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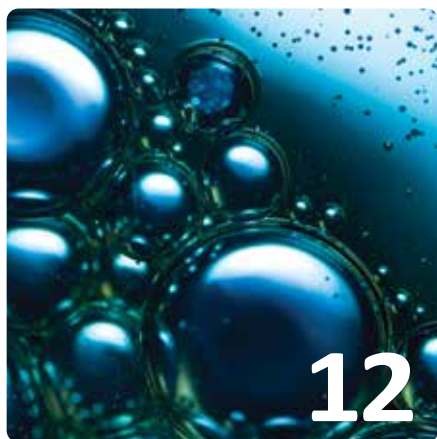
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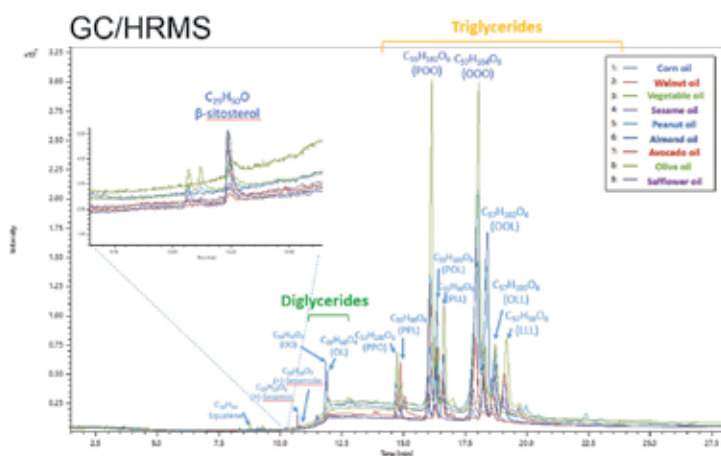
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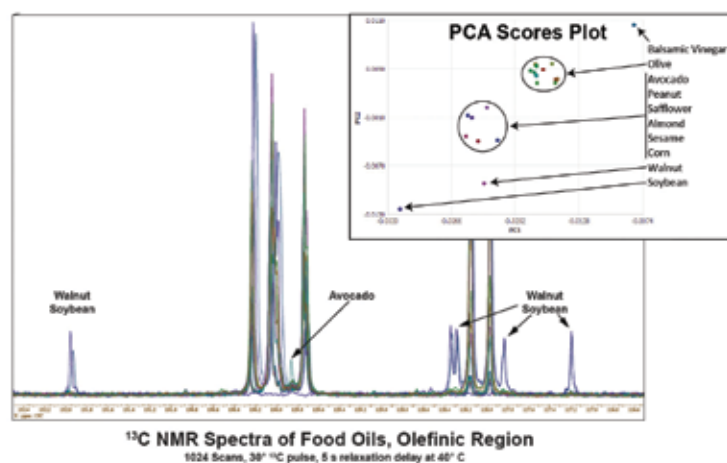
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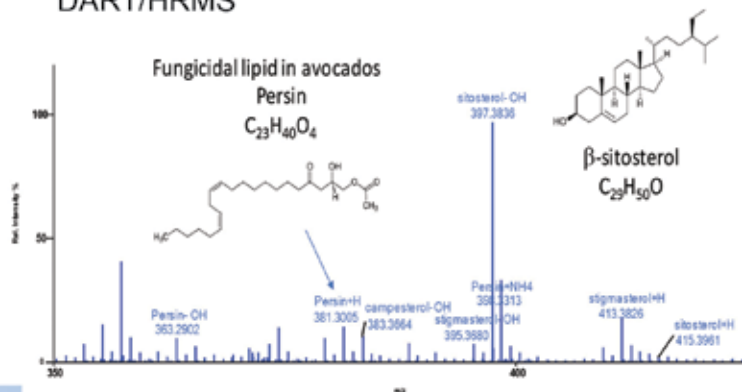
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# The latest additions to eco-friendly cleaning

Rebecca Guenard

Between January and August of 2020, the cleaning products industry produced an extra 427,000 gallons of hand sanitizer and increased the volume of cleaning supplies produced by 23% compared to the previous year (<https://www.cleaninginstitute.org/covid19report>). The surge in production was, of course, due to the industry's assistance with the COVID-19 public health crisis. Personal hygiene and disinfection may have ramped up since the pandemic, but they have always been essential to consumers.

- Cleaning formulators are developing new ways to make household and industrial cleaners better for the environment, but will their ingredients be accepted by consumers?
- One company found that adding protein to cleaners for vehicles used in public transportation reduces how often they need to be cleaned.
- Another company experienced the same effect with probiotics. They have added them to household surface cleaners and odor neutralizers.

As such an integral part of our everyday lives, the cleaning industry has also been committed to improving the sustainability of its products. Over the past decade, that goal has been primarily focused on eliminating petroleum-based ingredients from formulations. Researchers have developed plant-based surfactants using traditional chemical processing methods, as well as biosurfactants prepared from the fermentation of simple sugars and vegetable oils. Production of these biosurfactants has so far been prohibitively expensive, but recent sales of a rhamnolipid dish soap for South American markets indicate biosurfactants are becoming commercially viable.

In the meantime, some homecare ingredient manufacturers are developing new, innovative ways to clean. However, the function of these ingredients may be contradictory to consumers' idea of clean. Instead of stripping a surface of all biological matter, they leave a layer of bacteria or protein behind. Yet, these ingredients use less water and fewer harsh chemicals while remaining effective longer than typical formulations, extending the duration between cleanings. If the current, environmentally friendly trend continues to dominate the market, these ingredients will become the norm and the industry will shift towards new ways to clean.

## PROTEIN ADDITIVES FOR IMPROVED EFFICIENCY

"The development of our technology was a happy accident," says Matthias Reihmann, head of global product management at Gelita, headquartered in Eberbach, Germany. The company primarily makes gelatin for food. Reihmann says they were approached by a specialized cleaning agent manufacturer, named Reinwerk Solutions, that hoped adding Gelita's proteins would stabilize the microfoam structures in its industrial cleaners. One of its customers, a train company in northern Germany called Nord-Ostsee-Bahn (NOB), could not get its vehicle cleaners to foam properly during winter months.





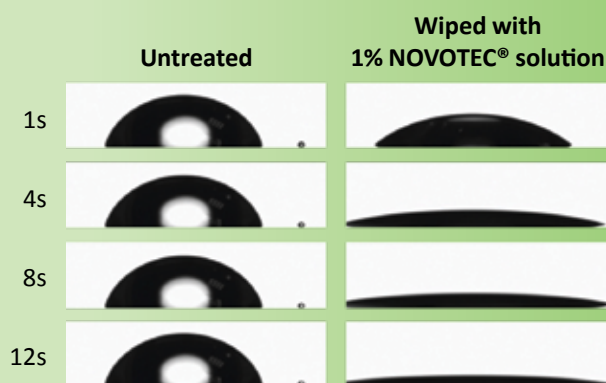
After a short, empirical trial, Reinwerk Solutions and NOB informed Reihmann that typically dirty trains were coming back to the depot completely clean. “They found out that only the trains covered in the Gelita protein were clean after their route,” he says. “Then we started the scientific work to see what the proteins were doing to cause this effect.”

Gelita’s gelatin products are made from collagen, which has an atypical amino acid sequence that contains more hydroxyproline than is found in other types of protein. The greater amount of hydroxyproline leads to protein folding that results in thermally stable fiber networks that explain collagen’s purpose as a structural substance in the body. Interestingly, these properties lead to surface behavior that improves cleaning.

The researchers performed quartz crystal microbalance analysis (QCM-D) and contact angle measurements to identify how the protein interacted with the surface to cause the cleaning benefit. They applied a glass cleaner containing proteins onto a QCM-D sensor and measured, in real-time, the thickness of the protein layer that formed, as well as the film’s viscoelastic properties. The team determined that upon the first cleaning, the protein and surfactants assembled into soft multilayers approximately 20–30 nm thick. When rinsed with water, some of the layers partially dissolved, releasing surfactant, while a thin layer of protein remained on the surface. Contact angle measurements on a variety of solutions containing the protein mixed with different surfactants indicated that glutamate-based surfactants worked most effectively to lower surface tension and improve cleaning (Fig. 1).

Gelita has since designated its cleaning additive, NOVOTEC® CB800 (Fig. 2, page 8). For over five years, the product has been successful throughout Europe as an additive in commercial vehicle cleaners. The experiments performed during that time indicate that the protective function of the protein endures for

#### Wetting behavior of a water droplet on a steel surface (cross sectional view)



**FIG. 1. A demonstration of how surface tension is reduced when a glass surface is cleaned with a solution containing NOVOTEC®.**

Source: Gelita.

approximately three months, even in demanding environmental conditions. When evaluating long-term operating costs, customers have found that NOVOTEC® CB800 eliminates the need for expensive, permanent coatings to protect vehicle paint. In fact, regularly using the product reduces repainting costs because the protein layer traps a thin film of water that shields dirt or sunlight from damaging the surface.

Reihmann says that the thin film of water the proteins trap at the surface prevent soil from penetrating into the paint. This allows the cleaning crew to remove the soil easily without aggressive cleaners. “You can cut back on the abrasiveness of your chemicals, which makes the cleaning safer for the workers and also more environmentally friendly,” he says. “You can get



FIG. 2. Comparison of a surface coated with and without NOVOTEC® before (1) and after (2) cleaning. Source: Gelita.

a much easier cleaning process which translates into more cost saving and improved environmental impact of your operations.”

The idea of using surface coatings in hopes of reducing water use and cleanser alkalinity is not new. These types of products have been on the market for decades. However, they are mostly based on water-repellant products, like waxes, silicones, and other hydrophobic film-forming molecules that are primarily petrochemically sourced. “NOVOTEC® CB800 is a natural product based on a protein type that is also used in food and pharma applications, but it has a lot of interesting chemical properties, particularly for surface interactions,” says Eric Yezdimer, senior manager of research and business development at Gelita, USA.

With the proven success of their products in Europe and with positive feedback from South America, Gelita is pursuing North American markets for customers focused on decreasing the environmental impact of their cleaning formulations. Since the proteins have proven effective not just for vehicles,

but also for household hard surface cleaners, they are planning to test other uses. “We have headed back to the lab to think about how it can best be used for fabrics,” says Reihmann. “We have started making formulations and doing some tests to develop a business case for a fabric product.”

## PROBIOTICS AS CLEANING INGREDIENTS

Advertising for current household cleaners emphasizes that cleaning means killing bacteria; however, as we have learned with the human gut, not all bacteria is out to get us. Encouraging the growth of good bacteria, called probiotics, can actually benefit hard surface cleaners.

The United Kingdom-based ingredient supply company, Croda, has recently launched two probiotic ingredients containing application-specific bacterial strains. One product, intended for hard surface cleaners, is comprised of bacterial strains that degrade common household organic soils. The

### Removal of cheese soil through repeated cleaning

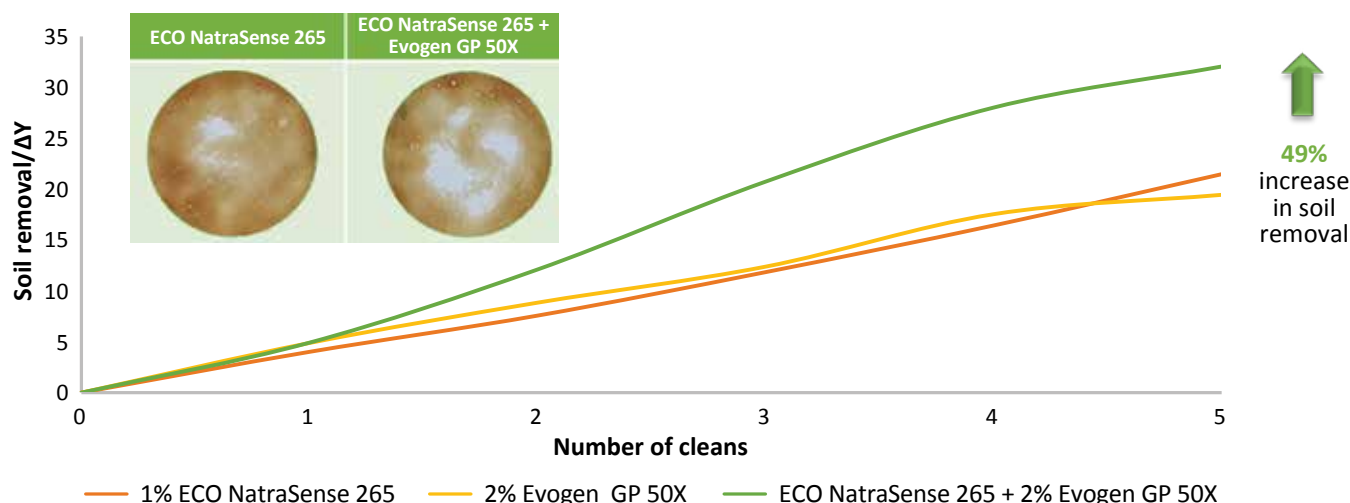


FIG. 3. Treatment of various malodors on fabric samples with a solution of Evogen ON 50x odor neutralizing probiotic shows significant odor reduction over 24–48 hours. Source: Croda.



other is designed for odor-neutralizing products. It contains bacteria that decompose soils which cause malodors, as well as the malodor molecules themselves (Fig. 3).

The company claims its products are made from 100% bio-based ingredients. The ingredients also maintain hard surface cleanliness and odor control longer than cleaners attempting to wipe out all living micro-organisms (<https://www.crodahomecare.com/en-gb/news/2021/01/genesis-biosciences-partnership>).

Scott Jaynes, research and technology manager at Croda, explains that probiotics can make household cleaners more eco-friendly in multiple ways. One way is by requiring less surfactant. "The enzymes produced by the probiotics break down soils and malodors on surfaces effectively, which means that less surfactant is needed to get the same level of cleaning out of your products," he says.

Surfactants are still required for the probiotic formulation to work most effectively. According to Jaynes, bacteria break down soils and odors, while surfactants help them to be solubilized and washed away. "The two products actually work synergistically," he says. "The surfactants remove visible soils for an immediate short-term cleaning effect, while the bacteria activate over time to remove the invisible soils you cannot see."

Another way Croda introduces more sustainability with these cleaners is by offering a range of 100% bio-based surfactants that can be combined with the probiotics. Jaynes says the probiotic ingredients are particularly effective when formulated with nonionic surfactants. Croda has a line of 100% renewable nonionic surfactants, known as the ECO Range, that are produced from plant-based alcohols and bio-based ethylene oxide, produced in their Delaware manufacturing site.

A household cleaning solution may seem like an unwelcoming environment for bacteria, but Jaynes says the probiotics are added to the formulation as spores, a dormant form of bacteria highly resistant to physical and chemical influences. Once the spores are applied to a soiled surface that provides a source of food and moisture, they will develop into growing bacteria. "The spores are stable with most other cleaning ingredients between a pH of about 4.5 to 10.5, so, they can be easily formulated into a wide range of household products," he says. Highly acidic or alkaline cleaners could deteriorate the spores and kill the bacteria, he admits, but the whole goal of the green cleaning trend is to avoid such extremes and replace hazardous formulations with safer, more sustainable alternatives.

Probiotic cleaners are not a completely new concept. They have been applied in industrial and institutional settings for years as floor and grease trap cleaners. Recent advancements in identifying, growing, and isolating these native bacterial strains have made them easier to produce and more effective for a wider market. However, consumers' minds have been ingrained with the message that all surfaces should be bacteria-free. Convincing them that it is beneficial for microbes to colonize their countertops could be a barrier.

Jaynes says that consumer interest in probiotic cleaners is growing in more developed areas of the world, like Europe, Asia, and North America. Market research conducted by Croda and other research firms showed that consumers around the

## Clean and efficient vacuum systems for refining and deodorising

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globe are willing to try these cleaners. It helps that the cleaners have no special storage requirements and can be stored in a cabinet just like similar products containing no bacteria.

Another incentive that may win apprehensive consumers over is the product's endurance. Probiotic cleaners do not stop working as soon as they are wiped away like conventional household cleaners do. The bacteria stay on a surface and keep cleaning for an extended time, breaking down soil and malodor molecules for several days after application (Fig. 4). Traditional cleaners can only offer cleaning at the moment they are applied. "Probiotics harness the power of nature to make cleaning more convenient for consumers," says Jaynes. "That is what we refer to as 'letting nature do the work.'"

## SOLVING THE PROBLEM OF SUSTAINABLE SURFACTANTS

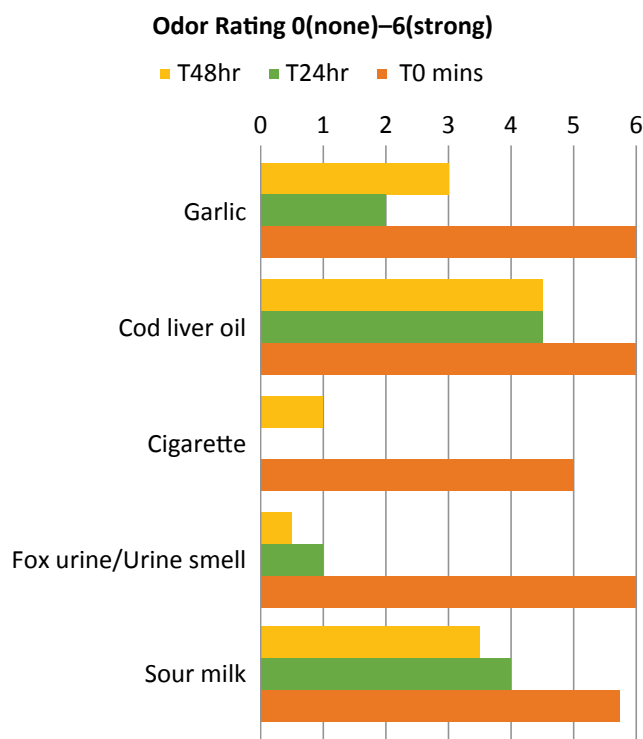
Between 2018 and 2019 the number of consumers who believed companies should invest in sustainability rose from 65 to 87%, according to an Innova Market Insights survey (<https://tinyurl.com/sustainabilitytrends>). The homecare industry has focused on fulfilling this desire for years by reducing plastic packaging, increasing biobased ingredients, and developing detergents that operate at lower temperatures.

The new surface cleaners described here are examples of the industry's ingenuity in certain sectors. But the industry must still solve the challenge of surfactants if it wants to reach its environmental goals. In a recent interview, Neil Parry, R&D program director for biotechnology and biosourcing at Unilever in the United Kingdom, said that in terms of volume, surfactants continue to be the biggest obstacle to sustainability. His company recently announced that in the next 10 years they will go from 16% renewable or recycled carbon to 100% (<https://cen.acs.org/business/consumer-products/Cutting-carbon-cleaning-Unilever/99/i2>).

Surfactants made from petrochemicals make up about half the surfactant volume on the market, particularly in laundry and dish detergent formulations. The non-renewable ingredients offer performance that consumers will not forfeit for an eco-friendly alternative. Even where formulators have been able to maintain performance through a plant-based ingredient, the source is predominately palm oil.

Palm oil's long-chain fatty acids make it ideal for producing plant-based surfactants, but palm tree agriculture does not have a reputation for sustainability, or for that matter, humane labor practices. As interest in finding plant-based alternatives to petrochemicals has increased in the past 50 years, so has palm agriculture. The Roundtable on Sustainable Palm Oil (RSPO) was established in 2004 to promote sustainable palm oil growth. All major brands in the household cleaner industry have committed to including only RSPO-certified palm oil in their formulations.

In the meantime, big-name investors, like Bill Gates, have put money into biotechnology start-ups that make palm oil using fermentation (<https://tinyurl.com/palmoilthrufermentation>). The company Gates supports, C16 Biosciences, is one of a handful implementing this technology in an effort to end deforestation. The cofounder and CEO of C16, Shara Ticku,



**FIG. 4. Demonstration of improved cleaning of burnt-on cheese soil over multiple cleaning cycles using the Evogen GP 50x probiotic in combination with the nonionic surfactant blend, ECO NatraSense 265. Cleaning is increased by 49% with the two ingredients versus cleaning with either the surfactant or probiotic alone.** Source: Croda.

told *Fast Company* magazine recently that her company can produce 3 million metric tons of palm oil a year. That amount represents only 5% of the yearly global production. Although it may not seem like much, with innovative ingredients like proteins and bacteria combined with the enzymes already common in some household cleaners, the industry could require fewer palm oil derivatives in the future.

The green cleaning movement has been a gleaming example of how to make an industry more eco-friendly. In some cases, that has involved re-defining "clean", and so far consumers seem to have accepted the new definitions. As the cleaning industry accepts even greater challenges toward achieving sustainability, their past success will hopefully reflect what they can accomplish in the future.

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## Information

Effective cleaning through a second skin—Why proteins improve cleaning, Reihmann, M., *et al.*, *SOFW Journal*, Volume 146, March 12, 2020.

Sustainable cost reduction in the exterior cleaning of trains and buses, Becker, H., *ETR*, 5, 67, 2015.



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# Advancements and further research trends for microbial biosurfactants in the petroleum industry

Raj Shah, Richard D. Ashby, and Nathan Aragon

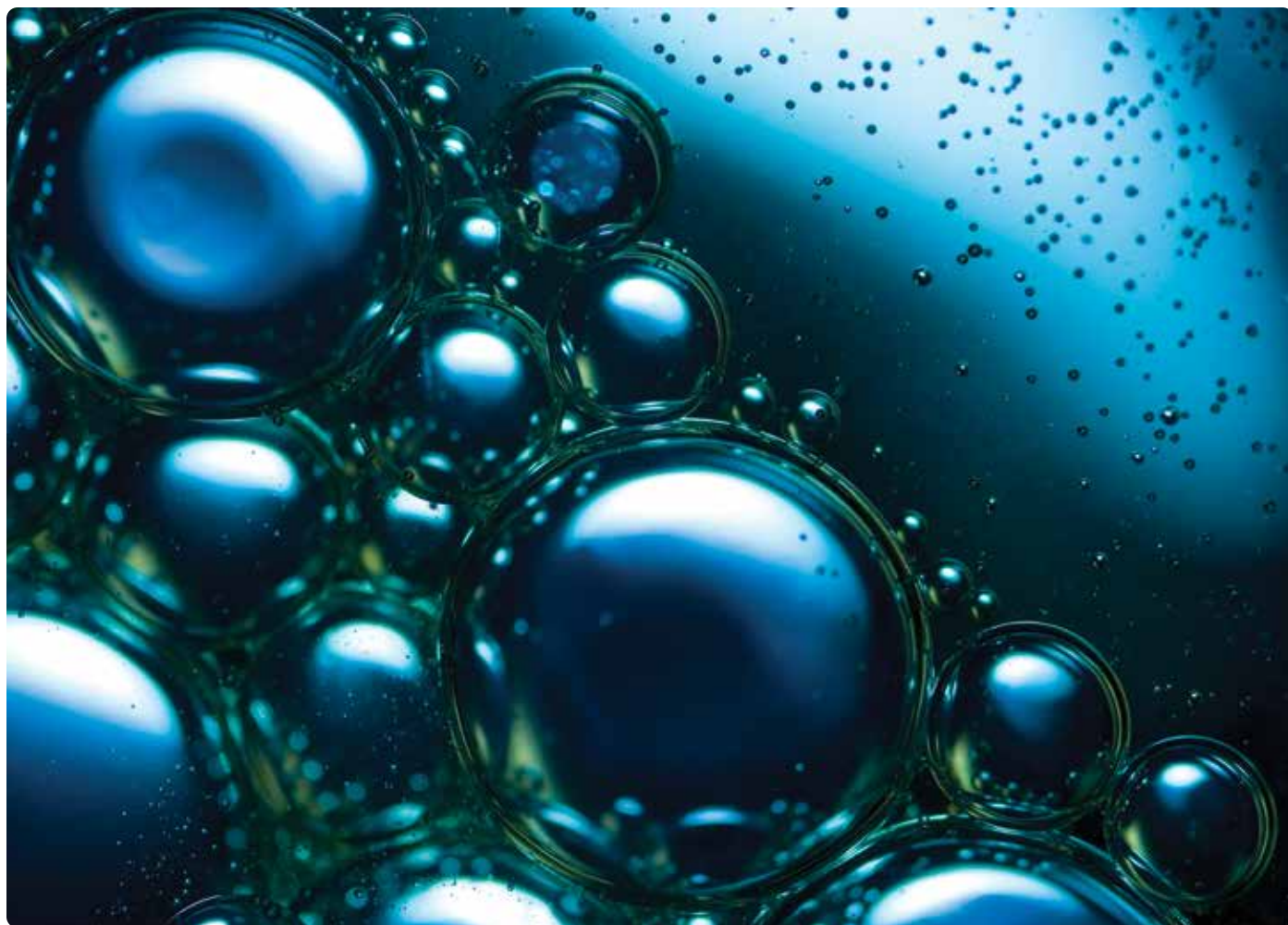
- Surfactants are widely used in the petroleum industry during many stages of oil recovery, refining, and spill cleanup.
- Because these processes release surfactants directly into the environment, much research has been done on the potential for replacing the more commonly used synthetic surfactants with more eco-friendly biosurfactants.
- This article highlights some recent studies of the effectiveness of biosurfactants applied to various aspects of the petroleum industry.

As worldwide efforts continue to focus on the implementation of greener, more environmentally friendly products and processes, many industries have been actively pursuing a more biorenewable platform for product synthesis and application. Surfactants comprise a multi-billion-dollar industry owing to their use in numerous everyday applications, such as in foods, medicines, toiletries, cleaners, automotive fluids, paints and coatings, and processing aids.

As such, surfactant disposal represents a significant ecological problem due to their presence in such large-scale applications as the detergent industry (especially in underdeveloped areas of the world) where pollution problems may exist, and in applications where surfactants are intentionally released into the environment to accomplish a specific task, such as with oil recovery and cleanup. This issue has necessitated a shift in focus from petroleum-based surfactants to the development of more eco-friendly, microbially produced biosurfactants.

Biosurfactants can be classified as either cationic, anionic, amphoteric, or nonionic based on the chemistry of their polar “head groups” and normally fit into one of four categories, including fatty acid-type (e.g., fatty acid soaps), glycolipids (e.g., rhamnolipids, sophorolipids, mannosylerythritol lipids), lipopeptides (e.g., surfactin, iturin, fengycin), and phospholipids and their derivatives (e.g., lysophosphatidylcholine). These molecules provide numerous advantages over petrochemical surfactants, including low toxicity, environmental compatibility/ biodegradability, and sustained activity under extreme variations in pH, salinity,





and temperature. A comprehensive publication covering the biosynthesis and application of many of the specific biosurfactants comprising each of these categories can be found in reference [1].

To put the global biosurfactant industry into perspective, it was worth about \$4.2 billion in 2017, and is expected to reach \$5.52 billion by 2022 [2]. The biosurfactant industry also has a very positive growth outlook even within the next 5 to 10 years. One source predicts that the global market for biosurfactants will experience a compound annual growth rate (CAGR) of approximately 5.5% from 2019 to 2026, from a current value of \$1.7 billion to \$2.5 billion. To put this into perspective, the food processing industry is predicted to have a CAGR of 16–17% from 2020 to 2026. Much of the biosurfactant industry growth in Europe will be attributed to regulation and consumer demand for eco-friendly products, while growth in Asia will result largely from personal care applications [3]. The biggest barrier to growth for biosurfactants is price, because synthetic surfactants usually cost about \$2 per kilogram and current methods of biosurfactant production cannot compete. Future research will most likely focus on bringing the price of biosurfactants to a level closer to synthetics [4].

Surfactants have widespread use in the petroleum industry during many stages of oil recovery and refining. As such,

there has been much research done on the potential for replacing the more commonly used synthetic surfactants with biosurfactants. Some of the potential outlets of biosurfactants in the petroleum industry include applications in enhanced oil recovery and transportation, oil waste treatment and spill cleanup, anti-corrosive and demulsifying agents, storage tank cleaning, control of sulfate-reducing bacteria, and extraction of bitumen from tar sands. Here we will highlight a few salient examples of recent studies done on the effectiveness of biosurfactants applied to various aspects of the petroleum industry.

### **BITUMEN REMOVAL FROM TAR SANDS**

Bitumen is extracted from oil sands either by surface mining or by underground oil sands recovery. During surface mining, hot water is mixed with oil sands to make a slurry that is composed primarily of bitumen. This slurry can then be treated and refined using biosurfactants.

In underground recovery, biosurfactants can be injected into the ground, along with hot water, to ease the separation of oil from the ground and to help transport the oil to the surface. Specifically, in this application the biosurfactants help to decrease interfacial tension between the oil and rock, overcome capillary forces which helps bring oil to the surface,



and increase the displacement of oil. This technique can gain many advantages by using the process of microbial enhanced oil recovery (MEOR), where 1) biosurfactants can be isolated and then injected into the ground (*ex situ*), 2) microorganisms can be introduced into the ground where they produce the surfactants afterward (*in situ*), or 3) by nutrient augmentation where essential nutrients are injected into the reservoir to stimulate the growth of indigenous biosurfactant-producing microorganisms.

The wastes generated during extraction of bitumen (extraction tailings) are usually sent to special tailings ponds where they are stored, and gravity is used to separate solids and water. This separation is often aided by surfactants. Many refineries also produce waste sludge that contains residual oil in water, and biosurfactants can be effectively applied to aid in the oil recovery from sludge. During storage of petroleum products, heavy oil often settles to the bottom of storage tanks, and biosurfactants can be used to help form less viscous emulsions of oil in water which make it easier to reclaim the oil. Transport of heavy oil through pipes is a challenge because often oil builds up as sludge deposits on the walls of the piping, leading to pressure reductions and reduced fluidity (and potential plugging problems) for the mixture that is transported; so biosurfactants may be used to help purge these pipelines [2].

## OIL SPILL BIOREMEDIATION

Surfactants are also widely known in their application to aid in bioremediation following an oil spill in either marine or terrestrial environments. The discharge of crude oil into the environment regardless of the source causes many deleterious effects on both the flora and fauna of the affected areas. Typically, when these unfortunate events occur, the lighter fractions of oil usually evaporate but heavier fractions require a more robust remediation effort which may be accomplished through microbial degradation processes.

In these processes, microorganisms can uptake oil droplets directly by either modifying their cellular surface or through the production of extracellular biosurfactants that encapsulate the oil droplets in micelles and aid in oil uptake. Chemical dispersants and surfactants are also usually added to spill areas because the natural process of environmental remediation can often take a very long time if left unaided. Once introduced, the surfactants aggregate at the oil-water interface and interact with the oil using their hydrophobic moieties while associating with water using their polar, hydrophilic moieties. This results in the formation of very small oil droplets that get dispersed into water where they can be encapsulated in micelles formed by the surfactants.

When applied to oil-contaminated soil, bioremediation can be accomplished either *ex situ* or *in situ* as described previously for MEOR. The *ex-situ* method involves the soil getting washed to separate out the oil either by mechanical means (gravity separation) or by surfactant washing. The *in-situ* method involves growing microorganisms in the soil and having them produce surfactants on their own, but the efficiency

of this is subject to many factors in the soil such as pH and nutrient presence and concentration [2].

## MEOR FOR OIL RECOVERY

As mentioned previously, microbial-enhanced oil recovery (MEOR) is a very promising application for biosurfactants to replace chemical surfactants. MEOR is a process used for oil recovery in which microorganisms or their metabolites are used to improve residual oil recovery. MEOR is normally less expensive than chemically enhanced oil recovery methods, especially when high biosurfactant productivities can be realized starting from low-cost raw material substrates.

Typically, under traditional oil recovery methods, a significant amount of crude oil (often 50% or more) remains trapped in small pores within the rock formation and is unrecoverable. A study was performed two years ago in Korea, where researchers analyzed performance characteristics of surfactin produced by *Bacillus subtilis* strain ATCC 6633 for the purpose of MEOR. The experiments were conducted in a high-pressure bioreactor designed to simulate conditions in a typical hydrocarbon reservoir with temperatures ranging from 35°C to 45°C and the pressure set around 10 MPa. It was found that 45°C resulted in the lowest final surfactin concentration of 61–73 mg/L. However, as the temperature dropped to 35°C the highest concentrations of surfactin were achieved, with values ranging between 106 mg/L and 125 mg/L.

The surfactin decreased interfacial tension of dodecane and brine in both aerobic and anaerobic conditions from 50–54 mN/m down to 8–10 mN/m in less than 30 hours and remained consistent at all temperatures in the range. The dodecane-brine-quartz system contact angle was reduced from 48–49° down to about 23° in less than 30 hours. This also did not show much variation at different temperatures.

A pore network model simulation was used to determine how the surfactin would improve oil recovery and residual oil saturation (ratio of pore volume occupied by oil to the entire pore network volume) and these parameters were measured at a given capillary pressure (difference in pressure between outlet and inlet pores). The results showed that the residual oil saturation decreased from 0.27 to 0.09 after application of the surfactin. This study demonstrated that this strain of *Bacillus* that could produce surfactin may be a viable candidate for MEOR activities but the authors caution that there should be more site-specific studies because of a wide variability in conditions at different reservoirs [5].

## TREATMENT OF WASTE EFFLUENT FROM REFINERIES

A large issue in the petroleum industry is the treatment of waste effluent from refineries that still contain a significant concentration of hydrocarbons. This oily wastewater can enter the soil, aquatic environments, or drinking water supply if it is not managed effectively.

Normally, physical/chemical separation technologies such as centrifugation, ultrafiltration, decantation, flotation, and flocculation can be effectively used for the separation of



oil-water mixtures. However, the utilization of biosurfactants as coagulants and/or dispersing agents has been shown to be capable of improving the efficiency of these techniques.

In a recent study, researchers from Egypt conducted a study on *Pseudomonas aeruginosa* ATCC 9027 and its rhamnolipid production capabilities under the conditions of four different initial oil concentrations (1%, 1.5%, 2%, and 2.5%). At each concentration, cell growth was carried out for a total of 360 hours in a mechanically agitated 10 L glass fermenter and the effect of the oil concentrations were observed on rhamnolipid production and on the percent removal of hydrocarbon waste. The maximum titer of rhamnolipids, 2.68 g/L, were obtained at 2% oil concentration. This was followed by an oil concentration of 1.5% which showed the next highest rhamnolipid titer at 2.41 g/L.

Regarding total oil removal by the synthesized rhamnolipids after a period of 360 hours, an initial hydrocarbon concentration of 1.5% led to 100% removal of aliphatic hydrocarbons, benzene, toluene, and xylenes. This was followed by the 2% initial hydrocarbon concentration in which the rhamnolipids were 99.9% effective in the total removal of oil. The 2.5% initial hydrocarbon concentration did not reach higher than 96.6% total removal of oil after the same time. The researchers stated that the 2% initial concentration gave the best overall results when considering both the production of rhamnolipids and the concomitant hydrocarbon removal [6].

One significant advantage of microbial biosurfactants is that many of them can remain stable over a wide range of environmental conditions. Researchers in China obtained a sample of *Bacillus licheniformis* Y-1 from the Dagang Oilfield and studied the characteristics of the biosurfactant that it produced. FTIR and  $^1\text{H}$  NMR analyses revealed that this strain produced a cyclic lipopeptide. This biosurfactant could reduce the surface tension of water from 74 mN/m to around 27 mN/m and it had a critical micelle concentration (CMC) of 40 mg/L. The lipopeptide was able to maintain the surface tension of

27 mN/m at a range of temperatures (between 10°C up to 80°C), salinities (NaCl concentration extending from 0 g/L up to 30 g/L), and pH (from pH 5 to pH 12). Below pH 5, the surface tension increased dramatically back to about 60 mN/m. When compared with other common surfactants such as Tween-80 and rhamnolipids, the lipopeptide from strain Y-1 had the highest emulsification index across different types of oils, with crude oil resulting in the highest at about 90% [7].

## MARINE SPILL REMEDIATION

For maximum application potential, microbial biosurfactants will need to compete well with synthetic surfactants in marine oil spill remediation, as this is one of the most important functions of surfactants in the petroleum industry. Recently, researchers from China isolated a lipopeptide that was secreted by *Bacillus subtilis* HSO121 and determined its surfactant properties to measure how it might perform in marine bioremediation. This lipopeptide had a CMC of  $8.69 \times 10^{-5}$  mol/L. The dispersion effectiveness (DE) of the lipopeptide was measured under the influence of various external factors such as surfactant-to-oil ratio (SOR), pH, temperature, and salinity. The DE was maintained above 70% as the temperature ranged from 15°C to 25°C, with the highest DE at about 73% at 20°C. As the pH was increased, the DE also increased with the highest DE of 77.4% at pH 11. The DE ranged from 56% at 0% (w/v) NaCl up to 71% at 4% (w/v) NaCl. Overall, the DE reached 70.2% with SOR of 1:10 (w/w) at 25°C, 3% (w/v) NaCl, and pH 7. A test of toxicity showed that the lipopeptide was much less toxic compared with other surfactants like sodium dodecyl sulfate (SDS) and Betaine. The 24-hour  $\text{LC}_{50}$  value for zebrafish was 1145 mg/L, whereas this value was 8.25 mg/L for SDS and 0.872 mg/L for Betaine. Biodegradability of the lipopeptide was observed against sodium dodecyl benzene sulfonate (SDBS) where each surfactant had an equal initial concentration of 30 mg/L. After 7 days of incubation, the lipopeptide was 100% degraded while the SDBS was 98.8% degraded. The researchers noted that the lipopeptide degraded much faster and was nearly 100% degraded after only the third day. Finally, the degradation rate of long-chain hydrocarbons of the lipopeptide was compared to a commercial dispersant and after two days, the degradation rate of hydrocarbons was 71.45% in the presence of the lipopeptide and 34.16% in the presence of the commercial dispersant [8].

## CHALLENGES AND UPCOMING RESEARCH

The largest challenge that the biosurfactant industry currently faces is producing them on a large scale in a cost-effective manner. Industrial production of biosurfactants is usually done in large fermenters so the growth and synthesis parameters must be designed optimally. One example of a biosurfactant that has shown promise from a synthesis standpoint is sophorolipids. Sophorolipids belong to the glycolipid class of biosurfactants and have been documented to be routinely produced from the yeast *Starmerella* (formerly *Candida*) *bombicola* in titers greater than 100 g/L from agricultural by-products.

Trying to optimize the media that microbial cultures are grown in for an enhanced yield has been considered. Studies

have shown that in some instances adding activated charcoal as a solid support to the medium increased surfactant yield significantly.

Lactones have been used as growth enhancers and have induced production of rhamnolipids specifically. The use of low concentrations of iron nanoparticles have also shown promise in past studies, with one study showing an increase in production by up to 80%. The possibility of designing a medium where microbes produce both biosurfactants and the enzyme lipase holds potential to be very economical, as it can combine two useful processes in one. A previous study found that significant amounts of both biosurfactant and lipase were produced by *Aspergillus* sp. in a submerged-state fermentation process. With a process like this, however, more investigation is needed for collecting and separating each product in an economical way [4].

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The examples here are meant to show the recent directions of research in this area and to introduce the potential for biosurfactants to be as efficient as their chemical counterparts. Without a doubt, many challenges still exist, such as cost, availability of microbial strains, and scale-up processes to produce biosurfactants on an industrial scale. All the studies presented here have been done in lab scale, and there is currently a paucity of examples of these biosurfactants being applied to real situations. Many advancements have been made, such as those described above, but it is certain that further process development and intensification will be a large focus of upcoming research in this area.

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# Why does lipid oxidation in foods continue to be such a challenge?

Eric A. Decker and Ipek Bayram

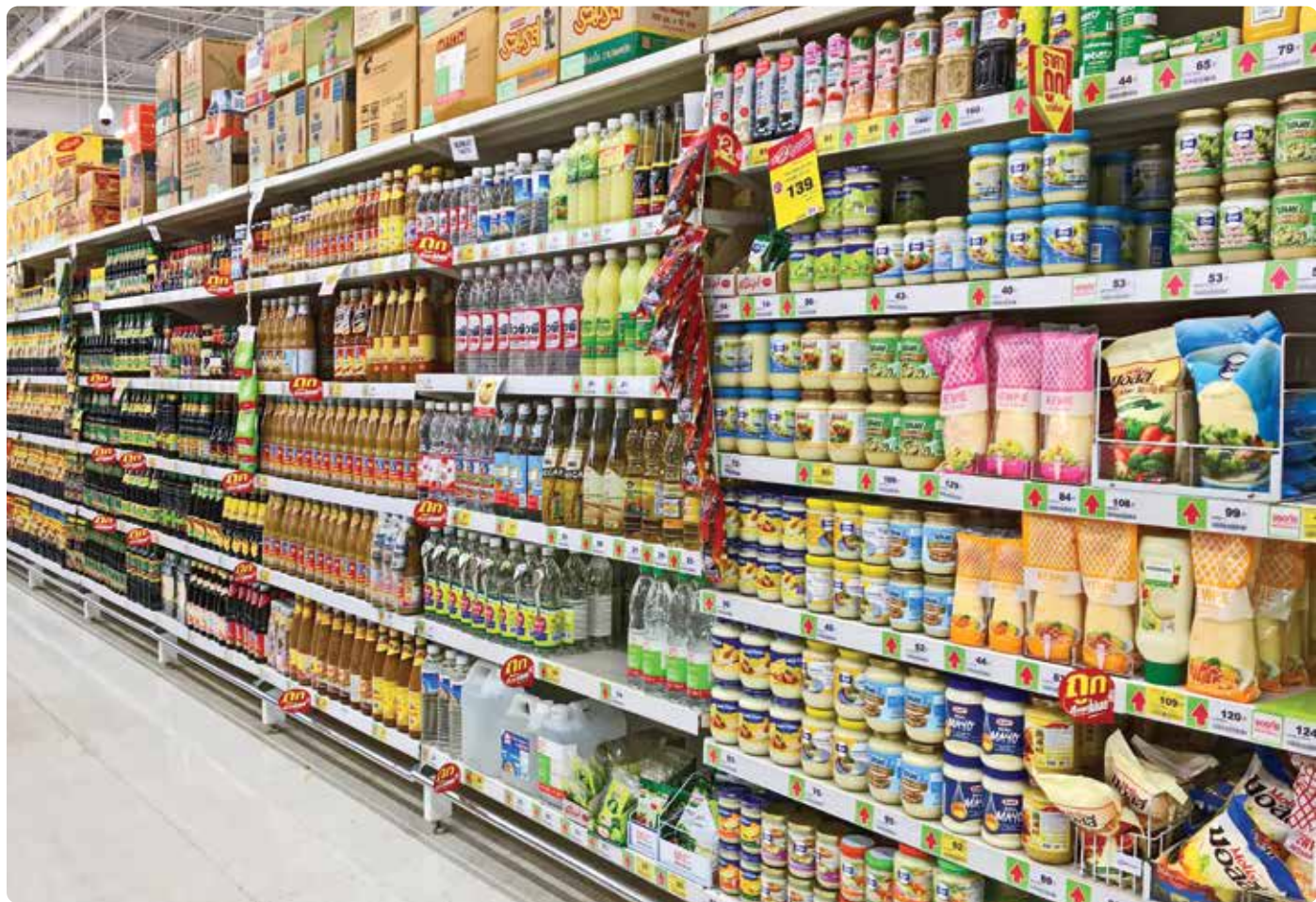
- Lipid reactions are extremely complex because they involve numerous prooxidants, antioxidants, and lipid substrates whose reactivity is impacted by the physical properties of complex food systems.
- Understanding the interactions between the factors impacting lipid oxidation reactions is key to developing novel antioxidant strategies.
- Synergistic antioxidant combinations represent a promising approach to decreasing oxidative rancidity if how and where they work can be better understood.

Eric A. Decker is the winner of the 2021 Supelco AOCS Research Award, sponsored by MilliporeSigma, which recognizes outstanding, original research in fats, oils, lipid chemistry or biochemistry. His open-access award presentation with the same title was given in April as part of the of the AOCS Awards Presentation Award Series.



Scientific observations and research on lipid oxidation began in the early 1800s. These included observations that oil absorbed oxygen and produced acids during the formation of rancidity. In the late 1800s, the iodine value method was developed, and it was found that iodine value decreased during rancidity development, thus implicating the involvement of unsaturated fatty acids. The role of lipid hydroperoxides was discovered in the 1930s–1940s, and methods to quantitate oxidation levels began in the 1910s and continue today. For an extensive review of the history of lipid oxidation, see Hammond and White (2011). After 200+ years of lipid oxidation research, it is somewhat surprising that it continues to be a challenge to food manufacturers, especially since it is a major cause of food quality defects and, therefore food waste. In addition, there is increasing evidence that the consumption of lipid oxidation products could negatively impact health, especially in the gastrointestinal tract (Zhang, *et al.*, 2019).





Control of lipid oxidation is difficult due to the multitude of different factors impacting its chemistry. Typically, lipid oxidation requires both oxygen and unsaturated fatty acids. Oil degradation can also occur at high temperatures in the absence of oxygen through thermal decomposition reactions, and saturated fatty acids in foods can oxidize when subjected to gamma radiation; however, the most common pathway is the free radical-promoted oxidation of unsaturated fatty acids. Lipid oxidation in foods is almost always accelerated by prooxidants, including transition metals (both free and protein-bound), enzymes, and singlet oxygen, despite being commonly referred to as autooxidation. Many physicochemical properties of foods also impact lipid oxidation reactions, such as water activity, pH, physical barriers that impede reactants (e.g., wall materials in dried foods), and prooxidant/antioxidant partitioning into different food environments. Because so many different factors affect lipid oxidation reactions and these factors vary widely among different foods, it can often be difficult to know how to develop effective strategies to slow down lipid oxidation reactions.

As mentioned above, unsaturated fatty acids and oxygen are the primary substrates for lipid oxidation reactions in foods that decrease food quality. Oxidation reactions increase approximately 10–12-fold when the level of unsaturation increases from one double bond to two double bonds.

This is because hydrogen abstraction from aliphatic carbons becomes much easier when two adjacent electrophilic double bonds attract electrons towards themselves (McClements and Decker, 2017). Further increasing the number of double bonds increases the oxidation rates 2-fold more for each added double bond due to the availability of extra reaction sites. Therefore, decreasing the level of unsaturated fatty acids in foods is an effective way to control lipid oxidation. Unfortunately, this goes against most nutritional recommendations that encourage decreasing saturated fatty acid consumption. One exception to increase oxidative stability while keeping nutritionally beneficial unsaturated fatty acids is to substitute polyunsaturated fatty acids with monounsaturated fatty acids. This strategy allows the utilization of specialty high-oleic acid seed oils (75–82% oleic acid), olive oil ( $\approx$ 74% oleic acid), and canola oil ( $\approx$ 60% oleic acid) to increase oxidative stability while maintaining positive nutritional facts panels.

Controlling oxidation reactions by altering oxygen concentration can be effective, but for some foods this is not always a practical strategy. Oxygen is a bi-radical that can add to fatty acid radicals (alkyl radicals) in diffusion-limited reactions. In other words, the activation energy for oxygen-alkyl radical reactions is close to zero, so the reaction speed is dictated by how long it takes oxygen and alkyl radicals to diffuse into close enough proximity to react (McClements and Decker, 2017).



This means that the majority of oxygen must be removed from food before oxidation rates significantly decrease. For example, in an experimental animal feed, over 65% of oxygen had to be removed before oxidation rates decreased. This is not difficult to accomplish in a low-moisture food because most of the reactive oxygen comes from the atmosphere, and much of it can be removed in less than a minute by nitrogen flushing (Zhang, *et al.*, 2020). However, in food such as oil-in-water emulsions, dissolved oxygen is much more reactive than atmospheric oxygen. This is also true of bulk oils where oxygen solubility is greater than in water. The unit operations to make emulsions (e.g., high shear mixing and homogenization) result in saturated dissolved oxygen concentrations. Similar to the animal feed, 60–80% of dissolved oxygen in an oil-in-water emulsion needed to be removed to get a slight improvement in oxidative stability. However, removal of more than 93% of the oxygen was needed to get meaningful protection in oil-in-water emulsions (Johnson, *et al.*, 2016). Unfortunately, dissolved oxygen is difficult to remove, and strategies like nitrogen flushing or purging of the product to get low enough oxygen levels to slow oxidation take over 15 minutes, a time that is not practical in most food processing operations.

Since lipid oxidation is a problem in all oxygen-consuming organisms, biology has developed a host of protection strategies, including free radical scavenging polyphenols, components to reduce the transition metal activity, enzymes to decrease lipid hydroperoxide concentrations, and singlet oxygen quenchers. However, when foods are processed, these antioxidant systems are often disrupted by inactivating enzymes, releasing protein-bound metals, and exposing lipids to the environment. This means the biological tissues that we convert into foods have much higher levels of pre-formed lipid oxidation products, such as lipid hydroperoxides, than the original living tissue.

Transition metals, particularly iron and copper, can decompose lipid hydroperoxides into free radicals, which in turn promotes a chain reaction that oxidizes other fatty acids. This pathway is especially important in lipid dispersions where the surface activity of lipid hydroperoxide allows them to concentrate at the oil-water interfaces of both emulsions and bulk oils where they are decomposed into free radicals by metals in the aqueous phase or metals associated with the water-lipid interface. Because metal-promoted lipid hydroperoxide decomposition predominates the other oxidation pathways in lipid dispersions, the use of metal chelators is an effective antioxidant strategy. Conversely, in low-moisture systems, such as the cracker model, neither metal chelators nor the addition of up to 10 times the endogenous iron concentration affected lipid oxidation (Barden, *et al.*, 2015a). The inactivity of metals in the crackers is also seen as lipid hydroperoxides increase during the early stages of storage, but it takes much longer for the formation of hydroperoxide decomposition products, such as hexanal. In foods where iron is very active, such as oil-in-water emulsions, hydroperoxide and hexanal formation happen simultaneously as the metals rapidly decompose the hydroperoxides into secondary oxidation products. Because of these differences in the prooxidants causing oxidation, different

strategies are needed to control oxidation in lipid dispersions versus low-moisture foods.

Because metal chelators are not effective antioxidants in many foods and because the most effective food chelator, EDTA, is not a natural ingredient and is not suitable for “clean” labels, many products utilize free radical scavengers for protection against oxidation. Free radical scavengers are reducing compounds that can donate electrons to lipid radicals, resulting in a transfer of the radicals from lipid to the antioxidant. The resulting antioxidant radical has lower energy; thus, it is not a strong promoter of further oxidation. However, this pathway results in the destruction of the free radical scavenger, so it only delays oxidation, and once the radical scavenger is consumed, lipid oxidation will resume.

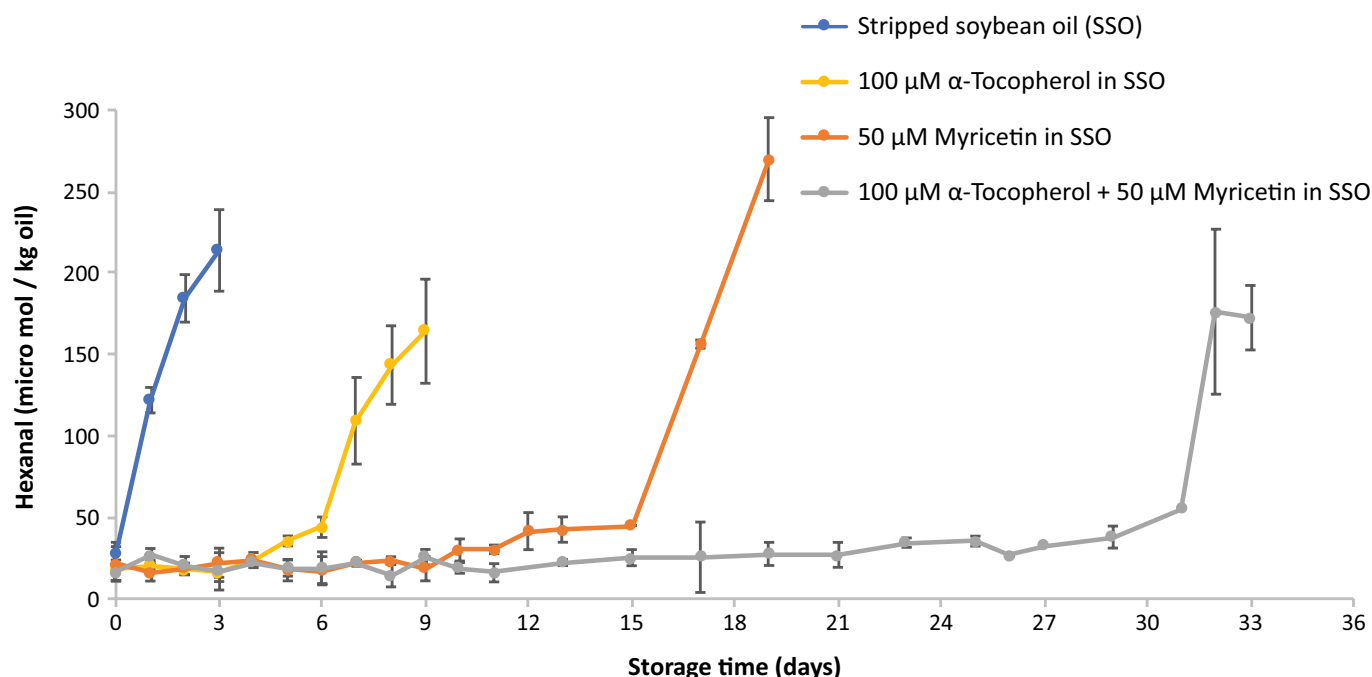
The location of these free radical scavengers in food systems has gained strong attention because the tendency of antioxidants to locate themselves in the aqueous phase, lipid phase, or at the oil-water interface has an impact on their ability to inhibit lipid oxidation. This was first described by William Porter of Natick Laboratories as the Antioxidant Polar Paradox. This hypothesis was centered on the observation that polar antioxidants were most effective in bulk oils, and non-polar antioxidants were best in emulsions since the antioxidants were retained in the lipid droplets. Carlos Bravo Diaz, of the University of Vigo, further refined the Antioxidant Polar Paradox using a surface-active probe to show that many free radical scavenging antioxidants concentrate at oil-water interfaces (Gunaseelan, *et al.*, 2006).

Pierre Villeneuve’s (CIRAD, UMR) work with “phenolipids” further showed the importance of the water-oil interface in lipid oxidation chemistry by showing that antioxidants with intermediate polarity and high surface activity (8–12 carbon tails) were the most effective in oil-in-water emulsions (Laguerre, *et al.*, 2009). However, Dr. Villeneuve’s work also showed that when surface-active antioxidants were too non-polar (20 carbon tail), antioxidant activity in emulsions was lost.

Similar phenomena were observed in different emulsion systems with rosmarinic acid esters, hydroxytyrosol esters, and dihydrocaffeic acid esters, suggesting that a certain level of hydrophobicity alters the partitioning of antioxidant in a manner that decreases antioxidant activity (Panya, *et al.*, 2012; Medina, *et al.*, 2009; Sørensen, *et al.*, 2011). These findings showed that the Antioxidant Polar Paradox was not just about nonpolar antioxidants being more effective in lipid dispersions.

While antioxidant partitioning has been a helpful way to predict an antioxidant activity in lipid dispersions and bulk oils, it has not been beneficial in predicting activity in more complicated food systems. For example, the 20 carbon rosmarinic acid esters developed by Pierre Villeneuve were more effective than the 12 carbon antioxidant esters in a low-moisture cracker system (Barden, *et al.*, 2015b). In addition, the one-carbon ester of caffeic acid was more effective than the 8 and 12 carbon esters in fish oil-enriched milk (Aleman, *et al.*, 2015).

Besides partitioning behavior, the activity of antioxidants can also be difficult to predict because antioxidants often interact with other food components to make them prooxi-



**FIG. 1. Formation of headspace hexanal of stripped soybean oil (SSO) containing 50 micromolar myricetin and 100 micromolar alpha-tocopherol at 55°C**

dativ. Metal chelators can increase the solubility of metals which can make them prooxidative if they are still catalytically active. Free radical scavenging antioxidants, such as catechin and ascorbic acid, can be prooxidative when they donate electrons to convert transition metals to their more reactive reduced state, thus increasing their prooxidant activity (Hu, *et al.*, 2004). Conversely, free radical scavenging antioxidants can donate an electron to an oxidized antioxidant to regenerate and thus increase its antioxidant activity. The classic example of this pathway is seen in biological tissues where ascorbic acid can reduce tocopherol quinones back to tocopherol, where it can scavenge additional radicals. Antioxidants such as myricetin inhibit lipid oxidation synergistically with alpha-tocopherol (Fig. 1) potentially through its low reducing potential (360 mV vs. 500 mV for alpha-tocopherol) and/or its ability to chelate metals. Catechin and epicatechin, which have higher redox potential than tocopherols (570 mV) do not exhibit synergistic activity through regeneration mechanisms (Yin, *et al.*, 2012).

The phospholipids phosphatidylethanolamine (PE) and phosphatidylserine (PS) also show synergistic activity with tocopherols but not by a simple reduction of tocopherol quinone. In this case, the PE or PS forms a complex with tocopherol quinone, and through a series of rearrangements, the tocopherol is regenerated (Doert, *et al.*, 2012). PE or PS in combination with tocopherols is very effective at inhibiting lipid oxidation in both oil-in-water emulsions and bulk oils, increasing lag phases 50–600%. Interestingly, only PS was synergistic with tocopherols in oil-in-water emulsions (Samdani, *et al.*, 2018), while only PE was synergetic with tocopherols in bulk oils (Xu, *et al.*, 2019). The majority of research that shows PE and PS synergism with tocopherols uses research-grade phospholipids, which are far too expensive to use as a food

additive. Recent work in our lab has shown that the phosphatidylcholine (PC) naturally found in commercial lecithins can be converted to PE or PS with the enzyme phospholipase D. These high PE or PS lecithins are effective in both oil-in-water emulsions and bulk oils.

Lipid oxidation is even more complex than described in this short article as prooxidants such as singlet oxygen, heme proteins, and lipoxygenases; antioxidants such as singlet oxygen quenchers; and physical factors such as water activity and solid fat content were not discussed. Also, sugars and proteins can exhibit antioxidant activity in some foods, and along with natural polyphenols and metal chelators, they provide inherent oxidative stability beyond food additives. Furthermore, food structures and conditions such as those in spray-dried powders, frying oil and fried foods, muscle foods, dairy foods, cereals and their flours, and nuts were not discussed. These all have unique issues that impact lipid oxidation reactions as the lipid location and type can vary from bulk lipids to surface lipids to cell membranes to lipid bodies (oleosomes). A further complicating issue is that in many foods, these factors are working simultaneously. For example, a dairy-based salad dressing would have iron-promoted oxidation of the emulsion, singlet oxygen-derived oxidation from light-activated riboflavin, metal chelation by casein and citric acid, endogenous tocopherols and phospholipids from the refined oil, and headspace and dissolved oxygen as well as oxygen absorbing through the packaging.

Much work has been published on the fundamentals of lipid oxidation in systems such as food dispersions, bulk and frying oils, muscle foods, and dairy products, which has led to more effective antioxidant strategies. For example, the body of work by numerous authors over the last 20 years has pro-

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# AOCS 2021 award recipients

AOCS honors those individuals and institutions who have taken research and technology to the next level, who have advanced the quality and depth of the profession, and who have leveraged their knowledge for the benefit of the Society. Their contributions are critical to AOCS and the advancement of the science and technology of oils, fats, proteins, surfactants, and related materials. The award winners designated with an asterisk (\*) presented a free online lecture as part of Awards Presentation Series. Visit [annualmeeting.aocs.org/aocs-awards-series](http://annualmeeting.aocs.org/aocs-awards-series) to view their recordings.



## SOCIETY AWARDS

### A. R. BALDWIN DISTINGUISHED SERVICE AWARD

*Recognizes an active or previously active member of the Society making outstanding contributions and service to the Society over a substantial time. For the first time ever, two winners have been chosen in the same year. Sponsored by Cargill, Inc.*



**Robert A. Moreau** had a distinguished research career at the Eastern Regional Research Center, USDA, ARS, in Wyndmoor, PA, including service as a US Delegate to the Codex Alimentarius Committee on Fats and Oils. His research focused on processes to obtain and analyze edible oil and health-promoting lipids from corn and other grains used to make

fuel ethanol. He received the AOCS Fellow Award in 2009, and was also recognized with the AOCS Herbert J. Dutton (2006) and Alton E. Bailey Awards (2015). His extensive contributions to the AOCS community include serving as a member of the AOCS Governing Board for 13 years, as an associate editor for *Lipids* for 20 years, and as a contributing editor for *Inform* magazine for more than a decade.



**Vijai K. S. Shukla** is CEO and Founder of International Food Science Centre A/S, Denmark, and has been active in food science research since 1969. His research interests have ranged from mechanisms of lipid autoxidation to innovations in analytical methodology. He has made a significant impact revealing the involvement of essential fatty acids in health and

diseases and has authored nearly 100 scientific papers and 15 book chapters. He has received numerous scientific awards, including the AOCS Stephen S. Chang Award in 2002 and AOCS Fellow Award in 2005. He has been part of the AOCS commu-

nity since 1985, and has made significant contributions, particularly in methods development. Dr. Shukla's leadership of the NMR and Mycotoxin Subcommittees of the Uniform Methods Committee has ensured that our methods remain current and appropriate for international trade. He has also served on the *Inform* magazine Editorial Advisory Committee and as associate editor for the *Journal of the American Oil Chemists' Society* for more than 20 years.

### AOCS AWARD OF MERIT

*Recognizes an AOCS Member who has displayed leadership in administrative activities, meritorious service on AOCS committees, or performed an outstanding activity or service.*



**\*Fereidoon Shahidi** is a research professor in the Department of Biochemistry at Memorial University of Newfoundland. His research interests are in nutraceuticals and functional foods with particular attention to lipids, proteins, polyphenols, natural antioxidants, and oxidation control. He has authored over 1,000 research papers and book chapters, 78 books, and

10 patents, and has received numerous awards, including the AOCS Stephen S. Chang Award, Alton E. Bailey Award, and the Supelco AOCS Research Award. He is currently the chair of the Scientific Council of the International Union of Food Science and Technology (IUFoST) and serves as the editor-in-chief of the *Journal of Food Bioactives* and the journal of *Food Production, Processing and Nutrition*. Dr. Shahidi is the principal founder of the International Society for Nutraceuticals and Functional Foods (ISNFF). He has been part of the AOCS community since 1992, and has served in numerous committees, including the *Inform* magazine editorial advisory committee, and has brought a level of excellence to AOCS programming with leadership roles in both the Protein and Co-Products and the Lipid Oxidation and Quality Divisions.

**AOCS FELLOW AWARD**

*Recognizes achievements in science or extraordinary service to the Society.*



**Douglas G. Hayes** is a professor of bio-systems engineering at the University of Tennessee, a UT-Oak Ridge National Laboratory Joint Faculty member, and a Guest Professor at Wuhan Polytechnic University and Jinan University, China. His research interests encompass surfactant self-assembly systems, particularly microemulsions, soft matter, and biobased

chemicals and materials. He has coauthored 90 journal articles, 23 book chapters, and three books. Dr. Hayes has been a member of AOCS since 1991 and has made a significant impact in AOCS journals and books. He served as a senior associate editor for the *Journal of the American Oil Chemists' Society* and is currently serving as Editor-in-Chief of the *AOCS Journal of Surfactants and Detergents*. He has held leadership roles in the Professional Educator Common Interest Group and served as secretary/treasurer, vice chair, and chair of the Biotechnology Division. He initiated the development of the biobased surfactants session that has been offered at the AOCS Annual Meeting every year since 2007. Dr. Hayes is currently serving a second term as Member-at-Large of the AOCS Governing Board and also serves on the AOCS Books and Special Publications Committee.



**\*Silvana Martini** is a professor in the Department of Nutrition, Dietetics, and Food Sciences at Utah State University. Her research focuses on the physico-chemical and sensorial characterization of food materials, particularly lipids. She studies how the quality of food materials is affected by their nano-, micro-, and macroscopic structure. Dr. Martini

has published more than 110 papers in peer-reviewed journals and 11 book chapters. Her work has been recognized by awards, including the AOCS Timothy L. Mounts Award in 2019 and the American Chemical Society's Young Scientist Award—Agricultural and Food Chemistry Division in 2014. Dr. Martini has been part of the AOCS community since 1999. She has taken leadership roles in the Professional Educator Common Interest Group and Recognition Program Committee, as well as chaired groundbreaking sessions at annual meetings and the Latin American Conferences. Since 2019, she has also served as a member of the AOCS Governing Board. Most recently, she was selected as the Editor-in-Chief for the *Journal of the American Oil Chemists' Society* after making significant impact as a senior associate editor for the same journal.

**Jun Ogawa** is a professor in the Division of Applied Life Sciences, graduate school of agriculture at Kyoto University. His research interests include screening and developing novel microbial functions for applications in life sciences, food sciences, environmental sciences, and green chemistry. His work



has a specific focus on fermentation physiology relating to functional lipid production. Dr. Ogawa has published over 250 papers on applied microbiology and his work has been recognized by awards including the Oleoscience Award by the Japan Oil Chemists' Society in 2015 and the AOCS Biotechnology Division Ching Hou Biotechnology Award in 2020. He

has served as a Director of the Japan Society for Bioscience, Biotechnology, and Agrochemistry. Dr. Ogawa has been a member of AOCS since 1998, and has participated in the Biotechnology Division sessions at almost every annual meeting since then. He has organized Biotechnology Division sessions and served as a Division officer and chair. He played a pivotal role in the 2018 JOCS-AOCS Joint Symposium and has been instrumental in supporting the participation of young researchers at the AOCS Annual Meeting.



**Karen M. Schaich** is a professor in the Department of Food Science at Rutgers University. Her research is focused on lipid oxidation, protein oxidation, and antioxidants in foods. She has published more than 90 papers and book chapters. Her work on alternate pathways of lipid oxidation has been recognized with the Institute of Food Technologist's Stephen

S. Chang Award. Dr. Schaich is also recognized as an educator who inspires her many undergraduate and graduate students. Her classes are noted for encouraging students to think and learn rather than memorize and she has earned local, regional, and national awards for teaching. She has been a member of the AOCS community since 1980, and is a past chair of the Northeast AOCS Section. She has served as associate editor for the AOCS Lipid Library Committee and is currently program and vice chair for the Lipid Oxidation and Quality Division. She has organized symposia at AOCS annual meetings dating back to 1987—frequently presenting and presiding in sessions with standing room only.

**SCIENTIFIC AWARDS****AOCS YOUNG SCIENTIST RESEARCH AWARD**

*Recognizes a young scientist who has made a significant and substantial research contribution in one of the areas represented by the Divisions of AOCS. Sponsored by the International Food Science Centre A/S.*



**\*Anne-Laure Fameau** is a researcher working at L'Oréal in France. Her research interests are in responsive soft materials made from lipids and green surfactants with a particular emphasis on foams and interfaces. After synthesizing these materials, she develops detailed structural characterizations of them using x-ray and neutron scattering techniques. She



has identified the presence of capillary forces at the nanoscale that reveal a fundamental assembly mechanism and highlight potential applications for soft materials in consumer products. She has published 38 peer-reviewed papers and reviews and three book chapters. She received the European Young Lipid Scientist Award 2018 and was a plenary speaker at the International Conference on Small Angle Scattering in Berlin, Germany in 2015. Dr. Fameau also enjoys transmitting her passion for science to young students. She visited many schools and gave scientific talks to students to promote science in France, and especially to promote science for girls.

## 2021 AWARD SPONSORS

AOCS thanks all award sponsors for their generous support. Sponsors make it possible for AOCS to recognize outstanding scientists, researchers, technicians, and students within our community.

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## ALTON E. BAILEY AWARD

*Recognizes outstanding research and exceptional service in the field of lipids and associated products. Sponsored by ADM.*



**\*David Julian McClements** is a distinguished professor in the Department of Food Science at the University of Massachusetts, an adjunct professor at Zhejiang Gongshang University, and a visiting professor at the School of Public Health at Harvard University. Current work in the McClements lab is focused on encapsulation strategies for the deliv-

ery of bioactive components and the use nanotechnology and structural design principles to improve the health and sustainability of processed foods. They are also working to develop next-generation plant-based foods, such as plant-based milk, meat, and fish. Dr. McClements has published 5 books and over 1,100 articles in scientific journals as well as numerous book chapters. He is currently the most highly cited author in food science and agriculture. His work has been recognized by numerous awards including the AOCS Stephen S. Chang Award in 2010 and the Supelco AOCS Research Award in 2016.

## STEPHEN S. CHANG AWARD

*Recognizes a scientist, technologist, or engineer who has made decisive accomplishments in research for the improvement or development of products related to lipids. Provided by the Stephen and Lucy Chang endowed fund.*



**\*Charlotte M. Jacobsen** is a professor in the National Food Institute at the Technical University of Denmark, where she leads the bioactives analysis and applications group. Her research is focused on lipid oxidation and non-enzymatic browning reactions in marine phospholipids, and on oxidative stability of foods enriched with functional lipids

including omega-3 enriched foods. Her group is also exploring the potential for micro- and macroalgae in production of omega-3 fatty acids, proteins, vitamins, pigments, and antioxidants. She has published in more than 225 peer-reviewed papers and book chapters. Her work has been recognized by awards including the Danish Danisco prize in 2003, the French La Médaille Chevreul in 2010, and the German DGF Normann Medaille in 2020. Dr. Jacobsen has been an AOCS member since 2000 has held leadership roles in the European Section and the Lipid Oxidation and Quality Division. She has chaired sessions at AOCS annual meetings that were noted for their quality and relevance to academic, government and industrial attendees. She has also served as an Associate Editor for the *Journal of the American Oil Chemists' Society*.

## SCHROEPFER MEDAL

*Recognizes a scientist who has made significant and distinguished advances in the steroid field. Originated by colleagues of George Schroepfer.*



**\*William J. Griffiths** is the chair of mass spectrometry at Swansea University in the UK. His research combines chemical derivatization with liquid chromatography and tandem mass spectrometry for the structural characterization of sterols, including characterization of oxysterols, bile acids, and hormonal steroids at ultrahigh sensitivity from biological samples. At Swansea,

Dr. Griffiths works with long term collaborator Dr. Yuqin Wang. Their group is revealing the involvement of oxysterols in human biology, particularly in relation to inborn errors of metabolism, neurodegenerative disease, and the immune system. His recent work has traversed earlier analytical boundaries and can quantitatively localize oxysterols in tissue using mass spectrometry imaging. Dr. Griffiths has more than 250 publications with more than 7,000 citations. He has edited two books and sits on the editorial board of the Journal of Lipid Research.

## SUPELCO AOCs RESEARCH AWARD

*Recognizes outstanding original research in fats, oils, lipid chemistry, or biochemistry. Sponsored by MilliporeSigma.*



**\*Eric Decker** is a professor in the Department of Food Science at the University of Massachusetts, Amherst. Dr. Decker is internationally renowned for his pioneering work in the lipid chemistry of foods. His group performs fundamental research in lipid oxidation mechanisms to develop practical antioxidant technologies, including clean label antioxidants, syner-

gistic antioxidant combinations, and antioxidant mechanisms in low-moisture foods. Dr. Decker has over 430 publications and has been listed as one of the most highly cited scientists in agriculture since 2005. His research and innovation have been recognized by numerous awards, including the AOCS Stephan S. Chang Award in 2008, and the AOCS Fellow Award in 2016. Dr. Decker has been an active member of AOCS community since 2001. He served as AOCS President from 2019 to 2020 and is currently chair of the AOCS Foundation. He has also served on committees for institutions such as the FDA, National Academy of Science, Institute of Food Technologist, USDA, and the American Heart Association.



Lee



Brenna



Pignitter



Zhao



Yoon



John



Patel



De Oliveira Vigier



Demchuk

## DIVISION AWARDS

### ANALYTICAL

#### Student Award

**Hefei Zhao**, University of Nebraska-Lincoln, USA

### BIOTECHNOLOGY

#### Ching Hou Biotechnology Award

**Suk Hoo Yoon**, Samyang Corporation, Korea

### EDIBLE APPLICATIONS TECHNOLOGY

#### Outstanding Achievement Award

**George John**, The City College of New York – CUNY, USA

#### Student Award

**Juhee Lee**, Utah State University, USA

### HEALTH AND NUTRITION

#### Ralph Holman Lifetime Achievement Award

**J. Thomas Brenna**, University of Texas at Austin and Cornell University, USA

#### New Investigator Research Award

**Marc Pignitter**, University of Vienna, Austria

#### Student Award

**Dhruv B. Patel**, University of Alberta, Canada

### INDUSTRIAL OIL PRODUCTS

#### ACI/NBB Glycerine Innovation Award

*Sponsored by American Cleaning Institute (ACI) and National Biodiesel Board (NBB).*

**Karine De Oliveira Vigier**, IC2MP-Université de Poitiers, France

#### Student Award

**Zoriana Demchuk**, North Dakota State University, USA



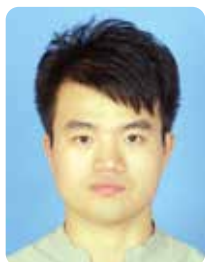
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## STUDENT AWARDS

### HANS KAUNITZ AWARD

**Yanting Shen**, Kansas State University, USA

### LIPID CHEMISTRY AND NUTRITION AWARD

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**Bingjing Zheng**, University of Massachusetts, Amherst, USA

### RALPH H. POTTS MEMORIAL FELLOWSHIP

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**Francisco Leyva Gutierrez**, The University of Tennessee, Knoxville, USA

### AOCS FOUNDATION

*AOCS Honored Student Award*

**Guanghui Li**, Jinan University, China

**Jorge L. Muriel Mundo**, University of Massachusetts, Amherst, USA

**Reed Nicholson**, University of Guelph, Canada

**Yunbing Tan**, University of Massachusetts, Amherst, USA

**Hualu Zhou**, University of Massachusetts, Amherst, USA

*Manuchehr (Manny) Eijadi Award*

**Reed Nicholson**, University of Guelph, Canada

*Peter and Clare Kalustian Award*

**Hualu Zhou**, University of Massachusetts, Amherst, USA

*Thomas H. Smouse Memorial Fellowship*

**Hongbing Fan**, University of Alberta, Canada

## BEST PAPER AWARDS

### AMERICAN CLEANING INSTITUTE (ACI) DISTINGUISHED PAPER AWARD

*Sponsored by American Cleaning Institute (ACI).*

**"Probe Molecules for Pulsed-Field-Gradient Diffusion**

**Nuclear Magnetic Resonance Experiments on Micelles"** (JSD 23(2):319-325).

Mark D. Lingwood, Benjamin J. Schepergerdes, Deja-Monae T. Hermosillo, Jalissa N. Delgado and Kaya P. Sanders

### ADM AWARD FOR BEST PAPER IN PROTEIN AND CO-PRODUCTS

*Sponsored by ADM.*

*Chemistry/Nutrition Category*

**"Trypsin Inhibitor and Urease Activity of Soybean Meal Products from Different Countries and Impact of Trypsin Inhibitor on Ileal Amino Acid Digestibility in Pig"** (JAOCS 97(10):1151-1163).

Juxing Chen, Karen Wedekind, Jeffery Escobar and Mercedes Vazquez-Añón



## NEXT YEAR'S AWARDS

While nominations for 2022 AOCS awards opens in July 2021, now is the time to begin considering candidates. Do you know a colleague or student that deserves to be nominated for one of these awards? Would you like to receive recognition and reveal your work to a broader audience?

Read the award descriptions and eligibility requirements on the AOCS website ([aocs.org/awards](http://aocs.org/awards)). Be prepared to submit your nomination materials by mid-August 2021. For more information regarding award eligibility, please contact Victoria Santo at [victoria@aocs.org](mailto:victoria@aocs.org).

### Engineering/Technology Category

**"Estimating Oil and Protein Content of Sesame Seeds Using Image Processing and Artificial Neural Network"** (JAOCS 97(7):691-702).

Mahdiah Parsaeian, Mojtaba Shahabi and Hamid Hassanpour

### EDWIN N. FRANKEL AWARD FOR BEST PAPER IN LIPID OXIDATION AND QUALITY

Sponsored by Kalsec, Inc.

**"Formation Kinetics of Monomeric Cyclic Fatty Acid Methyl Esters of Alpha-Linolenic Acid: Effects of Mono cis/trans Isomers"** (JAOCS 97(6):615-624).

Amélie Desmarais, Jean-Louis Sébédio, Khaled Belkacemi, Joseph Arul and Paul Angers

### PHOSPHOLIPID DIVISION BEST PAPER AWARD

Sponsored by the International Lecithin & Phospholipid Society (ILPS).

**"Nanoparticles Containing Constrained Phospholipids Deliver mRNA to Liver Immune Cells in Vivo without Targeting Ligands"** (Bioeng Transl Med. 2020;5:e10161).

Zubao Gan, Melissa P. Lokugamage, Marine Z. C. Hatit, David Loughrey, Kalina Paunovska, Manaka Sato, Ana Cristian and James E. Dahlman

## OTHER AWARDS

### LABORATORY PROFICIENCY PROGRAM AWARDS

AOCS' Laboratory Proficiency Program is the world's most extensive and respected collaborative proficiency program for oil- and fat-related commodities, oilseeds, oilseed meals, and edible fats. A full listing of the Laboratory Program winners is available on [aocs.org/series](http://aocs.org/series).

## AOCS MEETING WATCH

**October 5–7, 2021.** Plant Protein Science and Technology Forum, Chicago, Illinois, USA, and online.

**May 1–4, 2022.** AOCS Annual Meeting & Expo, Atlanta, Georgia, USA, and online.

**April 30–May 3, 2023.** AOCS Annual Meeting & Expo, Denver, Colorado, USA, and online.

For in-depth details on these and other upcoming meetings, visit <http://aocs.org/meetings> or contact the AOCS Meetings Department (email: [meetings@aocs.org](mailto:meetings@aocs.org); phone: +1 217-693-4831).



**The 2020 AOCS Annual Report is now available on [www.aocs.org](http://www.aocs.org).**



# The recent drama over dairy

*Olio is an Inform column that highlights research, issues, trends, and technologies of interest to the oils and fats community.*

**Rebecca Guenard**

COVID lockdowns caused us to find new ways to pass time indoors. We subscribed to all the streaming services, learned how to use Zoom, and opened neglected cookbooks. Renewed interest in home baking over the past year erupted into controversy when consumers accused the dairy industry of making an unpopular choice to meet a higher than usual demand.

For those unfamiliar with the story, nearly one year after the novel coronavirus outbreak, Canadian consumers began gathering empirical evidence that the properties of their butter had changed. They observed that butter, which typically melted at room temperature, had taken on an unfamiliar hardness and was not as easy to spread. A hubbub broke out on social media with one cookbook author going as far as describing the butter as rubbery and watery.

Some people targeted palmitic acid, a fatty acid, in animal feed as the likely source of butter's consistency change, causing public outcry over the product's fat composition. Confusion ensued as some media outlets reported that palm oil was being added as an ingredient in butter formulations. All the while, these anecdotal reports were missing an essential component: data.

"There has been no recent data to show that the consistency of butter has changed, and we are not aware of any significant changes in dairy production or processing," read a statement released by the Dairy Farmers of Canada on February 11<sup>th</sup>, 2021.

The United States Food and Drug Administration's (USFDA) regulation established in 1906, states that to be called butter a food product must be made exclusively from milk, cream, or both and can contain no less than 80% milk fat by weight. The Canadian Food Inspection Agency's (CFIA) regulations indicate similar specifications for what the product must contain when sold there. Aside from milk or cream, butter may also contain milk solids, bacterial culture, salt, and food coloring. Any other ingredient would be against the law.

"If a product is labeled as pure dairy butter, it cannot contain palm oil or any fat or oil substitute," says Jill Moser,

research chemist at the US Department of Agriculture. "That would be a form of adulteration." (US Code Title 21-Chapter 9-SubChapter IV-Section 342 "Food Adulteration").

Media outlets reporting that palm oil was being added to butter were obviously mistaken, so attention turned to the cows' feed. Public concern over what cows were eating was prompted by Sylvain Charlebois, an expert in food distribution and policy and senior director of Dalhousie University's Agri-Food Analytics Lab, in Halifax, Nova Scotia. In an interview with NPR, Charlebois said he suspected that farmers had increased the palm oil content in animal feed last October, when he saw a report about non-foaming milk (<https://tinyurl.com/Canadianbutter>).

How cow nutrition affects milk composition is a well understood phenomenon. Farming and feeding practices differ around the world based on factors like land availability and climate. Due to these different feeding methods, dairy scientists have observed that the composition of milk—particularly the fatty acid (FA) composition of milk fat—varies depending on a cow's intake.

According to research conducted two decades ago, cows in Ireland and New Zealand which mostly feed on fresh grass produce milk fat with higher levels of unsaturated fatty acids (UFA) ([https://doi.org/10.3168/jds.S0022-0302\(06\)72263-9](https://doi.org/10.3168/jds.S0022-0302(06)72263-9)). However, in the United States, Asia, and areas of Europe, farmers use a total mixed ration (TMR) feeding system, which allows them to control the balance of grains, protein, vitamins, and fat the cows consume. Studies have shown that these geographic areas tend to produce butter with lower UFA levels. The FA profile also affects the texture, sensory properties, and shelf-life of butter.

In 2016, a group of researchers at the University of Cork, in Cork, Ireland, conducted an extensive set of experiments that compared the quality characteristics, chemical composition, and sensory properties of butter under different cow feeding conditions (<https://doi.org/10.3168/jds.2016-11271>). Previous experiments showed that pasture-fed cows produced a yellow butter that was softer and more spreadable because of UFAs' lower melting point. The Cork team quantified the properties of butter from cows fed under three different systems: fed indoors on TMR, pasture fed on ryegrass, and pasture fed on ryegrass and clover.

The results of the feed system experiment are too detailed to share in their entirety, but the overall conclusion that the team reached was that butter analysis can distinguish between TMR and pasture fed cows. The FA profiles of the butter between the two are so distinct that they can identify a cow's feed system.

Overall, the team found no differences in the mean fat and moisture content of the butters. However, the saturated fatty acid profiles differed significantly. Pasture-fed cows produced butter with higher pentadecanoic acid (C15:0) and TMR fed cows were higher in palmitic acid (C16:0), although not by much (Table 1). Pasture-derived butters had more of the beneficial conjugated linoleic acid (CLA) isomers than TMR butters, particularly the *cis*-9,*trans*-11 isomer which was more than double. And pasture-raised cows produced butter containing more beta-carotene than indoor cows, hence the more noticeable yellow color. When the researchers asked a consumer panel about the sensory properties of the different types of butter, the pasture-raised product was preferred.

A likely source of the public's perceived butter discrepancies could be the result of seasonal changes in the product as cows are fed indoors during the winter months. Such product fluctuations occur every year, but maybe with less to do while waiting out the pandemic consumers noticed the change for the first time.

One component of TMR is palm oil supplements. Farmers add the supplements to feed at about a 5% ratio to provide a source of energy for cows. They have found that compared to other oils, palm works best with the microbiome of the cow and does not upset their digestion. Daniel Lefebvre, chief operations officer at Lactanet (Canadian network for dairy excellence), stated that "data from routine analyses of the fatty acid profile in milk do not indicate any increase in the proportion of palmitic acid in the past year beyond what would normally be expected."

## Information

Quality characteristics, chemical composition, and sensory properties of butter from cows on pasture versus indoor feeding systems, O' Callaghan, T.F., *et al.*, *J. Dairy Sci.* 99: 9441–9460, 2016.

Effects of feeding supplemental palmitic acid (C16:0) on performance and milk fatty acid profile of lactating dairy cows under summer heat, Warntjes, J.L., *Anim. Feed Sci. Technol.* 140: 241–257, 2008.

Diet, rumen biohydrogenation and nutritional quality of cow and goat milk fat, Chilliard, Y., *et al.*, *Eur. J. Lipid Sci. Technol.* 109: 828–855, 2007.

Nonetheless, given the recent controversy, Dairy Farmers of Canada has initiated an independent expert working group to assess reports of feed supplements affecting butter consistency. As of press time, they had established their key objectives to develop fact-based explanations for all the questions that have been raised. *Inform* will report on any future results. For more detailed information on how palm oil is used in feed, we recommend watching the panel discussion hosted by Dairy at Guelph, a cross-faculty group of researchers at University of Guelph, in Ontario, Canada (<https://www.youtube.com/watch?v=VrqZrQc3hOg>).

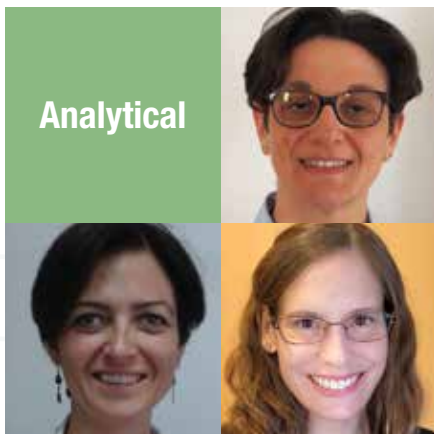
**TABLE 1. Relationship between cow feeding system and the fatty acid triglyceride content of butter, represented as the mean and SD of FAME in g/100 g of butter fat**

Fatty Acid	Feeding Systems		
	TMR	Ryegrass	Ryegrass + clover
Myristic acid (C14:0)	8.36 ± 0.83	8.36 ± 0.89	7.74 ± 0.56
Pentadecanoic acid (C15:0)	0.81 ± 0.10	1.00 ± 0.13	0.88 ± 0.06
Palmitic acid (C16:0)	23.87 ± 2.42	20.46 ± 2.23	18.42 ± 1.28
Stearic acid (C18:0)	7.06 ± 0.59	6.50 ± 0.80	6.56 ± 1.22
Oleic acid (C18:1n-9 <i>cis</i> )	13.79 ± 1.30	12.29 ± 1.14	11.79 ± 1.63
Linoleic acid (C18:2n-6 <i>cis</i> )	1.23 ± 0.11	0.47 ± 0.05	0.57 ± 0.06
γ-Linolenic acid (C18:3n-6 <i>cis</i> )	0.05 ± 0.00	0.03 ± 0.01	0.03 ± 0.00
Eicosenoic acid (C20:1 <i>cis</i> -11)	0.27 ± 0.04	0.55 ± 0.05	0.73 ± 0.07
CLA ( <i>cis</i> -9, <i>trans</i> -11)	0.58 ± 0.04	1.71 ± 0.06	1.35 ± 0.12
CLA ( <i>cis</i> -12, <i>trans</i> -10)	0.09 ± 0.02	0.09 ± 0.01	0.09 ± 0.01
α-Linolenic acid (C18:3n-3)	0.00 ± 0.00	0.10 ± 0.01	0.11 ± 0.01
SFA	52.49 ± 4.98	48.53 ± 5.06	44.97 ± 3.30
UFA	18.86 ± 1.01	17.69 ± 1.55	16.86 ± 1.79
MUFA	15.98 ± 1.52	14.83 ± 1.40	14.27 ± 1.71
PUFA	2.23 ± 0.08	2.86 ± 0.15	2.59 ± 0.17
Short-chain C4–14	20.94 ± 2.04	20.86 ± 2.45	19.29 ± 1.41
Medium-chain C15–17	26.24 ± 2.68	23.09 ± 2.61	20.79 ± 1.45
Long-chain C18–24	24.18 ± 1.21	22.26 ± 2.08	21.76 ± 2.98



# AOCS appreciates these 2021–2022

## Analytical



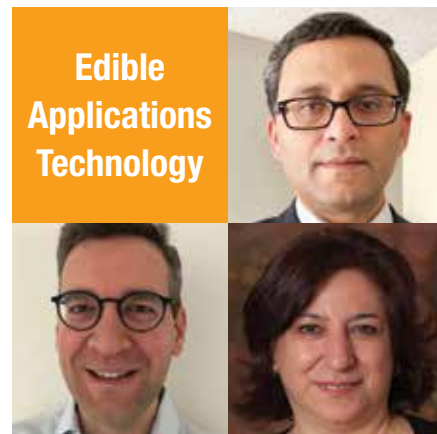
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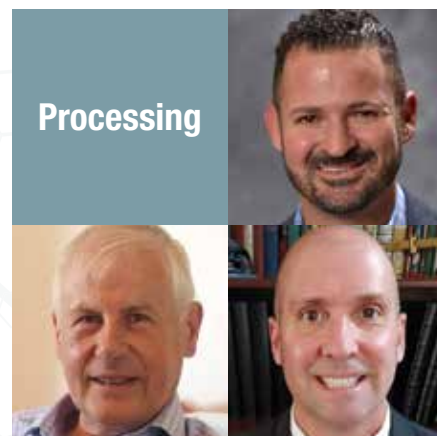
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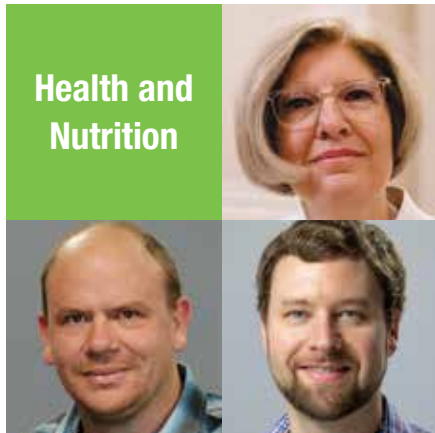
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# Host of unknown chemicals found in pregnant women and cord blood

*Regulatory Review is a regular column featuring updates on regulatory matters concerning oils- and fats-related industries.*

Researchers in California have detected 109 chemicals in a study of pregnant women, including 55 chemicals never before reported in people and 42 “mystery chemicals,” whose sources and uses are unknown.

The chemicals were found in the blood of 30 pregnant women and their umbilical cords during a suspect screening. The research team at the University of California, San Francisco, USA (UCSF), that conducted the study used a high-resolution mass spectrometry (HRMS) technique to analyze samples and compared the results with their own database, which includes data from the US Environmental Protection Agency (EPA) on high production volume chemicals.

The team screened for about 3,500 industrial chemicals and found 109 in the blood samples, many of which are plasticizers, flame retardants, and cosmetic ingredients.

Of these, they “tentatively identified” 55 substances not previously reported in human biomonitoring literature. They could find little to no information on sources or uses for 37 of the substances.

“These chemicals have probably been in people for quite some time, but our technology is now helping us to identify more of them,” said Tracey Woodruff, a former EPA scientist and professor of obstetrics, gynecology, and reproductive sciences at UCSF, in a press statement.

“The large presence of poorly characterized chemicals in maternal and cord blood samples warrants further investigation to understand where these chemicals might be coming from and how they may affect human health,” the researchers wrote in their paper published in *Environmental Science & Technology* on March 16, 2021 (<https://pubs.acs.org/doi/10.1021/acs.est.0c05984>).

The results show that there are potential new chemical exposures that have not been adequately characterized and

were not previously of concern for environmental health scientists and regulators.

## STANDARD SCIENCE

While these chemicals can be tentatively identified using chemical libraries, they need to be confirmed by comparing them to the pure chemicals produced by manufacturers that are known as “analytical standards,” and manufacturers do not always make these available.

These pure versions of industrial chemicals, or analytical reference standards, were key to the study. For example, the researchers used one standard to evaluate the presence and toxicity of a new per- and polyfluoroalkyl substance (PFAS).

Last year, Belgium-based chemical company Solvay issued a patent violation notification to a laboratory for selling a PFAS standard. The company recently denied NGO claims that it is deliberately hindering research.

“These new technologies are promising in enabling us to identify more chemicals in people. But our study findings also make clear that chemical manufacturers need to provide analytical standards so that we can confirm the presence of chemicals and evaluate their toxicity,” said co-lead author Dimitri Panagopoulos Abrahamsson, a postdoctoral fellow at UCSF.

“It’s very concerning that we are unable to identify the uses or sources of so many of these chemicals,” Professor Woodruff said in the statement. “EPA must do a better job of requiring the chemical industry to standardize its reporting of chemical compounds and uses. And they need to use their authority to ensure that we have adequate information to evaluate potential health harms and remove chemicals from the market that pose a risk.”

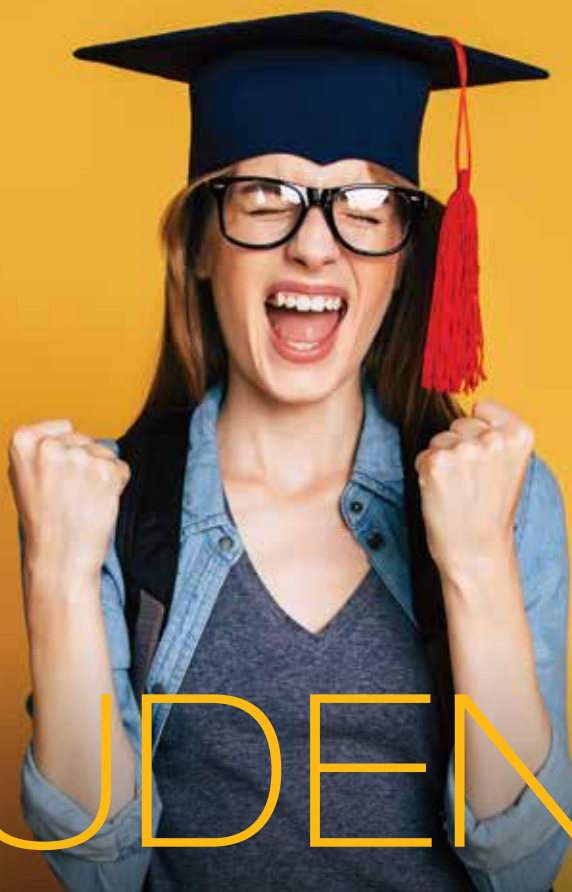
The study was funded by grants from the National Institutes of Health and the EPA.

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# How is the powder coating industry gaining traction across industrial applications?

*Markets in Motion covers market trends, opportunities, developments, and future prospects in AOCS-related industries.*

**Saloni Walimbe**

Paint has long been used as a traditional surface coating in various applications. However, traditional wet painting is limited by its lack of durability and the need for regular refinishing and maintenance.

In contrast, powder coating offers enhanced durability, high-quality finishes in terms of both aesthetics and functionality, and lower environmental impact.

Powder coating was first introduced in the 1940s and subsequently developed during the early '50s. Since then, the technology has continued to evolve significantly and is now used extensively by manufacturers of various industrial and household products.

Powder coating is a dry coating process that is primarily used to apply a metal finish on industrial equipment. The coating materials are applied in dry powder form, via an electrostatic process, and are then heat cured.

Powder-coated finishes are highly flexible and sturdy and can be used for myriad surfaces including concrete, plastic, steel, and metal, in outdoor as well as indoor applications. Surfaces with powder-coated finishes are highly resistant to abrasion, detergents, chemicals, corrosion, and scratches. Furthermore, the process is cost-effective, efficient, and compliant with environmental regulations.

Most powder coating materials are sought after as alternatives to regular liquid finishing materials, as they contain no solvents and emit little to no VOCs (volatile organic compounds) into the atmosphere. These materials do not need to be filtered or vented and do not require solvent recovery systems in the application area, as their liquid finishing counterparts do, leading to significant savings in terms of cost and energy. It is estimated that the global powder coating market

will reach a valuation of USD 17.5 billion by 2026 (<https://www.gminsights.com/industry-analysis/powder-coating-market>).

## SUSTAINABILITY AND REGULATORY PRESSURES DRIVE DEMAND FOR BIO-BASED VERSIONS

Intensifying pressure from both consumers and regulatory authorities is driving manufacturers to embrace more sustainable and environmentally friendly production processes. While powder coatings are already considered to play a commendable role in this effort, modern manufacturers are increasingly experimenting with renewable and bio-based powder coating options as a replacement for conventional petroleum-based resins.

A low-temperature bio-based resin could provide manufacturers with a more versatile and sustainable powder coating technology that could prove effective for a vast array of products and deliver better customization and design options. Also, a reduced dependence on petroleum could help improve the price stability of the product in the long run, while helping to minimize the industry's environmental footprint. Studies suggest that the replacement of just 25% of powder coating resins with more bio-based substitutes would lead to reduced carbon emissions and enhance the sustainability quotient of the powder coatings industry.

Bio-based powder coatings are gradually gaining ground across the industrial spectrum despite cost and performance hurdles. Meanwhile, emerging research into bio-based ingredients is helping to alleviate cost and performance concerns. For instance, Battelle is involved in the development of a bio-based resin designed to deliver superior performance in products that can cure at low temperatures, suitable for surface coating of MDF (medium-density fiberboard), wood, and various kinds of plastic.

Similarly, Allnex created a range of bio-based resins derived from recycled PET and C5- and C6 sugar-based renewable monomers. These carboxyl-based polyesters demonstrate high potential across various types of powder coating technology, including polyester hydroxyl-alkyl amide (HAA), TGIC cured formulas, and epoxy-polyester hybrids.



AkzoNobel also revealed an innovation in 2021 that is aimed at developing a more sustainable way to produce resin. The novel process is said to use bio-based monomers rather than conventional oil-based monomers. The innovation, developed in collaboration with the Dutch ARC CBBC (Advanced Research Center Chemical Building Blocks Consortium), is touted as a solution that could pave the way for advanced coating technology of the future.

## ANTIMICROBIAL POWDER COATING MATERIALS GAIN MOMENTUM IN THE COVID-19 ERA

The COVID-19 epidemic has caused unprecedented disruptions across markets worldwide and has created significant uncertainty among populations in all regions. The global economy has taken a significant hit, with many downstream application sectors witnessing a downturn, as they are not considered essential by customers. This, in turn, has affected many industries like the powder coatings market, which faced a considerable setback as its main application areas (furniture production, construction equipment manufacturing, oil and gas sector, and architectural applications) experienced slowdowns.

In recent months, however, powder coating technology is gradually witnessing a path to recovery as economic conditions start to improve. The coatings are also likely to have the ability to fulfill key economic and social needs, such as safety, sustainability, and low energy consumption, which could lead to their extensive use in low-cost projects across residential and commercial construction as well as other areas.

Many key powder coatings producers are engaging in strategies that expand their operational horizons beyond the

production of powder coatings into pre-treatment and surface preparation activities, while maintaining optimal environmental compliance of their products.

To illustrate, the powder coatings business of AkzoNobel launched a range of primers, including a high-performance powder coating primer designed for protecting blasted steel from corrosion, as well as a three-layer protective primer system designed for extremely corrosive environments.

The COVID-19 pandemic has also led to burgeoning efforts to develop antimicrobial coating technology for eliminating bacteria, fungi, and other microorganisms on surfaces.

Toward that end, in June 2020, Berger Paints India offered its Antimicrobial Powder Coatings for use across the medical industry, with an aim to curb COVID-19 transmission. The product, which was tested in UK-based labs, was designed to create an extra barrier against the spread of harmful microbes. Based on silver ion technology, Berger's Antimicrobial Powder Coatings, commercialized under the UltraCoat, QualiCoat, PermaCoat, and Duraberg brands, inhibit the spread of bacteria and microbes by maintaining a constant controlled release of silver ions and are capable of remaining active for several years.

PPG also made a similar move earlier in May 2020, when the company launched its quick-ship program for the swifter delivery of its specially formulated, silver ion technology-based antibacterial-protected powder coating, PPG SILVERSAN®.

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*Saloni Walimbe has been an avid reader since childhood, and she is currently following her passion for content creation by penning down insightful articles relating to global industry trends, business news, and market research. She spent two years as a content writer in advertising before making a switch to the market research domain.*



# Meet Sevim Erhan

*Member Spotlight is a slice of life that helps AOCS members get to know each other on a more personal level.*



Sevim Erhan signs the Peace Wall in Belfast, Ireland.

## PROFESSIONAL

*Flash back to when you were 10 years old. What did you want to be when you grew up?*

I always wanted to be a science teacher. I started tutoring when I was in high school. I then became a teaching assistant while I was doing my Ph.D., and continued to teach classes for a time after I graduated.

*Why did you decide to do the work you are doing now?*

Doing research is very rewarding as new solutions to problems emerge. I certainly did not realize that when I was very young but developed an interest in high school, where I was exposed to a chemistry laboratory. I was very much set to work on research and development while I was in a Ph.D. program at Western Michigan University and applied for a research associate position at the National Center for Agricultural Utilization Research in Peoria, Illinois, USA (NCAUR). I have been working for the agency since 1988.

I worked as a research scientist, lead scientist, and research leader for the first 20 years of my career at NCAUR. I was encouraged to consider senior executive service positions, so I entered a two-year program sponsored by the agency for preparing to be a good candidate for those types of positions. At the end of the first year of the program, the Center director position at the Eastern Regional Research Center (ERRC) became vacant and I applied and was selected for the position. I have been at ERRC as the director for the past 12 years.

## Fast facts

<b>Name</b>	Sevim Z. Erhan
<b>Joined AOCS</b>	1989
<b>Education</b>	Ph.D. from Western Michigan University (Kalamazoo, Michigan, USA)
<b>Job title</b>	Center Director, Eastern Regional Research Center (Philadelphia, Pennsylvania, USA)
<b>Employer</b>	Agricultural Research Service, United States Department of Agriculture
<b>Current AOCS involvement</b>	Member of Awards Committee

*Is there an achievement or contribution you are most proud of? Why?*

I'm proud of my Agricultural Research Service research focused on nonfood uses of vegetable oils. I have worked on several projects that resulted in nine patents and the licensing of those technologies, including soy inks and environmentally friendly elevator fluids, which are now in use at the Statue of Liberty. But I am most proud of the footprint ink I developed for newborns in hospitals. My daughter was the first baby in the United States to be footprinted with that ink. Several news channels featured the story at the time.

## PERSONAL

*How do you relax after a hard day of work?*  
With a cup of Turkish coffee.

*What is the most impressive thing you know how to do?*

As an engineering student in Turkey, I completed my mandatory apprenticeship in a glassblowing factory and was always very impressed with the workmanship. As it so happened, when I was a graduate student at Western Michigan University, for part of my Ph.D. thesis I needed over 100 glass vessels that were not commercially available at the size we needed. The chairman of the department taught me the basics of glassblowing. After a number of mishaps and misshapen products, I was happy to have gotten very good at creating exactly what I needed.

# PATENTS

## Emulsified oils

Lalgudi, R.S., Ohio Soybean Council, US10889693, January 12, 2021

Emulsions for treating shingles, concrete, metallic substrates, mammalian skins, human hair, or agricultural plants are described. The emulsions include soy alkyl and/or aryl ester, water, and a cationic surfactant to form the emulsion. Methods of using the emulsions are also described. Compositions including a modified oil alkyl and/or aryl ester comprising the transesterification reaction product of an oil and a surfactant having a hydroxyl group are described. Methods of using the compositions are also described. Methods of making a modified oil alkyl or aryl ester are described. The methods include transesterifying an oil with a surfactant having a hydroxyl group.

## Controlled blending of biodiesel into distillate streams

Fransham, R., *et al.*, Texon LP, US10889772, January 12, 2021

Methods are provided for accurately blending biodiesel into distillate streams to achieve a pre-determined percentage of biodiesel in the distillate, applicable to wild-type distillate streams as well as distillate streams that already contain some percentage of biodiesel.

## Phospholipid preparations for the improvement of sleep

Artzi, G.O.S., *et al.*, Enzymotec Ltd., US10894056, January 19, 2021

Phospholipid preparations for the improvement of sleep and/or treatment of sleep disorders. Methods of improving sleep and/or treating sleep disorders comprising administering the same.

## Stability of short-path-evaporation-treated oils

Bruse, F., Cargill, Inc., US10894931, January 19, 2021

The present invention relates to a process for increasing the oxidative stability of short-path evaporated oils. The process comprises the step of adding to the short-path evaporated-treated oil at least one antioxidant while the short-path evaporated-treated oil has a peroxide value of below or equal to 1.5 milli-equivalent peroxide/kg. The at least one antioxidant is preferably added at a temperature above the melting point of the short-path evaporated-treated oil.

## Nutraceuticals having sustained release for improved bioavailability and method of production

Madhavi, D.L., *et al.*, Bioactives LLC, US10898477, January 26, 2021

The present disclosure describes economical processes to improve the bioavailability of nutraceuticals by formulations that induce micronization and sustained release. The inventive process can be used to increase the solubility and bioavailability of lipophilic and moderately water-soluble nutraceuticals by combining excipients that increase the solubility and induce sustained release of the active compounds. The inventive process also can be used to increase the residence time of highly water-soluble nutraceuticals that are metabolized and eliminated quickly from the body, consequently increasing the therapeutic potential. The disclosed formulations advantageously are freely flowing powders that can be used to formulate with other ingredients into tablets, capsules, or the like; or used as bulk powders.

## Enhanced alkyl ester containing oil compositions and methods of making and using the same

McCurdy, Alexander T., *et al.*, Poet Research, Inc., US10899928, January 26, 2021

Vegetable oil compositions, as an example, corn oil, having an elevated lower alkyl ester content above about 7% weight percent of the total weight of the oil composition, and uses thereof are provided.

## Apparatus and method for manufacturing bio emulsion fuel using vegetable oil

Koh, J.C., *et al.*, US10947469, March 16, 2021

A bio emulsion fuel manufacturing apparatus and method using vegetable oil is provided, including an oil tank unit configured to refine a vegetable oil introduced from an oil inlet by using a coagulant agent and a centrifugal decanter; a water tank unit configured to pretreat a water introduced from a water inlet by using a water tank catalyst; a mixed oil unit connected to the oil tank unit and the water tank unit, and configured to produce a mixed oil by using an inline mixer; and an ionization catalyst unit connected to the mixed oil unit and configured to convert the mixed oil to a bio emulsion fuel by using an ionization catalyst group.

Patent information was compiled by Scott Bloomer, a registered US patent agent and Director, Technical Services at AOCs. Contact him at [scott.bloomer@aocs.org](mailto:scott.bloomer@aocs.org).



# Conversation with departing JAOCS Editor-in-Chief Jim Kenar

James A. Kenar is stepping down after a 5-year term as Editor-in-Chief of the *Journal of the American Oil Chemists' Society* (JAOCS). Kenar, a research chemist at the US Department of Agriculture–National Center for Agricultural Utilization Research (USDA–NCAUR), became Editor-in-Chief of JAOCS in 2016, and helped the journal transition to a new publisher in 2018. His successor, Silvana Martini, a professor in the Department of Nutrition, Dietetics and Food Sciences at Utah State University, will become the journal's first female Editor-in-Chief.



## WHAT ACCOMPLISHMENT AS EDITOR-IN-CHIEF ARE YOU MOST PROUD OF?

My graduate advisor, Alex Nickon, was an editor for *Tetrahedron*. He was passionate about his role as an editor and spent time to mentor me, his last student, in writing, reviewing, and editing. Although painful for both of us, I am thankful for that. Later, someone saw these abilities in my work and gave me an opportunity to become an editor for JAOCS. Acting as an editor (at any level) entails a fiduciary responsibility to ensure that an author's research is guided through an equitable editorial process that requires rigor, integrity, and dignity. I have always taken this seriously. The JAOCS editorial team, composed of seven senior associate editors and over 40 associate editors, is an awesome group of dedicated scientists, second to none. I am proud and humble to work alongside, lead, and build relationships with them, the AOCS staff (particularly Pam "North Star" Landman), and the publisher, Wiley, in our concerted effort to publish quality science for the journal's readership. I am grateful for the opportunity to pay forward my advisor's mentorship and have a small role in helping others improve their skills. Finally, I am delighted that Silvana Martini will take the reins as Editor-in-Chief of the journal. How cool is that!

## WHAT DID YOU LIKE MOST ABOUT BEING AN EDITOR?

Research by its nature can be a difficult and labor-intensive endeavor that can take months or years to understand and answer difficult questions. Although we speak many languages and have varied cultural differences, the larger pursuit of sci-

ence transcends these issues. I enjoy the privilege to read, think, and interact with the variety of research submitted to the journal from all over the world. It is a unique opportunity that has, by and large, been enjoyable. Effectively communicating research results and ideas in a simple, clear, and concise manner can be equally if not more difficult. Another enjoyable aspect of being an editor is the opportunity to assist researchers to successfully navigate the editorial process and contribute to strengthening, albeit in a small way, an author's message concerning the importance of their research.

## WHAT DID YOU LIKE THE LEAST?

Being a journal editor is comparable to a lightning rod at times. An editor makes difficult decisions that are not always popular and can have profound impacts. I have learned much about my leadership strengths and weaknesses, and openness to new ideas. An editor is a gatekeeper of science, and that role thrusts you into the important and precarious position of controlling the flow of ideas. It is critical not only to put aside preconceived ideas and be open and judge a paper on its own merits, but also to avoid thinking too highly of your position, as that will surely become your biggest failing. Being humble is important as is owning your mistakes and fixing them when possible. Overall, people are gracious and forgiving. For me, these aspects of being an editor are weighty.

*continued on page 48*





**Save the date!**

# **Plant Protein Science and Technology Forum**

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- |   |  |
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| <b>ANA</b> Analytical                     | <b>BIO</b> Biotechnology               |
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| <b>PRO</b> Processing                     | <b>PCP</b> Protein and Co-Products     |
| <b>S&amp;D</b> Surfactants and Detergents |  |

## Review Articles

### **EAT** Circular bioeconomy strategies: from scientific research to commercially viable products

Brandao, A.S., *et al.*, *J. Clean. Prod.* 295: 126407, 2021, <https://doi.org/10.1016/j.jclepro.2021.126407>.

This review considers the current scientific, technological, and commercial trends on valorization of agri-food and forest wastes. Specialized literature on circular bioeconomy (CBE), major high added-value product typologies, their feedstocks, and respective processing technologies were reviewed and framed in face of relevant patent literature and commercial products. Scientific articles are focused on chemicals for varied industrial sectors, derived essentially from agri-food wastes by using biotechnological processes. Patents and commercial products focus also on agri-food wastes but mainly on products for the food industry and using predominantly physical processes, seldom combined with chemical and biotechnological processes. Societal benefits of products and processes, including environmental perspectives, are frequently cited and aligned with the CBE concept. Despite the significant evolution observed in the last two decades, and an increasing volume of related patents, CBE research is not yet significantly mirrored by the market, showing that its full potential is still far from being realized. There is a need to develop further evidence that CBE-inspired products are indeed preferable to their fossil-based counterparts, from both economic and societal points of view, including environmental sustainability, and to communicate the findings to society at large.

### **H&N** The homeoviscous adaptation to dietary lipids (HADL) model explains controversies over saturated fat, cholesterol, and cardiovascular disease risk

Zinöcker, M.K., *et al.*, *Am. J. Clin. Nutr.* 113: 277–289, 2021, <https://doi.org/10.1093/ajcn/nqaa322>.

Saturated fatty acids (SFAs) play the leading role in one of the greatest controversies in nutrition science. Relative to polyunsaturated fatty acids (PUFAs), SFAs generally increase circulating concentrations of low-density lipoprotein (LDL) cholesterol, a risk factor for atherosclerotic cardiovascular disease (ASCVD). However, the purpose of regulatory mechanisms that control the diet-induced lipoprotein cholesterol dynamics is rarely discussed in the context of human adaptive biology. We argue that better mechanistic explanations can help resolve lingering controversies, with the potential to redefine aspects of research, clinical practice, dietary advice, public health management, and food policy. In this paper we propose a novel model, the homeoviscous adaptation to dietary lipids (HADL) model, which explains changes in lipoprotein cholesterol as adaptive homeostatic adjustments that serve to maintain cell membrane fluidity and hence optimal cell function. Due to the highly variable intake of fatty acids in humans and other omnivore species, we propose that circulating lipoproteins serve as a buffer to enable the rapid redistribution of cholesterol molecules between specific cells and tissues that is necessary with changes in dietary fatty acid supply. Hence, circulating levels of LDL cholesterol may change for nonpathological reasons. Accordingly, an SFA-induced raise in LDL cholesterol in healthy individuals could represent a normal rather than a pathologic response. These regulatory mechanisms may become disrupted secondarily to pathogenic processes in association with insulin resistance and the presence of other ASCVD risk factors, as supported by evidence showing diverging lipoprotein responses in healthy individuals as opposed to those with metabolic disorders such as insulin resistance and obesity. Corresponding with the model, we suggest alternative contributing factors to the association between elevated LDL cholesterol concentrations and ASCVD, involving dietary factors beyond SFAs, such as an increased endotoxin load from diet–gut microbiome interactions and subsequent chronic low-grade inflammation that interferes with fine-tuned signaling pathways.

### **H&N** **PRO** Current trends and possibilities for exploitation of grape pomace as a potential source for value addition

Chowdhary, P., *et al.*, *Environ. Pollut.* 278: 116796, 2021, <https://doi.org/10.1016/j.envpol.2021.116796>.

Grape pomace (GP) is a low-value by-product that contains a significant amount of high-value products. The huge amount of non-edible residues of GP wastes (seeds, skins, leaves, and stems)

produced by wine industries causes environmental pollution and management issues as well as economic loss. Studies over the past 15–20 years revealed that GP could serve as a potential source for valuable bioactive compounds like antioxidants, bioactive, nutraceuticals, single-cell protein, and volatile organic compounds. However, the selection of appropriate techniques for the extraction of these compounds without compromising the stability of the extracted products is still challenging. This review mainly summarizes the novel applications of winery wastes in many sectors, such as agriculture, pharmaceuticals, cosmetics, livestock fields, and also the bio-energy recovery system. It also summarizes the existing information/knowledge on several green technologies for the recovery of value-added by-products.

## LOQ Coffee by-products in topical formulations: a review

dos Santos, E.M., *et al*, *Trends Food Sci. Technol.* 111: 280–291, 2021, <https://doi.org/10.1016/j.tifs.2021.02.064>.

Coffee is the second largest commodity in the world and its market has grown regularly over the last 150 years. During production and processing of coffee beans many by-products are generated such as skin, pulp, mucilage, parchment, silverskin, and immature and defective coffee beans. About 50% of coffee fruit is discarded and can contaminate the environment. This review looks at potential applications for coffee by-products in topical formulations as well as the main bioactive compounds responsible for their biological activity. Coffee by-products have antioxidant, anti-inflammatory, antimicrobial, anti-aging, anti-cancer, anti-cellulite, and sunscreen activities, and therefore could be a low-cost, sustainable, safe, and effective alternative in the composition of topical pharmaceutical and cosmetic formulations. However, most studies focus primarily on antioxidant activity, while studies on the finished product are still lacking.

## PRO IOP Recent advances in the catalytic deoxygenation of plant oils and prototypical fatty acid models compounds: catalysis, process, and kinetics

Cheah, K.W., *et al*, *Mol. Catal.*, online February 26, 2021, <https://doi.org/10.1016/j.mcat.2021.111469>.

With the inevitable human innate aspirations for better urban mobility and sustainable economic development, bio-based transportation fuels are projected to play an essential role in the foreseeable automotive transportation sector. Agricultural-based renewable diesel (RD) is the prospective fuel of tomorrow due to its excellent fuel properties and environmentally friendly attributes. This review summarizes the evolution of research works related to upgrading of plant oils and fatty acids to diesel-like hydrocarbons via catalytic deoxygenation (CDO) technologies in the past decade. Throughout this review paper, a strong emphasis is put on the fundamental chemistry, reaction mechanism, and kinetic modelling. The influence of the key process parameters that may

affect the diesel hydrocarbon product yields/selectivity including the types of feedstock, types of catalyst, and key operating conditions are also explicated. This paper also addresses the technical barriers, challenges, and prospects of CDO technologies that could potentially bridge between the existing research gaps and industrial practices in these areas. In summary, this paper will help scientific researchers and industrial practitioners to explore the recent scientific advances and potential strategies in producing sustainable diesel fuel from natural plant oils and fatty acids.

## Original Articles

### ANA H&N New insights into wine taste: impact of dietary lipids on sensory perceptions of grape tannins

Saad, A., *et al*, *J. Agric. Food Chem.* 69: 3165–3174, 2021, <https://dx.doi.org/10.1021/acs.jafc.0c06589>.

Wine is very often consumed with a meal. Although it is well known to tasters that the taste of wine changes in the presence of food, the influence of dietary lipids on wine astringency and bitterness caused by grape tannins is not well established from a molecular point of view. In this context, we investigated wine tannin–lipid interactions by combining biophysical techniques to sensory analysis. Nuclear magnetic resonance and optical and electron microscopy showed an interaction between catechin, a majority component of grape tannins, and lipid droplets from a phospholipid-stabilized oil-in-water emulsion characterized by (a) an increase in the droplet size in the presence of catechin, (b) slowing of their size growth over time, and (c) an increase in lipid dynamics in the droplet interfacial layer. Those results were strengthened by sensory analysis, which demonstrated that dietary oils decrease the perception of astringency of grape tannin solutions. Our results highlight that dietary lipids are crucial molecular agents impacting our sensory perception during wine consumption.

### BIO PCP Microbial polyhydroxyalkanoate production from lignin by *Pseudomonas putida* NX-1

Xu, Z., *et al*, *Bioresour. Technol.* 319: 124210, 2020, <https://doi.org/10.1016/j.biortech.2020.124210>.

Biological approaches play an important role in lignin valorization, whereas many issues in this area remain unclear. Herein, ligninolytic enzymes in *Pseudomonas putida* NX-1 were systematically unraveled based on genome sequence technology. Particularly, a dye-decolorizing peroxidase was systematically studied by heterologous expression, enzyme purification, and enzymatic characterization, which suggested it possessed activities on both synthetic dyes and lignin-derived aromatics. Moreover, a complete pathway for polyhydroxyalkanoate biosynthesis was annotated, and the polyhydroxyalkanoate biosynthesis capability of *P. putida* NX-1 was experimentally confirmed with lignin as



the sole carbon source. Furthermore, the monomer compositions, molecular weights, and thermal properties of polyhydroxyalkanoate from glucose and lignin-derived aromatics were comprehensively determined by gas chromatography-mass spectrometry, gel permeation chromatography, differential scanning calorimetry, and thermogravimetric analysis. The results indicated that physical properties of polyhydroxyalkanoate prepared from glucose and lignin-derived aromatics were similar, which suggested lignin could be an alternative feedstock for polyhydroxyalkanoate production without compromising its quality.

## **EAT S&D** The role of hydrogen bonds in TAG derivative-based oleogel structure and properties

Rosen-Kligvasser, J. and M. Davidovich-Pinhasa, *Food Chem.* 334: 127585, 2021, <https://doi.org/10.1016/j.foodchem.2020.127585>.

Glycerol monostearate (GMS) and stearic acid (SA) share a similar carbon chain structure while SA has a carboxyl head group and GMS has two free hydroxyl groups. The current research focuses on the relationship between GMS and SA chemical structure, nano- and mesoscale crystal structure, and the oleogel macroscopic characteristics. Molecular analysis revealed the formation of different types of hydrogen bonds, which disappear upon temperature increase at different temperatures. Nano-structural analysis exhibited tight and ordered lamellar structures for SA compared with loosely packed short lamellar structures in GMS oleogel, presumably due to its larger hydrophilic head group. Microstructure imaging revealed ordered anisotropically orientated needle-like crystals in SA and isotopically ordered braid-like crystals in GMS oleogels. Mechanical analysis revealed that gel strength is enhanced when crystal structure is isotropically oriented, similar behavior seen in composite materials, where the structuring agent crystals behave like a reinforcing agent within the oil matrix.

## **H&N LOQ** A biorefinery approach for the valorization of spent coffee grounds to produce antioxidant compounds and biobutanol

Lopez-Linares, J.C., et al., *Biomass Bioenerg.* 147: 106026, 2021, <https://doi.org/10.1016/j.biombioe.2021.106026>.

Spent coffee grounds (SCG) have been proposed as a potential material within the biorefinery context. The optimization of the microwave-assisted extraction of antioxidant compounds with natural deep eutectic solvents (NADES), a promising green solvent, was conducted in this study. Under the optimal extraction conditions (120 °C, 15 min, 20% water in NADES and 0.53 ChCl:Glyc molar ratio), the obtained extract contained: total phenolic content (TPC), 0.48 mg of gallic acid equivalents (GAE) g<sup>-1</sup> SCG, coumaric acid being the most abundant; total flavonoid content (TFC), 0.44 mg of catechin equivalents (CE) g<sup>-1</sup> SCG; antioxidant activities: DPPH, 0.55 mg trolox equivalents (TE) g<sup>-1</sup> SCG; ABTS, 3.17 mg TE g<sup>-1</sup> SCG; and FRAP, 1.52 mg TE g<sup>-1</sup> SCG. The residual NADES extracted SCG

was microwave pretreated with dilute sulfuric acid, enzymatically hydrolyzed and fermented by *Clostridium beijerinckii*, generating 7.1 g L<sup>-1</sup> butanol (81 kg butanol t<sup>-1</sup> SCG and 126 kg acetone-butanol-ethanol (ABE) t<sup>-1</sup> SCG). In this way, SCG displayed its potential as a source to be used in an integrated biorefinery approach.

## **IOP BIO** Microbial lipid production from crude glycerol and hemicellulosic hydrolysates with oleaginous yeasts

Chmielarz, M., et al., *Biotechnol. Biofuels* 14: 65, 2021, <https://doi.org/10.1186/s13068-021-01916-y>.

Crude glycerol (CG) and hemicellulose hydrolysate (HH) are low-value side products of biodiesel transesterification, the pulp and paper industry, or lignocellulosic ethanol production which can be converted to microbial lipids by oleaginous yeasts. This study aimed to test the ability of oleaginous yeasts to use CG and HH and mixtures of them as carbon source. Eleven out of 27 tested strains of oleaginous yeast species were able to grow in plate tests on CG as sole carbon source. Among them, only one ascomycetous strain, belonging to *Lipomyces starkeyi*, was identified, the other 10 strains were *Rhodotorula* spec. When yeasts were cultivated in mixed CG/ HH medium, we observed an activation of glycerol conversion in the *Rhodotorula* strains, but not in *L. starkeyi*. Two strains—*Rhodotorula toruloides* CBS 14 and *Rhodotorula glutinis* CBS 3044 were further tested in controlled fermentations in bioreactors in different mixtures of CG and HH. The highest measured average biomass and lipid concentration were achieved with *R. toruloides* in 10% HH medium mixed with 55 g/L CG—19.4 g/L and 10.6 g/L, respectively, with a lipid yield of 0.25 g lipids per consumed g of carbon source. Fatty acid composition was similar to other *R. toruloides* strains and comparable to that of vegetable oils. There were big strain differences in the ability to convert CG to lipids, as only few of the tested strains were able to grow. Lipid production rates and yields showed that mixing GC and HH have a stimulating effect on lipid accumulation in *R. toruloides* and *R. glutinis* resulting in shortened fermentation time to reach maximum lipid concentration, which provides a new perspective on converting these low-value compounds to microbial lipids.

## **LOQ EAT** Subcritical water as hydrolytic medium to recover and fractionate the protein fraction and phenolic compounds from craft brewer's spent grain

Alonso-Riaño, P., et al., *Food Chem.* 351: 129264, 2021, <https://doi.org/10.1016/j.foodchem.2021.129264>.

The valorization of the brewer's spent grain (BSG) generated in a craft beer industry was studied by subcritical water hydrolysis in a semi-continuous fixed-bed reactor. Temperature was varied from 125 to 185 °C at a constant flow rate of 4 mL/min. Biomass hydrolysis yielded a maximum of 78% of solubilized protein at 185 °C. Free

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amino acids presented a maximum level at 160°C, with a value of 55 mg free amino acids/g protein-BSG. Polar amino acid presented a maximum at lower temperatures than non-polar amino acids. The maximum in total phenolic compounds was reached at 185°C. This maximum is the same for aldehyde phenolic compounds such as vanillin, syringic, and protocatechuic aldehyde; however, for hydroxycinnamic acids, such as ferulic acid and p-coumaric, the maximum was obtained at 160°C. This allows a fractionation of the bioactive compounds. Subcritical water addresses opportunities for small breweries to be incorporated within the biorefinery concept.

## PCP BIO Production of beta-carotene in *Saccharomyces cerevisiae* through altering yeast lipid metabolism

Zhao, Y., *et al.*, *Biotechnol. Bioeng.* February 19, 2021, <https://doi.org/10.1002/bit.27717>.

*Saccharomyces cerevisiae* is a widely used cell factory for producing fuels and chemicals. However, as a non-oleaginous yeast, *S. cerevisiae* has a limited production capacity for lipophilic compounds, such as beta-carotene. We engineered different lipid metabolic pathways in a beta-carotene producing strain and investigated the relationship between lipid components and the accumulation of beta-carotene. We found that overexpression of sterol ester synthesis genes *ARE1* and *ARE2* increased beta-carotene yield by 1.5-fold. Deletion of phosphatidate phosphatase (PAP) genes (*PAH1*, *DPPI1*, and *LPP1*) also increased beta-carotene yield by twofold. Combining these two strategies resulted in a 2.4-fold improvement in beta-carotene production compared with the starting strain. These results demonstrated that regulating lipid metabolism pathways is important for beta-carotene accumulation in *S. cerevisiae* and may also shed insights to the accumulation of other lipophilic compounds in yeast.

## PCP IOP Development of lignin-based heterogeneous solid acid catalyst derived from sugarcane bagasse for microwave assisted-transesterification of waste cooking oil

Nazir, M.H., *et al.*, *Biomass Bioenerg.* 146: 105978, 2021, <https://doi.org/10.1016/j.biombioe.2021.105978>.

The production of biodiesel by using homogeneous or heterogeneous catalysts is not favorable due to difficult catalyst recovery. In the case of homogeneous catalysts, purification of the product is difficult, while longer reaction times, severe reaction conditions, and high production cost are the drawbacks of heterogeneous catalysts. Different sulfonated catalysts were synthesized to overcome these problems and their feasibility on industrial scale. Therefore, the focus of this study was to synthesize a sulfonated catalyst using activated carbon produced from the lignin extracted from sugarcane bagasse and used in the transesterification of waste cooking oil with methanol using microwave as heating source. The catalyst was prepared by varying the sulfonation temperature (140–220°C)

for 120 min and characterized by using thermogravimetric analysis (TGA), scanning electron microscope (SEM), fourier transform infrared spectroscopy (FT-IR), surface area (BET), and elemental analysis by CHNS analyzer. The catalyst prepared at 180°C for 2 h showed excellent characteristics in terms of surface area, i.e., 30.31 m<sup>2</sup> g<sup>-1</sup>, acidic density 4.74 mmol. g<sup>-1</sup>, pore volume 0.03 cm<sup>3</sup> g<sup>-1</sup>, pore size of 9.44 nm, functional groups attachments, surface morphology, and crystallographic structure. The process of transesterification was optimized by varying reaction time (5–25 min), methanol to oil molar ratio (6:1–24:1), catalyst loading (5–20 wt% to oil) and temperature (40–70°C). The maximum yield (89.19%) of biodiesel was achieved after 15 min with a methanol to oil molar ratio of 18:1 at 60°C and 15 wt% of catalyst. The reusability and stability of the prepared catalyst up to six cycles with minor loss in its activity, i.e., 8% for low-grade feedstocks having higher value of free fatty acid content (FFA) was studied.

## PRO EAT IOP Potential of oilseeds native to Amazon and Brazilian Cerrado biomes: benefits, chemical and functional properties, and extraction methods

Cornelio-Santiago, H.P., *et al.*, *J. Am. Oil Chem. Soc.* 98: 3–20, 2021, <https://doi.org/10.1002/aocs.12452>.

The primary objective of this study was to shed greater light on the characteristics and multifaceted potential of oil extracts from kernels of *Bertholletia excelsa* (Brazil nut), seeds of the species *Plukenetia* and *Caryocar* found in the Amazon and Brazil's Cerrado biomes. These seeds have many substantial organoleptic, nutritional, and functional properties that are comparable or exceed those of better-known oils, and they manifest health benefits and prospective economic opportunities as an oil source for foods, pharmaceutical, and cosmetic industries. It is also hoped that this study gives rise to further research that may be beneficial to the industry and improve the local economies where these raw materials are found.

## PRO IOP Techno-economic analysis of *Camelina*-derived hydroprocessed renewable jet fuel within the US context

Shila, J. and M.E. Johnson, *Appl. Energy* 287: 116525, April 1, 2021, <https://doi.org/10.1016/j.apenergy.2021.116525>.

This study explores the techno-economic analysis of producing *Camelina*-derived Hydroprocessed Renewable Jet (HRJ) fuel in Montana using the hydro-deoxygenation (HDO) pathway. The HDO method requires added hydrogen and increases cost. The estimated break-even price of *Camelina*-derived HRJ fuel generated from the HDO reaction follows the UOP Honeywell procedure. Oilseed cultivation, lipid extraction, and HRJ fuel production were evaluated to estimate the HRJ fuel break-even price. In an extraction facility with annual processing capacity of 3000 Mg, the





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**AOCS Official Method Ca 17a-18**

Determination of Trace Elements in Oil by Inductively Coupled Plasma Optical Emission Spectroscopy

**Joint JOCS/AOCS Official Method Cd 29d-19**

2-/3-MCPD Fatty Acid Esters and Glycidyl Fatty Acid Esters in Edible Oils and Fats by Enzymatic Hydrolysis

**Joint JOCS/AOCS Recommended Practice Cd 29e-19**

2-/3-MCPD Fatty Acid Esters and Glycidyl Fatty Acid Esters in Fish Oils by Enzymatic Hydrolysis

**Joint JOCS/AOCS Official Method Ch 3a-19**

Determination of the Composition of Fatty Acids at the 2-Position of Oils and Fats-Enzymatic Transesterification Method using *Candida antarctica* Lipase

#### **REVISIONS**

**AOCS Standard Procedure Ba 6a-05**

Crude Fiber in Feed by Filter Bag Technique

**AOCS Official Method Cc 7-25**

Refractive Index of Fats and Oils

**AOCS Official Method Cd 26-96**

Stigmastadienes in Vegetable Oils

**AOCS Official Method Cd 27-96**

Steroidal Hydrocarbons in Vegetable Oils

**AOCS Official Method Cd 3d-63**

Acid Value of Fats and Oils

**AOCS Official Method Cd 29c-13**

2- and 3-MCPD Fatty Acid Esters and Glycidol Fatty Acid Esters in Edible Oils and Fats by GC/MS (Difference Method)

**AOCS Official Method Ce 8-89**

Tocopherols and Tocotrienols in Vegetable Oils and Fats by HPLC

**AOCS Official Method Ch 3-91**

Fatty Acids in the 2-Position in the Triglycerides of Oils and Fats

**AOCS Official Method Ch 5-91**

Specific Extinction of Oils and Fats, Ultraviolet Absorption

**AOCS Analytical Guidelines Ch 7-09**

International Trade Standard Applying to Olive and Olive-Pomace Oils

**AOCS Official Method Ch 8-02**

Wax Content by Capillary Column Gas-Liquid Chromatography

**AOCS Procedure M 1-92**

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breakeven price of *Camelina* oil was \$0.35 per liter over a 20-year operating period and \$0.34 per liter over a 30-year period. For a 20-year operating period, the deterministic breakeven price of HRJ fuel was \$0.87 per liter with a commercial hydrogen and \$1.01 per liter when the plant generated its own hydrogen supply; a 30-year operating period had \$0.02 per liter savings. The sensitivity analysis indicates a break-even price between \$0.87 and \$1.44 per liter in a facility with an on-site hydrogen plant, and between \$0.75 and \$1.26 per liter when purchasing hydrogen. An additional \$0.02 per liter of capital investment cost is incurred to produce HRJ fuel instead of renewable diesel. Depending on the fuel product, investors would have a capital cost penalty of \$0.13 to \$0.15 per liter for producing hydrogen on-site.

## PRO EAT BIO IOP A novel strategy for triacylglycerides and polyhydroxyalkanoates production using waste lipids

Argiz, L., et al., *Sci. Total Environ.* 763: 142944, 2021, <https://doi.org/10.1016/j.scitotenv.2020.142944>.

Lipids are one of the main components of the organic matter present in the effluents of the food-processing industry. These waste

streams can be biotransformed into valuable triacylglycerides (TAGs) and polyhydroxyalkanoates (PHAs), precursors of biofuels and biomaterials. These compounds are yielded by mixed microbial cultures and, considering that both TAG and PHA accumulators may coexist within the community, it seems crucial to define those operational strategies that might control the selection of the dominant metabolic pathways (TAG or PHA accumulation). In this work, residual fish-canning oil was used as a carbon source in a two-stage process (culture selection and intracellular compounds accumulation) in which the substrate was simultaneously hydrolyzed in these two stages without the need for a previous fermentation unit. Maximized preferential TAG or PHA storage was mimicked in the accumulation reactor by imposing certain selective pressures in the enrichment one. Uncoupling C and N feedings and limiting nitrogen availability in the medium allowed PHA production (82.3 wt% of PHAs, 0.80 CmmolPHA/CmmolS) to be maximized. When low pH in the famine phase was considered as additional selective pressure, it was possible to shift the ratio TAG:PHA from 4:96, obtaining 43.0 wt% of TAGs (0.67 Cmmol TAG/CmmolS). This novel and simplified process demonstrated versatility and efficiency in the storage of TAGs and PHAs from a unique residual feedstock, and using an open culture proved that product selection can be harnessed if choosing the right operational conditions in the enrichment stage.

## AOCS JOURNALS

continued from page 40

### IN WHAT WAYS HAS SCIENTIFIC PUBLISHING CHANGED DURING YOUR EDITORSHIP, AND WHAT CHANGES DO YOU FORESEE THE NEXT EDITOR-IN-CHIEF WILL FACE DURING THE NEXT FIVE YEARS?

Publishing research, at least in my mind, is and always has been about reporting new findings honestly and with integrity to the scientific community in an effort to further knowledge and understanding. From this perspective, I suspect editors will always have a role in scientific publishing, although the manner and speed at which scientific findings are disseminated is changing tremendously. In tandem, the business of publishing scientific articles has become extremely competitive and lucrative as evidenced by the plethora of new journal offerings. It is becoming increasingly difficult for authors to distinguish reputable from predatory journals, for what was once black and white is now grey. Social media also plays a role that is not fully appreciated and requires care in its use to ensure the scientific record remains credible and fad science is not unjustly propagated. These developments put additional pressures on journals and, thereby, editors to keep scientific integrity and quality high, be mindful of impact factors, regardless of one's belief about their relevancy (see Hartel, 2021 for an interesting perspective), and grow readership while staying

## References

Hartel, R.W. (2021) Serving the industry. *Journal of Food Science*, 86:254-254, <https://doi.org/10.1111/1750-3841.15191>.

true to the journal's niche. Keeping the journal efficient, providing opportunities for early career scientists as editors, and finding new avenues to grow in light of these pressures is critical to navigate going forward.

### IS THERE A PARTICULAR NON-SCIENTIFIC INTEREST OR ACTIVITY YOU ENJOY, AND WHAT BEARING HAS IT HAD ON YOUR LIFE AND CAREER?

My family certainly keeps me centered on what's important, and I am thankful for the joy they bring into my life. I have a lot of varied interests away from science and research such as, woodworking, sports, and general tinkering. These activities are creative outlets that afford me the opportunity to continually learn and push my personal skillsets to new levels in different areas.

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