicate that the cooking process is more efficient to inactivate ATF than dry extrusion (3-5 vs 3-9 TIU/mg). Nevertheless, dry extrusion as the preparation step for pressing, allows a better yield for oil extraction than cooking (residual oil in meal : 5,4% vs 6,7%) and a higher level for the protein solubility in soda (77% vs 73%). Economical study of a crushing plant of 20,000 tons per year shows that the both crushing costs are similar (33\$/t). Cooking-pressing is yet more versatile than extrusion-pressing.

### **Fatty Acid Profile and Chemical Composition of Seeds from *Jatropha curcas* During Fruit Ripening.**

A.F. Faria-Machado<sup>1</sup>, R. Antoniassi<sup>1</sup>, H.R. Bizzo<sup>1</sup>, P.C. Damasceno-Jr<sup>2</sup>, S.C. Freitas<sup>1</sup>, G.K. Donnagema<sup>3</sup>, <sup>1</sup>Embrapa Food Technology, Rio de Janeiro, RJ, Brazil, <sup>2</sup>Institute of Agronomy/UFRRJ, Seropédica, RJ, Brazil, <sup>3</sup>Embrapa Soils, Rio de Janeiro, RJ, Brazil

*Jatropha curcas* (Euphorbiaceae) is a non-edible oil seed, which is considered a potential source for biodiesel production in several countries around the world. However, the feasibility of this crop has been hampered by the discontinuous blossom, which produces fruits with different ages, leading to heterogeneous ripening and making the mechanical harvesting more difficult. Therefore, the fruits are usually kept in the tree until they become brown and dried. This study was carried out to evaluate the effect of fruit ripening in the fatty acid and chemical composition of *J. curcas* seeds. The fruits of different genotypes, in maturity stages from green to dark brown, were collected from an experimental cultivation at the Institute of Agronomy/UFRRJ. After drying, the seeds were grounded, the oil extracted with petroleum ether (30-60 °C) in a Soxhlet apparatus for 16 h and analyzed by gas chromatography. Chemical composition was determined according to AOAC methods (2010). During ripening, the contents of oil (5-40% dry matter) and protein (10-25%) increased, while moisture and neutral fiber levels decreased. Regarding the fatty acid composition, palmitic and linoleic acids decreased, respectively, from 25 to 12% and from 40 to 25%, whereas the oleic acid increased from 20 to 50%.

### **Proximate Composition of Harvested Nigerian Shea Fruits and the Physico-Chemical Properties Extracted Shea Butter (*vitellaria paradoxa*).**

J.U. Obibuzor, R.D. Abigor, V.O. Omoriyekemwen, I.B. Omamor, Nigerian Institute For oil Palm Research (NIFOR), P.M.B. 1030, Benin City, Edo State, Nigeria

Shea butter has variety of applications in edible oil, pharmaceuticals, and cosmetics industries. Its composition and quality vary markedly with geography, physiological state, integrity and method of processing of the shea kernel. Usually the butter is made from the fruits picked at the foot of the tree and the time lag between picking and processing affect the quality of the processed butter. The proximate composition of harvested mature shea fruit in Bida, Nigeria and the physico-chemical properties of the extracted butter were investigated. The percentage proximate composition of the kernel were moisture, 24.05, crude fibre, 12.77, ash 2.95, protein, 4.20, carbohydrate, 18.9, moisture, 9.0 and oil content, 51. The extracted oil; colour, refractive index, density and viscosity were 2.2 red 13.0 yellow and 1.778, 0.84g/cm<sup>3</sup> and 2.6cP, free fatty, 0.35%; acid, peroxide, saponification and iodine values 0.98 mgKOH/kg, 8.50 meq oxygen/kg oil, were 207.78 and 34 respectively. The fatty acid composition is similar to values in the literature. An overall improvement in the quality of butter compared with those produced around Bida was observed. Harvesting and processing physiologically matured shea fruit does not adversely affected Nigerian butter quality.

### **Influence of Water and Free Fatty Acids on Supercritical Methanol Treatment of Soybean oil for Biodiesel Production.**

P. Olivares-Carrillo, University of Murcia, Campus de Espinardo, Murcia, Spain

Biodiesel is being developed and promoted as an alternative to petroleum diesel fuel. However, current commercial use of refined vegetable oils for biodiesel production is impractical and uneconomical due to the high feedstock cost. Low-grade oil, typically waste cooking oil, may be a better alternative; nevertheless, the high free fatty acid (FFA) and water content in waste cooking oil has become the main drawback for this potential feedstock. In the present study, the effect of the water and FFA (oleic acid) content in soybean oil on the non-catalytic synthesis of biodiesel with supercritical methanol was investigated using an experimental design based on a two-factor Doehlert uniform network. This design allows determination of the possible interaction between these two variables. The reaction conditions used were a methanol-to-oil molar ratio of 43, a temperature of 300°C and a reaction time of 45 min. The results show that

the presence of free fatty acids does not affect the process because the transesterification of triglycerides and the esterification of free fatty acids occur simultaneously without any soap formation. Furthermore, the presence of water, which is very harmful to the conventional transesterification process, in this case favors the yield of the reaction.

### **Enzymatic Production of High Quality Fish Oil PUFA Concentrates.**

T. Balle<sup>1</sup>, H. C. Holm<sup>1</sup>, D. Cowan<sup>2</sup>, J. Henman<sup>1</sup>, M. L. Damstrup<sup>1</sup>, <sup>1</sup>Novozymes A/S, Krogshøjvej 36, 2880 Bagsværd, Denmark, <sup>2</sup>Novozymes A/S, 282 Chartridge Lane, Chesham, Bucks, United Kingdom

Novozymes A/S has developed several solutions for improving the processing of fish oil for use in pharmaceuticals and nutraceuticals. These include reducing free fatty acid content in crude fish oil, improving refining yield and large scale enzymatic ethanolysis and condensation of PUFA onto glycerol for production of high value Omega-3 products. Reduction of processing temperature and energy consumption, decreased lipid oxidation, replacement of harsh chemicals and increased oil yields are among the immediate benefits of Novozymes enzymatic solution for fish oil processing.

### **Canceled - Microalgae Flocculation: Impact of the Flocculant Type, Algae Species, and Cell Concentration.**

### **Development of a Laboratory Scale Electrostatic Coalescer Unit for Separation of Water-oil Emulsions for Biofuel Production.**

William Holmes<sup>1</sup>, Emmanuel Revellame<sup>1</sup>, Lader Lerma<sup>1,2</sup>, L. Antonio Estevez<sup>2</sup>, Rafael Hernandez<sup>1</sup>, W. Todd French<sup>1</sup>, <sup>1</sup>Dave C. Swalm School of Chemical Engineering, Mississippi State University, MS State, Mississippi, USA, <sup>2</sup>University of Puerto Rico, Mayagüez, PR, USA

The electrostatic coalesce technology has proved to be an efficient means of separating water-in-oil type emulsions for many years in the petroleum industry. With the increases of renewable fuels and chemicals over the last decade the need for separation of dispersed aqueous has become increasingly important. This technology will be evaluated to separate microbial mixture (without drying) present in wasted secondary sludge, specifically grown for lipid accumulation, as well as lipid present in microalgae. In this study, the development of lab scale electrostatic coalescence unit in the de-emulsification of water-oil mixture and the agglomeration of micelles present in the organic phase of an aqueous system using high electric field. Phospholipids were used as surrogates of microbial cell membranes. Recent work shows that, under a pulsed electric field, chains of water droplets are usually created during periods of high voltage, followed by rapid coalescence during periods of reduced or no voltage. The presentation will describe the electro coalescence unit's mechanisms, electrode design, applied electric field, the types of the dispersion and the electric field configuration for this type of oil/water mixture.

### **Integrating Enzyme-assisted Aqueous Extraction Processing in the Dry-grind Ethanol Plants.**

J.M. L.N.de Moura<sup>1</sup>, N.M. de Almeida<sup>2</sup>, L. Yao<sup>1</sup>, S. Jung<sup>1</sup>, T. Wang<sup>1</sup>, L. Johnson<sup>1</sup>, <sup>1</sup>Iowa State University, USA, <sup>2</sup>Universidade Federal da Paraiba, Brazil

Enzyme-assisted aqueous extraction processing (EAEP) of soybeans is an environmentally friendly technology that has the potential to replace the hazardous hexane in current oil-extraction plants. This technology allows simultaneous extraction of oil and protein from soybeans, which are fractionated into cream (oil-rich fraction), skim (protein- and sugar-rich fraction), and insolubles (fiber-rich fraction) that can be further converted into edible oil, biofuel, and protein for food or feed purpose. Adopting mechanical treatments, better enzymes, and a countercurrent extraction strategy have improved oil and protein extraction yields up to 98 and 96.5%, respectively. Since most of the extracted oil is recovered as free oil, the main challenge in the process is finding high-value uses for the other two fractions (skim and insolubles). Skim proteins recovered by membrane filtration could produce protein concentrates suitable for food applications adding value to this fraction. The presence of soluble carbohydrates in the skim may enable its utilization into slurring ground corn for fermenting to fuel, increasing fermentation rate, ethanol yields, and improving

the nutritional quality of distiller's dry grains with soluble (DDGS). The insoluble fraction could be converted to fermentable sugars to produce bioethanol and other chemicals.

#### **Upstream: Pilot Scale Biocrude Optimization Study.**

S. Kyle Barfield, William E. Holmes, Rafael Hernandez, W. Todd French, Andro H. Mondala, Mary Hetrick, Magan Green, Allyson E. Holmes, Dave C. Swalm School of Chemical Engineering, Mississippi State University, Mississippi State, MS 39762, USA

The steady rise in the price of oil is due to the dramatic increase in oil consumption throughout the world. In recent years, the need for cost effective and sustainable alternative fuel resources has become necessary in order to offset the demand on petroleum-based fuel. It has been well established that oleaginous microorganisms are capable of producing large amounts of triacylglycerol (TAG), a metabolic by-product that is synthesized when the organisms are cultivated on media that contains high sugar content and low nitrogen. Our previous work has shown that the oleaginous microorganism, *R. glutinis*, can survive in municipal wastewater as well as produce lipids when the water is supplemented with a carbon source. The MSU biocrude pilot scale facility has been operational since the second half of 2011. The main components of the facility are two 500-L fermenters, a membrane separator, a spray dryer, and a solvent recovery system. The aim of this study is to describe the fermenters and optimize the operating conditions of the membrane separator when the fermenters are inoculated with activated sludge and *R. glutinis*. Concurrent studies are being performed on the spray dryer and the solvent recovery system.

#### **Downstream: Pilot Scale Biocrude Optimization Study.**

Clint Diamond, Bonnie O'Neal, Jesse Simmons, Lauren Hartley, William E. Holmes, Rafael Hernandez, W. Todd French, Andro H. Mondala, Allyson E. Holmes, Dave C. Swalm School of Chemical Engineering, Mississippi State University, Mississippi State, MS 39762, USA

The price of conventional fossil fuels is dramatically increasing as the supply of this finite resource depletes, stimulating the need for sustainable energy research. Many of the chemicals produced from fossil fuels can be synthesized from renewable energies (i.e. biomass). Our previous studies have shown oleaginous microorganisms producing large amounts of TAG. The organism *R. glutinis* yields up to 60% of its dry weight as lipids. The MSU biocrude pilot scale facility is the focus of this study. Optimization of the spray dryer unit was accomplished by analyzing the effects of changing variables: inlet temperature, feed pump speed and nebulizer speed. Preliminary results show that at a nebulizer rotation speed of 50 rpm and a pump speed of 65rpm with an inlet temperature of 250°C optimum dryness of less than 2% water content is reached. Optimization of the solvent recovery unit carried out by analyzing the effects of temperature and pressure on the recovery of lipids from solvent. Preliminary results show that running at 300mmHg vacuum and a temperature range from 55-65°C it is possible to remove the solvent from the mixture while keeping the lipids intact. The Bligh and Dyer method is used to extract lipids from the cells.

#### **Synthesis of Fatty Acid Methyl Ester from Hazelnut Oil under Ultrasonic Conditions.**

Sevil Yucel, Didem Ozcimen, Cem Kesgin, Yildiz Technical University, Chemical and Metallurgical Faculty, Department of Bioengineering, Istanbul, Turkey

Fatty acid methyl esters (FAME) are obtained with thermal heating using acid or alkali catalyst traditionally. Low frequency ultrasonic method is used in various chemical processes to enhance reaction rate and yield. Fat and alcohol should be fully mixed in the production of FAME, ultrasonic mixing method appears to be effective to improve mass and heat transfer as well as provide a better mixing of reactants. In this study, the effect of ultrasonic on the alcoholysis reaction of hazelnut oil was studied using KOH catalyst in both 20 kHz frequency (200 W) homogenizer and 35 kHz (400 W) frequency ultrasonic cleaner. Reaction time, alcohol:oil molar ratio, catalyst amount and reaction temperature are experimental parameters studied. Ultrasonic homogenizer gave higher yields compared to ultrasonic cleaner and the traditional method. The highest FAME yield was obtained with ultrasonic homogenizer under 5:1 methanol oil molar ratio, 1% KOH catalyst, 20 min reaction time at autogenic temperature. Ultrasonic homogenizer experiments were carried out at ambient temperature without the need for a heating unit as well as in the classical method, the energy savings were achieved in this respect. Results offered that ultrasonic method can be an alternative method compared to classical method.