Sustainability Newsletter

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In This Issue:

Editor's Comment

2018 will perhaps be viewed as a year of contrasts: the images of ocean plastics pollution were as omnipresent as internet cat memes, though they were definitely not as cute; on the other hand, amazing breakthroughs in plastics and chemicals technology are unlocking new business opportunities to turn waste plastic into value (see our report from Agilyx pp. 6-7).

Still, dead seagulls, turtles, seahorses, and more, have all featured as the background for plastics. Critically for our industry, these images are NOT about litter. Our CEO, Pat Farrey, has issued a call to arms for SPE members and the plastics industry at large (see p. 3). There has never been a more compelling time for us to engage with our local communities to drive bottom-up understanding of the complexities of polymers. We do not have the luxury of retreating to our offices, labs or classrooms to focus solely on the needs of our businesses or universities. Society at large needs our expertise to deliver knowledge, science, and business solutions to what is surely one of the biggest collective challenges we face.

And yet the complexities abound: plummeting oil prices and increasing resin production; rapid urbanization and energy constraints; lighter weight / lower density materials with lower CO2 emissions that wreak havoc on recycling systems / economics. The effects of China's National Sword policy combined with an outraged public mean that there is no going back to the status quo ante in terms of end of life matters for polymer-based materials. We are looking at an uncertain future where technology and regulations are not necessarily aligned. We - SPE members - must take the lead.

Conor Carlin – Secretary & Newsletter Editor

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It has never been more important to be a member of your professional society than now, in the current climate of change and global growth in the plastics industry. Now, more than ever, the information you access and the personal networks you create can and will directly impact your future and your career.

Active membership in SPE – keeps you current, keeps you informed, and keeps you connected.

The question really isn't "why join?" but …

Why Not?

Have an idea for an article?

Submission Guidelines

• We are a technical journal. We strive for objective, technical articles that help advance our readers' understanding of plastics and sustainability (recycling, bioplastics, circular economy); in other words, no commercials.

• Article length:1,000 - 2,000 words. Look to past articles for guidance.

• Format: .doc or .docx

Artwork: hi-res images are encouraged (300 dpi) with appropriate credits.

Send all submissions to:
Conor Carlin, Editor **cpcarlin@gmail.com**

A Call to Arms

By Patrick Farrey, CEO, SPE

Last Sunday evening (December 16, 2018), the long-running news show 60 Minutes presented a segment called Plastic Plague (S51, E12, 13:45, Dec. 16, 2018). It focused, as these kinds of reports often do, on the very real problem of plastic debris in the ocean, supported by the requisite images of bags and bottles harming seal life.

Yet, once again, the report had no voice from the plastics industry. Not a single plastic manufacturer, professional, trade association, or industry advocate was asked to tell a different side of the story.

Unfortunately, there is no reason to wonder why. We have no right to shake our heads about unfair reporting or claim the high ground about fake news. The plastics industry, collectively, has almost no voice on this subject. We have, in political parlance, let the other side own the narrative.

Yet we all ("we" being the plastics professionals among us) know that the issue is not a "plastic problem"; it is a disposal and collection infrastructure problem, one that largely originates in developing countries from where the vast majority of plastic ocean debris comes. People (and their governments) living in these developing countries rely on plastic packaging to deliver to them clean, safe, life-sustaining food and water and life-saving medicines and supplies. Proper disposal of used plastic packaging materials is not a major priority in the social consciousness of people battling life and death issues of hunger and disease every day.

So why does this huge global industry remain effectively moot? With the exception of an occasional corporate press release about the funding of a cleanup effort or a commitment to "reduce waste x% by 20XX," we passively let shows like "60 Minutes" dictate what viewers' minds will retain: that plastic is horrible. (Heck, even the opening graphic for the segment featured the Grim Reaper.)

We're moot, I fear, because we don't know where to start. It feels like a huge issue which, in a lot of ways, we never saw coming. But we are a young industry! Bakelite is just over one hundred years old, and the real explosion of plastic development didn't start until nearly forty years after that. So it's forgivable that we aren't really well-organized or well-prepared for this sort of media full-court press.

But no more. We cannot clam up and slip sheepishly away when we see the injured sea turtle anymore. We need to speak up.

To be fair, "60 Minutes" mentioned, in passing, a few of the good things about plastics. Even the featured author of Plastic: A Toxic Love Story admitted that a life without plastic is today unimaginable. But that's not enough.

SPE, the Society of Plastics Engineers, needs to find its collective voice. We need to be prepared to say, unashamedly, that the good of plastics far outweighs the bad – and we are working to fix the bad, too.

SPE believes that plastic is a modern miracle; ubiquitous and necessary for the enjoyment of safe, convenient, economical and reliable products we use every day. And, as the leading society for plastics professionals, we recognize that we also have much impact on the sustainability of our world.

As such, SPE strongly supports the following:

- The continued research and development of plastic technologies and products which minimize negative impacts on the environment while remaining fit for purpose;
- Improved collection and separation infrastructures which return clean, economical, usable post-industrial/post-consumer plastic to the manufacturing stream for conversion into second-life products or for conversion into new energy sources;
- The continued research and development of the technologies and processes which will make the aforementioned happen on an accelerated schedule;
- An ongoing effort to curb the flow of debris, of all material types, into the ocean and to recover those materials already in our ecosystems;
- A commitment to the education of global stakeholders (legislators, NGOs, public and private sectors) on the fact- and science-based data available for a balanced, informed understanding of these problems and their current and future potential solutions.

Surely, SPE cannot tackle any of these issues alone. But we need to start somewhere. We have great expertise and knowledge in our ranks that is not being harnessed to its fullest potential. The journey of a thousand miles begins with a single step.

Sustainability in the News

Total Corbion PLA Starts Up Its 75,000 Tons Per Year Bioplastics Plant

By *Bioplastics Magazine*

December 12, 2018—Total Corbion PLA, a 50/50 joint venture between Total and Corbion, has announced the start-up of its 75,000-ton-per-year PLA (Poly Lactic Acid) bioplastics plant in Rayong, Thailand. The plant has already successfully produced the company's Luminy PLA resin brand.

The new facility will produce a broad range of Luminy PLA resins from renewable, non-GMO sugarcane sourced locally in Thailand: from standard PLA to innovative, high heat PLA and PDLA with unique properties. The products will meet customers' needs in a wide range of markets, including packaging, consumer goods, 3D printing, fibers and automotive, and are specifically optimized for extrusion, thermoforming, injection molding and fiber spinning processes.

Total Corbion PLA will leverage the integration with its lactide plant, the monomer required for the production of PLA, that has simultaneously been expanded to 100,000 tons per year production capacity. The 1,000 ton- per-year PLA pilot plant, which has been operational since the end of 2017, is located on the same site and will be used for product development.

The start-up marks a major milestone for both the joint venture and the bioplastics market. With this additional 75,000 tons per year facility, the global production of PLA bioplastics will increase by almost 50%, to 240,000 tons per year. PLA is a fast-growing polymer market with an estimated annual growth rate of 10% to 15%.

Corbion, that supplies the lactic acid to this fully integrated plant, is happy with the news: "The successful start-up of this state-of-the-art PLA plant is the result of impressive teamwork by many. This is good news for consumers and producers who want to make a conscious choice to improve their carbon footprint and make their contribution to a circular economy. A world of innovation and business opportunities has opened up while contributing to a better world" says Tjerk de Ruiter, CEO at Corbion.

EU Agrees to Bans on Many Single-Use Plastics

By Sharhzad Pourrhiahi, *Plastics News*

December 19, 2018—The European Parliament and the Council of the European Union have reached a provisional political agreement on the ambitious new measures proposed by the European Commission to tackle marine litter at its source, targeting the 10 plastic products most often found on beaches, as well as abandoned fishing gear.

The agreement, reached Dec. 19, is based on the single-use plastics proposal presented in May by the EC as part of the European Plastics Strategy, adopted earlier this year.

The new EU directive has been billed as "the most ambitious legal instrument" addressing marine litter.

As part of the directive, where alternatives are easily available and affordable, single-use plastic products will be banned from the market, such as plastic cotton swabs, cutlery, plates, straws, drink stirrers, sticks for balloons, products made of oxodegradable plastic and food and beverage containers made of expanded polystyrene. For other products, the focus is on limiting their use through a national reduction in consumption; on design and labeling requirements; and waste management/clean-up obligations for producers.

The new rules contribute to a broader effort of turning Europe into a more sustainable, circular economy, reflected in the Circular Economy Action Plan adopted in December 2015.

"I warmly welcome today's ambitious agreement reached on our Commission proposal to reduce single use plastics. This agreement truly helps protect our people and our planet," Frans Timmermans, EC first vice-president responsible for sustainable development, said.

The provisional agreement must now be formally approved by the European Parliament and the Council. Following

its approval, the new directive will be published in the EU's Official Journal and the member states will have to transpose it after two years.

Coca-Cola Provides Loan to Advance PET Recycling Tech

By Jared Paben, *Plastics Recycling*

December 19, 2018—One of the world's largest beverage companies will lend money to a Dutch startup that is commercializing a PET depolymerization technology.

Coca-Cola Co. on Dec. 13 announced a loan agreement with Eindhoven, Netherlands company Ioniqa Technologies.

Ioniqa uses a proprietary technology to break down otherwise difficult-to-recycle PET scrap into its component monomers, which can then be polymerized into new clear PET for food and drink packaging. The chemical recycling approach, which involves using a magnetic catalyst, can recover plastic from contaminated and colored streams of material.

"Partnering with the Coca-Cola Company is a further validation of our journey to launch this unique process for transforming hard-to-recycle PET waste into high-quality, food-grade material," Tonnis Hooghoudt, CEO of Ioniqa, stated in a press release.

The Coca-Cola deal is the latest for the startup. Earlier this year, Ioniqa announced a partnership with global virgin PET producer Indorama Ventures and international brand owner Unilever. Indorama will polymerize the monomers generated by Ioniqa's process to create new PET.

A spin-off from the Eindhoven University of Technology, Ioniqa is moving from pilot stage toward industrial-scale production. It is building a plant, slated to come on-line in 2019, capable of processing 10,000 metric tons per year.

According to the recent press release, the loan "is designed to accelerate the development and deployment of high-grade recycled content PET for use in bottles used by the Coca-Cola Company." A Coca-Cola spokesperson said the loan amount and terms are confidential.

The Ioniqa deal is the second time in a month Coca-Cola has highlighted its support for depolymerization technologies. It signed a five-year procurement framework agreement with Quebec company Loop Industries, which uses a different depolymerization process on difficult-to-recycle PET streams. Along with that, Coca-Cola European Partners, which bottles Coca-Cola products for sale in several Western European countries, signed an offtake agreement with Loop.

Coca-Cola touched on both agreements in a story posted to its website, noting its goal is to use 50 percent recycled content in its packaging by 2030.

Did you know

the SPE Foundation offers numerous scholarships to students who have demonstrated or expressed an interest in the plastics industry?

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Chemical Recycling of Polystyrene: Agilyx Revealed

By Eve Vitale, Executive Board Member, PLASTICS Recycling Committee

It was a cool day as the tour van rolled up to Agilyx, a clean facility tucked away in an industrial park in the Portland, Oregon area. The autumn rain was holding off for another day and the sun flirted with us from behind the clouds. Fifteen sustainability aficionados from the PLASTICS Industry Association's Recycling Committee disembarked and were met by a coffee barista who was making authentic Portland espresso drinks and serving them up in polystyrene cups. No problem for us recyclers as Agilyx' game-changing expertise is the chemical recycling of polystyrene. We had heard that the Agilyx process converted used polystyrene back to a liquid styrene monomer allowing the manufacture of new polystyrene without any degradation of quality and we were itching to see the technology up close and personal.

Our secondary greetings (after the fabulous coffee) were from John Desmarteau, Project Engineer who also does double duty in community relations, and Joe Vaillancourt, the Chairman and CEO of Agilyx, who gave an informative presentation that had us ready to see the technology. The Agilyx team of dedicated professionals is very passionate about what they currently do and what they intend to do to make the business of polystyrene, a super-useful polymer, more sustainable.

While we sat under a tent in the parking lot enjoying our hot beverages and the introductory remarks, we saw the intake of post-industrial recyclate as a full truck rolled in. We were told that much of their feedstock is local, but some of it comes quite a distance. They also receive household quantities 24/7 in their parking lot but require advanced planning for any more than a truckload. There was plenty of expanded packing foams—the big white blocks of EPS that come with your computers and TVs and take up so much room in your trash, as well as lots of food service items from local schools. Dirty, dirty, dirty, but as we soon saw, it didn't hamper the system's ability to process and convert.

We also got a look inside their research lab and spent considerable time with their chemist. She explained the iterative investigation to enhance the performance and scope of their system, which can also convert waste plastics into high grade synthetic crude oil. Agilyx bills it as a "proprietary technology that is a continuous feed and self-cleaning waste plastic solution". Their synthetic crude is further refined by the consumer depending on what the end use is. Their website says it can be refined into gasoline, diesel fuel, jet fuel, fuel oil, or lubricants. This is super cool since sustainability buffs are always looking for physical and chemical ways to capture the lost energy of waste plastics.

Jon Timbers, Senior Manager of Sustainability and Innovation at American Styrenics LLC (AmSty), who is on the PLASTICS Recycling Committee, gave an impassioned pitch for the Agilyx technology and vision. AmSty had committed to be a pull-through customer thereby creating demand which is critically important in new technology ventures.

Mr. Timbers' passion for the sustainability efforts was contagious, but it wasn't hard to get us all on board. It's one of the things we "do" as the PLASTICS Recycling Committee—explore technologies that create chemical and circular recycling pathways for end-of-life plastics, if they are environmentally and economically sustainable. That's the rub in recycling—it must be economically sustainable for a circular economy. This means taking the current economy of designing, using, and disposing of goods and redesigning it to take into consideration end-of-life options for goods, even "single-use" goods. The goal is to find ways to design out waste and pollution, and to capture the high value of materials to their fullest and best potential.

The PLASTICS Recycling Committee represents PLASTICS members across the association's four councils, bringing equipment makers, brand owners, processors, and material suppliers together to align their efforts to put recycling at the forefront of their businesses. The Committee works to

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identify and expand end-use opportunities for recycled plastics, by working from a place of identified need and demand for recycled content.

A few weeks after our visit, AmSty and Agilyx signed a letter of intent to form a joint venture which will assume operations of the first-in-kind polystyrene recycling facility somewhere near the current Oregon location. Now that's a happy ending that allows us to use our polystyrene without guilt or regret.

Eve Vitale was recently elected to the Executive Board of PLASTICS Recycling Committee. She is also the President of the Detroit SPE Section, Chief Executive of the SPE Foundation, and Consultant for Series One, LLC . We are very grateful that she found the time to contribute to our little magazine!

A Journey Toward Packaging Sustainability

By Donna L Visioli, E I DuPont de Nemours, Wilmington, DE, USA; Karlheinz Hausmann and Sarah Perreard, DuPont de Nemours International, Geneva, Switzerland

Editor's Note: This paper was originally presented at ANTEC 2017.

Abstract
Packaging sustainability has many contributing factors including: renewable materials; reduced package weight; recyclable materials; reduced food waste (for food packaging); and reduced packaging waste. These factors and interactions among them are described, along with examples of implementation.

Introduction
Packaging sustainability has many contributing factors including: renewable materials; reduced package weight; recyclable materials; reduced food waste (for food packaging); and reduced packaging waste. Concurrently, packaging cost must be kept constant or reduced.

An approach based on the factors of reduce/recycle/rethink/renew can provide a useful framework going forward. These factors are linked in the circular economy model, which is an alternative to a traditional linear economy (make, use, dispose) in which resources are used for as long as possible, the maximum value is extracted from them while in use, then recovery and regeneration products and materials occurs at the end of service life (1). Below we describe these factors and how they interact, along with examples of implementation.

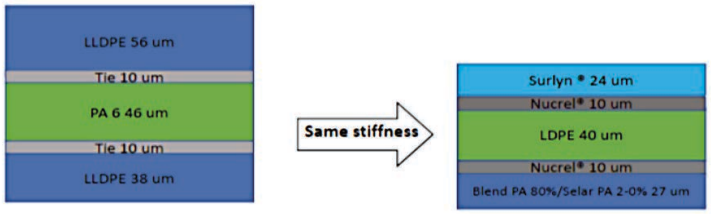
Reducing Waste
Excess packaging is linked to broad market issues. Excess packaging has affected margins for shippers like UPS and FedEx, reducing the amount of value-add space available in their trucks and planes. As a result, shippers moved away from an old weight-based charge scheme to a volumetric charge scheme called dimensional weight pricing in which shipping charges are higher for low weight, high packaging volume item. This resulted in a market incentive, in the form of higher shipping fees, for companies reduce packaging. Additionally, if packages were right-sized to fit a given product, shippers could fit 30% more packages per truck, since the limiting factor for packages in a truck is usually the volume of packages rather than their weight (2).

In the case of food packaging, reducing waste includes reducing both the packaging waste and the food waste due to improper or sub-optimized packaging.

Reduction of packaging waste can be accomplished by light weighting. Much of this can be accomplished by the transition from rigid to flexible packaging which has been ongoing for a number of years (3). The impact of switching to flexible packaging incudes not only reduced weight, which impacts shipping cost, but also reduced package production cost. The production process for flexible packaging, in some cases, requires 85% less energy than rigid packaging production (4).

Reducing flexible packaging weight while maintaining integrity, enhancing durability, and maintaining the stiffness required for filling and shelf presentation at lower thickens requires a well-engineered approach to package design. A computer-based stiffness model has been developed to

re-engineer packaging structures and produce up to 30% lighter packaging with improved overall performance and cost (5). The model predicts bending stiffness of multilayer packaging structure. For a multicomponent structure, stiffness in bending mode depends on the position of the layers. If put on the outside, stiffer materials have the strongest influence on overall film structure, enabling a decrease in the overall thickness of the inner layers. An example using stiffer ethylene copolymers Nucrel® and Surlyn® (supplied by DuPont™) is below:



Case studies based on this model for food packaging have shown packaging weight reduction of 20% – 30% while maintaining the integrity and barrier properties required by the package contents.

Developments in film converting equipment can contribute to light weighting. Coex bi-orientation technologies (Triple Bubble®) can be used in production of 7 to 13 layer structures. These structures are produced by blown film coextrusion of multiple layers (7-13 layers) of film in one step followed by water quenching to produce an amorphous (disordered) film which is subsequently reheated and oriented in the machine and transverse directions simultaneously (6). The film is then annealed to relax the polymer chains and stabilize the film (6). These structures, which can be used in place of conventional laminated structures. are up to 67% lighter than traditional structures while maintaining the required mechanical and barrier properties (7).

Food Waste Reduction

Packaging contributes to food waste reduction by increasing the shelf life. The shelf life of foods can be extended by changing the package type (8). A study of Austrian retailers shows that waste of packaged food can be reduced significantly when the package type is optimized: for example, cheese waste can be reduced from 5% to 0.14%, and bakery waste can be reduced from 11% to 0.8% (9). In the case of beef steak, increasing the shelf life of sirloin steak from 6 days to 16 days has been shown to reduce food waste by 50%.

Shelf-life by Packaging Type

		Whole Muscle		Ground	
Packaging type	Color	Shelf-Life (d)	Display-Life (d)	Shelf-Life (d)	Display-Life (d)
Vacuum Bags/Pouches	Purple	60 - 90	60 - 90	45 - 60	45 - 60
Air-Permeable Overwrap	Red	5 - 7	3 - 7	2 - 3	2 - 3
Master Pack Low Oxygen	Purple	28 - 35	2 - 7	25 - 30	2 - 3
Masterpack High Oxygen	Red	10 - 14	2 - 7	7 - 10	2 - 3
High Oxygen	Red	12 - 16	3 - 4	10 - 12	3 - 4
Low Oxygen	Purple	25 - 30	2 - 7	25 - 30	2 - 7
Peelable Low Oxygen	Red	15 - 22	3 - 7	15 - 22	3 - 7
Low Oxygen w/ CO	Red	35	35	28	28

In the study above, a distinction has been made between case life, which is the time during which color is not significantly changed, and shelf life, which is the amount of time passing before the meat is unfit to eat, as seen below (10).

Changing the package type also leads to reduced package weight. Changing from the traditional tray and cling wrap for packaging meat to vacuum skin packaging results in a 3X lighter package with 3X longer shelf life (9).

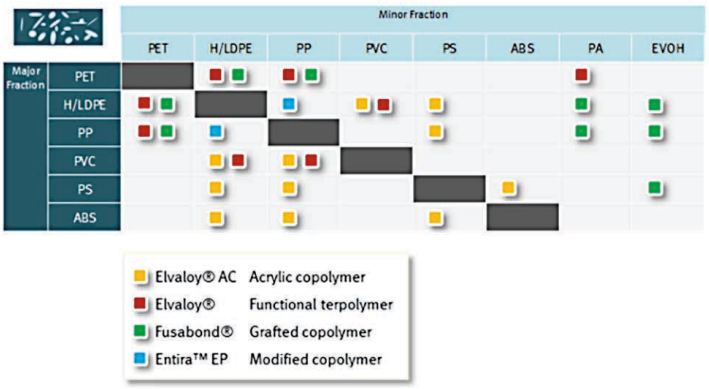
Recycle

Despite ongoing efforts to facilitate recycling of plastics, only a small fraction of plastic waste is recycled. In 2008, only 13.3% of plastic packaging was recycled in the US (11). Plastic (PET) soft drink bottles and PE milk jugs have a high value in recycling, since they are single material, but in the US, only 27 % of these are recycled (11).

Successful plastic recycling depends on both the disposal and collection of the plastic waste, and on the chemistry and consistency of the mixed polymer steam chemistry. These factors interact, and success may depend on integrating them. This can involve collaboration between different players in the value chain.

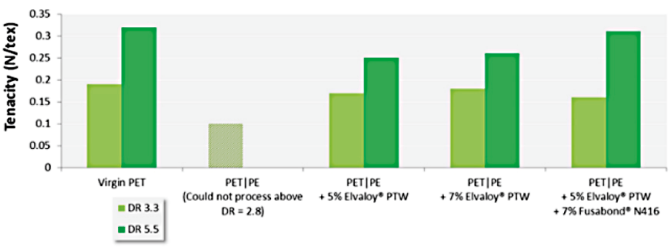
Disposal and collection of plastic waste can be enabled by public education and outreach, as documented in the REACH study in the US in 2011 (12). The consistency of the polymer stream and understanding its chemistry is critical for enabling use of recycled mixed plastics for higher value applications. Increasingly packaging films are multilayer and contain multiple components in barrier, adhesive, and structural layers.

Properties of polymers from mixed-stream recycle can be enhanced by using impact modifiers. Compatibilizers can couple inorganic contaminates in recycling streams, resulting in better mixing and compatibility, which can improve impact resistance. For incompatible blends, the compatibilizer can improve mechanical properties either by simply improving the dispersion of the minor phase in the major phase; or if the compatibilizer contains reactive comonomers such as glycidyl methacrylate or maleic anhydride, it can react with either or both phases. A portfolio of recycling compatibilizers is required to accommodate the variety of polymers included in postconsumer recycling, although the majority are PET and conventional polyolefins:



Improvement in performance for PE-contaminated PET is exemplified below (13). This example involved production of textile fibers from PE-contaminated PET; because developing a stable fiber spinning process is inherently sensitive to contaminants, this result so an especially good demonstration of the property improvement due to compatibilizers:

Mechanical Properties of PE-Contaminated PET* Compatibilized with DuPont™ Elvaloy® PTW



*model blend: 92.5% PET/7.5% PE by weight

A good example of how compatibilizers contribute to collaboration across the value chain is the collaboration between DuPont and Cimflex to enable used multilayer agrochemicals bottles in Brazil to diverted from landfills and turned into high-value recycled content for higher value products. Adding 5% compatibilizer improves toughness, elongation and processibliity sufficiently to allow manufacture of products such as pipes, hoses, and motor oil containers (14). Another good example is using store drop-off recycling programs for LDPE grocery bags enables the recycling of polyethylene-based multilayer barrier packaging as part of Dow's Recycle-Ready® technology. A compatibilizer is also included in this technology package (15).

Most post-consumer plastic waste is used for applications other than food packaging due to concerns about contamination of food by components of the recycled plastic. The FDA has developed a process for the manufacturer who wishes to use recycled plastic for a food-contact application (16).

Rethink

Rethinking, or designing to recycle, has been encouraged by the Institute of Scrap Recycling Industries, (ISRI) for more than 25 years (17). This Design for Recycling® initiative encourages manufacturers to think about the ultimate destiny of their products during the design stage of a product's development. In the case of flexible packaging, design to recycle can include use of monolayer films such as using structural and sealant layers with similar chemistry so that they can use a recycle code of 1 (PETE), 2 (HDPE), or 4 (LDPE) rather than 7 (other). However, this approach requires use of thicker films and is only suitable for applications requiring low to moderate oxygen barrier unless reduced shelf life is acceptable. An alternative approach to designing to recycle is use of simplified multilayer films (eliminating paper, metallization, solution-based adhesives, carbon black); this approach enables lightweighting while allowing for excellent barrier. Optimally, the multilayer films can contain integrated compatibilizers to facilitate recycling.

Renew

Renewable raw materials can be suitable for use in flexible packaging. A thorough life cycle analysis is necessary to quantify the environmental impact of such materials. Early efforts to develop bio-based plastics have caused controversy over using food ingredients such as corn

for making plastics has been extensively discussed (18). Presently there are only a few biobased resins widely used: PTT (poly (trimethylene terephthalate); polymers based on FDCA (Furan-2,5-dicarboxylic acid); and polysaccharide based polymers and blends made with them.

The diol used to prepare PTT, 1,3-propanediol, is renewably sourced via DuPont's fermentation process. Based on the weight of the diol in the polymer, PTT polymer commercialized by DuPont™ as Sorona ® is 37% renewably sourced. It is used primarily in fiber applications (carpet fibers, apparel, etc.) because of tis durability and stain resistance as well as for molding applications because its good chemical resistance, and scratch resistance an eliminate the need for lacquer topcoat (19).

FDCA (2,5-Furandicarboxylic acid) has been included by the US Department of Energy as one of 12 priority chemicals for establishing the "green" chemistry industry of the future (20). It can be prepared by dehydration of sugars using hexamethyl furfural as an intermediate which then can be enzymatically converted to FDCA. Furan-2,5-dicarboxylic acid (FDCA) has been suggested as an important renewable building block because it can substitute for terephthalic acid (TPA) in the production of polyesters and other current polymers containing an aromatic moiety. DuPont has announced the production of FDCA for use in PTF (21). FDCA-based polyesters such as PTF (polytrimethylene furandicarboxylate) are of interest for packaging applications because they offer better CO2 barrier than PET.

Polysaccharide based polymers such as cellulose, chitin and chitosan can be compounded with natural and synthetic polymers (22) for a wide variety of applications. A recent example of this is the polyethylene/starch-based film produced by BiologiQ under the name TaterMade™ which contain 25% renewable content (23).

Compounding of the potato starch with DuPont's ethylene copolymer compatibilizer enables production of TaterMade™ film having higher tensile strength than LDPE (24).

Conclusions

Although sustainability of packaging has been a concern for many years, more work is needed. Despite near-universal efforts to promote recycling, only 14% of plastic packaging is collected today. The results have had enormous environmental consequences. An estimated 150 million tons of plastics are in our ocean today. Under business as usual projections, this figure is expected to grow until it exceeds the aggregate weight of fish in the ocean by 2050 (25). Challenges lie ahead in collecting and sorting of films and trays, consolidating streams to reach critical volumes of consistent quality, and application development for recycled or renewable materials. The EU target is 75% of packaging recycled by 2030 (26); Recycling policy in the US is less uniform, but some states have set forth goals similar to the European goals (27). Cost effective solutions will continue to be required to meet these demands.

Combining ongoing efforts around recycling with other factors contributing to sustainability use of (renewable materials, reduced package weight, recyclable materials, and waste reduction) will be necessary to develop solutions to sustainability which will achieve the target recycling rates.

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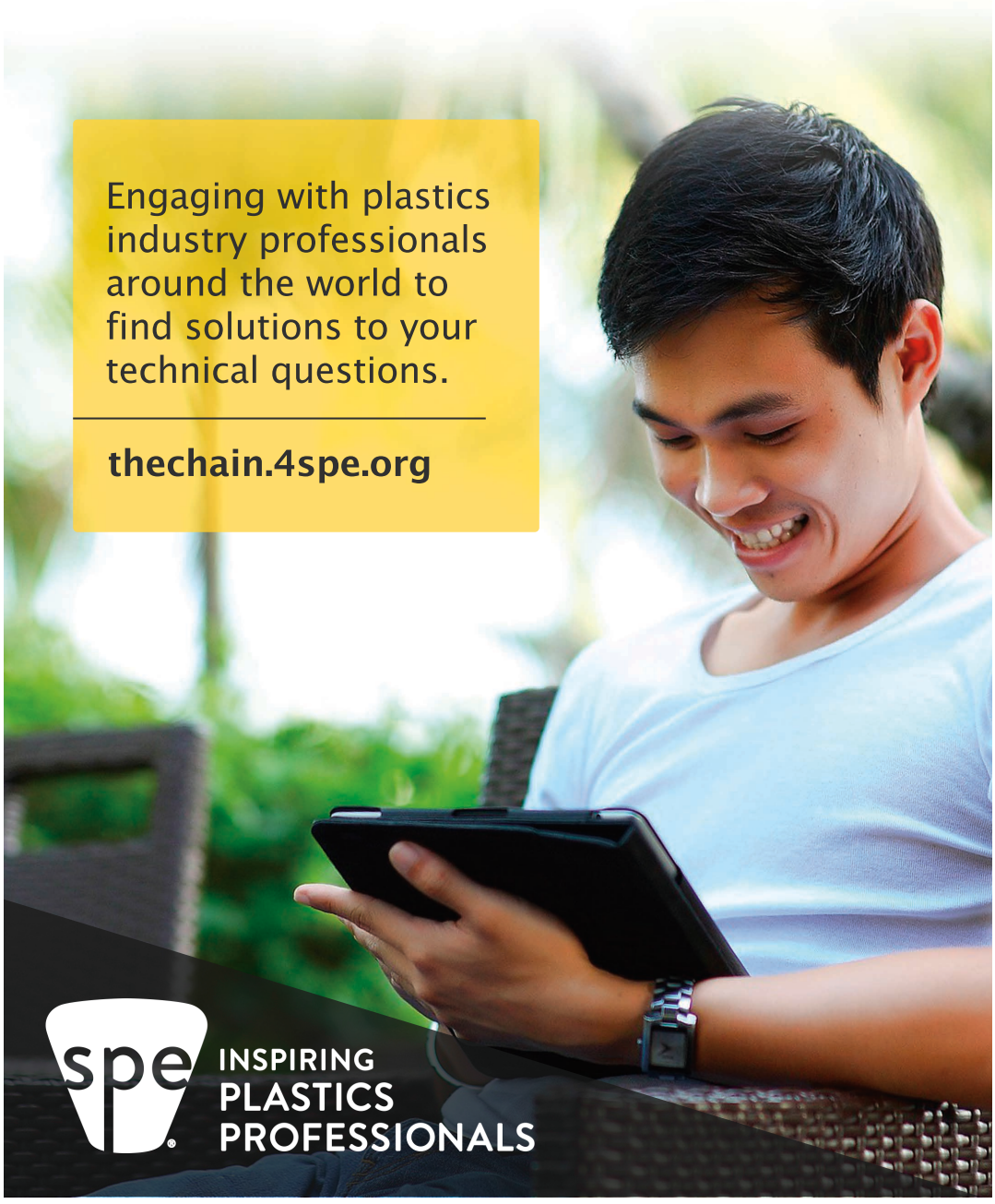

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