Beyond Weight Reduction: Plastics and Composites Reshape Car Design

Use of new materials set to rise rapidly in coming years, enabling innovation

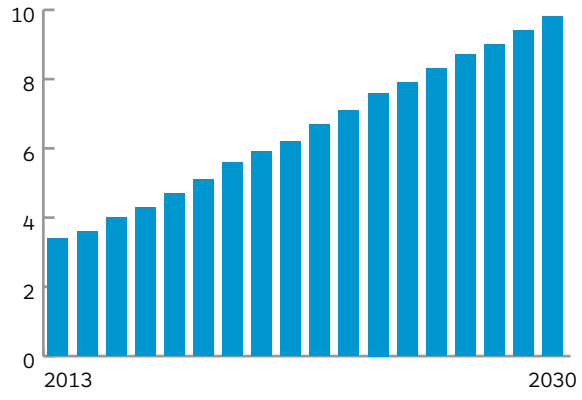
In the automotive world, practical concerns are critical, such as reducing car weight, improving gas mileage and meeting government standards for emissions and efficiency. But equally important are emotional factors, like the feeling a person gets when looking at the sexy lines of a new Lamborghini—the intangible sensation that quickens the pulse of a potential car buyer.

Luckily for the car industry, a new generation of materials has arrived that can yield automobile designs appealing both to the head and to the heart. Advanced plastics and composites not only can reduce car weight and improve mileage, they also can bestow car designers with a freedom of expression that would be impossible with conventional metals, like steel and aluminum.

Because of this, usage of such materials in automotive applications will increase rapidly during the next few years.

By 2020, the average car will incorporate nearly 350 kilograms of plastics, up from 200 in 2014, according to IHS Chemical. Meanwhile, the market for carbon fiber in car manufacturing is expected to nearly triple in the coming years. Usage of carbon fiber in automotive manufacturing will increase to 9,800 metric tons in 2030, up from 3,400 in 2013.

Global Automotive Consumption of Carbon Fiber Composite (Thousands of Tons)



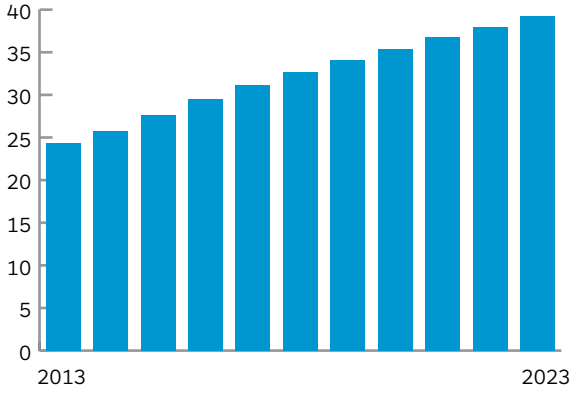
Source: IHS

Traffic jam

Cars represent a fast-growing market for the chemicals industry, with global car shipments expected to nearly double over the next 17 years, rising to 104.1 million units in 2020, up from 56.9 million in 2003, based on information from IHS Automotive. The majority of the growth will be propelled by the fast-expanding Chinese market.

Shipments of all types of specialty chemicals for the automotive industry will rise to $39.2 billion in 2023, up from $25.8 billion in 2014.

Global Forecast of Specialty Chemicals for Automotive Applications (Billions of U.S. Dollars in 2005 Dollars)



Source: IHS

The material world

Uses for these materials range from headlights and windshields, through to body panels and even under the hood.

The plastics consumed are often compounded with fiberglass and additives to improve mechanical properties and stability.

The types of plastics used in automotive run the gamut from commodity polymers to advanced materials.

For example, the widely used high-density polyethylene (HDPE) is employed in fuel tanks. Unsaturated polymers like polymethyl methacrylate (PMMA) are utilized to make hatchbacks. Automotive connectors are made using engineering-grade polybutylene terephthalate (PBT).

Lighten up

From a practical perspective, automakers are adopting new materials in order to reduce the weight of their vehicles to comply with government regulations. In the United States, for example, the Corporate Average Fuel Efficiency (CAFE) standards mandate that carmakers' passenger vehicle fleets average 54.5 miles per gallon by 2025.

To meet U.S. and European objectives for greenhouse gas emissions for 2020 and 2025, car road loads must be reduced by 30 percent, according to an estimate from IHS Automotive. This reduction will be required in addition to large-scale adoption of advanced engine, transmission, and hybrid technologies.

The use of carbon fibers and polymer matrix composites are believed to enable car body-weight reductions of 25 percent to 70 percent.

For the most part, mainstream automakers will employ traditional metalworking approaches to weight reduction, as these offer a cost-effective application of known competencies, secure supply chains, and, most importantly, existing capital equipment.

However, manufacturers may adopt more radical approaches, extensively employing plastics or composites.

Plastic surgery for cars

Beyond the practical advantages of using plastics and composites, these materials can greatly enhance the design and aesthetic appeal of cars.

One example of these improvements is in the design of car windows.

The plastics industry has for some time tried to replace all the glass used in cars with polycarbonate (PC). This effort is well underway, with almost every vehicle on the road today having a PC headlamp and a PC/PMMA rear lamp.

The next target for PC suppliers is car windows. While a limited number of vehicles have switched from conventional glass windows to ones using PC glazing, cost and regulation issues have limited the proliferation of this material.

However, the use of PC in windows could allow for greater innovation than now possible with glass. For example, components can be integrated into the glass, enabling carmakers to produce entirely new designs. The window/light/tailgate could now be integrated together, offering a great design prospect in terms of style and lines of the car with the overall price also providing a major weight savings over the standard construction method.

More ambitiously, concept cars shown by carmakers make extensive use of plastics, changing the traditional angular and metallic car enclosure into a motorist's own, personal crystal-clear bubble of polished polycarbonate.

High carbon-fiber diet

With car glass and interiors already having adopted plastics and composites, the auto industry now is turning things inside out—looking at ways to use these materials in body panels. This is leading to some ingenious developments.

Carbon fiber has long been used to manufacture the highest-end race cars. However, this technology is now being employed to reduce the weight of standard vehicles by producing body panels from carbon fiber, a process already commercialized by leading automotive supplier Magna International Inc. These include Class A exterior panels, like door panels, fascia and hoods.

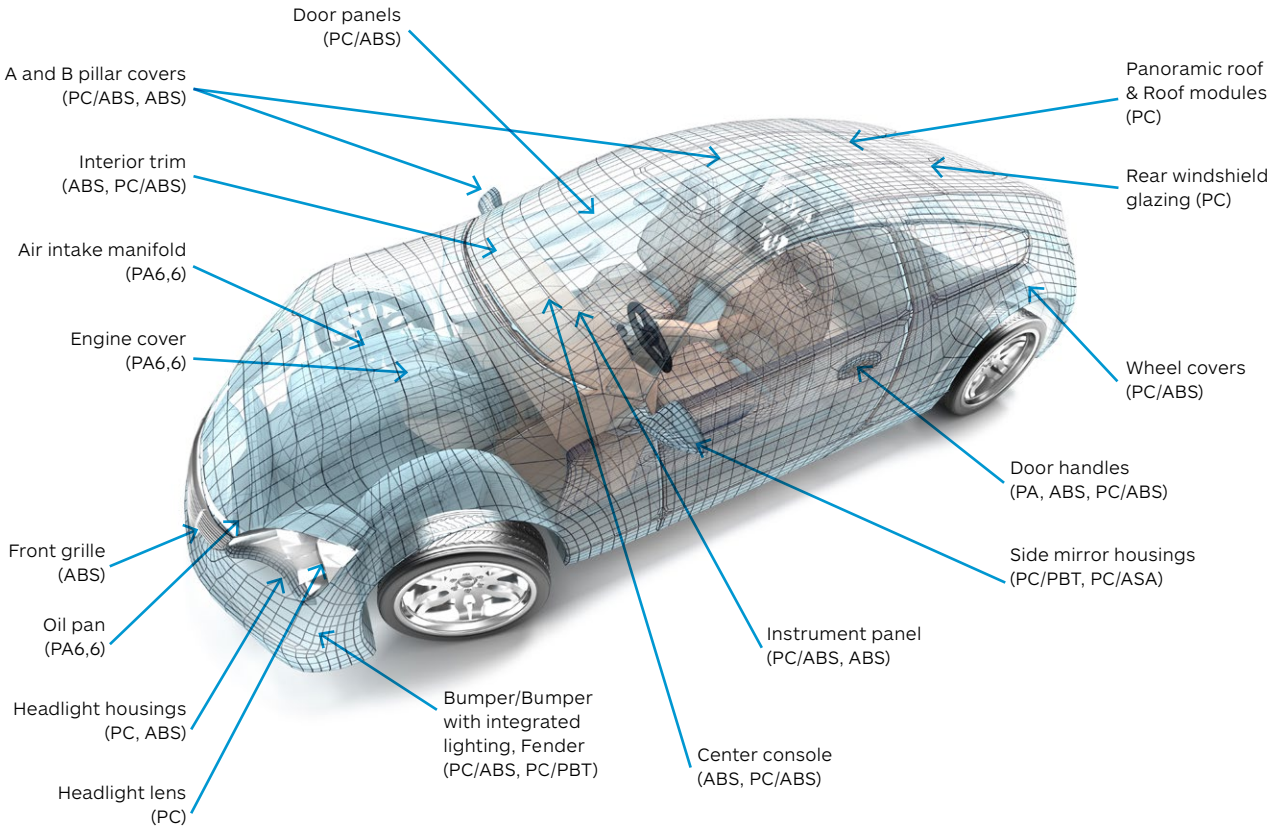
Even so, the cost of carbon fiber remains a high-cost option, limiting its usage.

For its part, the chemical industry has come up with an answer to the cost issue: foam, polymer, fiber composites.

Using standard polymer materials extruded with glass fibers and sandwiched with structural foams, the industry can now reproduce these Class A surfaces at a greatly reduced weight of metals and cost of carbon, while still maintaining the structural integrity.

One such system launched at the K 2013 plastics trade fair by Bayer Material Science. The use of carbon fiber and polymer matrix composites are believed to enable body-weight reductions of 25 percent to 70 percent at "affordable" prices.

Both commodity and engineering polymers are playing an increasing role in automotive light weighting solutions



BASF has become a frontrunner in this lightweight revolution, developing solutions to impregnate fibers with resins and then over mold with plastics to produce lightweight structural components. This material already is being adopted in everyday vehicles. For example, the system is readily employed by Opal in some of its mass-production vehicles.

Today the technology is allowing the replacement of some auto parts with plastic composites. By 2020, IHS expects these plastics to enable not just wholesale structural changes but also completely new vehicle designs and concepts.

U.S. steel becomes U.S. carbon

U.S. automakers are making extensive use of carbon fiber in high-performance cars, including the SRT Viper, the Shelby Mustang GT500KR and the new Chevrolet Corvette Stingray.

However, usage of carbon fiber has spread beyond sports cars and into the electric vehicle segment.

Platforms like the Tesla Roadster will increasingly look to carbon fiber light-weighting solutions. This could push carbon fiber prepreg demand beyond the 1,650 metric ton level by 2020.

The SRT Viper integrates a total of 26.7 kilograms of carbon fiber, with the most extensive usage in the hood, roof assembly and the light gate. With carbon fiber in the rocker, the hood, the fender, the roof assembly, the roof bow cover and the splitter, the Corvette Stingray contains a total of 15.6 kilograms of carbon fiber. The Shelby Mustang's carbon fiber splitter comes in at 0.6 of a kilogram.

BMW takes carbon fiber to the next level

BMW is taking the use of carbon fiber further, employing it in the structural elements of cars, including the i8 plug-in hybrid and the i3 electric vehicle.

While the BMW i8 remains in the high-performance sports car sector, the BMW i3 represents a more

mainstream affordable car. What's more, the i3 includes a whopping total of 300 kg of carbon fiber per vehicle.

Supply chain risks create roadblocks

While these new materials hold great promise in the automotive industry, there are some major potential risks in the supply chain.

Makers of composites and advanced plastics operate in a restricted supply base that required considerable effort and expense needed for new suppliers to enter. Furthermore, product performance reliability and reproducibility is vital, which can be a challenge for producers in developing economies. Although margins are medium to high, manufacturing costs are impacted by crude oil via energy and raw materials.

With a small supply base subject to quality and raw materials issues, the availability of these materials is susceptible to disruptions.

For example, in 2011 a fire and explosion at a plant operated by Evonik Industries AG caused a cessation in the world's supply of nylon 12, commonly used in automotive applications. It took nearly two years for Evonik to regain its volume of nylon 12.

Automotive companies sourcing these materials must develop strategic procurement strategies to account for conditions throughout the supply chain.

Under the hood

As the chemical industry further develops these new materials, the possibilities really are endless. In the future, suppliers will increase the compounding of speciality materials into various polymers to improve strength, stiffness, heat resistance. This will allow the industry to look under the hood to see what metal parts can be replaced with high-temperature plastics.

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