ENVIRONMENTAL SYSTEMS DIVISION NEWSLETTER

01 FEBRUARY 2021

The ESD Newsletter is a monthly newsletter involving ALL members of ESD. Members are encouraged to forward materials, authored papers on Environmental and Environmental Systems topics, and comments on newsletter topics or current events to the Editor. Your participation is greatly appreciated.

The ESD newsletter features **Five** Sections:
(Please use the **blue** links below to navigate within the newsletter)

1. ESD DIVISION NEWS

ASME ENERGY STORAGE COMMITTEE

The Energy Generation and Storage Technology Group (EGSTG) formed a new Energy Storage Committee (ESC) in the Spring of 2020. The ESC is dedicated to the advancement of energy storage systems: for both utility and distributed systems. The focus of ESC extends across most of the other ASME Divisions and Sectors. This Committee works with the government, industry, academia, ASME Codes & Standards, ASME Government Relations and other relevant professional and regulatory organizations to discuss, review, and promote practices that lead to the development, enhancement, and deployment of energy storage technologies.
The core values of ESC are to:

- Support international/intersociety professionals wishing to advance the application of energy storage thru basic research applied research, development, and implementation
- Create and publish peer-reviewed high-value content, reference documents
- Facilitate the creation, dissemination, and application of knowledge (science, engineering, technology) and information in energy storage within and outside ASME
- Attract students and young engineers into this area and provide them a forum to grow and advance their careers
- To encourage and facilitate a process for members to provide their expertise in the standards-setting process for energy storage
- To promote codes and standards for new areas energy storage
- To provide closer interface within and outside ASME through joint efforts/collaboration
- To help members keep pace with the latest developments

The main purposes of the Committee are fivefold:

- To develop and maintain the Energy Storage Matrix so that all (not only those on the Committee) know the status of the various technologies
- To develop standards (both ASME and IEEE as well as others) for energy storage: the Committee is a resource (e.g., people, volunteers, knowledge) for the various groups working on standards
- As central coordinating Committee (group) for sharing knowledge and answering questions on Energy Storage
- As a networking center for those directly (and indirectly) working on Energy Storage
- To develop events on Energy Storage such as webinars, forums, and conferences

ESC members include engineers (and others) conducting research and practicing engineers in energy storage, storage equipment design, regulatory programs, operations, design, maintenance, and testing of energy storage systems. Membership on the ESC is open to all ASME members, other professional society's (e.g., IEEE, AIChE, etc.), the governmental and regulatory community, and other interested individuals. Membership on the Committee is free to all. The intent is for the ESC to transition into an ASME Energy Storage Division in approximately one to two years. If you are interested in becoming a member of the Committee or need more information, please contact Arnie Feldman, Chair (jjdsenv@att.net).

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ASME Environmental Systems Division Competition for Students & Early Career Professionals

ABSTRACT EXTENSION

Show off your speaking skills and highlight your technical, management and policy knowledge as they relate to the environment. The competition aims to encourage students and early career engineer's involvement in technical, management, and policy-making issues related to the environment.

ASME is excited to host an E-Fest Digital event on April 24, 2021 (finals). The competition is open to and divided in to three groups: Undergraduate Students, Graduate Students and Early-Career Engineers. The topics are for each Group are:

GROUP NO.	GROUP/LEVEL	TOPICS	FOCUS AREAS
I	Undergraduate Students	Waste to Energy	Technical Solutions to Environmental Problems
II	Graduate Students	Clean Energy Technologies & Systems	Technical Solutions to Environmental Problems and Environmental & Sustainable Management
III	Early Career	Environmental Remediation & Restoration	Environmental Management and Policy Making Aspects

The Competition will have three rounds (each round being an elimination round) including an abstract submission, semi-final video and live (digital) final presentation. For the schedule of see the Competition Rules and Timing at Download the 2021 Environmental Systems Division Competition Rules. Abstract submission due by February 15, 2021 11:59pm EST.

If you have other questions about the Environmental System Division Competition please email esd@asme.org

The links to the Rules and Webinar are: Competition Rules

https://efests.asme.org/getattachment/48e72745-6ef4-4a71-a078-527b57590d5f/2020_ESD-Competition-Guidelines_FINAL.pdf.aspx?lang=en-US]

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2. ENVIRONMENTAL TECHNOLOGIES

Gene-editing 'scissor' tool may also be a 'dimmer switch.'

In a series of experiments with laboratory-cultured bacteria, Johns Hopkins scientists have found evidence that there is a second role for the widely used gene-cutting system CRISPR-Cas9 -- as a genetic dimmer switch for CRISPR-Cas9 genes. Its role of dialing down or dimming CRISPR-Cas9 activity may help scientists develop new ways to engineer cells for research purposes genetically. A summary of the findings was published on Jan. 8 in Cell. First identified in the genome of gut bacteria in 1987, CRISPR-Cas9 is a naturally occurring but unusual group

of genes with the potential for cutting DNA sequences in other types of cells that were realized 25 years later. Its value in genetic engineering -- programmable gene alteration in living cells, including human cells -- was rapidly appreciated, and its widespread use as a genome "editor" in thousands of laboratories worldwide was recognized in the awarding of the Nobel Prize in Chemistry last year to its American and French co-developers.

CRISPR stands for clustered, regularly interspaced short palindromic repeats. Cas9, which refers to CRISPR-associated protein 9, is the enzyme's name that makes the DNA slice. Bacteria naturally use CRISPR-Cas9 to cut viral or other potentially harmful DNA and disable the threat. In this role, "CRISPR is not only an immune system, but it's also an adaptive immune system -- one that can remember threats it has previously encountered by holding onto a short piece of their DNA, which is akin to a mug shot." These mug shots are then copied into "guide RNAs" that tell Cas9 what to cut. Scientists have long worked to unravel the precise steps of CRISPR-Cas9's mechanism and how its activity in bacteria is dialed up or down. Looking for genes that ignite or inhibit the CRISPR-Cas9 gene-cutting system for the common, strep-throat causing bacterium Streptococcus pyogenes, and the Johns Hopkins scientists found a clue regarding how that aspect of the system works. Specifically, the scientists found a gene in the CRISPR-Cas9 system that, when deactivated, led to a dramatic increase in the activity of the system in bacteria. The product of this gene appeared to re-program Cas9 to act as a brake, rather than as a "scissor," to dial down the CRISPR system. "From an immunity perspective, bacteria need to ramp up CRISPR-Cas9 activity to identify and rid the cell of threats, but they also need to dial it down to avoid autoimmunity, when the immune system mistakenly attacks components of the bacteria themselves".

To further nail down the particulars of the "brake," the team's next step was to understand better the product of the deactivated gene (tracrRNA). RNA is a genetic cousin to DNA and is vital to carrying out DNA "instructions" for making proteins. TracrRNAs belong to a unique family of RNAs that do not make proteins. Instead, they act as a kind of scaffold that allows the Cas9 enzyme to carry the guide RNA that contains the mug shot and cut matching DNA sequences in invading viruses. TracrRNA comes in two sizes: long and short. Most of the modern gene-cutting CRISPR-Cas9 tools use the short form. However, the research team found that the deactivated gene product was the long-form of tracrRNA, the function of which has been entirely unknown. (Ref. 1)

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FRC East explores new laser technology

Removing coatings and corrosion from aircraft components often requires abrasive blasting, sanding, and hazardous chemicals to prepare the surfaces for rework. Engineers and artisans at Fleet Readiness Center (FRC) East recently observed a demonstration of a quicker, more efficient way to clean these parts for repair, using laser light to remove corrosion and coatings from containers and aircraft components. FRC East's Advanced Technology and Innovation Team and Materials Engineering Division have been working to bring laser ablation technology to the facility because the laser system is quicker, cleaner and safer than traditional metal cleaning methods, according to team members. Plastic blasting and mechanical removal with sanders are similar processes, but they create a lot more dust and waste. This laser ablation system cooks and bakes off all the organic substances of the paint, so the only thing

that is removed is the heavy metals that are not converted into carbon dioxide or water vapor. The laser ablation system sends nanosecond-length pulses of light onto the surface to be cleaned. When the contaminants absorb the light, they turn into a gas. The pressure removes the particles from the surface, leaving the bare metal clean and ready for coating without damaging its structural integrity. Besides, any waste generated is pulled into a vacuum with a filter. Any time you have plastic media blasting or some of these other processes; the waste produced is considered hazardous waste. It is very expensive to remove and dispose of. "With this process, the only hazmat that you have to deal with is the filter and the media that's collected into the HEPA filter. There's a whole lot less waste, and it's a whole lot safer for the environment, a whole lot cheaper for our facility – just benefits all around." It will save a lot in blasting material, paying for the hazmat, removal of the material and the maintenance on the machine itself. The first step would be getting one of these handheld systems for use in the packaging and preservation shop to use on engine cans, possibly on some ground support equipment and then plan to move forward once the research is complete. With all of its benefits, the laser ablation system is expensive; handheld units cost between $400,000 and $500,000. FRC East engineers say they expect the system would pay for itself in the end, with reduced costs for purchase and disposal of hazardous materials and the benefits of quicker turnaround time, improved worker safety, and decrease environmental hazards. (Ref. 2) **Back to Newsletter's Page 1**

3. ENVIRONMENTAL REGULATIONS

EPA introduces additional action items under its 2019 PFAS action plan

In January 2021, the United States Environmental Protection Agency ("EPA") introduced several new action items to further complement its progress under the 2019 Per-and Polyfluoroalkyl Substances ("PFAS") Action Plan. These action items put EPA one step closer to formal regulation of these substances and provide PFAS manufacturers, producers, users, and discharges a blueprint of the compliance requirements that will dictate their operations within the coming years. PFAS are human-made chemicals that are typically produced by industrial and manufacturing operations and used in consumer goods. During production and use, these substances have been found to migrate into soil, water, and air, and are not known to readily breakdown, thus leading to their "forever chemicals" moniker. While a thorough examination of the health effects of these substances is ongoing, EPA has found that exposure to certain PFAS compounds can result in increased cholesterol, impacts to infant birth weights, effects on the immune system, cancer, and thyroid hormone disruption. With an increased focus on these substances by states and the United States Congress, EPA's revised actions items seek:

- Development of National Primary Drinking Water Regulations for PFOA and PFOS: Under the Safe Drinking Water Act, EPA is preparing to issue a final regulatory determination for perfluorooctanoic acid ("PFOA") and perfluorooctane sulfonic acid ("PFOS") – the two most widely known PFAS. Development of primary drinking water

regulations could result in the development of PFAS discharge limitations for sources discharging upstream of drinking water intakes.

- Advanced Notice of Proposed Rulemaking Addressing PFOA and PFOS: EPA is issuing an Advanced Notice of Proposed Rulemaking for public comment to obtain additional information on PFOA and PFOS to guide the Agency's future regulation of these substances. Specifically, EPA is seeking comment as to whether PFOA and PFOS should be regulated as a hazardous substance under CERCLA or RCRA.
- Further Evaluation of PFAS in Drinking Water: EPA is proposing to collect new data on 29 additional PFAS under its fifth Unregulated Contaminant Monitoring Rule. EPA intends to use the results to determine the need for additional PFAS regulation under the Safe Drinking Water Act.
- Toxicity Assessment for PFBS: EPA has released a toxicity assessment for perfluorobutane sulfonic acid ("PFBS"). While not a regulation, the toxicity assessment is a key feature in determining future regulation of PFBS.
- Advanced Notice of Proposed Rulemaking Regarding the Presence and Treatment of PFAS in Wastewater: EPA is seeking to collect data on the presence of PFAS in manufacturers' wastewater discharges. This information will guide EPA's determination as to whether these substances warrant formal regulation through national Effluent Limitation Guidelines.

Manufacturers, producers, users, and dischargers of PFAS must prepare now for these regulations' impacts. As the information on these substances continues to develop, PFAS users must: (1) determine the presence of PFAS in their operations; (2) determine paths of exposure to PFAS from their operations (air, water, waste, consumer use, etc.); and (3) proactively develop their action plan to address these substances to ensure compliance once formal regulations are implemented. (Ref. 3) **Back to Newsletter's Page 1**

New Lead and Copper Rule to Raise Costs for Water Utilities

The Environmental Protection Agency's (EPA) new Lead and Copper Rule (LCR) is not expected to impact utility credit quality over the near-term. Still, it could have a material effect on certain water utilities' capex and credit profiles over the medium- to long-term, particularly for those utilities that serve communities with a large proportion of older homes and buildings that will likely require greater lead service line (LSL) remediation, Fitch Ratings says. The LCR is expected to raise near-term operational costs for all utilities and negatively affect capital budgets in the longer term as LSLs are identified and replaced. Overall, the EPA expects annual costs to implement the LCR to be as much as $839 million, up to 80% more than the prior rule, with most of these costs borne by the water utilities. The increased costs of monitoring, outreach and LSL replacement may crowd out other operating costs and infrastructure projects. They could lead to higher rate increases than currently anticipated by utilities, heightening concerns in the industry over service cost affordability.

Utilities will face increased operational costs under the LCR with requirements for identifying LSLs and increased water testing and outreach. If lead is detected more than the trigger threshold of 10 parts per billion (ppb), a utility will need to review water treatment, implement corrosion control measures and/or replace LSLs. Smaller utility systems serving fewer than 10,000 people are granted more flexibility concerning these measures in

implementing the LCR. Under the new rule, utilities have three years to inventory LSLs, which will provide more visibility on which systems will bear greater costs for replacement. The EPA estimates 6.3 million to 9.3 million homes across the country with LSLs and millions of other buildings with lead solder and/or faucets with lead. Older homes and other buildings in areas with relatively higher levels of poverty have been identified by the Government Accountability Office (GAO) in its December 2020 drinking water report as more likely to have lead pipes. Those systems serving older and poorer residences will face a greater capital burden of replacing LSLs but may also have the least flexibility to absorb increased capital costs.

After LSLs have been inventoried, the LCR requires an annual LSL replacement rate of 3% versus 7% under the old rule for communities exceeding the 15 ppb federal action level. While the required percentage replacement rate of LSLs is lower, the new LCR closes loopholes from the previous rule that led to much lower replacement rates. Further, the new rule requires a full replacement of LSLs, including both the utility and privately owned portion of the line, to count toward the replacement rate. In contrast, the prior rule included partial and other types of replacement in the calculation. Because of the changes being implemented, the EPA expects annual investment in LSLs replacements to be as much as 70x higher under the new rule than the prior one. The rule becomes effective 60 days following its publication in the Federal Register. Biden's administration will have the opportunity to decide whether it will allow the final rule to go into effect or propose a new rule. States may pass more stringent lead water level regulations than those in the new LCR. (Ref. 4) **Back to Newsletter's Page 1**

4. EDITORIAL BOARD SELECTIONS

The quest for delicious decaf coffee could change the appetite for GMOs

Coffee is one of the world's most popular drinks, but that cup can come with a price of jitters or sleeplessness. The stimulant in coffee — the thing that gives it its kick and can lead to those jitters — is caffeine, and it can be addictive. Decaffeinated coffee is coffee with almost all of the caffeine removed; decaf coffee drinkers report less anxiety and improved sleep. However, decaf is comparatively unpopular, representing only 10 percent of the global coffee market. Some of the approaches being explored to create a better decaf cup are the changes that could create a secure food future. Historically, there has been opposition to the widespread adoption of genetically modified organisms (GMOs), but maybe the turning point will come through better-tasting decaf. All commercially grown coffee contains caffeine. To produce decaf, between 97 and 99.9 percent of the caffeine is removed. There are several ways to do this, but they all depend on the caffeine being dissolved out of the coffee beans before they are roasted. Natural solvents include CO2, coffee oil or water, but other chemicals are also used, including methyl acetate and ethylene chloride. Genetic engineering could allow us to turn off the entire caffeine synthesis pathway, avoiding the complication of theobromine. By editing the relevant genes, we could create beans that would grow caffeine-free and theobromine-free.

Low-caffeine Robusta has been created in the laboratory using a process called RNA inhibition (RNAi) to turn down the activity of one of the genes involved in caffeine production by 70 percent. This technique is promising, but almost 20 years after initial success, coffee has not yet come to market. It is also possible to create caffeine-free coffee in the laboratory by using the gene-editing technique known as CRISPR-Cas9. This approach has been used to create

hardy coffee plants that could withstand global climate change and could be adapted to create decaf.

One advantage of both laboratory techniques is that they could be done directly in various coffee beans that already yield high-quality coffee. Because the techniques do not require creating hybrids, the entire process could be done in as little as six years. Modern agriculture must continue to evolve. Our warming planet and expanding population put the global food supply in jeopardy. Wheat, rice and soybean, for example, combine to provide two-thirds of human calories, but crop yields from all three are in decline as global temperatures increase. Modern, laboratory-driven agriculture has the potential to combat this threat by drastically increasing yields. Similarly, globally, bananas are a dietary staple for 400 million people, but a fungus threatens to destroy the commercial agriculture of this crucial crop. A genetically engineered banana could avert this disaster. (Ref. 5) **Back to Newsletter's Page 1**

Co-processing for sustainable waste management solution

Waste disposal has been a growing problem in every country across the globe. As urbanization continues, as technology advances, and as populations increase, so does the level of the world's waste. Leading cement manufacturer CEMEX Holdings Philippines takes on the call for better waste management and reduced plastic waste by providing a sustainable disposal solution through an industrial process called co-processing. Co-processing is a proven sustainable waste disposal solution that reduces pollution and landfill space through the simultaneous recycling of materials and energy recovery by utilizing a cement kiln. The kiln is the heart of the cement manufacturing operations and is the main equipment utilized to produce clinker, the main component for cement. Coupled with proper segregation, co-processing helps reduce waste accumulation in dumpsites by taking the plastic and rubber-based waste and integrating these into the cement manufacturing process after the necessary pre-treatment. Non-recyclable waste is then converted into usable heat to help power the cement kiln, thereby reducing the dependency on fuel or electricity consumption. Continuously operating at extremely hot temperatures of around 1,500 Celsius, the cement kiln guarantees the complete breakdown of waste and toxic substances, ensuring that no residual waste materials are created. Co-processing has also helped minimize environmental impact and health hazards to nearby communities and lessen landfill spaces' burden by up to 30%. Aided with strict compliance on international standards on quality (ISO 9001), environment management (ISO 14001), and health and safety (ISO 18001), CEMEX conducts co-processing in an environmentally friendly and secure way and is duly accredited by the Department of Environment and Natural Resources (DENR). As a testament to its commitment to protect and conserve the environment, CEMEX Holdings Philippines was recognized in 2019 by the DENR – Environmental Management Bureau (EMB) for its waste management solutions and for the TSeK or *Tamang Segregasyon Para Sa Kalikasan* program services that are being offered to its chosen communities. CEMEX first earned the DENR-EMB recognition in 2017 to commit as donor partner to the government's Adopt-a-River Program. (Ref. 6) **Back to Newsletter's Page 1**

Efficient solid-state depolymerization of waste PET

Plastic pollution has become one of the most complex environmental issues, especially in increasing production and demand for plastic materials. While polymer chemistry innovations have radically changed our lives in the mid-20th century, the outstanding properties of plastics such as durability, chemical stability, strength and many other characteristics pose a serious problem for recycling such materials. According to some estimates, by the year 2050, there will be more plastic waste than fish in oceans by total weight, with the annual production of plastic materials reaching more than 1.1 billion tons. Global production of plastics in 2015 was estimated to approximately 380 million tons and the cumulative amount of waste generated from the 1950s until 2015 was around 6.3 billion tons. Only 9% of the waste was recycled and a staggering 60% of all plastics ever made ended up in the environment. Rationalizing using plastic products and increasing consumer awareness to sort and recycle waste is important in pollution reduction. Polyethylene terephthalate (PET) is a synthetic polyester widely used to produce soft-drink bottles and textile fibers. PET is a thermoplastic made of repeating units of terephthalic acid and ethylene glycol, linked together via an ester bond. Hence, the popular name polyester, which is mostly used in the textile industry. The ester linkage can be cleaved by hydrolysis to transform PET waste back into its monomer constituents. Current chemical methods of PET recycling require organic solvents at high temperatures and pressures to achieve depolymerization into monomer derivatives in practical yields. Exploring the possibilities of using ball milling in PET depolymerization, scientists from the RBI Laboratory for Physical-Organic Chemistry successfully decomposed PET into monomer terephthalic acid at ambient temperature and pressure, with terephthalic acid being also the starting material for the production of this plastic.

Mechanochemistry has recently become one of the most promising fields of chemical science due to its extremely high efficiency, simplicity, speed, and the ability to significantly reduce the use of toxic organic solvents or completely avoid their use in chemical reactions. Although the International Union of Pure and Applied Chemistry (IUPAC) ranked mechanochemistry and the degradation of polymers into monomers among the top ten innovations in chemistry that will change the world, an effective mechanochemical PET degradation has not yet been described in the scientific literature. In the latest study, it describes highly efficient alkaline hydrolysis of waste PET in the solid-state at ambient temperature and pressure, achieved by mechanochemical ball milling with PET conversion and monomer isolated yields up to 99%.

Excellent yields were also achieved by the so-called vapor-assisted aging of manually mixed or pre-milled solid mixtures of PET and sodium hydroxide in a humid environment or the presence of alcohol vapors. Aging in alcohol vapors represents an even milder route to PET depolymerization with 99% conversion at room temperature. Published results show that mechanochemical milling and vapor-assisted aging, as two complementary solid-state techniques, have the potential for alkaline degradation of waste PET plastics and PET textile on larger scales as well. The described methodology could serve as a platform for developing new and efficient environmentally friendly processes for terephthalic acid production from waste PET abundant in the environment instead of non-renewable sources such as fossil fuels. (Ref. 7)

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New route to chemically recyclable plastics

As the planet's burden of rubber and plastic trash rises unabated, scientists increasingly look to the promise of closed-loop recycling to reduce waste. A team of researchers at Princeton's Department of Chemistry announces the discovery of a new polybutadiene molecule -- from a material known for over a century and used to make common products like tires and shoes -- that could one day advance this goal through depolymerization. The Chirik lab reports in Nature Chemistry that during polymerization, the molecule, named (1, n'-divinyl) oligocyclobutane, enchains in a repeating sequence of squares. This previously unrealized microstructure enables the process to go backward, or depolymerize, under certain conditions. In other words, the butadiene can be "zipped up" to make a new polymer; that polymer can then be unzipped back to a pristine monomer to be re-used. The research is still at an early stage and the material's performance attributes have yet to be thoroughly explored. However, the Chirik lab has provided a conceptual precedent for a chemical transformation not generally thought practical for certain commodity materials.

In the past, depolymerization has been accomplished with expensive niche or specialized polymers and only after a multitude of steps, but never from raw material as common as that used to make polybutadiene, one of the top seven primary petrochemicals in the world. Butadiene is an abundant organic compound and a major byproduct of fossil fuel development. It is used to make synthetic rubber and plastic products. To take a really common chemical that people have been studying and polymerizing for many decades and make a fundamentally new material out of it -- let alone have that material have interesting innate properties -- not only is that unexpected, but it's also really a big step forward. The Chirik lab explores sustainable chemistry by investigating the use of iron -- another abundant natural material -- as a catalyst to synthesize new molecules. In this particular research, the iron catalyst clicks the butadiene monomers together to make oligocyclobutane. However, it does so in a highly unusual square structural motif. Normally, enchainment occurs with an S-shaped structure that is often described as looking like spaghetti. Then, to affect depolymerization, oligocyclobutane is exposed to a vacuum in the presence of the iron catalyst, which reverses the process and recovers the monomer. The Chirik lab's paper, "Iron Catalyzed Synthesis and Chemical Recycling of Telechelic, 1,3-Enchained Oligocyclobutanes," identifies this as a rare example of closed-loop chemical recycling. The material also has intriguing properties as characterized by the Chirik lab and chemists at ExxonMobil's polymer research center. For instance, it is telechelic, meaning the chain is functionalized on both ends. This property could enable it to be used as a building block in its own right, serving as a bridge between other molecules in a polymeric chain. Besides, it is thermally stable, meaning it can be heated to above 250-degrees C without rapid decomposition. Finally, it exhibits high crystallinity, even at a low molecular weight of 1,000 grams per mol (g/mol). This could indicate that desirable physical properties -- like crystallinity and material strength -- can be achieved at lower weights than generally assumed. The polyethylene used in the average plastic shopping bag, for example, has a molecular weight of 500,000g/mol. (Ref. 8) **Back to Newsletter's Page 1**

Making Protein 'Superfood' from Marine Algae

Marine microalgae-based cellular agriculture is a promising new way to sustainably produce plant-based "meat" and healthy "superfoods" for the future. Researchers at Flinders University's Centre for Marine Bioproducts Development (CMBD) in Australia respond to growing interest from consumers looking for healthier, more environmentally friendly, sustainable, and ethical alternatives to animal proteins. Marine microalgae, single-cell photosynthetic organisms from the ocean, could be the solution to the world's meat protein shortage. The CRC's mission is to find ways to develop the third-generation Australian high-value marine bio-industry (instead of the first-generation of fisheries and the second-generation of aquaculture) and transform Australia's emerging marine bioproducts sector into a globally competitive industry. The center's focus will be on industry and market-driven innovations to improve both the supply chain and value chain to deliver cost savings, improved production, and competitive capacity for Australia to access high-value marine bioproducts markets worldwide.

Their research spans the entire value chain, from microalgae cultivation and advanced circular biomanufacturing to the development of high-value functional food. Microalgae come in a diverse range of nutritional profiles and advanced cultivation strategies can be developed for tuning microalgae to produce protein-, oil-, and carbohydrate-dominant types that can be processed into a broad range of functional foods, including healthy cell patties, chips, pastes, jams, and even caviar. Two freshwater microalgal products currently on the market are the high protein Chlorella and Spirulina varieties used to produce foods such as green pasta, drinks, and beverages. Marine species are of significant interest as they do not require scarce freshwater and cropland. Their unique nutritional profiles such as their high DHA and EPA content (long-chain omega 3 fatty acids), are essential for infant and brain development and cardiac health. Bioreactors for upscaling upscaled aquatic production of photosynthetic microalgae can also combat greenhouse gas emissions and climate change. One 90 x 90 x 210 cm (3 x 3 x 7 ft) bioreactor unit can absorb up to 400 times more carbon dioxide than the same footprint of trees. Using sunlight, certain varieties of microalgae create oxygen and convert carbon dioxide into organic carbon (protein, carbohydrates, pigments, fats, and fibers), just like plants, but do not require valuable arable land for their production. They are therefore often called the rainforests of the oceans.

Using sunlight, photosynthetic microalgae create oxygen and convert carbon dioxide into organic carbon (protein, carbohydrates, pigments, fats, fibers, and micronutrients), just like plants, but do not require valuable arable land for their production. This means microalgae can be sustainably harvested and converted into eco-friendly superfoods. Putting one and one together, microalgae and innovative production and processing could help to service the world's booming population and growing demand for sustainable protein production. Along with research into processing techniques, the CMBD team is also investigating the use of waste or harvested seaweed for biodegradable plastics production, another sustainable solution to non-degradable petroleum-based plastics. (Ref. 9)

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5. ESD NEWSLETTER READER COMMENTS

None received this month.

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ESD NEWSLETTER BOARD

Editor: DR. K. J. SREEKANTH – (sreekanthkj@kisr.edu.kw)
Assoc: DR. JAMES ZUCCHETTO – (jimzuc@comcast.net)

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ABOUT NEWSLETTER

ENVIRONMENTAL ENGINEERING features the application of environmental technologies to engineering systems to attain optimal performance according to established standards. The Newsletter of the Environmental Systems Division (ESD) will attempt to highlight a variety of environmental technology applications aimed at enhancing engineering systems performances in accordance with the latest standards by presenting excerpts of and links to selected articles from a variety of websites.

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