Sustainability Newsletter

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In This Issue:

Editor’s Commentary

At the time of writing, the SPE Sustainability Division is completing a new round of elections for the Board of Directors. We have been encouraged by the recent increase in interest from many members who want to join our board and help to rebuild the division. As we like to say, everyone should be a member of Sustainability since this a topic that affects all of us in many ways. Biobased materials, energy conservation, recycling technologies, additives development… these are just a few of the areas where the drive to achieve the triple bottom line is manifested in the plastics industry.

In this issue of the newsletter, we offer more original content with a technical paper on recycled carbon fibers for automotive applications and the final installment of our excerpt series from “Plastics and Sustainability.” This chapter covers sustainable considerations in material selection. From a simple, linear viewpoint, the initial choice of plastic (or any material) has an obvious and direct effect on the product’s function and form. From a more holistic view, the choice of material has profound implications for use, disposal and end-of-life. We know that plastics are superior to alternative materials such as glass and paper in many situations, but when we are selecting among plastics, we also have to be aware of disposal and end-of-life matters. This has become a critical area for our industry because without acceptable disposal methods, whether through recycling, composting or even some type or energy recovery system such as incineration, plastics remain firmly in the crosshairs of the public.

At the recent SPE Council meeting in Charleston, SC (see Council Summary), many members expressed their concerns about our society’s ability to respond to public concerns about plastics pollution. As a community of individuals, however, it is up to each of us to take action at the local level. Who better to inform and educate local schools and community groups about the benefits of plastics than the experts? It is very clear that many of us consider ourselves environmentalists – this is not paradoxical. With a strong and vibrant base of dedicated plastics professionals, we can build and develop tools and content to help shape the conversation and combat the negative perceptions of polymer-based materials.

At the national level, the Division continues to partner with PLASTICS. We are the official judges for the Re|Focus Sustainability Innovation Awards which takes place next May. The awards are designed to celebrate those companies pushing the boundaries of innovation by driving environmental advantages in product design, utilizing sustainable materials, and facilitating end of life recovery. We are in the process of uploading over 1000 papers and presentations to the new SPE Online Technical Library, giving us a unique value proposition to attract and retain new members. The SPE Foundation’s PlastiVan now incorporates sustainability modules in their education program. And there is much, much more we can do.

Who is ready to roll up their sleeves and join us?

Conor Carlin – Secretary & Newsletter Editor
George Staniulis – Interim Chair

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Sustainability in the News

Quantifying Environmental Benefits of Recycled Plastic

By Jared Paben, *Resource Recycling*

August 22, 2018—Researchers have calculated substantial upsides from making products out of recycled PET, HDPE and PP instead of prime plastics.

For example, using RPET may generate half the greenhouse gas emissions (GHG) of virgin plastic, according to preliminary data released by Franklin Associates. The reductions may be even greater for recycled polyolefins.

Franklin Associates is conducting the research on behalf of the Association of Plastic Recyclers (APR). APR's president, Steve Alexander, noted that brand owners will be able to reference the data to calculate progress toward their sustainability goals when they use recycled plastic. He called the life cycle inventory research "a critical tool to utilize and market the value of recycled materials."

The research investigated GHG emissions from "cradle to gate," including collection, transportation, sorting and processing into flake or pellet. Franklin Associates didn't attempt to study impacts associated with manufacturing finished products because of the wide variety of products made from plastics and their varying environmental impacts.

The most important part of the analysis was collecting data from plastics reclaimers, Sauer said. Her company gathered detailed information from seven PET reclaimers, five HDPE reclaimers and three PP reclaimers.

The work found that the majority of greenhouse gases generated within the recycling chain come via the reclaimers. For food-contact PET, nearly 90 percent of their gases were associated with reclaimer operations. For HDPE and PP pellet, 70 to 75 percent were generated by the processing steps. PET was higher because of the additional environmental impacts from the decontamination steps.

Kara Pochiro, APR's communications director, said APR members will get an early look at the recycled PET, HDPE and PP report before it's released to the public this fall. The data will also be available at the group's Oct. 9-11 meeting in St. Petersburg, Fla.

Plastics Industry Seeks Infrastructure Dollars for Recycling

By Steve Toloken, *Plastics News*

September 13, 2018—Plastics industry executives fanned out over Washington Sept. 12 for their annual lobbying day with a new message: a push for more federal government spending on recycling to try to address public concerns about plastics in the environment.

The lobbying fly-in traditionally focuses on more pocketbook issues like trade policy, worker training and regulation, and those remained high on the agenda for the more than 100 executives who took part.

But rising concerns over plastic waste and worries over bans or taxes on plastic packaging led to an expanded focus this year.

"Recycling infrastructure is really the new key point that we want to raise," said Scott DeFife, vice president of government affairs for the Washington-based Plastics Industry Association, the lead organizer among five trade associations at the event.

For the industry groups, that means pushing for Congress and President Donald Trump's administration to change how Washington views federal infrastructure spending.

Instead of being a vehicle mainly for building things like roads and airports, they want some federal infrastructure spending to be earmarked for city and state recycling operations such as materials recovery facilities and waste to energy plants.

"We're saying some infrastructure spending should be on recycling, waste to energy, whatever needs to be done to properly handle plastic waste," said Chairman Wylie Royce. "On top of that you're creating recycling jobs."

DeFife said the effort is in its very early stages and the association is still putting together detailed legislative proposals.

But including it as part of lobbying day is another sign of how waste issues are taking a higher profile for industry groups: the CEO of the American Chemistry Council, for example, in June said he was delaying his planned retirement specifically to work on plastics waste issues.

DeFife said the federal government should see the global trade in recyclables as it sees world trade in wheat or other farm commodities.

"In D.C. they think of infrastructure as roads and bridges, and we're trying to get them to think of our material as an asset," DeFife said. "It should be invested in."

True Confessions: A Plastics Engineer Reflects on the Plastic Bag Ban

By Eric Larson, *(published in PlasticsToday.com)*

September 9, 2018—A couple of years ago, I wrote an article for PlasticsToday discussing the efforts to ban plastic bags. Ironically, the article was published the week after the November 2016 elections when California voters approved Proposition 67, which prohibited grocery stores from giving away single-use bags for free. It also created new standards for reusable bags, and allowed grocery stores to sell reusable bags at a minimum price of $0.10 per bag.

Plastic bag opponents

Most of the arguments for banning plastic bags involved environmental issues. Opponents claim that they don't decompose easily (I agree) and often end up in our oceans, lakes and rivers (I agree with the consequences, but not with the reasons why this happens). The opponents had a well-organized marketing campaign, backed by substantial research and case histories.

Plastic bag proponents

Most of the arguments to retain plastic bags came from the plastics industry. The main argument was that the manufacturing of plastics bags was more environmentally friendly, and that banning plastic bags would have a negative economic impact. In other words, some people would lose their jobs. In my opinion, that was a lousy argument. Doing something stupid just because it saves jobs is never a good idea.

We know that working in a coal mine is a dangerous job, one of the most dangerous occupations in America, according to the Bureau of Labor Statistics. The mining industry has one of the highest worker fatality rates,[1] and coal miners frequently suffer adverse health effects including hearing loss and chronic lung diseases. We also know that burning coal contributes to acid rain, which not only affects human health, but also increases the corrosion rate of our already crumbling infrastructure. Can you imagine the push back if a lobbying group came up with the following marketing strategy: **We are going to promote burning coal because it saves coal miners' jobs**.

Proponents also argued that California already had an established infrastructure for recycling plastic bags. However, after some research, I was stunned to learn that the recycling rate was around 3%.[2] In other words, 97% of plastic bags are used once and thrown away. I was also unable to find any data on the percentage of recycled material that was used in a typical plastic bag (I suspect it is close to 0%). As a comparison, a typical aluminum beverage can contains 70% recycled metal.[3]

Voting results

Proposition 67 passed with more than 53% of voters in support. While this may seem like a small margin of victory, it is not: Since 1976—the year I graduated from high school—the winning presidential candidate has received 53% or more of the popular vote only twice.[4] It was a landslide victory, the repercussions of which are still being seen today.

Human behavior

In my previous article, I stated my belief that plastic waste was caused by human behavior.

"The fact that single-use plastic bags are in our waterways is not because they are plastic, it is because of human behavior. Lazy, careless, thoughtless people are throwing these bags out of their windows, over the sides of the boat or tossing them aside as they walk."

In my previous article, I also wrote about the need for intelligent solutions. Bans? We don't need no stinking bans! But maybe we need more plastic bans to shake up the industry and get everyone to be more proactive.

How many times should you use a plastic bag before you recycle and re-process it?

How do you go about changing human behavior? Should we let industry innovators come up with new solutions? Should we allow free-market forces to determine the best path forward? Maybe we should just wait and see until some zealot puts an extruder on the banks of the Potomac and starts squirting resin pellets directly in the river, and plastic of all kind is forever banned?

From time to time, I have gotten into heated "discussions" with people who smoke cigarettes. Not about the smoke, but about the cigarette butts they leave lying around. They toss them aside, and when confronted often respond: "What's the problem? It's biodegradable."

"Oh yeah, then why don't you eat it, and biodegrade it yourself?"

"Are you kidding me? That's disgusting."

That's exactly right. Cigarette butts are disgusting. They shouldn't be on the sidewalk, on the beach or anywhere near people or pets. But nobody is pushing the cigarette industry to implement collection and recycling systems for cigarette butts. On the other hand, the tobacco industry is heavily regulated, highly taxed and suffering from the effects of countless class action lawsuits. Is the same thing going to happen to the plastics industry? |

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

Recycled Carbon Fiber Thermoplastic Compounds for Automotive Applications

By Christopher M. Surbrook, Midland Compounding & Consulting, Inc., on behalf of JM Polymers

Background: Carbon Fiber Reinforced Plastics
Carbon fiber reinforced plastic (CFRP), is a very strong and light weight plastic. Similar to glass-reinforced plastic, these fibers are used to increase the strength and stiffness of the polymer into which they are incorporated. The resulting materials provide tensile and modulus values comparable to aluminum with about half the weight. Because of these mechanical properties, the materials have many applications in aerospace, automotive, bicycles, and sailboats where balancing strength and stiffness with density are important. They are also becoming increasingly common in small consumer goods as well, such as laptop computers, golf clubs, and musical instruments.

The following chart shows the prediction for overall carbon fiber demand and supply through 2020. Demand will outstrip supply by the end of that period, which likely will prompt additional expansion from carbon fiber suppliers, perhaps in the 2018-2019 timeframe. Through 2024, the data also anticipate a compound annual growth rate (CAGR) in carbon fiber demand of 9.21%.

Carbon Fiber Demand and Supply, in metric tonnes (MT)

	Carbon fiber demand	Carbon fiber supply (nameplate)	Carbon fiber supply (actual)*
2010	48,370	79,650	47,790
2015	82,400	143,595	93,171
2020 (est.)	150,200	180,600	129,965

**Actual output is less than nameplate, due to capacity knockdown.*

Table 1: Carbon Fiber Demand & Supply - Source: Composites Forecasts and Consulting LLC[1]

Currently, the aerospace industry is the largest consumer of carbon fiber reinforced materials where the carbon fiber is most commonly used to reinforce thermoset plastics. The thermosetting resins used are primarily vinyl epoxy and polyester. The carbon fiber is typically woven or aligned and then saturated with uncured resins which generates a material referred to as pre-preg. The pre-preg materials are then catalyzed and cured into parts. Due to the rigorous demands of aerospace applications, typical work in process scrap rates for raw materials are approximately 30%. It is estimated that the aerospace industry will scrap almost 9,000 tonnes annually by 2020, and that approximately 3,400 tonnes of that scrap will be comprised of carbon fiber.

An article in Composites World titled "Carbon Fiber Reclamation: Going Commercial"[2], Carl Ulrich, Managing Director of Allstreams LLC (McLean, VA) explained, "Carbon fiber recycling is an attractive market niche because it's driven not just by the financials, but also by recent government incentives, and by the desire for manufacturers to have green manufacturing processes and products."

Carbon fiber recycling not only prevents the waste of virgin carbon fiber in landfills after its first use, but components produced using the recycled fiber are themselves recyclable, because carbon can retain a significant portion of its virgin properties even after a second reclamation. Further, the recycling process itself significantly reduces energy costs. Boeing estimates that carbon fiber can be recycled at approximately 70 percent of the cost to produce virgin fiber ($8/lb to $12/lb vs. $15/lb to $30/lb), using less than 5 percent of the electricity required (1.3 to 4.5 kWH/lb vs. 25 to 75 kWH/lb).

Sustainability
The following excerpt from the same Composites World article explains well the argument for the sustainability of recycling carbon fiber from composites:

One compelling aspect of recycling is the potential for manufacturers to optimize usage of the virgin fiber it buys. "There are clear product sustainability and cost advantages when you can take scrap from one manufacturing process *and turn it into a feedstock for another part of your product," Carberry claims, although he admits that the full extent of that advantage is not yet clear. "First, we have to clear the technological hurdles [of working with new technology], and then we have to qualify recycled carbon fiber for use on aircraft before we can begin to forecast the market potential."*

Toward that goal, Boeing worked with RCF Ltd., Materials Innovation Technologies, LLC (MIT) [currently operating as Carbon Conversions, Inc.], the University of Nottingham (UK), and Adherent Technologies to produce a proof-of-concept molded armrest using carbon fiber reclaimed from pre-production Boeing 787 parts. Although the short, chopped fibers yielded by recycling processes cannot replace continuous fibers in aerospace manufacturing, they could be used on tertiary aerospace parts. Further, Spooner sees high-quality recycled carbon fiber, milled and chopped, competing well with industrial-grade virgin fiber

"We can always be competitive with milled and chopped virgin carbon fiber," Spooner contends. "In theory, we're a little cheaper because we're not affected by carbon fiber prices in the world, and we know our costs to manufacture," he explains. "Also, we can offer a consistency of supply because we have different supply routes than traditional carbon producers."

MIT hopes to capitalize on the potential high quality of the recycled chopped carbon fiber, creating an effectively intermediate-modulus material that falls between virgin aerospace- and industrial-grade products. Toward that end, MIT separates carbon fiber scrap by modulus and then chops it to one-inch lengths prior to pyrolization. MIT has worked with a number of major compounders to qualify its reclaimed material for use in compounded materials. MIT also plans to use much of its reclaimed fiber in-house, to manufacture complex fiber preforms for part manufacturers via its proprietary three-dimensional (3-D) engineered preform (3-DEP) process.

According to Firebird's president Thomas Hunter, however, carbon fiber recyclers who target end-uses will face several challenges along the way: "A lot of research has been done in the area of recycling the carbon fiber," he says, but points out that "this research hasn't really focused on product applications."

Typically, he contends, fiber produced from pyrolysis is not well suited for most molding operations without further treatment. Although the pyrolysis process creates a very active surface on the carbon fiber, which can promote good fiber/resin bonding, the process also removes the sizing and results in a fluffy, "cotton ball" of fibers. Firebird is working to fine-tune its microwave recycling technologies to produce raw recycled fibers that more closely resemble virgin fiber, says Hunter.

"You can't put a fluffy, dry fiber into a thermoplastic [compounding] machine, because it won't work," Spooner agrees, and he believes that stepping beyond the recycling of raw fiber to facilitate new product development will be critical to widespread customer acceptance. RCF Ltd., for example, has compounded its milled and chopped fiber into thermoplastic pellets for injection molders." [2]

Recycled Carbon Fiber Evaluation

In 2010, Midland Compounding was introduced to carbon fiber being recycled through an effort led by Boeing Corporation. Bill Carberry, Program Manager for Boeing's Airplane and Composite Recycling explained, "There are many technologies in development, some that include supercritical fluids and microwaves, but these are still pretty much at laboratory scale. Pyrolysis, with and without the aid of a catalyst, seems to be the front-running technology at the present". Samples of recycled carbon fibers were evaluated from different companies working with Boeing to recycle the carbon fiber. Each sample was evaluated for length, loose bulk density, and its ability to be fed into an extruder using a gravimetric feeder.

The forms evaluated included milled, semi-continuous, staple, chopped, chopped with sizing. Chopped, staple and semi-continuous fibers had low bulk densities and were difficult to feed. Milled and chopped fibers with sizing had higher bulk densities and were able to feed at commercial run rates. Chopped fibers with sizing offered the highest tensile strength values. The results from this study are listed in the following table.

A ladder loading study was conducted to determine the impact the recycled carbon fibers would have on improving the tensile and flex properties of recycled nylon 66. The levels studied were 5%, 10%, 15%, 20%, 25%, and 35% recycled carbon fiber in PA66 by weight. The data in Table

ASTM	D638				D256
	TENSILE STRENGTH	ELONGATION AT BREAK	BREAK STRENGTH	ELONGATION AT YIELD	Notched IZOD
SPECIMEN NAME	PSI	%	KSI	%	Ft lb/in
Baseline Polypropylene Total 3484 (PP)	4800	10	3100	360	1.1
PP + 10% recycled CF	5300	6	3300	11	1.2
PP + 10% recycled CF w/compatibilizer	8400	2	5400	2	1.25

Table 2: Results from Boeing study comparing mechanical properties of modified recycled carbon fibers.

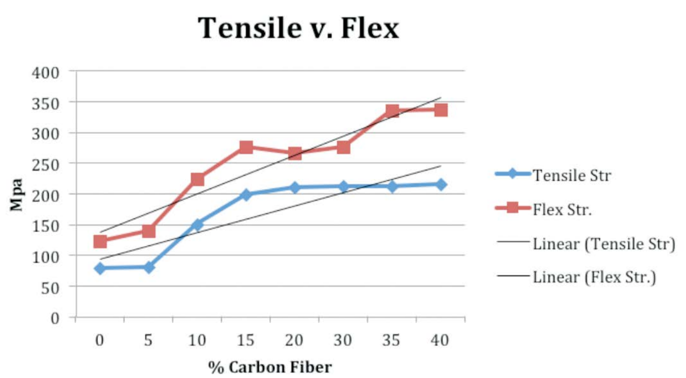


Figure 2: Tensile and Flex Properties of PA66 filled with Recycled Carbon Fiber.

2 demonstrates the relatively linear increase in both tensile and flex strength as the loading levels increase. However, it was observed that the rate of increase in tensile strength plateaus at about 20% carbon fiber, but the flex strength continues to rise at approximately the same rate up to 40% carbon fiber.

This work was then compared with recycled chopped fiberglass for reinforcing recycled polyamide 66. Recycled carbon fibers show 28-30% higher tensile and flex strength

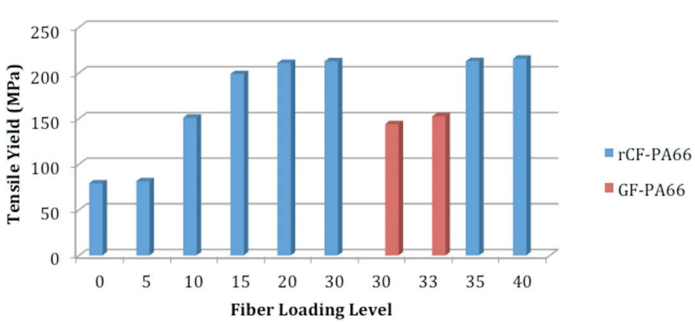


Figure 3: Tensile Properties of Chopped Fiberglass vs Chopped Recycled Carbon Fiber Reinforced PA66.

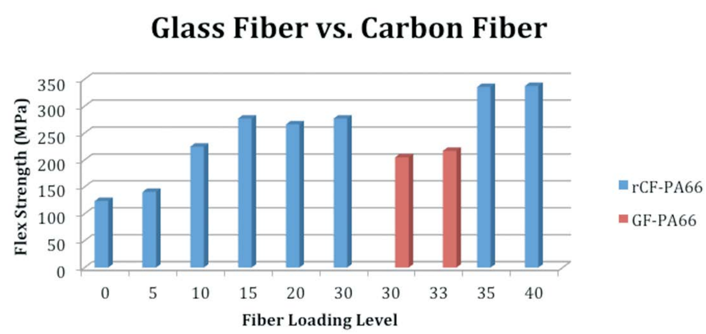


Figure 4: Flex Properties of Chopped Fiberglass vs Chopped Recycled Carbon Fiber Reinforced PA66.

than chopped fiber glass at the same loading levels by weight.

Recycled Carbon Fiber Filled Recycled PA66 Compared to Prime Carbon Fiber Filled PA66

A study was conducted by Ford Motor Company Research and Innovation Center North American[3]. The primary intention of the study was to compare and contrast alternate carbon fiber material systems available within the Tier 2 supply base for application on the Instrument Panel structure. Five material suppliers were contacted, and a total of 14 different materials were evaluated. These compounds were all reinforced nylon 66 with different loading levels and types of fibers. Midland Compounding provided samples of recycled carbon fiber compounded into recycled nylon 66. The following 3 tables list the results from that study. The compounds provided by Midland Compounding are listed as sample E.

Ford selected a plenum bracket as the part to be injection molded for evaluation. That part was subjected to compressive loading until the part failed. The part was crushed under quasi-static loading conditions and compressed at a rate of 5mm/minute. The failure load is reported as the average crush strength.

Figure 5: Whole part with sample positions 4-7 shown.

Figure 6: Crush testing device.

Following are the results from the crush test for those samples that were reinforced with 40% carbon fiber. Three parts were tested from each different composition.

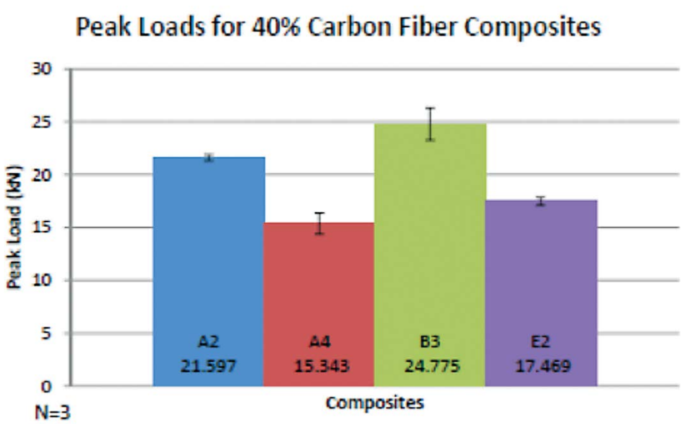


Figure 7: Comparison of Crush Strength Results.

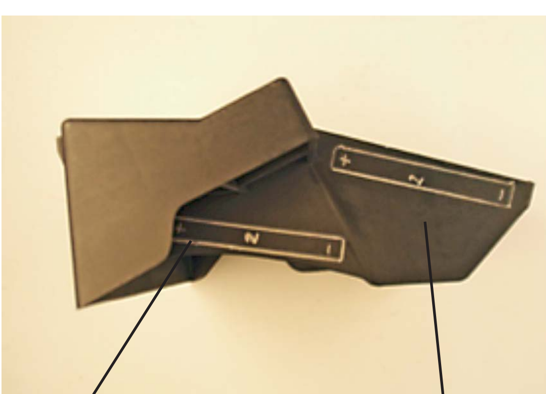
Sub-sized tensile bar specimens were excised from the parts via water jet. These specimens were taken from 7 different locations in the part.

Based on tensile data, location 1 exhibits the lowest mechanical properties. Location 1 was the first location to fail during the crush test. Low mechanical properties could be due to its location relative to the gate and a lack of carbon fibers in that area. Location 2 proved to have stronger mechanical properties than location 1 in tensile testing. Location 2 was still the second location to fail during the crush test. This could be due to the fiber orientation in relation to the force being applied to the part. Based on tensile testing and the crush test, the data shows that location 3 exhibits the strongest mechanical properties. Location 3 very rarely failed during the crush test. Locations 4-7 performed very similarly. The data showed that location 4 exhibited the best mechanical properties out of locations 4-7. Location 6 was selected to be representative of these four locations. The properties decreased slightly moving from location 4 to location 7. In the crush test, very few parts failed in this area- most likely because this area did not receive the majority of the load. Even though very few parts failed in this area, based on the data, the area around location 3 still exhibits the strongest mechanical properties. (Specimen 1, 2 and 3).

Figures 8 and 9 show the comparison in ultimate tensile strength and modulus of elasticity for those compounds that had 40% carbon fibers filler by weight.

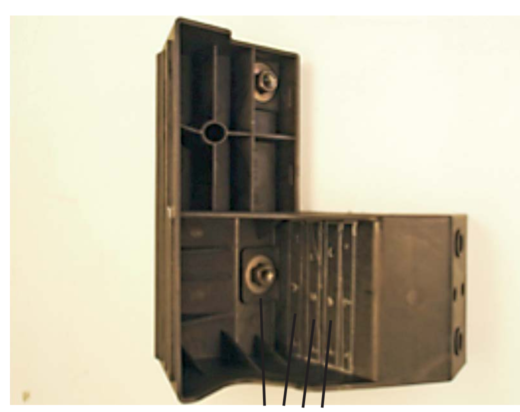
Improvement of Recycled Carbon Fiber Filled Recycled PA66

In 2018, more parts were molded for Ford Motor Company to study the recycled carbon fiber compounds. These



Specimen 1 *Specimen 2*

Specimen 3



Specimen 4 through 7

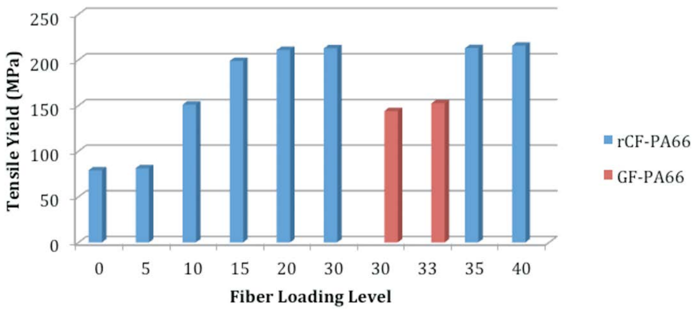


Figure 8: Comparison of Tensile Strength Results.

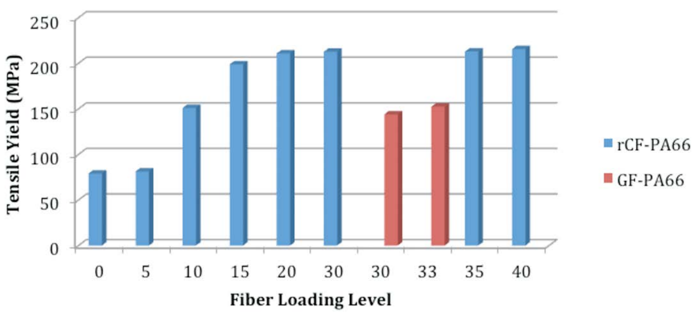


Figure 9: Comparison of Tensile Modulus of Elasticity Results.

parts were molded on the same tool as the original parts molded in 2015. Ford tested the new parts and compared the findings with the work originally done in 2015. Like the study in 2015, parts were tested for compression strength and micro tensile bars were cut from parts for tensile properties testing. The following are the comments and results from the Research and Innovation Center's study[4]. The benchmark material noted in this research is a compound made from prime nylon 66 filled 40% by weight with recycled carbon fiber.

The average tensile strength has not changed from the 2015 formulation, and all JM Polymers formulations are 25% lower than the benchmark. (Table 3).

The JM Polymers 40% rCF formulation's modulus increased by 100%, and both current formulations are much greater than the recycled/virgin benchmark (Table 4).

The 40% rCF tensile strength decreased by half when injected into a plenum bracket. While the 40% rCF PB has a lesser modulus than the tensile specimens, it is more than double that of the old [2015] formulation. The current JM Polymers formulation is double that of the benchmark (Table 5).

The Ford Research and Innovation Team has developed a method to count and measure individual fibers within the tested parts. Based on the results from the fibers count and measurement work, Ford has concluded that the increased average length of the recycled carbon fiber and higher count of longer fibers is the primary contributing factor to the improved tensile modulus performance. The average fiber length of the 40% rCF formulation has increased by over 50% (Table 6).

The Future of Recycle CF Compounds

It has been shown that compounds made from recycled carbon fiber and recycled plastic can deliver up to 75% of the same performance as compounds made from virgin resin material. The recycled carbon fiber compounds provide 25-30% higher performance than chopped fiberglass compounds while providing a weight savings of 8-10%. Investments continue to be made for increasing the recycling capacity to recover more carbon fiber from composites providing upwards of 9000 tonnes of additional carbon fiber to the global market.

Based on the anticipated shortfall in the supply of prime carbon fiber and the current rate of scrap generated of carbon fiber composites in aerospace applications, it makes good business sense to develop commercial processes to utilize this untapped stream of carbon fiber. With participation from each of the stakeholders it should be possible to identify opportunities within automotive applications that can be satisfied with the performance of the recycled carbon fiber compounds and manufacturing methods that control the volatility inherent in the recycling of goods and provide a consistent, predictable material.

References

1. *Supply and demand: Advanced fibers* (2017), Composites World, March 17, 2016

2. *Carbon Fiber Usage in Aerospace Industry*, www.3mb.asia, Posted on July 19, 2016

3. Ford Motor Company Research and Innovation Center Test Report, July 2015

4. Ford Motor Company Research and Innovation Center Test Report, July 23, 2018

Plenum Bracket Comparison - Ultimate Tensile Strength								
	Location							
	1	2	3	4	5	6	7	Average
Material ID	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa
Benchmark 40% rCF PA66 (n=3)	85	125	175	135	130	119	110	126
2015 JM Polymers 40% rCF PA66 (n = 3)	50	95	150	110	110	85	75	96
2018 JM Polymers 40% rCF PA66 (n = 6)	75	95	125	115	90	85	45	90
JM Polymers 20% rCF PA66 (n = 6)	85	115	118	90	90	85	46	90

Table 3: Plenum Bracket Comparison: Ultimate Tensile Strength.

Plenum Bracket Comparison - Tensile Modulus of Elasticity								
	Location							
	1	2	3	4	5	6	7	Average
Material ID	GPa	GPa	GPa	GPa	GPa	GPa	GPa	GPa
Benchmark 40% rCF PA66 (n=3)	6	11	17	12	11	9	7	10.4
2015 JM Polymers 40% rCF PA66 (n = 3)	4	12	20	11	9	8	6	10.0
2018 JM Polymers 40% rCF PA66 (n = 6)	17	23	34	19	18	15	15	20.1
JM Polymers 20% rCF PA66 (n = 6)	13	19	25	15	13	12	12	15.6

Table 4: Plenum Bracket Comparison: Tensile Modulus of Elasticity.

	Ultimate Tensile Strength	**Tensile Modulus**
Material ID	MPa	GPa
Benchmark 40% rCF PA66 Plenum Bracket (n=21)	126	10
2015 JM Polymers 40% rCF Plenum Bracket (n = 21)	96	10
40% rCF PA66 ISO T-bars (n = 8)	196	29
2018 JM Polymers 40% rCF Plenum Bracket (n = 42)	89	20

Table 5: Mechanical property comparisons for tested specimens.

Fiber Length Retention Comparison				
Material ID	**Location**	**Count**	**Ln *(um)***	**Lw *(um)***
2015 JMP Plenum Bracket	1	397	117.0	161.5
	2	369	112.4	158.3
	3	166	105.9	149.9
	4	391	122.0	10.6
	5	299	124.6	187.1
	Average	***1622***	***117.4***	***167.1***
2018 JMP Plenum Bracket	1	4891	158.7	203.1
	2	10278	166.1	239.0
	3	13685	205.5	283.9
	4	2668	189.0	240.6
	5	9662	195.7	260.2
	6	2830	172.3	216.9
	Average	***44014***	***185.8***	***254.9***

Table 6: Fiber length retention comparison.

Plastics Sustainability

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

*[**Editor's note:** This is the sixth and final article in our series. 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 6: Sustainable Considerations in Material Selection

The process of selecting materials for a new product – or of finding alternatives to a material used in a current product – can be extremely analytical. Usually, various material physical properties for the product are identified and then weighted according to their importance in the application. Possible materials are identified and then scored in some way according to how they meet key requirements. A ratio or performance index of various key properties may be created to highlight which materials are the optimal choices (these ratios may relate strength with density, or cost per unit of some key property, and so forth). And then some final computation might be used to rank the materials according to their overall suitability in terms of properties and costs[i].

Also mentioned below is the sometime controversial term biodegradability. Many bioplastics are inherently biodegradable and can be shown to completely degrade during composting using test standards such as ASTM D6400. Other biodegradable plastics depend on the use of biodegradability-enhancing additives; these compositions claim to degrade in common disposal environments over a long duration. But the degree of degradation is often only estimated via extrapolations from test data (an issue also discussed more in Chapter 2). This chapter, at least, will assume that any biodegradable materials that are discussed can be confirmed to totally degrade as per standard testing.

6.1 A Broad Example of Materials Selection: Plastics vs. Metals and Glass

A basic way to illustrate the process of material selection is to simply compare general categories of materials such as plastics, metals, and glass. Table 6.1 shows comparisons between the general characteristics that are pertinent to an application in which these three broad groups of materials often compete (here, specifically food and beverage packaging).

Table 6.1 elucidates certain advantages plastics have over metal and glass, especially in non-engineering applications. Plastics are relatively impact-resistant, resisting permanent dents and breakage. They are inexpensive, low-density materials possessing good strength-to-weight ratios, even when compared with metals and glass. They can be attractively colored and vividly decorated without added labels. And they are processed at relatively low temperatures (although they are not easily formed or machined into complex shapes in common room-temperature processes like metal stamping).

Food-grade plastics are safe and inert for food and beverage packaging, though controversies do arise. Ironically, metal beverage containers have recently been associated with a plastics related health issue, since steel and aluminum cans use a liner of epoxy resin based on bisphenol-A. Here, food product makers face public scrutiny of a type that they would not face when using non-BPA - containing plastics packaging.

Metals and glass do have their advantages, though. Compared with metals and glass, plastics have limited recyclability in current practice, with even a 50% recycling yield of a waste stream of packaging plastics being considered about as high as might be practically expected. Metals and glass can be re-melted multiple times without significant property degradation, permitting their almost complete recycling into other products (steel in particular is the most frequently recycled material of all materials). Glass and metals are also hard and stiff and serve as strong barriers to gas and moisture. They have a much longer history of use in consumer products than plastics, which has helped them maintain consumer confidence at a high level; accordingly, plastic products are often designed to mimic metals or glass – rarely is it the other way around.

Plastics are also replacing metals and glass outside of the packaging arena. Take the case of automotive fuel tanks, for example. High-density polyethylene fuel tanks have become common, replacing steel tanks starting in the 1970s. But higher requirements for blocking evaporative fuel emissions, handling new alternative fuels, and accommodating new vacuum seals in fuel tank designs, plus new steel-forming processes, are tending

Table 6.1 General comparison of plastics, metals, and glass for food and beverage packaging.

Material Characteristic	Plastics	Metals	Glass
Physical Properties			
Density	Low	High	High
Strength per weight	High	High	Medium
Stiffness per weight	Medium	High	High
Impact resistance	Good	Fair	Poor
Barrier properties	Fair	Good	Good
Environmental/Life-cycle Impacts			
Toxicity	Medium	Medium	Low
Production energy & emissions	Low	High	Medium
Recyclability	Limited	High	High
Costs & Marketability			
Material costs	Low	Low-Medium	Low
Processing costs	Low	Medium	Medium-High
Aesthetics flexibility	High	Medium	Low
Consumer perception	Negative-Neutral	Neutral-Positive	Positive

to make steel favored again as a tank material [6]. Other improvements in advanced high-strength steels are enabling the production of lighter weight steel structures that resist competition from plastics composites. Still, plastics loaded with higher levels of longer reinforcing fibers are becoming options for more structural, metal-like applications. Thus a material selection process comparing these materials for some applications would need to be redone every few years.

6.2 Material Selection for Common High-Volume Plastics Applications

6.2.1 Plastics Selection for Beverage Bottles: PET vs. rPET vs. bio-PET

Beverage bottle production is an area dominated by one polymer type, PET . But there is increasing competition within the application between PET materials with different life-cycle signatures – mainly different kinds of "cradles," if we are to use the "cradle-to-grave" metaphor:

• Traditional, fossil-fuel-based virgin PET offers bottle manufacturers the chance to produce bottles with the absolute lowest wall thickness for the job; the material is also highly recyclable.

• Bottles containing recycled PET (rPET) content are also entering the market, "closing the loop" for the material/application. However, state-of-art recycling processes are required for producing food-grade rPET with adequate purity and proper viscosity (melt fl ow) for bottle manufacturing. In North America, bottle producers have started producing bottles containing rPET at 25% content or more (consider the case example below, at the end of this section). And "bottle-to-bottle" recycling plants in China likewise have started producing food-grade rPET pellets, using recycled material obtained at about a 40% yield from incoming PET bottle streams[ii].

• PET partially or wholly based on renewable, plant-based sources (bio-PET) is identical to traditional virgin PET in terms of properties and recycling . The Coca-Cola Company reportedly expects to convert all it bottles to bio-PET "PlantBottle" materials by 2020, and H.J. Heinz Co. Australia Ltd. is said to be adopting the material for its ketchup bottles[iii]. (And PepsiCo 's recent announcement of 100% bio-based PET bottles coming online indicates the potential level of bio-PET commercialization.)

6.2.3 Selection for Housewares and Food Service Tableware

Broadly defined, "housewares" covers multiple items and tools in everyday use. They are often expected to be durable enough to last for years of use, and when made of plastic, are expected to be inexpensive. Plastic housewares include kitchen tools and utensils, washable storage containers and cups, bathroom accessories, toys, hangers, and hooks and hardware for light use. Given their durability requirements and their contact with water and food, plastic housewares are expected to be made from traditional, inert, nondegradable materials such as polypropylene, polycarbonate, ABS, and thermosetting polymers, when heat resistance is required.

Until more durable bioplastics become widely available to handle these applications, housewares manufacturers will continue to rely on traditional materials. But "green plastic" opportunities exist in housewares. The bacteria-produced bioresins in the polyhydroxyalkanoate (PHA) family, having polypropylene-type properties, are slowly making progress in this sector through initial uses for items such as pens[iv]. Another way of greening housewares is to produce them with more recycled content, a trend also starting to gain force.

Example case: Bioresin manufacturer Cereplast® has provided starch-based bioresin blends for compostable tableware such as forks, knives, spoons, plates, and cups. The materials are reportedly designed to degrade within 180 days or less in composting, or within 2–3 years in a landfill . This satisfies the minimal environmental demands questioned in the first question above, except that industrial composting options are limited for handling used tableware. The third question above can be satisfied by clear labeling on the product packaging, symbols on the products themselves, or signage where the tableware is provided. Otherwise it might be difficult to justify the extra costs of this application, given that these products appear to be very similar to other disposable tableware, at least in the eyes of the average consumer.

6.3 Bio-based Plastic Selection

Material selection is being made more and more difficult by the growing numbers of bioplastics coming into the market, and by their unfamiliar properties. The following subsections group traditional and bio-based plastics with similar properties, applications, and polymer families, aiding in making comparisons and for selecting between them.

6.3.1 Selecting Bio-based Resins: PLA, PHA, TPS, and Bio-based PE

This section will offer some background for comparing three modern biologically synthesized resin families: PLA, TPS, and polymers and copolymers from the PHA family of bacteria-synthesized resins. Complicating matters for bio-synthesized resins are the additives and blends that are needed for allowing TPS, PLA , and PHA to compete better with traditional commodity resins. Additives can improve impact strength, melt strength, thermal stability, crystallization nucleation, and other key properties. Bioresin additives preferably should not reduce a bioresin's percentage of bio-based content, its biodegradability, or especially in the case of inherently transparent PLA , its clarity. Moreover, when additive masterbatches are used to mix additives in with the biopolymer, biodegradable carrier resins should be used[vi]. Unfortunately, another complicating factor is that different bioresins often cannot use the same additives[vii].

Example cases: Because bioresins have limitations in providing many of the properties provided by traditional resins, materials selectors will be tempted to consider using blends of bio- and fossil-fuel resins (this issue relates to the concern of question 1 above). Some compromise may be needed when evaluating these resin blends' green attributes against needed properties.

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SPE Council Summary

September 21-22, 2018

Charleston, SC

SPE Council convened in Charleston, SC for the Fall 2018 meeting. At the beginning of proceedings, President Brian Grady called for a moment of silence to honor the passing of several distinguished SPE members.

Clear and relevant governance is the foundation of a well-run society and SPE continues to refine its policies and by-laws. Several items were amended and approved during Council thanks to the diligent leadership of Councilor Bruce Mulholland.

All presentations and data discussed during Council meetings are available on The Chain on Leadership Lane. We encourage councilors to remind all their respective chapter members that The Chain is our primary method of communication for SPE business.

Financial Review & CEO Report

CEO Farrey presented a financial report that covered Society finances through June 30, 2018. Since then, the July 2018 financial report has been made available (see below). The operational performance was strong, with costs trending downward despite increased headcount and salary increases at SPE HQ. The information systems overhaul will produce $200k in net savings annually when older contracts are unwound (see below).

The SPE financial investment portfolio has declined and remains behind budget. Farrey explained that SPE's financial portfolio continues to be conservative, targeting 6% annual return.

Farrey presented an update on the initial impact of Council's decision to stay with the old chapter dues system after having implemented a new software program. The current way of doing business results in higher costs ($5k one-time charge, $6k monthly accounting fees) while reducing efficiencies such as enabling auto-renewal for members. After much discussion, both in Council and

	Jul-18	Month	Month Budget	YTD	YTD Budget	Annual Budget
REVENUES						
	Membership/HQ	$167,226	$159,333	$1,233,501	$1,115,334	$1,912,001
	Foundation	$44,096	$38,625	$211,874	$270,375	$463,500
	HQ Events	$6,500	$833	$791,289	$884,333	$888,500
	Supported Events	($6,794)	$0	$101,946	$112,500	$348,500
	Total Revenues	$211,028	$198,791	$2,338,610	$2,382,542	$3,612,501
EXPENSES						
	Membership/HQ	$209,850	$243,013	$1,657,221	$1,701,094	$2,916,161
	Foundation	$7,716	$49,125	$195,661	$343,872	$589,495
	HQ Events	$41	$157	$558,172	$714,998	$715,781
	Supported Events	($1,890)	$0	($4,208)	$8,450	$22,600
	Total Expenses	$215,717	$292,295	$2,406,846	$2,768,414	$4,244,037
RESULTS						
	Operational result	**($4,689)**	**($93,504)**	**($68,236)**	**($385,872)**	**($631,536)**
	Investment/Interest	$8,364	$33,417	$2,052	$233,917	**$401,000**
	Wiley Deferred revenue	$12,500	$12,500	$87,500	$87,500	**$150,000**
	Total Result	**$16,175**	**($47,587)**	**$21,316**	**($64,455)**	**($80,536)**

during recess, VP of Sections, Scott Eastman, brokered a compromise that allows chapters to lock-in the amount of pass-through funds for two years at the level received on June 30, 2018 while embracing the new software system. Of course, this number can increase as chapters attract and retain new members.

New Programs & Initiatives

SPE continues to build programs that deliver value for members. Director of Member Experience, Sue Wojnicki, presented an overview of a new content strategy, including licensed learning courses from the Institute of Packaging Professionals (IOPP) titled, "Fundamentals of Plastics Packaging Technology". SPE-developed webinars, which are free for SPE members and $199 for non-members, are being rolled out through the remainder of 2018 covering topics such as artificial intelligence and plastics in the automotive sector. To support this and other programs, a new marketing program manager has been hired to create and improve processes for member acquisition and retention.

A new mentor program has been launched. SPE members can sign up to be a mentor, a mentee, or both. This development comes in response to previous ideas from councilors and members about taking advantage of the knowledge and skills of our 22,000-strong community of plastics professionals.

In addition to new programs, the new IT infrastructure continues to create benefits make life easier for volunteer leaders such as live membership reporting where membership chairs can access reports at any time. In addition, SPE can now help Chapters process credit cards for incidental payments received for things like newsletter ads, sponsorships, etc. Through a simple online payment gateway form, Chapters may now accept credit card payments and HQ will clear the transaction and remit the revenue back to the Chapter.

SPE has discontinued the use of paid conference calling systems which results in a cost savings of ~3K/month, Chapters can take advantage of new, free, better systems such as Zoom and staff will offer support of Zoom if questions arise. Pinnacle Awards forms can now be completed entirely online whereas before they had to be printed, completed by hand, scanned and emailed to SPE.

The SPE Online Technical Library now contains over 14,000 items. With improved search functionality, this is a valuable tool for chapters to promote the content created by their members at conferences or other events. Each chapter is responsible for deciding which content is suitable for inclusion. Instructions for uploading can be found on the main SPE website: Content > Leadership Resources > Leadership Documents. SPE will provide additional guidance in the following weeks.

Chapter Insurance Program

Following recent discussions on The Chain that clarified the need of each chapter to have its own insurance coverage, Farrey announced that a global agreement has been negotiated by SPE to offer insurance for all chapter board members for $450/yr starting on October 1, 2018. This amount is significantly less than previous programs where the average cost to the chapters was $1200/yr. Chapters must have the following in order to be insured using the program developed by HQ: 1) bylaws are on file with SPE HQ; 2) a current roster with all board members, all of whom must be SPE members must be provided to SPE HQ; 3) financial forms (IRS 990 and annual report) must be on file with SPE. A webinar covering all details will be hosted by SPE at 11h00 EST on September 27, 2018. Details about the program are posted at www.4spe.org/

chapterinsurance. SIGs and student chapters are exempt as they are covered by SPE. Chapters that already have coverage are encouraged to talk to Farrey directly about the transition.

SPE Foundation Report

SPE Foundation Director, Eve Vitale, announced that the Foundation Annual Report will be available at ANTEC 2019 in Detroit. Vitale reviewed multiple initiatives underway through the Foundation including increased advocacy efforts with PLASTICS for both workforce development and recycling infrastructure funding; PlastiVan outreach programs with Kettering University, Baylor University, SPE Divisions including Thermoforming and Composites, and a virtual classroom seminar with students in Australia in partnership with the AUS/NZ Section.

2019 Executive Board Elections

There are 3 open positions on the SPE Executive Board. Terms begin March 17, 2019. Elections will be held beginning in January 2019 for the following positions:

- President-Elect: 1-yr term, 3-yr commitment
- VP Events: 3-yr term
- VP Young Professionals: 3-yr term

Past-President Al-Zubi reviewed the timeline and mechanisms for the election process. All details are posted to Leadership Lane.

The next Council meeting will be held via conference call on December 13. A one-hour meeting is expected, and the primary purpose of the meeting will be to review the budget.

Respectfully submitted,
Conor P. Carlin
EB Secretary, VP Marketing & Communications

SPE PLASTIVAN™ PROGRAM

SPE PLASTIVAN™ SPONSORSHIP

With a national focus on STEM disciplines at all educational levels, both private and public resources are being marshalled to address a shortage of skilled employees across manufacturing industries. It is critical for plastics and related companies to be active in their communities, both to demonstrate career opportunities and to promote the benefits of plastics which are often misunderstood.

The PlastiVan™ Program is a great way to excite young people about the science and the vast opportunities the plastics industry has to offer. The program travels to schools and companies throughout North America, educating middle- and high-school students about plastics chemistry, history, processing, manufacturing, sustainability and applications. Corporate sponsors have a unique role to play in this community outreach program, linking the wonders of plastics to applications and jobs in the real world.

COSTS OF SPONSORSHIP

The fee for the PlastiVan™ program is $1500 a day. Your sponsorship covers travel & expenses for educators as well as all materials. SPE coordinates all scheduling and communication with schools. This allows more students greater access to the wonders of plastics in their own communities. Sponsorship of the PlastiVan™ Outreach Education Program is a tax-deductible donation.

BENEFITS OF SPONSORSHIP

As part of the sponsorship package, companies gain access to students, parents and educators in local communities. Sponsoring companies can choose to provide a list of local schools or SPE staff can work with you to select schools and arrange schedules. Many companies choose to send a representative to speak directly to the audience about products and career opportunities. In addition, SPE can help coordinate PR with local press to craft stories about the PlastiVan™ visit. These stories are then added to SPE's library of testimonials highlighting the success of the PlastiVan™ program.

BECOME A **SPONSOR** TODAY!

For more information or to schedule a school visit, contact:

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