Plastics and Polymer Composites in Light Vehicles

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Executive Summary

The $449 billion North American light vehicle industry represents an important sector of economy of all three nations and a large end-use customer market for chemistry. In 2019, the 16.23 million light vehicles assembled in the United States, Canada, and Mexico required some 5.77 billion pounds of plastics and polymer composites valued at $6.7 billion, or $412 in every vehicle.

The latest data indicate that the average weight of North American light vehicles rose slightly in 2019. At an average of 355 pounds per vehicle, the use of plastic and composites gained five pounds per vehicle from 2018. Polypropylene, however, is also used in thermoplastics polyolefin elastomers (TPO) and its use in that area is reported separately under rubber. In addition, carbon fiber is utilized to manufacture carbon fiber reinforced plastics (CFRP) for automotive applications. Average TPO and carbon fiber use has increased by one pound from 2019. At 36 pounds per vehicle if they were included in plastics and polymer composites the total would be equivalent to about 391 pounds per vehicle. A change in consumer preferences for larger trucks and SUVs played a role. The percentage of total vehicle weight was 8.9% in 2019. Plastics and polymer composites are still essential to a wide range of safety and performance breakthroughs in today's cars, minivans, pickups and SUVs. In fact, the use of plastic and polymer composites in light vehicles has increased from less than 20 pounds per vehicle in 1960 to 355 pounds per car in 2019.

The role of plastics is actually much larger as these materials are compounded with colorant and other additives that impart functionality and other positive attributes. The value of these additives and compounding services along with value-added among producers of plastic automotive parts and components bring the market for finished automotive plastics and polymer composite products up to $21.3 billion in the United States. These automotive plastic products are produced at 1,591 plants located in 45 states. These plants directly employ about 63,075 people and feature a payroll of $3.3 billion. Michigan is the leading state in terms of direct employment (15,261) and is followed by Ohio (8,775), Indiana (8,221), Tennessee (4,354), Minnesota (3,081), Pennsylvania (2,899), Wisconsin (2,307), Illinois (2,199), North Carolina (1,739), and New York (1,583).

Producers of automotive plastics and polymer composites purchase plastic resins, additives, other materials, components and services. As a result, the contributions of plastics and polymer composites go well beyond their direct economic footprint. The automotive plastics and polymer composites industry fosters economic activity indirectly through supply-chain purchases and through the payrolls paid both by the industry itself and its suppliers. This, in turn, leads to induced economic output as well. As a result, every job in the automotive plastics and polymer composites industry generates additional employment elsewhere in the US economy, for a total of nearly 159,000 jobs.

Introduction

This report presents the latest results of an assessment of the chemistry and other materials make-up of light vehicles, a major end-use customer for American chemistry. We examine the market for all of North America. That is, the North American Free Trade Agreement (NAFTA) comprised of the United States, Canada and Mexico.

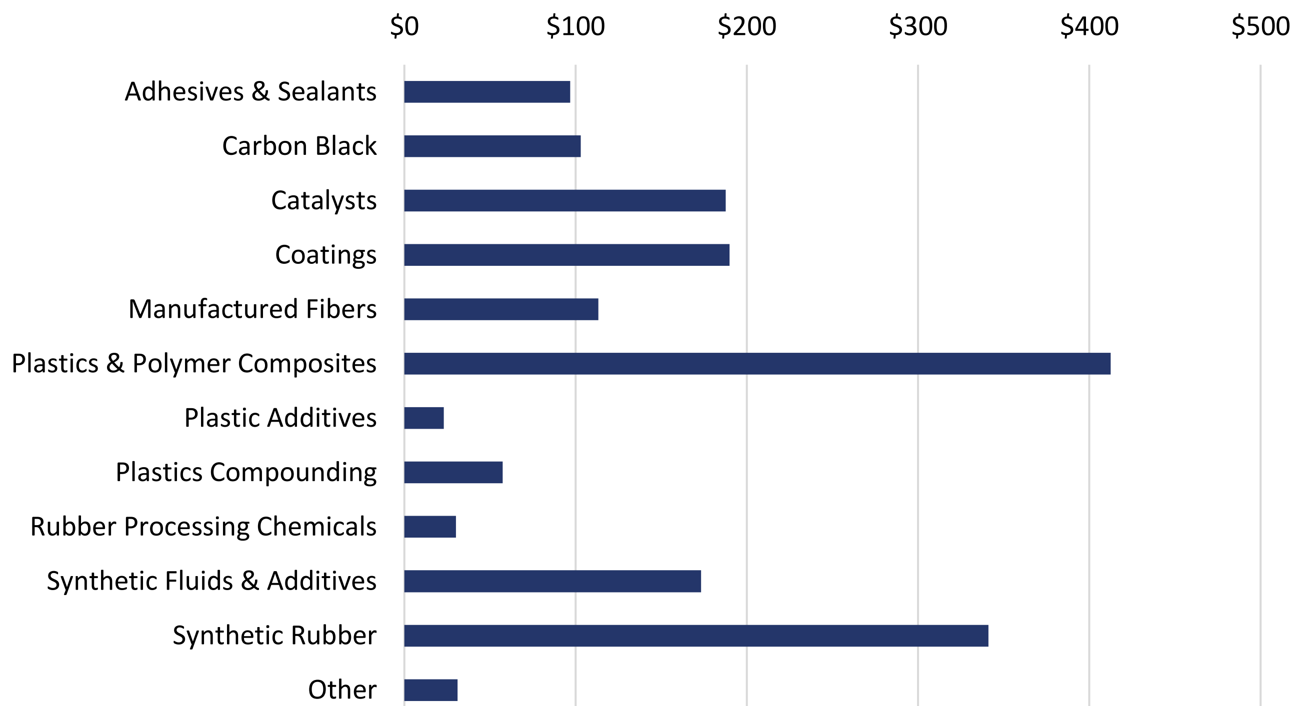
With 16.23 million light vehicles assembled in North America during 2019, this important market represents the equivalent of some $51.2 billion in chemistry. This 2019 value has increased significantly from 2009 during the last recession, when 8.52 million units were assembled and the associated chemistry value was $24.8 billion.

Chemistry and Light Vehicles

The light vehicle industry represents a large share of the North American economy, totaling $449 billion in shipments (at the manufacturer's level) in 2019 and employing 1.71 million workers. The light vehicle industry continues to be an important customer for most manufacturing industries, including the chemical industry. This relationship is particularly strong in basic and specialty chemicals because every light vehicle produced in the United States, Canada and Mexico contains on average $3,152 of chemistry (chemical products and chemical processing). The chemistry value per vehicle has grown considerably over the past 10 years, having grown over 9% since 2009 when it was calculated at $2,907 per vehicle. Included in the chemistry value, for example, are antifreeze and other fluids, catalysts, plastic instrument panels and other components, rubber tires and hoses, upholstery fibers, coatings and adhesives. Virtually every component of a light vehicle, from the front bumper to the rear tail-lights features some chemistry.

Figure 1

Average Value of Direct Chemistry Content of North American Light Vehicles in 2019 ($/vehicle)



The average values of direct chemistry content in North American light vehicles in 2019 for a variety of segments of the business of chemistry are presented in Figure 1 (measured in dollars per vehicle). Only details on the direct chemistry value of materials are presented (the chemistry value from processing and other indirect chemistry is not displayed).

Table 1
Average Value of Chemistry Content of North American (NAFTA) Light Vehicles ($/vehicle)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Adhesives & Sealants	$80	$82	$88	$90	$91	$92	$91	$90	$92	$94	$97
Carbon Black	95	101	107	107	105	104	85	80	92	103	103
Catalysts	137	144	161	159	165	172	170	168	171	181	188
Coatings	159	164	173	171	175	193	194	191	192	193	190
Manufactured Fibers	127	116	114	108	111	109	101	98	106	112	113
Plastics/Polymer Composites	372	392	441	423	424	427	406	391	421	454	412
Plastic Additives	20	21	24	23	24	24	22	22	24	25	23
Plastics Compounding	50	52	59	57	59	60	56	55	59	63	57
Rubber Processing Chemicals	28	32	43	34	30	29	27	29	34	33	30
Synthetic Fluids & Additives	132	136	162	169	165	166	160	157	158	169	173
Synthetic Rubber	352	406	541	421	359	336	309	333	383	380	341
Other	9	8	11	12	11	13	13	17	26	29	31
Materials	**$1,560**	**$1,652**	**$1,925**	**$1,773**	**$1,717**	**$1,723**	**$1,635**	**$1,631**	**$1,758**	**$1,837**	**$1,759**
Processing/Other Chemistry	1,346	1,435	1,611	1,666	1,668	1,665	1,322	1,288	1,381	1,453	1,393
Total Chemistry Content	**$2,907**	**$3,087**	**$3,536**	**$3,439**	**$3,385**	**$3,388**	**$2,956**	**$2,920**	**$3,139**	**$3,290**	**$3,152**

The direct chemistry value during 2019 averaged $1,759 per vehicle, 56% of the total chemistry value. Details on chemistry used are presented in Table 1. The remaining 44% (or $1,393 per vehicle) was from processing and other indirect chemistry (for example, glass manufacture uses soda ash and other processing chemicals).

Materials and Light Vehicles

The light vehicle industry is an important customer for a number of metal and other materials manufacturing industries. For plastics and polymer composites in particular there is significant competition with other materials, especially aluminum and steel.

In 2019, average vehicle weight rose by one pound to 3,977 pounds. In 1990, average vehicle weight was 3,452 pounds. In 2000, the average vehicle weight was 3,880 pounds. The rising popularity of SUVs was a contributing factor in rising vehicle weight during the 1990s and for the first half of the 2000s. From 2004 through 2007, average vehicle weight exceeded 4,000 pounds.

Higher gasoline prices in 2008, however, prompted a reversal of this trend and a shift to smaller, more fuel-efficient vehicles. As a result, average vehicle weight slipped to 3,854 in 2009 and to 3,867 in 2010. An economic recovery (with rising incomes) and renewed popularity of larger vehicles in combination with lower gasoline prices then fostered increases in weight. Offsetting this is further penetration by plastics and composites and other lightweight materials which reduces average vehicle weight.

Table 2
Average Materials Content of North American (NAFTA) Light Vehicles (pound/vehicle)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Average Weight	**3,854**	**3,867**	**3,920**	**3,816**	**3,822**	**3,845**	**3,895**	**3,935**	**3,950**	**3,976**	**3,977**
Regular Steel	1,462	1,421	1,405	1,334	1,321	1,307	1,290	1,293	1,217	1,210	1,190
High- & Medium-Strength Steel	510	541	594	604	612	632	680	719	761	769	793
Stainless Steel	67	70	71	66	72	71	73	72	71	71	71
Other Steels	30	31	31	29	31	31	31	31	31	30	29
Iron Castings	201	236	255	263	264	271	260	241	241	248	238
Aluminum	319	332	337	342	348	361	387	404	414	426	427
Magnesium	11	11	11	10	10	9	9	10	10	9	11
Copper and Brass	69	73	72	71	70	67	66	68	70	69	68
Lead	41	40	39	35	35	35	35	35	38	37	38
Zinc Castings	9	9	9	8	8	8	8	8	9	9	10
Powder Metal	40	40	41	43	44	45	44	43	44	43	42
Other Metals	5	5	5	5	5	4	5	5	5	5	5
Plastics/Polymer Composites	365	344	340	325	323	323	328	329	345	350	355
Rubber	245	228	224	207	199	198	199	199	208	211	217
Coatings	35	35	32	28	28	28	28	29	30	29	29
Textiles	56	54	49	49	50	49	45	45	47	47	47
Fluids and Lubricants	214	215	217	215	218	220	220	222	222	222	220
Glass	87	90	96	93	94	94	93	92	95	97	94
Other	88	90	91	89	90	91	93	91	92	95	94
As a Percent of Total Weight	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Regular Steel	37.9%	36.8%	35.8%	35.0%	34.6%	34.0%	33.1%	32.9%	30.8%	30.4%	29.9%
High- & Medium-Strength Steel	13.2%	14.0%	15.1%	15.8%	16.0%	16.4%	17.5%	18.3%	19.3%	19.3%	19.9%
Stainless Steel	1.7%	1.8%	1.8%	1.7%	1.9%	1.8%	1.9%	1.8%	1.8%	1.8%	1.8%
Other Steels	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.7%
Iron Castings	5.2%	6.1%	6.5%	6.9%	6.9%	7.0%	6.7%	6.1%	6.1%	6.2%	6.0%
Aluminum	8.3%	8.6%	8.6%	9.0%	9.1%	9.4%	9.9%	10.3%	10.5%	10.7%	10.7%
Magnesium	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.3%	0.2%	0.3%
Copper and Brass	1.8%	1.9%	1.8%	1.9%	1.8%	1.8%	1.7%	1.7%	1.8%	1.7%	1.7%
Lead	1.1%	1.0%	1.0%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	0.9%	1.0%
Zinc Castings	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Powder Metal	1.0%	1.0%	1.0%	1.1%	1.2%	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%
Other Metals	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Plastics/Polymer Composites	9.5%	8.9%	8.7%	8.5%	8.4%	8.4%	8.4%	8.4%	8.7%	8.8%	8.9%
Rubber	6.4%	5.9%	5.7%	5.4%	5.2%	5.1%	5.1%	5.1%	5.3%	5.3%	5.5%
Coatings	0.9%	0.9%	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%	0.7%	0.7%
Textiles	1.5%	1.4%	1.3%	1.3%	1.3%	1.3%	1.2%	1.1%	1.2%	1.2%	1.2%
Fluids and Lubricants	5.6%	5.6%	5.5%	5.6%	5.7%	5.7%	5.7%	5.6%	5.6%	5.6%	5.5%
Glass	2.2%	2.3%	2.4%	2.4%	2.5%	2.4%	2.4%	2.3%	2.4%	2.4%	2.4%
Other	2.3%	2.3%	2.3%	2.3%	2.4%	2.4%	2.4%	2.3%	2.3%	2.4%	2.4%

Note: Polypropylene is also used in thermoplastics polyolefin elastomers (TPO) as well and its use in that area is reported separately under rubber. Average TPO use is about 36 pounds per vehicle.

The performance of vehicles has improved significantly over the years. According to EPA data, for example, the average horsepower (HP) of model 2019 vehicles was 244 HP, compared to 214 HP in 2010, 181 HP in 2000 and 135 HP in 1990. Average fuel efficiency now averages 25.5 miles per gallon (MPG) compared to 22.6 MPG in 2010, 19.8 MPG in 2000 and 21.2 MPG in 1990. Although vastly improved engine technologies have played a role, so have chemistry and lightweight materials.

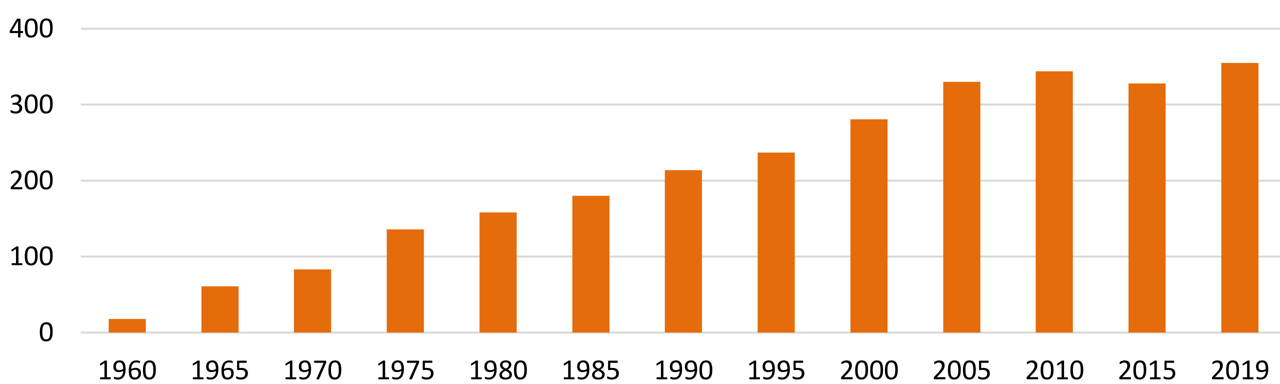
Regular steel and high- and medium-strength steel are the dominant materials in light vehicles. Combined, these steels account for slightly less than 50% of average vehicle weight. High- and medium-strength steel have been gaining share away from regular steel. In addition, the hot-stamping process offers many advantages and has supported steel use. Other steel and iron castings have generally lost share. Combined, all iron and steel (including castings) accounted for 58% of average vehicle weight, down from 60% in 2010, 65% in 2000, and 70% in 1990.

Over the last several decades, lightweight materials have gained share away from iron and steel. For example, aluminum retained its share in 2019, rising 0.2% (or one pound) to an average of 427 pounds per vehicle. This is largely the result of the F-150 truck, the most popular vehicle model produced. Aluminum use represented 10.7% of average vehicle weight, up from 8.6% in 2010, 6.9% in 2000 and 4.7% in 1990. During this period, other lightweight materials such as magnesium and plastics and composites have also gained market share away from iron castings, steel, lead, and other heavier materials. Details on materials used are presented in Table 2. Additional metals include copper and brass, lead, and zinc, and others in both powder and solid form. Glass, rubber, coatings, textiles, fluids and lubricants, and other materials round out the composition of a typical light vehicle.

Plastics and Polymer Composites in Light Vehicles

Light vehicles represent an important market for plastics and polymer composites, one that has grown significantly during the last five decades. The average North American light vehicle now contains 355 pounds of plastics and polymer composites, 8.9% of the total weight. Although this share is off from the prior peak of 9.5% in 2009, it is up from 344 pounds in 2010, 281 pounds in 2000 and 214 pounds in 1990. In 1960, most vehicles contained less than 20 pounds of plastics and polymer composites. The typical light vehicle may contain over than 1,000 plastic parts.

Figure 2
Long-Term Trends in NAFTA Light Vehicle Plastics & Polymer Composites Use (pounds/vehicle)



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Composites are any combination of polymer matrix and fibrous reinforcement. Glass, carbon, aramid, and other fibers provide strength and stiffness while the polymer matrix (or resin) of polyester, polyurethane, epoxy, polypropylene, nylon, or other resin protects and transfers loads between fibers. This creates a material with attributes superior to polymer or fiber alone. In recent years, carbon fiber-reinforced composites have made inroads into light vehicle applications.

Plastics and polymer composites have been essential to a wide range of safety and performance breakthroughs in today's cars, minivans, pickups and SUVs. Today's plastics typically make up 50% of the volume of a new light vehicle but less than 10% of its weight, which helps make cars lighter and more fuel efficient, resulting in lower greenhouse gas emissions. Tough, modern plastics and polymer composites also help improve passenger safety and automotive designers rely on the versatility of plastics and polymer composites and the aesthetic possibilities when designing today's vehicles. In addition, many plastic resins are recyclable.

- **Automotive Body Exterior -** Plastics and polymer composites have revolutionized the design of body exteriors. From bumpers to door panels, light weight plastic provides vehicles with better gas mileage compared to many alternatives and allows designers and engineers the freedom to create innovative concepts that otherwise would be impossible. In the past, metals were synonymous with auto body exterior design and manufacturing. However, they can be susceptible to dents, dings, stone chips and corrosion. They also tend to be heavier and more expensive than plastics. Specifying plastics and composites for automotive body exterior panels and parts can allow manufacturers to adopt modular assembly practices, lower production costs, improve energy management, achieve better dent resistance, and use advanced styling techniques for sleeker, more aerodynamic exteriors.

- **Automotive Interior -** The elements of automotive interior design -- comfort, noise level, aesthetic appeal, ergonomic layout, and durability -- have a great effect on a consumer's purchasing decision. Plastic automotive interior parts address all of these aspects, and more, in a remarkably effective and efficient manner.

- **Automotive Safety -** The versatility of plastics allows design options that reduce vehicle weight while producing safer vehicles. Included are plastic composite structures in the front end of a vehicle that reduce vehicle weight without compromising safety and plastic components in crumple zones that help absorb energy while lowering vehicle weight. Plastics are also used in door modules to maintain or improve side impact safety, plastic layers in automotive safety glass prevent passenger injuries, and plastic foams can add strength to automotive body cavities and increase occupant safety in vehicles.

- **Automotive Electrical Systems –** Over the last 20 years, the electrical systems of light vehicles have undergone a major revolution. Automotive electrical and electronic system components are now more numerous and important with computer chips regulating and monitoring ABS brakes, fuel injection, and oxygen sensors, GPS navigation equipment, obstacle sensors, state-of-the-art audio systems, and other systems. Plastics make possible the inclusion, operation, interconnection and housing of sockets, switches, connectors, circuit boards, wiring and cable, and other electrical and electronic devices.

- **Automotive Chassis -** A chassis is the supporting frame of a vehicle. It gives the vehicle strength and rigidity, and helps increase vehicle safety and performance. Plastics are making inroads into the chassis market. Plastics can enhance passenger safety by improving the chassis' ability to absorb energy generated during a crash. The chassis is also especially important in ensuring low levels of noise, vibration and harshness (NVH) throughout the vehicle. Not only does a reduction in NVH allow for a more pleasant driving experience, but by putting less stress on connecting components, it can help increase the life span of these components. Innovations in plastic technology have brought about the development of successful chassis applications and structure, support and suspension performance.

- **Automotive Powertrains -** The powertrain is one of a light vehicle's most complicated parts. The term "powertrain" refers to the system of bearings, shafts, and gears that transmit the engine's power to the axle. Included are composite drive shafts that increase torque. Plastics help reduce the number of parts needed to assemble these complex components. Plastics also help reduce vehicle weight, which helps lower assembly costs while increasing fuel efficiency. For example, the utilization of lightweight plastics in a vehicle can allow manufacturers to utilize smaller, lighter weight engines.

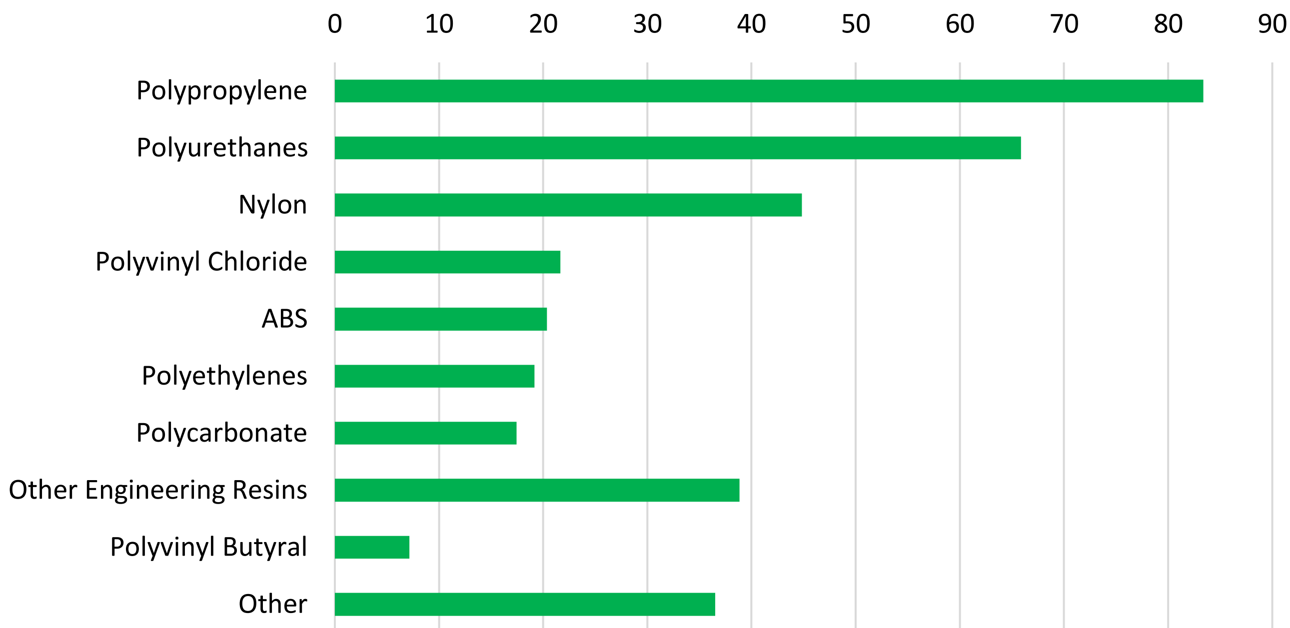
- **Automotive Fuel Systems -** For automotive fuel system components, plastics have several advantages that enable them to outperform metals in key areas. Plastic frees engineers from many design constraints that metal imposes. Plastic's light weight makes vehicles more fuel-efficient and from a safety standpoint, rupture-resistant plastics with high impact strength are helping keep automotive fuel tanks and related delivery systems leak-proof, corrosion-resistant, and reliable.

- **Automotive Engine Components -** Many of today's automotive engine components are plastic. From air-intake manifolds and systems to cooling systems to valve covers and other engine parts, plastic helps make engine systems easier to design, easier to assemble, and lighter in weight. Plastics' versatility has revolutionized automotive engine component design.

The automotive market is an important market for plastic resins such as nylon (polyamides), other engineering polymers, and thermoplastic polyesters. Light vehicle applications often account for over 30% of the demand for each resin. Other resins include ABS and polyvinyl butyral. For the latter resin which is used in safety glass, the automotive market accounts for over 85% of total demand. Engineering polymers such as nylon, polycarbonate (and polycarbonate blends) and others are supplanting metals in many applications. Typical plastics and composite applications include exterior panels, trim, and bumper fascia, as well as interior trim panels, window encapsulation, headlamp housings, manifolds and valve covers, electronic/electric parts and components, wiring harnesses, steering wheels, insulation, dampening and deadeners, upholstery, mechanical parts and components, safety glass, and myriad other uses.

Average plastics and composites per vehicle use increased five pounds (1.4%) to 355 pounds in 2019, and plastics and composites maintained its share of the overall weight of a typical vehicle. Over 15 major resins find significant use in light vehicles. Details on resin use are presented in Tables 3 and 4. Major polymers used in light vehicles include on average 83 pounds of polypropylene (PP), 66 pounds of polyurethanes, 45 pounds of nylon, 22 pounds of polyvinyl chloride (PVC), 20 pounds of acrylonitrile-butadiene-styrene (ABS), 19 pounds of polyethylene resins, and 17 pounds of polycarbonate resins.

Figure 3
Average Plastics & Polymer Composites Use in North American (NAFTA) Light Vehicles in 2019 (pounds/vehicle)



Polypropylene is also used in thermoplastics polyolefin elastomers (TPO) and its use in that area is reported separately under rubber. Average TPO use is about 36 pounds per vehicle and if it were included in plastics and polymer composites the total would be the equivalent of 391 pounds per vehicle.

Table 3
Average Large Volume Plastics Content of North American (NAFTA) Light Vehicles (pounds per vehicle)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Plastic/Composites	**365**	**344**	**340**	**325**	**323**	**323**	**328**	**329**	**345**	**350**	**355**
Polypropylene	79	85	85	84	82	83	83	83	85	84	83
Polyurethanes	56	56	57	54	54	58	59	58	63	64	66
Nylon	42	37	38	38	38	38	38	38	41	43	45
Polyvinyl Chloride	38	30	26	22	21	20	20	20	21	22	22
ABS	27	23	21	18	18	17	18	19	19	20	20
Polyethylenes	18	17	17	17	17	16	17	18	18	19	19
Polycarbonate	21	18	17	17	16	15	16	15	16	17	17
Other Engineering Resins	45	38	37	35	36	36	37	37	39	39	39
Polyvinyl Butyral	7	7	7	7	7	7	7	7	7	7	7
Other	34	34	35	34	34	33	34	33	35	36	37
Total Plastic/Composites	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Polypropylene	21.5%	24.6%	25.0%	25.7%	25.5%	25.6%	25.3%	25.1%	24.8%	23.9%	23.5%
Polyurethanes	15.4%	16.3%	16.7%	16.7%	16.8%	17.9%	17.9%	17.7%	18.2%	18.4%	18.5%
Nylon	11.4%	10.8%	11.2%	11.5%	11.7%	11.6%	11.6%	11.6%	12.0%	12.2%	12.6%
Polyvinyl Chloride	10.3%	8.6%	7.5%	6.9%	6.7%	6.3%	6.0%	6.1%	6.2%	6.2%	6.1%
ABS	7.3%	6.6%	6.2%	5.6%	5.4%	5.3%	5.4%	5.7%	5.5%	5.6%	5.7%
Polyethylenes	4.8%	4.9%	5.0%	5.3%	5.3%	5.1%	5.2%	5.4%	5.1%	5.5%	5.4%
Polycarbonate	5.6%	5.2%	5.1%	5.1%	4.9%	4.7%	4.8%	4.7%	4.7%	4.8%	4.9%
Other Engineering Resins	12.2%	11.1%	11.0%	10.7%	11.1%	11.2%	11.3%	11.3%	11.3%	11.2%	10.9%
Polyvinyl Butyral	2.0%	2.0%	2.0%	2.0%	2.1%	2.1%	2.1%	2.2%	2.1%	2.0%	2.0%
Other	9.4%	9.8%	10.2%	10.4%	10.5%	10.2%	10.5%	10.2%	10.3%	10.2%	10.3%

Note: Polypropylene is also used in thermoplastics polyolefin elastomers (TPO) but its use in that area is reported separately under rubber in Table 2. TPO use averages about 36 pounds per vehicle. Polypropylene resin applications include Interior trim, under-the-hood components, HVAC components, battery cases, and other OEM uses.

Over the last two decades, other engineering resins such as polyacetal, polyphenylene ether (PPE), and thermoplastic polyester engineering resins have supplanted metals in a number of applications. Average use of these resins was per vehicle 39 pounds in 2019, up from 38 pounds in 2010, 30 pounds in 2000, and 20 pounds in 1990. Polycarbonate and nylon are also classified as engineering resins (as are some ABS grades) and if polycarbonate and nylon resins were included, total engineering resin consumption would be 101 pounds. An average of seven pounds of polyvinyl butyral are used per vehicle. Additional resins such as acrylics, phenolics, unsaturated polyester, and others account for the remaining 37 pounds.

Table 4
Average Engineering & Other Plastics Content of North American (NAFTA) Light Vehicles (pounds per vehicle)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Other Engineering Resins	**45**	**38**	**37**	**35**	**36**	**36**	**37**	**37**	**39**	**39**	**39**
Polyacetal	8	6	5	4	5	5	4	4	5	5	5
Polyphenylene Ether (PPE)	12	13	13	13	13	13	13	13	14	14	14
Thermoplastic Polyester Engineering Resins	23	17	16	16	15	15	16	17	17	17	17
All Other Engineering Resins	3	2	3	3	3	3	3	3	4	4	4
Other Plastic/Composites	**34**	**34**	**35**	**34**	**34**	**33**	**34**	**33**	**35**	**36**	**37**
Acrylics	5	4	4	4	5	5	5	5	5	5	5
Phenolics	10	12	12	12	12	12	12	12	12	13	13
Unsaturated Polyester	14	12	12	12	12	12	12	11	12	12	13
All Other Resins	6	5	6	5	5	5	5	6	6	6	6

Additional opportunities to reduce weight with plastics and polymer composites are possible. These include: 1) reducing the weight of existing plastic and composite parts with the use of low density additives, nanoparticles, and alternate fibers; and 2) converting more metal parts to plastics and composites. Furthermore, industry mega trends for future mobility, including self-driving vehicles and ride-sharing platforms will create numerous unique opportunities for plastics and composites due to increased safety requirements and new vehicle architectures. As a result, the light vehicle market presents significant opportunities for further diffusion of plastics and composites in the future.

Other Chemical Products and Light Vehicles

A variety of other products of chemistry are used in the manufacture of light vehicles. Most chemistry is used in processing and other indirect chemistry (e.g., soda ash in glass manufacture) but also over 280 pounds of rubber, textiles and coatings are used as well.

The typical light vehicle utilizes, on average, 217 pounds of rubber, mainly in tires but also in non-tire applications such as belts and hoses, and other components. Natural rubber is used but by far the most widely used rubber is styrene-butadiene rubber (SBR) which is used in tire and a variety of non-tire applications. Common uses include radiator and heater hoses, various body and chassis parts, bumpers, weather-stripping, door and window seals, mats, grommets, tubes, fan belts and various molded and extruded goods. Thermoplastic polyolefin elastomers (TPO) are another widely used elastomer. Applications include a wide variety of exterior, interior and under-the-hood and chassis applications. Combined, natural rubber, SBR and TPO elastomers account for three-fourths of overall rubber consumption. Other elastomers include butyl rubber, chlorinated polyethylene, chlorosulfonated polyethylene, copolyester-ether, ethylene-propylene, nitrile, polybutadiene, polychloroprene (neoprene), polyisoprene, polyurethane, silicone, styrenic thermoplastics and other elastomers. Since the 1970s, design improvements have reduced tire weights which enhances fuel efficiencies. In recent years, longer-lasting, low- rolling-resistance tires and new materials have been developed and as these products penetrate markets, fuel performance should be enhanced.

The typical light vehicle utilizes 47 pounds of manufactured fibers, primarily synthetic fibers. Very few natural fibers are used and rayon and melamine fiber use has largely disappeared. Most notable synthetic fibers are traditional woven fibers of nylon and polyester but also non-woven fabrics of polypropylene and polyester used in various facings, backings, liners, acoustic panels, reinforcements and panels, and automotive filters. These fibers are derived from hydrocarbons. In recent years, traditional textiles are being supplanted by polyurethanes. Carbon fiber is typically blended with plastics to create carbon fiber reinforced plastics (CFRP) for automotive applications. Carbon fiber's high-strength but very low weight properties can play a major role in automakers' efforts to reduce vehicle weight.

The typical North American light vehicle also features 29 pounds of coatings (dry weight). In automotive applications, coatings enhance value by making the vehicle attractive and protecting it. Without coatings, vehicles would quickly rust, be dull in appearance, and have a very short service life. Light vehicle applications include topcoats, primers and coatings for underbody components and include solvent-borne, water-borne and powder coatings. Powder coatings are based mainly on epoxy and polyester resins, which upon heating react with curing agents to form very durable coatings that emit virtually zero VOCs (volatile organic compounds). These have gained in use relative to traditional solvent-borne coatings in recent decades. Coatings use has declined in recent years because of reduced waste generation during application, thinner coatings, and the switch to higher solids coatings as well as greater plastics and polymer composite use.

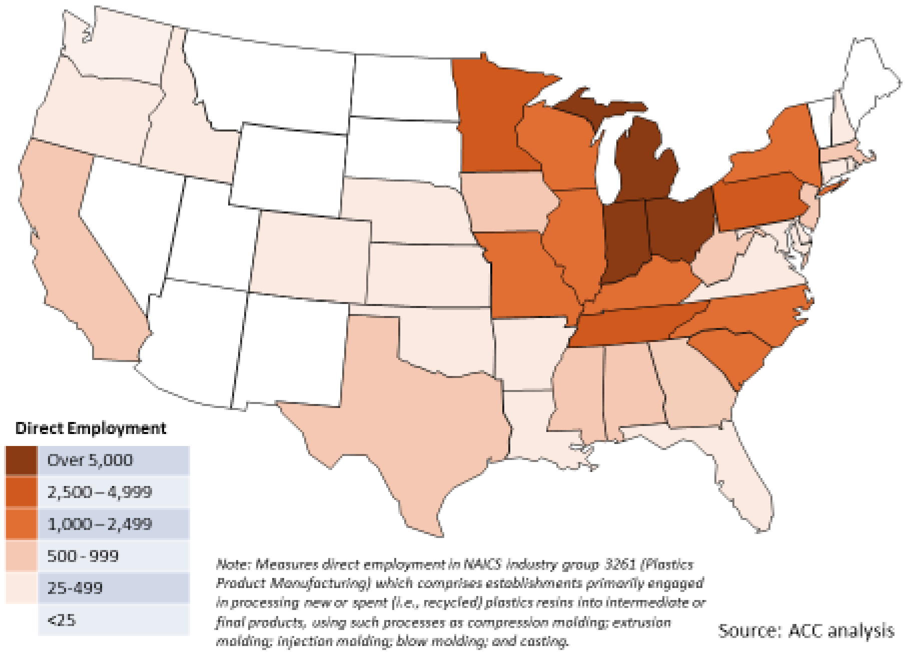
In addition to these materials, chemistry also plays a role in the 220 pounds of fluids and lubricants that a typical light vehicle contains. These include engine oil lubricants, transmissions fluids, windshield wiper fluids, refrigerants for air conditioners, and other products. All of these contain chemical additives to enhance performance while others such as fluorocarbon refrigerants are products of chemistry. In engine oil lubricants, synthetic lubricants are gaining market share away from traditional petroleum products. The rise of EVs (electric vehicles) will affect this category.

Economic Footprint of Automotive Plastics and Polymer Composites in the USA

Light vehicles represent an important market for plastics and polymer composites, one that has grown significantly during the last five decades. The following analysis assesses the jobs (by state) associated with plastic products used in automotive applications in the United States. It measures jobs (and shipment value and the value of wages and salaries) by state at the level of plastic product manufacturing. That is, at the level of North American Industry Classification System (NAICS) industry group 3261 (Plastics Product Manufacturing) which comprises establishments primarily engaged in processing new or spent (i.e., recycled) plastics resins into intermediate or final products, using such processes as compression molding; extrusion molding; injection molding; blow molding; and casting.

Table 5 contains data on 2019 jobs by state as well as shipment and wages and salaries values for automotive plastic products. Shipments measure the value of these finished or fabricated products used in these automotive applications by establishments in NAICS industry group 3261 and produced within that state. In addition to direct employment, the analysis also measures indirect employment supported by the automotive plastic products sector via purchases from its supply chain and induced employment from the spending of those employed directly or indirectly by the automotive plastic products sector.

Figure 4
Automotive Plastics & Polymer Composites Direct Employment by State (2019)



The analysis is based on plastic processing volume data compiled by Townsend Solutions and data from the Bureau of Labor Statistics and the Census Bureau. The state data are for 2019.

- The value of automotive plastic products produced in the United States was $21.3 billion.
- These automotive plastic products are produced at 1,591 plants located in 45 states.
- These plants directly employ over 63,075 people and feature a payroll of $3.3 billion.
  Michigan is the leading state in terms of direct employment (15,261) and is followed by Ohio (8,775), Indiana (8,221), Tennessee (4,354), Minnesota (3,081), Pennsylvania (2,899), Wisconsin (2,307), Illinois (2,199), North Carolina (1,739), and New York (1,583).

The economic contributions of the US automotive plastics industry are numerous, though often overlooked in traditional analyses that consider only the direct jobs and output of the industry. Not only are jobs created directly by the industry, additional jobs are supported by the US automotive plastics industry and by subsequent expenditure-induced activity. The US automotive plastics industry pays its employees' wages and salaries and purchased supplies and services (including transportation, contract workers, warehousing, maintenance, accounting, etc.). These supplier businesses, in turn, made purchases and paid their employees, thus the US automotive plastics industry generates several rounds of economic spending and re-spending.

In addition to the direct effects of the US automotive plastics industry, the indirect and induced effects on other sectors of the economy can also be quantified. The economic impact of an industry is generally manifested through four channels:

- Direct impacts - Such as the employment, output and fiscal contributions generated by the sector itself
- Indirect impacts - Employment and output supported by the sector via purchases from its supply chain
- Induced impacts - Employment and output supported by the spending of those employed directly or indirectly by the sector
- Spillover (or catalytic) impacts - The extent to which the activities of the relevant sector contribute to improved productivity and performance in other sectors of the economy

This report presents the jobs created that are related to the first three channels. Spillover (or catalytic) effects do occur, but these positive externalities are difficult to accurately quantify and were not examined in the analysis.

To estimate the economic impacts from the US automotive plastics industry, the IMPLAN model was used. The IMPLAN model is an input-output model based on a social accounting matrix that incorporates all flows within an economy. The IMPLAN model includes detailed flow information for 440 industries. As a result, it is possible to estimate the economic impact of a change in final demand for an industry at a relatively fine level of granularity. For a single change in final demand (i.e., change in industry spending), IMPLAN can generate estimates of the direct, indirect and induced economic impacts. Direct impacts refer to the response of the economy to the change in the final demand of a given industry to those directly involved in the activity. Indirect impacts (or supplier impacts) refer to the response of the economy to the change in the final demand of the industries that are dependent on the direct spending industries for their input. Induced impacts refer to the response of the economy to changes in household expenditure as a result of labor income generated by the direct and indirect effects.

An input-output model such as IMPLAN is a quantitative economic technique that quantifies the interdependencies between different industries (or sectors) of a national economy. Although complex, the input-output model is fundamentally linear in nature and as a result, facilitates rapid computation as well as flexibility in computing the effects of changes in demand. In addition to studying the structure of national economies, input-output analysis has been used to study regional economies within a nation, and as a tool for national and regional economic planning. A primary use of input-output analysis is for measuring the economic impacts of events, public investments or programs such as base closures, infrastructure development, or the economic footprint of a university or government program. The IMPLAN model is used by the Army Corp of Engineers, Department of Defense, Environmental Protection Agency, and over 20 other agencies, numerous government agencies in over 40 states, over 250 colleges and universities, local government, non-profits, consulting companies, and other private sector companies.

As shown in Table 5, the direct output and employment generated by the US automotive plastics industry is significant. The $21.3 billion industry directly generated an estimated 63,075 jobs and $3.3 billion in payroll. But the full economic impact of the industry goes well beyond the direct jobs and output. Businesses in the automotive plastics and polymer composites industry purchase plastic resins, plastic additives, other raw materials, compounding and other services, and other products throughout the supply chain. Thus, it is estimated that 73,018 indirect jobs are supported by US automotive plastics and polymer composites operations. Finally, the wages earned by workers in the automotive plastics and polymer composites industry and throughout the supply chain are spent on household purchases and taxes generating what is calculated as over 85,775 payroll-induced jobs. All told, the $21.3 billion in automotive plastics output generates a total of nearly 159,000 jobs. As a result, each job in the automotive plastics industry generates additional employment elsewhere in the US economy. These data are shown in Table 6.

Table 5
US Automotive Plastics & Polymer Composites Direct Jobs, Output and Wages & Salaries by State (2019)

State	Shipments ($ million)	Shipments/ Person	Payroll ($ million)	Wages/ Person	Direct Employment
AL	$344	$353,301	$47	$47,931	975
AR	$51	$323,078	$7	$46,970	157
CA	$296	$376,457	$47	$59,584	785
CO	$21	$257,182	$5	$62,400	81
CT	$54	$299,627	$11	$62,149	181
FL	$52	$328,150	$8	$51,931	157
GA	$244	$428,531	$29	$50,172	569
IL	$750	$341,160	$143	$64,867	2,199
IN	$2,205	$268,169	$391	$47,558	8,221
IA	$228	$271,735	$43	$51,250	839
KS	$99	$341,250	$14	$47,107	290
KY	$573	$392,444	$76	$52,235	1,459
MD	$30	$310,807	$7	$72,418	98
MA	$280	$370,320	$49	$65,153	757
MI	$5,474	$358,697	$824	$53,991	15,261
MN	$753	$244,261	$176	$57,213	3,081
MS	$281	$339,228	$36	$43,605	829
MO	$258	$229,698	$57	$50,325	1,123
NE	$14	$276,910	$2	$44,245	52
NH	$52	$176,098	$17	$56,550	294
NJ	$172	$306,255	$35	$62,632	561
NY	$710	$448,679	$89	$56,423	1,583
NC	$540	$310,471	$91	$52,616	1,739
OH	$3,287	$374,620	$437	$49,850	8,775
OK	$17	$377,702	$2	$49,590	45
OR	$16	$216,229	$4	$52,129	76
PA	$882	$304,277	$156	$53,764	2,899
SC	$441	$406,389	$60	$54,976	1,084
TN	$1,659	$381,071	$207	$47,649	4,354
TX	$396	$418,932	$52	$55,216	946
VA	$115	$445,119	$16	$59,911	259
WA	$25	$318,872	$4	$53,883	77
WV	$139	$226,933	$28	$45,552	612
WI	$642	$278,129	$123	$53,338	2,307
Other	$170	$486,940	$18	$50,169	350
Total	**$21,270**	**$337,215**	**$3,312**	**$52,501**	**63,075**

Sources: ACC analysis based on data from the Bureau of Labor Statistics, the Census Bureau, and Townsend Solutions.

Table 6
US Automotive Plastics & Polymer Composites Direct, Indirect and Induced Jobs by State (2019)

State	Direct Employment	Indirect Employment	Induced Employment	Total Employment
AL	975	980	1,024	2,004
AR	157	158	145	303
CA	785	1,175	1,092	2,267
CO	81	109	126	235
CT	181	171	222	393
FL	157	232	240	472
GA	569	767	799	1,566
IL	2,199	2,704	3,575	6,279
IN	8,221	8,140	10,046	18,186
IA	839	798	878	1,676
KS	290	303	321	624
KY	1,459	1,439	1,632	3,071
MD	98	97	146	243
MA	757	801	1,077	1,878
MI	15,261	18,112	23,386	41,498
MN	3,081	4,048	4,866	8,914
MS	829	800	739	1,539
MO	1,123	1,294	1,472	2,766
NE	52	57	60	117
NH	294	297	397	694
NJ	561	631	779	1,410
NY	1,583	1,554	1,538	3,092
NC	1,739	2,157	2,197	4,354
OH	8,775	11,184	11,944	23,128
OK	45	49	45	94
OR	76	94	93	187
PA	2,899	3,408	4,281	7,689
SC	1,084	1,168	1,251	2,419
TN	4,354	4,935	5,619	10,554
TX	946	1,445	1,476	2,921
VA	259	273	288	561
WA	77	88	79	167
WV	612	489	483	972
WI	2,307	2,661	2,971	5,632
Other	350	400	442	842
Total	**63,075**	**73,018**	**85,729**	**158,747**

Sources: ACC analysis based on data from the Bureau of Labor Statistics, the Census Bureau, and Townsend Solutions.

ACC Plastics Division

ACC's Plastics Division advocates to enhance opportunities for plastics and promotes their economic, environmental and societal benefits. Representing resin producers and distributors, the Plastics Division creates value for its members by promoting the benefits of plastics, advocating for responsible public policies, and advancing plastics interests in strategic markets. ACC's Plastics Division applies a three-pronged approach to strategic plastics issues management: (1) aggressive advocacy and grassroots action; (2) pre-emptive and targeted communications; and (3) highly focused technical and scientific programs. These integrated efforts enable the Plastics Division to effectively manage emerging and high-profile issues in the environmental and health arenas. Examples include product sustainability, recycling, and other end-of-life issues as well as chemical migration concerns specific to plastic products. In addition, the Plastics Division's four Market Issues Teams – Automotive, Building and Construction, Electrical and Electronics, and Packaging and Consumer Products – work with key customers and the plastics value chain to advantage plastics in strategic markets. Their activities include pre-competitive marketing, leveraging federal research dollars, advocating code and policy changes, and resolving potential obstacles to growth.

The automotive industry continues to be an important customer for the chemical industry. This is especially true for basic and specialty chemicals because the average light vehicle produced in the United States contains $3,152 of chemistry. The Automotive Market/Issue Team (AMIT) operates in a political and technical environment managing key issues affecting the automotive plastics market such as energy policy, climate change, emissions control, substance disclosure, recycling, environmental sustainability, competitive material challenges, and specific Federal/State technology development programs such as Freedom CAR. The AMIT is a proactive group dedicated to expanding the automotive market for plastics, and the team is focused on those pre-competitive initiatives that will help overcome unnecessary barriers to expanding opportunities for plastics.

The Automotive Center in Troy, Michigan provides a forum to showcase the best in today's automotive plastics applications, encourages innovative thinking, and promotes broader applications for plastics in the industry.

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Economics and Statistics Department

The Economics & Statistics Department provides a full range of statistical and economic advice and services for ACC and its members and other partners. The group works to improve overall ACC advocacy impact by providing statistics on American Chemistry as well as preparing information about the economic value and contributions of American Chemistry to our economy and society. They function as an in-house consultant, providing survey, economic analysis and other statistical expertise, as well as monitoring business conditions and changing industry dynamics. The group also offers extensive industry knowledge, a network of leading academic organizations and think tanks, and a dedication to making analysis relevant and comprehensible to a wide audience.

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Appendix: Data Sources and Methodology

The information presented in this report is an update building on ACC's earlier assessments of materials use per vehicle. Those previous assessments depended upon the materials use per vehicle data supplied by American Metal Market with some adjustments for non-automobile light vehicles (SUVs, light-duty trucks, mini-vans, etc.) The reporter who tabulated this data, however, retired and the data are no longer available. The assessment presented here reflects an attempt to resurrect and re-estimate the data for materials use per vehicle. While the original data reflected typical domestic automobile use of materials, the present assessment reflects the average for all light vehicles on an OEM (original equipment manufacturer) basis. The analysis also builds upon research on automotive high-tech materials initiated during the 1980s (and since maintained) by Dr. TK Swift, the primary author of this analysis.

A "bottoms-up" approach was taken by examining light vehicle use by type of material. We examined over 70 distinct materials. The data for the materials use were provided by trade associations and government statistical agencies. Data sources include The Aluminum Association, American Composite Manufacturers Association, American Fiber Manufacturers Association, American Iron & Steel Institute, Copper Development Association, International Magnesium Association, and the Rubber Manufacturers Association. The provision of data and advice from these associations are gratefully acknowledged. Data from the Bureau of the Census and the US Geological Survey were also used.

The plastics and composite data are derived from the American Chemistry Council's Plastics Industry Producers' Statistics (PIPS) service, which provides relevant, timely, comprehensive and accurate business statistics on the plastic resins industry. This was supplemented by an exhaustive search of the trade literature. The averages are calculated using an assessment of the material consumed with adjustments made to take into account replacement demand. The sum of the individual materials data are close to the comparable average vehicle data provided by the Environmental Protection Agency (EPA) and the Office of Energy Efficiency and Renewable Energy (EERE) of the US Department of Energy (DOE).

The data represent the average use of materials for light vehicles assembled in North America. That is, the NAFTA region, which includes the United States, Canada, and Mexico.

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