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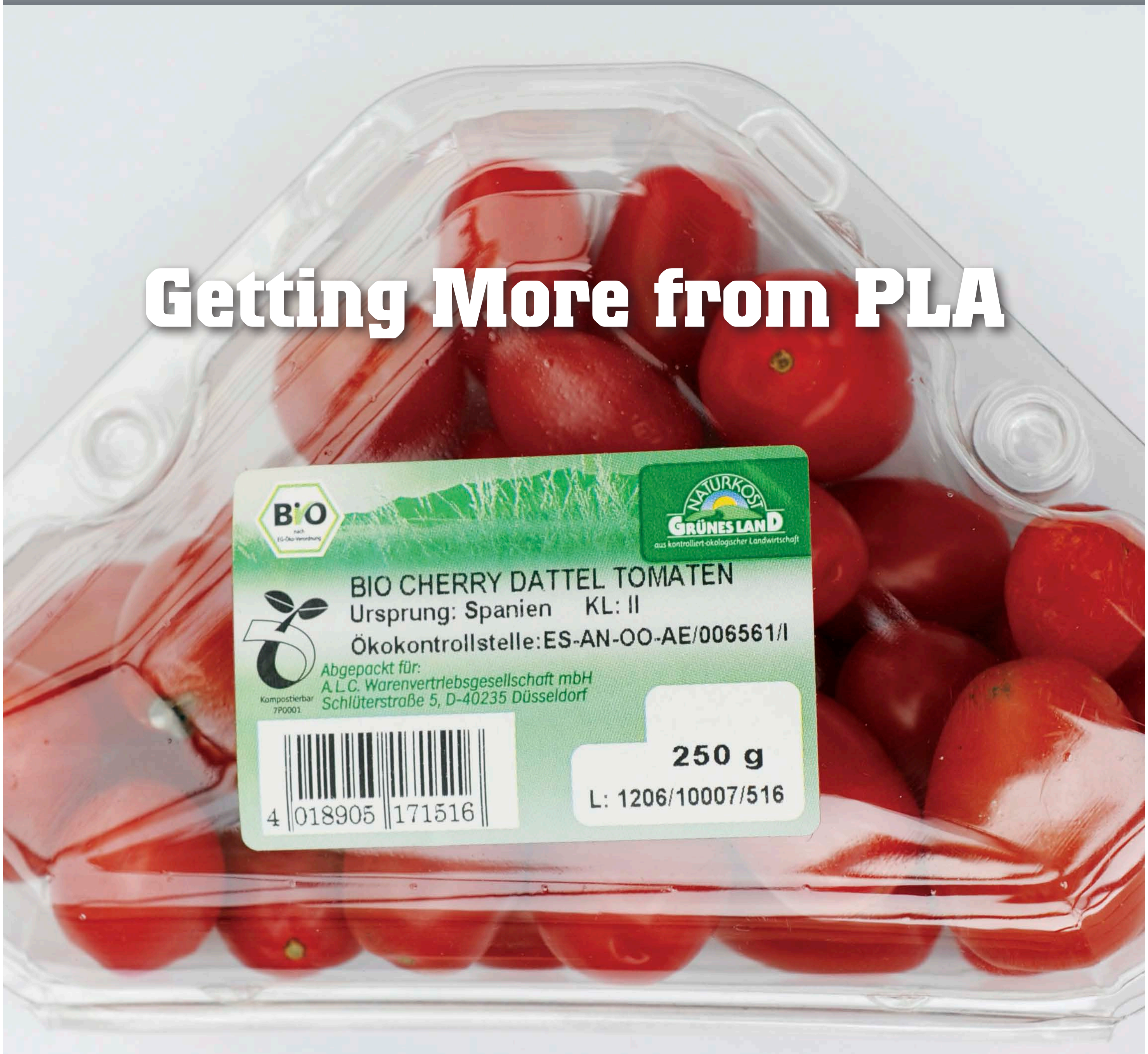
Getting More from PLA



Cover image courtesy of Dr. Michael Thielen, bioplastics MAGAZINE, Germany

In This Issue:

Sustainability in the News

U.S. PET Bottle Recycling Rate Falls Again

By *Plastics in Packaging* (UK)

November 1, 2017—The US recycling rate for PET bottles has dropped for the second successive year, claims a report by the National Association for PET Container Resources (Napcor) and the Association of Plastic Recyclers (APR), with a decline in the containers covered by deposit programmes to blame.

The PET bottle recycling rate fell to 28.4 per cent in 2016, according to the report on Postconsumer PET Container Recycling Activity, having dropped from 30.1 per cent in 2015. and 31 per cent the year before. Total collection volumes declined by 2.4 per cent, despite an increase of more than 3 per cent in the total volume of PET bottles available for recycling in the country.

The report cited an 11 per cent decrease in exports to Asia and other markets outside North America, marking the sixth year of off-shore decline. However, US and Canadian end market applications observed increased growth of more than 5 per cent.

The recycling rate was calculated by using the total volume of recycled PET material – 1.75 billion pounds (793,786 tonnes) – taken as a percentage of the total volume of PET resin utilised in US bottles and potentially available for recycling, which is 6.17bn/lb (2.8bn tonnes).

Of the 1.75bn/lb collected, 1.37bn/lb (621,421 tonnes) was purchased and processed by domestic PET reclaimers and the other 22 per cent was sold to export markets, making this the lowest export volume reported since 2004.

In regards to rPET utilisation in US and Canadian end market applications, total volumes increased by more than 5 per cent to 1.5bn/lb (680,388 tonnes) in 2016. Fibre, bottle and strapping markets all demonstrated growth in 2016, while rPET use in sheet and thermoforms dropped, likely due to the impacts of low virgin prices on this market segment.

Advanced RPET Plant on the Way Near LA

By Jared Paben, *Resource Recycling*

October 25, 2017—Construction is underway on a massive Los Angeles-area plastics recycling facility that will take PET bales all the way to bottle preforms, extruded sheet and thermoform packaging.

The 302,000-square-foot facility in Vernon, Calif. is being built for a new company, rPlanet Earth. Taking in baled post-consumer PET, including material from curbside collections, the plant will sort, wash, decontaminate and convert it into food and drink packaging. It will melt flakes for molding and extruding, skipping a pelletizing step.

The company's products will be made from RPET flakes and, at customers' requests, may contain virgin PET, but rPlanet Earth won't sell flakes or pellets.

"When we were looking to put this together, we thought that that business model made the most sense and would make the company sustainable from an operations and profitability standpoint, where some other folks struggle that only produce a flake or a pellet," said Bob Daviduk, co-CEO of rPlanet Earth. "We don't believe that the flake or pellet business is a good one to be in over the long run."

Joe Ross, co-CEO, noted that when you sell a pellet it could be used to make carpet or any number of industrial products, but major retailers want to have true closed-loop systems.

Daviduk said rPlanet Earth has already invested substantial sums of money. Last year, it invested about $35 million. By the end of this year, it expects to spend another $55 million, and next year it anticipates spending another $10 million to $15 million, he said, for a total expected investment of more than $100 million.

"It's a huge investment. It's a huge commitment to increasing the supply of recycled content out in the marketplace – and high-high-quality recycled content," Daviduk said. "Obviously good enough that we believe we'll meet any brand owners' specifications."

Ross noted rPlanet Earth will use Krones' bottle-grade flake production technologies, which have achieved scientific approval with Coca-Cola. Ross has prior experience in the packaging world, including with companies producing recycled-content PET products.

The technology rPlanet Earth is implementing has a green light from the U.S. Food and Drug Administration to produce food- and beverage-contact products.

The front-end sorting system will be provided by Eugene, Ore.-based Bulk Handling Systems. In addition to processing PET collected through bottle redemptions, rPlanet Earth plans to run Grade B material from curbside programs through the plant. That means they need a robust sorting system up front to remove non-PET plastics, Daviduk said.

He noted that China's ban on recovered plastic imports is "a big positive for us."

"A lot of Grade B material was shipped to China, and now you've got a major buyer that's effectively out of the market," he said.

The project has received financial support from the state and federal governments.

It received $20.5 million in low-cost debt financing through the U.S. Treasury Department's New Market Tax Credit (NMTC) program, which is designed to spur investments in low-income communities. Additionally, the California Department of Resources Recycling and Recovery (CalRecycle) provided $2 million in low-interest loans through its Recycling Markets Development Zone program. The state has also approved sales tax breaks for the construction project. |

Michelin Acquires Lehigh Technologies

October 18, 2017—Michelin today announced that it has acquired Lehigh Technologies, a specialty materials company that uses patented cryogenic turbo mill technology to transform rubber from end-of-life tires and industrial goods into materials for new tires and other products, reducing the amount of raw materials initially needed, such as elastomers and fillers from oil- and rubber-based sources.

"We are always looking for ways to achieve safer and more sustainable mobility, including by using high technology recycled materials, without compromising safety or other performances, while consuming less ofthe natural resources that are available in finite stocks," said Pete Selleck, chairman and president of Michelin North America. "Lehigh Technologies, the technological leader in this area, is a natural fit, as it will equip.

Michelin with tools to reduce the amount of raw materials that we need to produce new products for all of our current and future customers in the tire and non-tire industries."

"This acquisition demonstrates Michelin's strategic intent to bring its expertise in materials to markets that extend beyond tires, and in particular, to foster the use of advanced rubber recycled materials in the tire and non-tire industries," said Christophe Rahier, senior vice president of strategic planning materials for the Michelin Group.

Lehigh Technologies, based in Tucker, Ga., near Atlanta, employs about 100 people. The firm produces highly engineered, versatile raw materials called micronized rubber powder (MRP). MRP is a low-cost, high performance, sustainable material that substitutes for other oil- and rubber-based materials used in manufacturing tires, plastics, asphalt and construction materials. Its customers include some of the largest tire companies in the world, as well as companies in construction materials, asphalt modification and other markets.

"This deal provides Lehigh Technologies with an incredible opportunity to continue our growth," said Alan.

Barton, CEO of Lehigh Technologies. "With the full backing of Michelin, we can continue to expand our capabilities, execute our global growth strategy and pursue new market opportunities." Michelin completed the acquisition on Oct. 13. |

Plastics Sustainability

Excerpted from *Plastics Sustainability* (2012) by Michael Tolinski with permission from Scrivener Publishing LLC.

[***Editor's note***: *This is the third article in a series that will run over 6 installments. We are grateful to the publisher for granting us this unique opportunity to share excerpts from an important (and enjoyable) book on a topic that is central to our industry. The SPE Sustainability Division is proud to offer this benefit to our members. We encourage everyone to purchase the complete book which is available on Amazon.*]

Chapter 3: Polymer Properties and Environmental Footprints

To support the process of making "greener" judgments about plastics, various polymers and polymer families touched on below are described in terms of their properties and environmental impacts from their synthesis, use, and end-of-life stages. First, some key concepts about polymers are reviewed that are critical to consider when comparing plastics in terms of environmental sustainability, and then individual polymers will be discussed. This discussion is by no means comprehensive; rather, it gives special attention to materials that are most important in the fossil-/bioplastic debate.

3.1: Background on Polymers and Plastics

Polymer properties vary according to what chemical building blocks are used to create the polymer: generally, the more complex or expensive the monomers are, the more extreme the properties of the resulting polymer are.

To become useful plastic products, polymers require additives for protecting the polymer chain from heat, oxygen, or light damage, and for providing specific properties for an application. Some plastic compounds contain only a small total percentage of additives, while some, such as flexible PVC, may contain over 30% additives. Fillers are also added to displace the amount of expensive polymer that is needed or to stiffen the polymer matrix; these fillers may be added at weight percentages well over 30%. Reinforcements such as glass fiber or other kinds of fibers provide specific mechanical or electrical property enhancements when compounded with polymers for engineering applications.

Plastics are used in so many different applications for at least five main reasons: (1) polymer backbones made from various monomers can provide a wide range of properties; (2) the molecular structure of each kind of polymer can be controlled in production to produce specific properties; (3) at the polymer compounding stage, additives, fillers, and reinforcement can be very efficient and flexible ways to achieve desirable properties; (4) plastic product design and processing options allow great latitude for exploiting a material's strengths or hiding its weaknesses; and (5) the processing variables during the molding or forming of plastics can themselves be used to enhance a product's properties.

When considering plastic compounds in all their compositions and forms, selecting the right compound for a product is difficult to do, even when just comparing their basic material properties. Careful consideration of their environmental and human-health impacts complicates the equation. Fortunately for plastics, commercial polymers are usually composed of molecules that are too large or heavy in molecular weight (>10,000) to be easily transported across biological membranes, making them less prone to affect biological processes[i]. But of course, there are still many plastics additives and remnants or residuals from polymerization in the compound; these have a greater potential of being released into the environment and interacting with life processes.

[From "Twelve Principles of Green Chemistry"]
Principle 6: *"The energy required for chemical processes should be measured, evaluated and minimized."*

Table 3.1 cites rough numbers quantifying the total energy required for producing different polymers. These sets of estimates come from both old and new sources, reflecting differences in the ways polymer energy requirements are calculated and improvements over time in production technology efficiencies. In making their calculations, the researchers attempted to combine both the inherent fuel-energy feedstock content of fossil-fuel polymers, plus the total synthesis process energies required for producing each polymer. Here, the biopolymers PLA and PHA appear very energy-efficient to produce. However, the accuracy of such general numbers is difficult to verify,

Table 3.1 Total production energy content and price estimates for various polymers covered in this chapter.

Polymer	Production Energy per Polymer Volume [85] (1988) (kJ/cm³)	"Cumulative Energy Demand" per Produced Polymer Volume [15] (2010) (kJ/cm³)	Approx. Energy Content per Unit Polymer mass (kJ/g)	Density	Relative Price per Unit mass (per unit volume) (HDPE = 1)
Polyethylene (LDPE)	65	72	71–78	0.92	1.1 (1.05)*
Polyethylene (HDPE)	90	73	76–94	0.96	1 (1)
Polypropylene	160	68	75–178	0.9	1.2 (1.1)*
Polystyrene	110	92	87–105	1.05	1.1 (1.2)*
PVC	120	83	59–85	1.4	0.95 (1.4)*
PET (bottle resin)	n/a	124	89	1.4	1 (1.45)*
Nylon 6/6 (PA 6.6)	240	n/a	218	1.1	1.8 (2.1)*
ABS	130	n/a	125	1.04	1.25 (1.35)*
Polycarbonate	200	129	108–167	1.2	2.5 (3.1)**
PLA	n/a	79–98***	64–79	1.24	1–3 (1.24–3.7)**
PHA	n/a	92	68	1.35	2–3 (2.7–4.0)**

*Calculated ratios based on values averaged from [3] and [4]

**Estimates based on ranges of values from several sources

***PLA manufacturer NatureWorks LLC estimates that 42 MJ/kg (J/g) is required for producing its resin, a value that is equivalent to about 53 kJ/cm³ [5]

Note: The third & fifth column values were calculated using the first, second, and fourth columns' values

considering all the possible material/process factors that could be included in the calculations. Plus, the numbers do not include energies required for compounding and forming polymers into plastic products, and these energies vary according to each application, forming process, and polymer.

Of course, apart from these green concerns, a material's mechanical properties determine whether a polymer can be used for an application in the first place. Table 3.2 gives some representative mechanical properties for the polymers covered in this chapter, showing how property ranges of key biopolymers (PLA , PHA) overlap with those of traditional, fossil-fuel-based polymers.

3.2 Common Commodity Thermoplastics

The key commodity plastics below, combined, make up by far most of the total volume of plastics produced and used. Thus, extra details are given here about their production and disposal impacts.

3.2.1 Polyethylene (PE)

PE is a polyolefin – a polymer built from repeating units of simple hydrocarbons. PE is the most versatile and popular polymer chemistry for low-value applications, and it comes in many different grades and forms.

3.2.1.3 End-of-Life

Most PE products are recyclable, at least theoretically. But given the wide range of PE 's applications for packaging various contaminating materials, the collection, sorting, and cleaning of postconsumer PE is often too difficult for recycling to be economically viable. One success story is HDPE blow-molded as beverage bottles (commonly used for milk), which is recycled at roughly the same rate as PET beverage bottles in the United States, although the

Table 3.2 Representative property ranges of polymers covered in this chapter.

Polymer	Density	Tensile Modulus (GPa)	Tensile Strength (MPa)	Elongation at Break (%)	Notched Izod Impact Strength (J/m)
Polyethylene (LDPE)	0.92	0.2–0.3	8–30	100–900	500 to no break
Polyethylene (HDPE)	0.96	0.8–1.5	28–32	10–300	150 to >1000
Polypropylene	0.9	1.1–1.5	25–33	50–300	70–150
Polystyrene (general purpose)	1.05	3.3–3.4	34–36	1–2	20 or less
PVC (unplasticized)	1.4	2.8–3.0	50–55	60	70–80
PET	1.4	3.0	50–75	50–300	20
Nylon 6/6 (PA 6.6)	1.1	2.9	60–80	60–80	50–110
ABS	1.04	2.1–2.4	20–55	8	200–350
Polycarbonate	1.2	2.3–2.4	60–110	100–110	700
PLA	1.24	3.0–3.5	26–144	3.5–8.1	16–144
PHA	1.3–1.4	0.1–3.0	19–25	4–450	26–37

Note: Ranges for traditional polymers based on values from multiple sources; value ranges for PLA and PHA are from NatureWorks LLC datasheets [6] and Mirel Bioplastics provisional datasheets [7], respectively

recyclate is reused mainly in non-food bottles and PE pipe.

PE products present many recycling challenges. Not only must LDPE, LLDPE, and HDPE be separated during sorting, the HDPE used for rigid injection-molded containers (like food tubs) has much different melt-flow properties than the blow-molded HDPE in narrow- neck containers (bottles). So these grades may also be separated for creating recycling streams of optimum value. Moreover, unpigmented (natural) HDPE products must be segregated from colored HDPE products in high-value recycling streams. Still, HDPE (along with polypropylene) is the most collected type of non-bottle rigid plastic for recycling[ii]. These recyclable rigid products include pallets, tubs, buckets, and household containers.

3.2.2 Polypropylene (PP)

Another polyolefin, polypropylene, is used for similar applications as PE, though it is generally stiffer and more heat resistant. PP differs from PE in that PP's properties allow it to be used in some durable engineering applications.

3.2.2.3 End-of-Life

Polypropylene products are often recyclable, though its recycling is less common than with PE because it is less often used for common, high-volume packaging applications. PP grades are often heavily filled or pigmented, making them harder to sort and reclaim (however, unpigmented and clarified grades of PP are becoming more popular for food packaging, potentially increasing PP 's recycling value). Engineered PP film and sheet also create volumes of recyclable material. In landfills, PP, like PE, is inert, and in incineration it produces basic combustion products. Thus, PP and PE, the common polyolefins, offer recyclability and chemical simplicity. They have rarely been linked with toxicity scares, which have allowed them to develop a public reputation as "friendlier" plastics. They are also relatively soft and flexible, perhaps also helping their image. However, their low densities and low costs are curses as much as blessings, since polyolefin shopping bags and other frequently littered PO materials have become the target of product bans.

3.2.3 Polyvinyl Chloride (PVC, or "Vinyl")
No common plastic has created as much antagonism in public discourse as PVC – yet few polymers are used as widely. Whereas a polyolefin can receive a favorable ranking in terms of green chemistry and recyclability in an LCA, PVC more commonly receives failing grades[iii,iv]. Its poor environmental image is perhaps a contributing factor in its overall decline in US production from 2000–2009, while polyolefin production increased during that period.

Yet PVC is effective in durable applications, especially in construction. As an inexpensive polymer partially synthesized from the chlorine atoms in ordinary salt, PVC 's most prevalent and dependable uses are "under the radar" – in house siding, electrical cable coverings, and window frames. But as discussed in Chapter 1, its use in more personal applications has been reduced over the years, at least partially due to the public's concerns about health issues connected with the phthalate plasticizers used in flexible PVC, and the vinyl chloride and toxins associated with PVC's production and incineration.

Over its decades of its use, PVC's basic composition has slowly raised increasing concerns. Although PVC itself is relatively stable and inert, vinyl chloride monomer is considered toxic and carcinogenic, and must be carefully controlled and monitored in the plant environment. Hydrogen chloride must also be handled properly to prevent its conversion to hydrochloric acid upon release. Recent concerns about chlorinated dioxins in the environment have also called for monitoring whether these compounds are produced and released from PVC production facilities. In 2011, the US Environmental Protection Agency (EPA) proposed stronger emissions standards for all 17 US PVC production facilities, limiting the permissible releases of all the above compounds from process vents, equipment leaks, wastewater, storage vessels, and heat exchangers[vi].

3.2.3.2 End-of-Life
Methods for recycling unplasticized PVC from construction uses have been developed. But virgin PVC 's low price and its additives-intense formulations make recycling hard to justify economically – even with post-industrial materials whose exact composition is known. Of all the traditional thermoplastics mentioned in this chapter – including the more common engineering polymers – PVC is the material that is least often bought/sold by recyclers and material brokers[vii].

3.5 Biopolymers: Polymers of Biological Origin
This section will focus on the newest generation of biopolymers, or bioresins, terms that are here defined as polymers synthesized only by biological processes using biomass or other naturally renewable, non-fossil-fuel resources as feedstock. These are distinguished from the common polymers discussed above in that although some traditional polymers can be synthesized in conventional processing using chemicals derived from renewable resources, they are usually based on fossil-fuel resources and processes. Thus the term "bio-based" is used generally as a qualifier for polymers or plastics that are composed of substances derived from renewable or biological resources, synthesized using biological or conventional chemical processes.

The biopolymer sector within the world of plastics presents a range of new terminology to be differentiated and alternative chemistries to be described. This accounts for the lengthier subsections below, compared with those above. The biopolymers focused on here – polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and starch-based polymers – represent the newest generation of bioresins for which significant commercial growth is projected.

3.6 Additives and Fillers: Conventional and Bio-based
For a producer of a plastic to be able to claim that a material is 100% bio-based, both the entire polymer and all its additives must be made from material of renewable or natural origin. Many common additives used in plastics are already based on natural-occurring compounds, such as fatty acids. Many fillers and reinforcing fibers discussed below are also of natural origin and have low environmental impacts.

3.6.4 Nanocomposites
Various clays are used in polymers to provide specific properties. "Nanoclay" fillers are now used to create nanocomposites, or polymers with small loadings (<5%) of filler particles with nanometer scale dimensions. Organically modified nanoclay fillers can be separated (or "exfoliated") into sheet-like particles with molecular scale thickness. Dispersed in a polymer, the resulting composite provides unique mechanical and electrical properties

for specialized applications, using a relatively simple thermoplastic polymer as the matrix material. Nanoclay fillers are also being developed for use in biopolymers, such as PBAT/PLA blends[viii].

[In the next issue: Applications: Demonstrations of Plastics Sustainability]

References

i. Anastas, P.T., Bickart, P.H., Kirchhoff, M.M. (2000). Designing Safer Polymers, New York: Wiley-Interscience.

ii. Verespej, M. (2011, February 21). ACC: US non-bottle recycling rate rises, Plastics News, p. 4.

iii. Griswold, M. (2009, October 1). New plastics scorecard favors biobased resins, Plastics News http://www.plasticsnews.com, 2009.

iv. Tabone, M.D., Cregg, J.J., Beckman, E.J., Landis, A.E. (2010). Sustainability metrics: Life cycle assessment and green design in polymers, Environmental Science & Technology, 44, 8264–8269.

v. Market data book, Plastics News (2010, December 27).

vi. EPA updates emission rule for PVC plants, Environmental Leader, (2011, April 19), http://www.environmentalleader.com/2011/04/19/epaupdates-emission-rule-for-pvc-plants/, 2011.

vii. North American recyclers & brokers, Plastics News, (2010, May 21), http://plasticsnews.com/headlines2.html?id=18677, 2011.

viii. Shahlari, M., Lee, S. (2010). Polymer-clay nanocomposites of poly(butylene adipate-co-terphthalate) and poly(lactic acid) blend: 1. Effects of incorporating organically modified silicate layers and the mixing sequence on the morphological and rheological properties, ANTEC 2010 [Proceedings], Society of Plastics Engineers.

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Reducing PLA Production Cost

By Udo Muehlbauer, Thyssenkrupp Industrial Solutions, Uhde Inventa-Fischer GmbH, Berlin, Germany

[*Reprinted with permission from Bioplastics Magazine, Sept/Oct 2017*]

Earlier this year at a bioplastics conference in Bangkok, "Jem's Law" about the growth of the PLA market was presented. Jem's Law basically says that PLA volumes doubled every 3 to 4 years in the past and therefore will continue to do so in the future. With some knowledge of the actual production capacities one can calculate that the PLA market will be around 600,000 t/a in 2022 / 2023. All in all, this would mean that there is a need for 5 additional PLA plants with a capacity of 75,000 t/a until 2022. Even though all forecasts have to be treated with necessary caution, Jem's Law can be considered fairly realistic compared with earlier ones about the markets for bioplastics.

PLA Economics: size, price, efficiency

If PLA plants are to be built in the future, economics will of course play a crucial role. Besides the well-known factors of plant size (the bigger, the better) and feedstock prices (the lower, the better), raw material conversion – which determines specific feedstock demand – must not be neglected.

What factors influence the conversion of lactic acid to PLA? One is the formation of side-products. In the case of PLA, provided one uses the right catalyst, this is comparatively low. In practice, more than 95% of what is theoretically possible can be converted into lactide and polylactide.

Unwanted meso-lactide increases production costs

But lactic acid is an optical active substance with a L(+)- and a D(-) configuration, and three different types (enantiomers) of lactides: L-lactide, D-lactide, and meso-lactide. Each one results in different PLAs in terms of properties and processing behavior. The repartition of the enantiomers in the lactide feedstock determines PLA properties like crystallinity/crystallization time to a major extent and consequently also heat distortion temperature and hydrolysis resistance.

What's more, the lactide composition cannot be adjusted to the desired level without separation of meso-lactide, the lactide enantiomer with a L(+)- and D(-)- configuration. Using optically pure L(+)- lactic acid is not sufficient to obtain an optically pure lactide. Racemization of L-lactide (or D-lactide), mainly during depolymerization of lactic acid polycondensate to lactide, leads to the formation of meso-lactide. In many applications a small percentage of meso-lactide is advantageous. But there are also applications where meso-lactide should be as low as possible. And it appears that their share is growing, for example in durables and most fibers, or if high heat is required. In general, more meso-lactide is produced than is needed.

This raises the question of what to do with the surplus meso-lactide. To write it off as a loss is not an option as this would increase production costs severely. Fig. 1 shows production cost as a function of raw material conversion. A loss of 10% due to racemization leads to a decrease in conversion from 96% to 83% which in turn increases production cost by more than 12% (all calculations based on Uhde Inventa-Fischer's PLAneo® technology for an industrial scale plant on a European price basis).

Selling or downgrading back to lactic acid have drawbacks

A better option is to hydrolyze meso-lactide back to lactic acid. Technically, this is not a challenge. But due to its racemic nature the quality of the lactic acid is lower than the original feedstock-based lactic acid. It goes without saying that the conversion of high-grade lactic acid into a low-grade version is economically unfavorable. Besides bad economics, a producer of PLA has the drawback of having to deal with two completely different markets – selling PLA on the one hand and lactic acid to the cosmetics industry, for examples, on the other (unless he is already a lactic acid producer).

An even better option would be to sell meso-lactide as a chemical intermediate or monomer for different applications and to different markets with the aim of achieving higher prices. As meso-lactide has not existed as a commercial product before, there is no established market. New applications have to be developed and markets have to be found. Whether these markets will develop and to what size remains to be seen.

Using polymerized meso-lactide to form a single product: PLAneo

The solution that Uhde Inventa-Fischer has developed initially appears obvious: like L-lactide, meso-lactide is purified and polymerized. This is easier said than done, however. Beside the fact that meso-lactide is much more sensitive to side-reactions than usual polymer-grade lactide, the molecular weight of poly-meso-lactide has to be comparatively high in order to obtain good mechanical properties. Both facts add up to stringent requirements for the purity of polymer-grade meso-lactide.

The second step of the PLAneo technology is not as obvious. Instead of producing a second polymer, which would have limited possible applications due to its amorphous nature, polymeso-lactide is blended with the main crystallizable PLA-melt, both polymerized continuously in parallel lines, to give one product.

Optimized yield, same product properties

The resulting polymer maintains all relevant mechanical, optical and physical properties: tensile strength, E-modulus, crystallization behavior and melting point do not change. Only the b*-value of the PLA pellets is slightly increased. This holds true irrespective of whether distillation or crystallization is used to purify the main lactide stream. Processing of PLAneo is just as straightforward as standard PLA.

Applying separate polymerization of meso-lactide and L-lactide and blending it afterwards means no meso-lactide has to be discarded or used in a less economical way. The specific demand of lactic acid converges to its theoretical minimum of 1.25kg per kg of PLA.

Nobody knows exactly how the PLA market will develop. We will see whether Jem's Law will continue to prove true in the future and how many new plants will come on-stream. But the ones using technology that maximizes raw material yield will definitely have an advantage.

Global Trends 2017

By PLASTICS Industry Association

Editor's Note: The following is taken from the recently released annual Global Trends report from PLASTICS (formerly SPI). It presents commentary and data on the state of the US plastics industry. Though thermoforming is not broken out in the data, the section under "equipment" highlights a trade deficit while other areas of the plastics supply chain show a surplus. The complete report can be downloaded at www.plasticsindustry.org.

The 2017 Global Trends report shows yet another decline in the U.S. plastics industry's trade surplus, from $7.1 billion in 2015 to $4.7 billion in 2016. Much as it was last year, this decline was driven by a strengthening U.S. economy that depends heavily on imports to meet demand for plastic products.

This fact is borne out elsewhere in the report, most acutely in the apparent consumption figure, which is derived by combining imports and exports and subtracting that sum from the amount of total shipments made by the industry. In 2016, apparent consumption grew 1.8 percent which, as the report observes, reflects the greater use of U.S. plastics output domestically.

Additionally, that the U.S. plastics industry maintains its trade surplus at all makes it something of an anomaly among similarly situated manufacturing sectors. That it has done so for more than two decades consecutively, through a period in which the very nature of manufacturing and the global economy both changed drastically, illustrates just how durable the figure is, and speaks to the U.S. plastics industry's continued impact on the international market.

The report also found in 2016 that Mexico and Canada remain the top destinations for exports from the U.S. plastics industry, with the industry exporting $15.4 billion to Mexico and $11.7 billion to Canada. The industry's largest trade surplus is with Mexico at $10.7 billion, and its fifth-largest surplus is with Canada at $719 million.

This has been the case for the U.S. plastics industry in previous years, but it warrants special mention in this year's edition of the report as the agreement that has enabled these figures to benefit the U.S. plastics industry's trade balances with its neighbors—the North American Free Trade Agreement (NAFTA)—is in the midst of renegotiation and, according to some observers, facing elimination if the new agreement does not meet the needs of American companies to some unspecified degree.

It has been noted before that the U.S. plastics industry maintains its trade surplus due to agreements like NAFTA, and other free trade agreements the U.S. maintains with other friendly nations. The revocation of NAFTA would have serious ramifications for the continued health of the U.S. plastics industry, and its renegotiation could as well, if undertaken without care.

That's why PLASTICS has collaborated with its counterparts in Mexico and Canada—the Asociación Nacional de Industrias del Plástico A.C. (ANIPAC) and the Canadian Plastics Industry Association (CPIA)—to present NAFTA negotiators in all three countries with a set of priorities that the North American plastics industry agrees, as one, are worth revisiting in NAFTA's renegotiation. These priorities were delivered to trade officials earlier in 2017 and the three organizations remain involved in the renegotiation of this landmark agreement that benefits each country's plastics industry and the millions of people they employ.

In its new section providing an outlook on specific export markets, the 2017 Global Trends report notes that "the U.S. has a powerful competitive advantage in resin product due to its scale, infrastructure and low cost raw materials. It would take a great deal of nationalism and protectionism to erase that advantage."

Nonetheless, that the U.S. plastics industry is well positioned to weather a storm of protectionism does not mean that this storm need not be feared. Uncertainty as to the country's commitment to its leading role in the expansion of free trade has already impacted the decision making in boardrooms across the globe. Should anti-trade rhetoric eventually transform into anti-trade policy, in the U.S. and in other nations across the developed world, the impacts on business and investment activity will only increase.

If nothing else, the 2017 Global Trends report, and the continuing example of the U.S. plastics industry, off er proof of the type of benefits free, open trade can confer to industries, and to the people they employ. There will always be room for improvement in domestic and international trade policy—always some way to make trade fairer, market access more open and consumer demand easier to meet from abroad. Even though a full retreat into protectionism is unlikely, to move in that direction would be a step backward for both the U.S. plastics industry and the global economy as a whole.

EXECUTIVE SUMMARY

This edition of the Plastics Industry Association's (PLASTICS') annual Global Trends study analyzes U.S. trade data on an industry-wide and segment-specific basis for 2016.1 It is divided into five sections. Section I describes exports, imports and the trade balance for the industry and its four segments: resins, plastic products, molds and machinery. Section I also measures trade flows as a percentage of domestic shipments. Section II analyzes apparent consumption and market shares for the industry and its segments. Section III discusses trade in goods that contain resins and plastic products, labeled "contained trade" in this study. Section III also discusses the impact of contained trade on the industry's overall trade position and measures the "true" consumption of resins and plastic products in the U.S. Section IV discusses the implications of this study's findings for the industry. Finally, Section V presents an outlook for U.S. plastics industry exports, with emphasis on the top-five export-destination countries. The study's key findings are:

INDUSTRY-WIDE TRENDS

- The industry's trade surplus fell 33.7 percent to $4.7 billion in 2016 from $7.1 billion in 2015.
- Industry exports fell 3.3 percent, and imports rose 0.8 percent.
- Mexico and Canada remained the U.S. plastics industry's largest export markets. In 2016, the industry exported $15.4 billion to Mexico and $11.7 billion to Canada.
- The industry had its largest trade surplus with Mexico in 2016—$10.7 billion.
- China is the industry's third largest export market. However, the industry, overall, had its largest trade deficit with China—$10.2 billion in 2016.
- The estimated value of domestic shipments decreased by 2.2 percent in 2016, to $293.7 billion. Shipments figures were depressed by low oil prices, which lowered the selling prices of plastics industry products, especially resin.
- Exports were at 19.5 percent of domestic shipments in 2016, down from 20.3 percent in 2015.
- Reflecting the greater use of U.S. plastics output domestically, apparent consumption of plastics industry goods grew 1.8 percent, from $284.0 billion in 2015 to $289.0 billion in 2016—faster than shipments growth.
- "True" consumption includes all the resins and plastic products that U. S. residents consume, including those that are contained in imported goods. The "true" consumption growth rates computed in this study show that underlying U.S. plastics demand remains solid.

RESIN TRENDS

- The U.S. resin industry had a $16.5 billion surplus in 2016, which was down 7.4 percent from the $17.9 billion surplus in 2015, mostly because of lower resin prices. On a real, tonnage basis, the resin surplus decreased only 2.9 percent.
- U.S. natural gas costs fell 4.0 percent in 2016, while the average crude oil price paid by U.S. refiners fell by a greater 16.1 percent. This further reduced the cost advantage of U.S. resin producers, which rely primarily on gas-based feedstocks. Nevertheless, overseas resin producers, which mostly use crude oil-based feedstocks, also became less advantaged because the sharp decline in the crude oil price paid by U.S. refiners benefited their competitors in the U.S. that do rely on crude oil.
- Resin exports decreased 4.9 percent in dollar terms, while imports decreased 1.9 percent.
- The resin industry had a $6.0 billion surplus with Mexico, followed by a $2.7 billion surplus with China.
- The resin industry had its largest trade deficit with Germany, at $0.9 billion.
- Resin exports accounted for 37.0 percent of domestic shipments, while imports were 17.1 percent.
- Apparent consumption of resins rose 4.2 percent, from $63.9 billion in 2015 to $66.6 billion in 2016. Domestic resin prices fell 4.7 percent, as measured by the Producer Price Index, which suggests that apparent consumption increased 8.9 percent in real, tonnage terms.
- U.S. resin producers held a 78.6 percent market share (percent of apparent consumption) in 2016, up from 77.3 percent in 2015.

■ The estimated value of resins contained in exported goods was $19.5 billion, and the estimated value of resins contained in imported goods was $43.9 billion, which meant that the segment had a $24.4 billion deficit in contained resin trade.

PLASTIC PRODUCTS TRENDS

■ The country's deficit in plastic products increased from $8.0 billion in 2015 to $9.0 billion in 2016, an increase of 11.6 percent—mostly because of China's exports, the higher-valued dollar and the improving U.S. economy.
■ Exports of plastic products fell by 1.5 percent, while imports grew 1.7 percent.
■ The U.S. had its largest plastic products surplus with Mexico, at $4.0 billion.
■ China accounted for the largest plastic products trade deficit, at $12.3 billion, up 2.4 percent from 2015.
■ Exports of plastic products were 12.0 percent of domestic shipments, and imports were 16.4 percent.
■ Apparent consumption of plastic products grew by 1.0 percent, from $210.6 billion in 2015 to $212.6 billion in 2016. As measured by the Producer Price Index, domestic plastic products prices fell 1.3 percent in 2016, suggesting that apparent consumption growth was 2.4 percent in real terms.
■ U.S. producers of plastic products held an 84.3 percent market share (percent of apparent consumption), down slightly from 84.4 percent 2015.
■ The estimated value of plastic products contained in exports was $25.1 billion, and the estimated value contained in imports was $51.5 billion, giving the U.S. a $26.4 billion deficit in contained plastic products trade.

MOLDS TRENDS

■ The U.S. moldmaking industry had a $1.2 billion trade deficit in 2016, which was 6.8 percent more than the deficit in 2015.
■ Mold exports fell 1.9 percent, while imports rose 3.9 percent.
■ The U.S. moldmaking industry had its largest surplus with Mexico at $351 million. It had its largest deficit with Canada at $735 million.
■ Exports of molds were 19.8 percent of domestic shipments, and imports were 62.2 percent.
■ Apparent consumption of molds for plastics rose 4.2 percent, from $3.9 billion in 2015 to $4.1 billion in 2016.
■ U.S. moldmakers held a 56.3 percent market share (percent of apparent consumption) in 2016, up from 56.1 percent in 2015.

MACHINERY TRENDS

■ The U.S. plastics machinery industry registered a $1.7 billion trade deficit in 2016, a 2.7 percent increase from 2015. The increase was due to strong domestic demand, along with a strong dollar that helped overseas producers compete for that demand.
■ Exports were flat, and imports rose 1.5 percent.
■ The industry had its largest surplus with Mexico at $294 million, and its largest deficit with Germany at $643 million.
■ Exports of machinery were 33.7 percent of domestic shipments, and imports were 75.1 percent.
■ Apparent consumption of plastics machinery rose 4.0 percent, from $5.5 billion in 2015 to $5.7 billion in 2016. Domestic shipments rose by 4.5 percent.
■ U.S. machinery producers held a 46.9 percent market share (percent of apparent consumption), up from 45.6 percent in 2015. ❙

End Market Demand for Recycled Plastic

Editor's Note: The following excerpt is taken from the October report of the same name, prepared by More Recycling with input from Plastic Forming Enterprises. The complete report is available for download at www.morerecycling.com.

The American Chemistry Council (ACC), the Association of Plastic Recyclers (APR) and the Sustainable Packaging Coalition (SPC) spearheaded this comprehensive study to document end market demand for post-consumer resin (PCR). In addition to funding the study, each organization engaged their members and industry contacts to stimulate participation in a voluntary survey. This report covers the results of the survey for polyethylene (PE), polypropylene (PP) and polystyrene (PS)[1] PCR use in 2016 among brand companies and manufacturers/converters. It also evaluates the opportunity for market expansion.

The study partners distributed the survey to members of nine different trade associations, captured data from 11 different types of converters and seven industry sectors, and collected responses from 126 companies, including many of the largest global brand companies. Despite the reach of the survey distribution, not all end-users participated in the study. Since most of the respondents were packaging manufacturers/converters, and a large portion of recycled plastic is used in applications beyond new packaging, more material was likely purchased for use in end products than was captured by this study. Participation in the survey was strong among large brand companies and converters.

The study findings include the following:

- The most commonly-cited barriers to using PCR are as follows: 'not enough price advantage over virgin resin' and 'not enough PCR available that matches our specifications.'
- The most commonly reported equipment need was vented or vacuum-degassing extruders.
- Lumber and fencing had the highest level of PCR content among the reported products – at close to 100% on average.
- Rigid plastic applications (such as carts and plumbing products) had similarly high levels of PCR content, although they exhibited a broader range in the percent of PCR use, at 25-100%.
- Bottles and bags had the lowest level of PCR content among the reported products – at 25% PCR on average.
- Eighteen companies opted to publicly share their interest in purchasing PCR (see Appendix A).
- Total reported PCR purchases in 2016 were 1.16 billion pounds.
- The survey revealed the following capacity to purchase PE, PP and PS PCR—that meets both the price and specifications competitive with virgin resin.
    - 2,098-million pounds Polyethylene (PE)
    - 444-million pounds Polypropylene (PP)
    - 312-million pounds Polystyrene (PS)

Comparing to reported pounds purchased for recycling in 2015, end market demand for the current level of PE and PP scrap plastic acquired in the United States for recycling is not adequate. The total capacity to purchase PE PCR that meets both price and specification requirements is 76% of the total reported as acquired for recycling in 2015. Even with the narrowing of that delta with yield loss in the reclamation process, if we want recycling rates to increase, demand for recycled content will need to increase to absorb that supply. The fundamental economics of plastic recycling are stressed while the cost of virgin resin is low. This stress on the system has a ripple effect. Without adequate end use demand there are fewer investments in maintaining collection, separation, and processing operations. To ensure the longevity of the plastic recycling sector in the United States, we must find ways to support the recycling system while the economics of recycling are stressed.

References

1. The survey included five resins: polyethylene (PE), polystyrene (PS), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride (PVC). PP responses were gathered to add to data APR received as part of their PP Fit For Use Study in 2016. Results for PET and PVC are not provided due to a lack in responses for those two resins.

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