Chemistry and Automobiles

Lighting the Way to the Future of Motor Vehicles

March 2023

Executive Summary

Automobiles that are lighter weight, more fuel efficient and safer for occupants are made possible by plastics and other products of chemistry. The $367 billion North American automobile manufacturing industry represents a significant end-use market for the chemical industry. In 2021, more than 13 million passenger automobiles and light-duty trucks were produced in the United States, Canada, and Mexico and, on average, each vehicle contains over $4,000 in chemistry.

Over the past decade, the chemistry value per vehicle has grown by an average of 20% (or $669). This includes $710 in plastics and polymer composites, $651 in synthetic rubber and elastomers, $540 in semiconductors and other electronic chemicals, $324 in fluids and lubricants, and $241 in textiles, along with hundreds of dollars worth of other products of chemistry.

The average weight of an automobile in 2021 was 4,287 pounds, up 121 pounds (3%) compared to 2020. Plastics and polymer composites account for nearly 10% (411 pounds) of the average weight, up 16% compared to 2012 (354 pounds). Plastics are used in a variety of innovative ways to help make cars safer and more fuel efficient. Plastics can make vehicles more lightweight, help increase fuel efficiency and reduce carbon emissions, and help provide safety benefits like seatbelts and airbags. In addition to plastics and polymer composites, the typical vehicle includes 219 pounds of synthetic rubber (5% of total vehicle weight), 195 pounds of fluids and lubricants, 99 pounds of textiles, and 45 pounds of coatings – all products of chemistry.

Innovation in the automotive industry continues to advance and automobiles are becoming increasingly technology focused. These innovations – and those yet to come – are made possible by products of chemistry.

Introduction

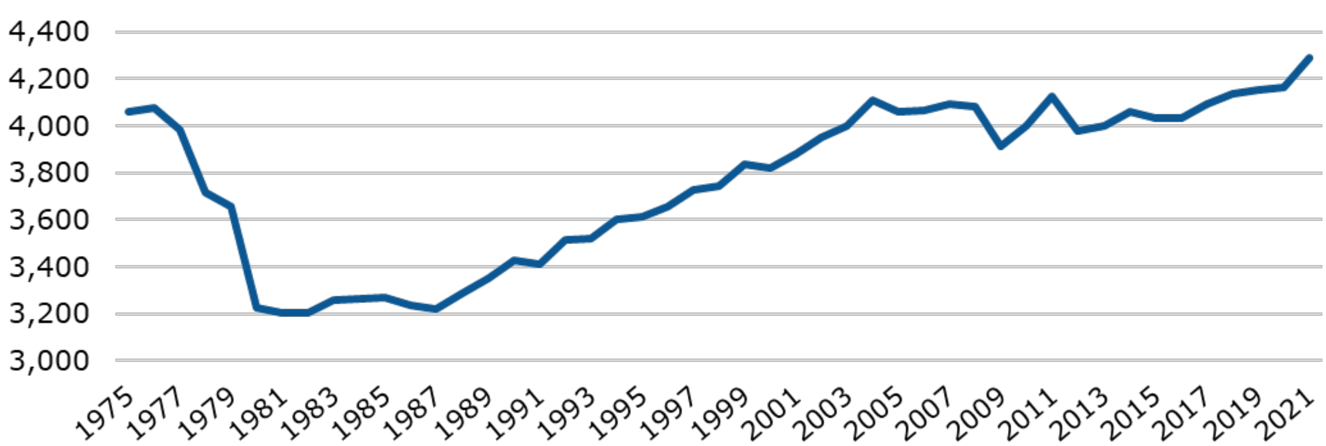
Plastics and other products of chemistry are essential to today's automobile, which includes both passenger automobiles and light-duty trucks (pick-up trucks, minivans, and sport utility vehicles). This report presents an analysis of the volume and value of chemistry components in an average automobile produced in North America.[1]

More than 13 million automobiles were produced in North America in 2021, accounting for $367 billion in sales. These vehicles were manufactured by more than twenty companies and include hundreds of models. While this report attempts to quantify the chemistry content in an average automobile, it should be noted that the components of individual vehicles can vary widely.

Trends in Automobiles

In 2021, the average weight of an automobile rose by 121 pounds (or 2.9%) to 4,287 pounds – the highest since 1975. Over the past two decades, the average vehicle weight has hovered around two (U.S.) tons, or 4,000 pounds, around the same weight as the average vehicle in 1975. However, the average vehicle weight has fluctuated over the past several decades. In the 1980s and 1990s, the average weight was closer to 3,500 pounds.

Figure 1. Average Vehicle Weight (lbs)



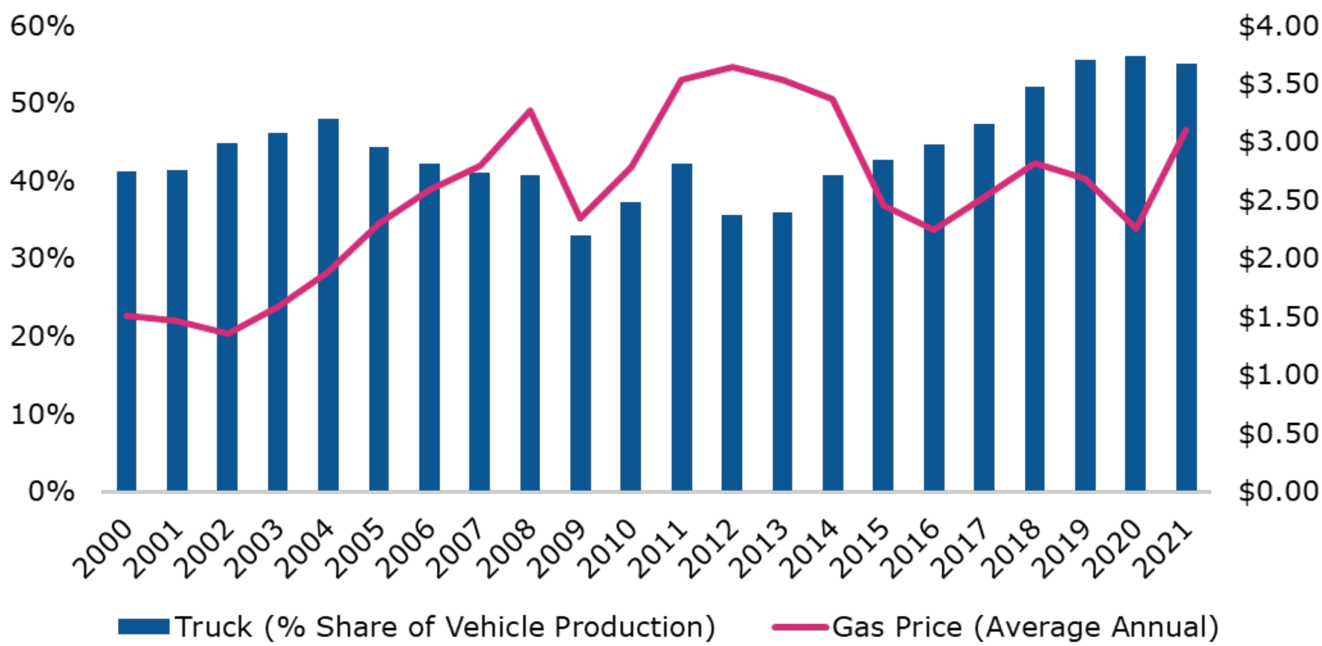
Source: EPA

[1] Note, for the purposes of this report, the term "automobile" is used to refer to a class of vehicles including passenger cars (e.g., sedans, wagons, small sport utility vehicles) and light trucks (e.g., pickups, minivans, larger sport utility vehicles). The term "vehicle" is used interchangeably with "automobile" except when otherwise delineated.

The rising and falling of average vehicle weights over time can be attributed to a number of factors, such as consumer preferences, gasoline prices, and material composition. For example, the average automobile weight began to increase in the 1990s as light-duty trucks and SUVs became a larger share of the automotive market. In fact, trucks (including larger SUVs and minivans) have continued to increase market share over the past several decades and have held more than 50% of the market since 2018.

Since larger vehicles generally use more fuel (i.e., gasoline or diesel), consumers tend to purchase smaller vehicles when average gas prices are high. This trend has been particularly visible over the past two decades, as illustrated in the following figure. After gasoline prices reached (then) record highs in 2008, the market share for trucks fell more than seven percentage points, from 40.7% to 33.0%, the following year. In the early 2010s, gas prices averaged around $3.50 per gallon, and trucks maintained a market share between 35% and 40%. As gas prices dropped in the latter half of the decade, the vehicle market share held by trucks grew, increasing every year between 2015 and 2020.

Figure 2. Light-Duty Truck Share of Market and Average Gasoline Prices



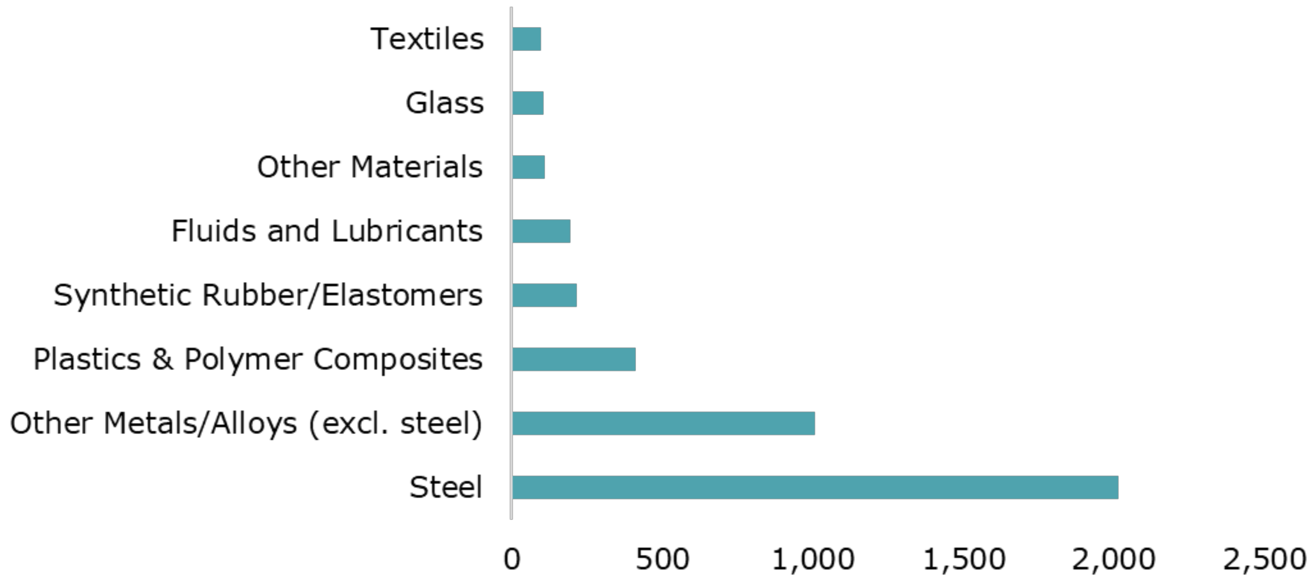
Source: EPA, U.S. EIA
Note. Data for U.S. only

The material composition also plays a key role in the overall weight of the vehicle. As plastics and polymer composites and other lightweight materials replace heavier materials, such as steel and other metals, the vehicle weight is reduced. All told, the fluctuations in average vehicle weight cannot be attributed to a single factor, but rather a multitude of elements reflecting the ever-changing dynamics in the automotive industry.

Automotive Chemistry

The automobile manufacturing industry represents a large share of the North American economy, totaling $367 billion in manufacturers' shipments in 2021. Motor vehicle manufacturing is also an important end-use market for the chemical industry; nearly every component of an automobile contains, or has been touched by, chemistry. In 2021, on average, every automobile manufactured for sale in North America contained $4,069 in chemistry (chemical products and processing chemicals).

Figure 3. Materials Content of an Average Automobile (lbs/vehicle)



Over the past decade, the chemistry value per vehicle has grown by an average of 20% (or $669). Chemistry is used throughout automobiles from the front bumper, which uses plastics such as polyethylene and/or polypropylene, to the tail light housing, which is often made with polycarbonate, acrylonitrile butadiene styrene (ABS), and/or polybutylene terephthalate (PBT). Chemistry is a key component of automotive exteriors, such as paints and coatings, windows and windshields, and door handles. Automotive interiors such as airbags and seatbelts, seating, and dashboards are also products of chemistry.

Plastics and Polymer Composites

Automotive Applications

Lightweight plastics and polymer composites play a critical role in today's automobiles, as well as in the transition to next-generation vehicles, as they enable vehicle weight reduction that helps automakers meet increasingly stringent fuel economy standards, while enhancing safety for drivers, passengers, and pedestrians.

Today's plastics make up 50% or more of the volume of an average vehicle but less than 10% of its weight, according to ACC calculations. Weight reduction in automotive design is a key driver in boosting fuel efficiency, reducing emissions and lowering costs for motorists. The performance of vehicles has improved significantly over the years: according to EPA data the average horsepower (HP) of model 2021 vehicles reached a high of 252, compared to 230 in 2011 and 138 HP in 1991. Average fuel efficiency (real-world miles per gallon) is now 25.3 compared to 19.6 MPG twenty years ago. Although improved engine technologies and drive train have played a role, so have chemistry and lightweight materials.

The following are just a few examples of how plastics and polymer composites contribute to the safety, performance, and aesthetics of today's vehicles. For more detailed information on the uses and benefits of plastics and polymer composites in automobiles, visit http://www.plasticmakers.org/autos

Exterior - From bumper to bumper, plastics help keep the vehicle—and the passengers inside—safe. Bumpers made of materials such as thermoplastic olefins (TPOs), polycarbonates, polyesters, polypropylene, and polyurethanes provide impact resistance as well as design flexibility. Plastic composites in automobile hoods can improve a vehicle's aerodynamics, while also contributing to the overall design aesthetic. Plastics also resist dents, dings, and corrosion, making them especially desirable for door panels and hoods. Plastics used in exterior components can be formulated with UV resistance and engineered to perform in extreme temperatures.

Interior - Many modern car interior parts are made with polymers, including lightweight seats, instrument panels, durable upholstery, sound control fabrics, the headliner, dash, and door panels. Instrument panels made from resins such as ABS, polycarbonates, and polypropylene allow for complex designs in items such as airbag housings, center stacks for instrument panels, and large, integrated instrument panel pieces. Consoles (e.g., armrests, cup holders, and storage spaces) would be difficult to reproduce as efficiently and with the same performance results using any family of materials other than plastics.

Safety - Many of the essential safety features in vehicles are made possible by chemistry and plastics. According to the National Highway Traffic Safety Administration (NHTSA), seat belts—which are typically made from polyester—saved nearly 15,000 lives in 2017. Air bags, which are commonly made from high-strength nylon fabric, are credited with saving 50,457 lives in the period from 1987 to 2017. Fiber-reinforced polymer composites can absorb four times the crush energy of steel while polypropylene and polyurethane foams and other polymer composites provide additional impact protection. Automated driver safety assist systems rely on plastic for the multitude of cameras and sensors that enable automated safety innovations, including back-up cameras and automated emergency braking systems.

Windshields, Windows & Sunroofs - North American windshields come as a multi-layer unit; the combination can be thinner, lighter, and stronger than tempered glass alone. The tear-resistant plastic layer helps prevent occupant ejection. Plastics can provide glare prevention and UV protection, as well as sealing solutions for sunroofs and windows.

Lighting - Plastics can operate at high temperatures, making them desirable materials for head lights, fog lights and tail lights. Plastic LEDs and acrylic fiber optic light tubes help make controls and instrument panels more readable. Plastics' use in safety door lighting helps alert oncoming cars of stopped roadside vehicles. Exterior lighting helps the driver see other vehicles and pedestrians, while also making the vehicle more visible to other vehicles.

Chassis - The chassis is the primary framework of an automobile, forming a base for the entire vehicle. The chassis supports the other parts of a vehicle, as well as the passengers. Plastics are essential to today's car chassis design, providing lighter weight, higher stiffness, and lower cost than traditional materials such as steel. Innovations in plastic technology contribute to successful structural applications, year after year. It would not be possible to achieve many of these enhancements as efficiently and with the same performance using other materials.

Electrical - A car's electrical system used to be limited to a few components, but today's vehicles rely on electrical components for myriad functions. Less than two decades ago, dashboards were crammed with heavy copper wiring. But advances in acrylic fiber optic cables have eliminated the need for copper. This means enhanced illumination of the interior, more accurate GPS data, and highly responsive ABS sensors. Plastics are also used in switches and sockets, connectors, and wiring.

Under the Hood - As under-the-hood conditions become more challenging, automakers and their suppliers increasingly rely on high-temperature plastic car parts to help reduce weight and cost, increase parts integration, and provide for longer service life. The powertrain, a system of bearings, shafts, and gears, is one of a car's most complicated parts. Plastics can help reduce the number of parts needed per component. Automakers rely on plastic's high strength to weight ratio combined with its anti-corrosive properties for electric vehicles and hybrid electric vehicles. Temperature resistant and thermally conductive plastics are used in heat sensitive applications, including electric vehicle battery parts and enclosures. Replacing metal components with plastics in EVs aids in weight reduction, reduces corrosion, provides design flexibility, and helps help keep batteries safe during collisions -- and on average weigh 35% less than metal enclosures. Compared with metal assemblies, large-format all-plastic housings enable cycle time reductions and contribute to lighter vehicle weight, thus extending the range of electric vehicles.

Weight of Plastics & Polymer Composites in Automobiles

The average automobile contained 411 pounds of plastics and polymer composites in 2021, 9.6% of a vehicle's total weight. This is up 16% compared to 2012. Over a dozen major resins find significant use in automobiles, including on average 97 pounds of polypropylene (PP), 84 pounds of polyurethane foam, 41 pounds of nylon, 34 pounds of high-density polyethylene (HDPE), and 31 pounds of polyvinyl chloride (PVC).

The average weight of polyacetal resins, which are used in fuel system applications such as caps, valves, and pumps, has grown 25% since over the past decade. Over the same period, HDPE use has increased 21%, polypropylene has increased 20%, and polybutylene terephthalate, used in under-the-hood and automotive electronics applications, has increased 20%. Most other major resins have also seen double-digit growth (in pounds) compared to 2012.

Table 1. Plastics & Polymer Composites in an Average Automobile (lbs/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Polypropylene	81	83	84	84	85	88	91	93	93	97
Polyurethane Foam	73	74	76	76	76	78	80	81	82	84
Nylon	37	38	38	38	38	39	39	39	39	41
High-Density Polyethylene (HDPE)	28	28	27	27	28	29	31	31	32	34
Polyvinyl Chloride (PVC)	25	26	27	27	27	28	29	30	30	31
Acrylonitrile Butadiene Styrene (ABS)	23	23	22	22	22	24	22	21	21	21
Polycarbonate	18	18	18	17	17	18	18	18	19	20
Phenolic Resins	12	11	11	11	11	12	12	13	13	15
Polyacetal Resin	8	8	8	8	8	9	9	9	9	10
Polyvinyl Butyral	6	6	6	6	6	6	6	6	6	7
Polybutylene Terephthalate (PBT)	5	5	5	5	5	5	5	5	5	6
Polymethyl Methacrylate (PMMA)	4	4	4	4	4	5	5	5	5	5
Other Plastics*	34	36	36	36	36	36	37	38	38	40
Plastics & Polymer Composites Total	**354**	**360**	**362**	**361**	**363**	**377**	**384**	**389**	**392**	**411**

*Other Plastics includes liquid crystal polymers, high-performance polyamides, polyphenylene ether, unsaturated polyester, and polyphenylene sulfide resins, among other small-volume plastics.
Note. See *Data and Methodology* for data sources.

Synthetic Rubber and Elastomers in Automobiles

The average automobile contained 219 pounds of synthetic rubber and elastomers, with an additional 79 pounds of natural rubber, in 2021. Olefinic thermoplastic elastomers, such as thermoplastic polyolefins, accounted for 53 pounds of total vehicle weight, followed by styrene-butadiene rubber (SBR) at 46 pounds. Polybutadiene and polyurethane elastomers made up 25 pounds each. While tires account for the majority of rubber use in vehicles, synthetic rubber and elastomers are used in a wide range of applications, including seals and gaskets, weatherstripping, mats and flooring, and hoses, among others.

The use of most synthetic rubber and elastomers has grown over the past decade, while the weight of natural rubber in an average automobile has dropped by 10%, from 88 pounds in 2010 to 79 pounds in 2021. In general, synthetic rubber offers superior qualities compared to natural rubber, particularly in its temperature and abrasion resistance. Additionally, property-enhancing chemical additives can further improve the performance of synthetic rubber and elastomers.

Table 2. Synthetic Rubber/Elastomers in an Average Automobile (lbs/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Olefinic Thermoplastic Elastomers	49	49	49	49	50	50	51	52	52	53
Styrene Butadiene Rubber	39	40	41	40	40	41	43	43	43	46
Polybutadiene	20	21	21	21	21	22	23	23	24	25
Polyurethane Elastomers	23	24	23	23	22	22	23	24	24	25
Ethylene-Propylene Elastomers	20	20	19	20	19	20	21	21	21	22
Butyl Rubber	13	12	12	12	12	13	13	14	15	16
Other Synthetic Rubber	23	21	22	21	21	22	23	23	24	25
Nitrile Elastomers	7	7	6	6	6	6	6	6	6	7
Synthetic Rubber/ Elastomers Total	**194**	**194**	**193**	**192**	**191**	**196**	**203**	**206**	**209**	**219**

Note. See *Data and Methodology* for data sources.

Other Chemical Products

Numerous other products of chemistry are used in automobiles, both in the composition of the vehicle itself and in the manufacturing processes.

The average vehicle contains 195 pounds of fluids including lubricants, engine oil, transmission fluid, antifreeze, gear oil, and windshield wiper fluids, among other products. These types of fluids contain chemistry, such as methanol in windshield wiper fluid, ethylene glycol in antifreeze, propylene glycol in engine coolants, and polyalphaolefins in synthetic lubricants. Automotive fluids often contain performance-enhancing chemical additives as well.

On average, today's automobiles contain 106 pounds of glass, an increase of 26% over the past decade. The most common type of glass – in automotive and myriad other applications – is soda-lime glass, which is primarily comprised of three chemical compounds: silica, sodium carbonate (soda ash), and calcium carbonate. Various other polymers and chemistries are used as layers and laminates to impart additional functionality to automotive glass, such as shatter-resistance, improved clarity, and UV-resistance.[2] Today's vehicles contain more glass than ever before: not only do larger vehicles require larger windshields, side windows, and sunroofs, but the surface area of windshields continues to grow as drivers desire increased visibility. Additionally, glass is used in dashboards and consoles, which increasingly include chemistry-enabled functionality such as touch screens.

The use of textiles (e.g., synthetic fibers, nonwovens, composites) in the average automobile has grown to 99 pounds in 2021, an increase of 27 pounds compared to 2012. Textiles are used throughout automobiles; in addition to the visible uses such as upholstery, flooring, and

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[2] https://cen.acs.org/articles/100/i14/Automotive-glass-manufacturing-and-recycling-presents-unique-challenges.html

seatbelts textiles are used in door panels and as reinforcement for tires and belts, among other applications.

The typical North American vehicle also uses an average of 45 pounds of coatings. In addition to the paint that provides color to the vehicle, coatings include primers, topcoats, and protective coatings for underbody components. A wide range of types of chemistries are used in automotive coating applications, including acrylic, melamine, polyurethanes, and thermosetting resins.

Table 3. Other Chemical Products in an Average Automobile (lbs/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Textiles	72	74	78	81	81	86	89	91	94	99
Coatings	46	44	45	44	44	45	41	42	42	45
Glass	84	84	89	91	93	94	99	100	101	106
Natural rubber	88	86	84	81	81	81	82	81	79	79
Fluids & Lubricants	191	192	199	198	194	188	190	183	187	195
Carbon Fiber	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5

Note. See *Data and Methodology* for data sources.

Other Automotive Materials

Since the start of the automotive industry, steel and steel alloys have comprised a large share of an automobile’s weight. For much of the twentieth century, steel was the primary material used in automobile chassis and bodies. While steel can provide the strength needed in automobiles, it is also extremely dense. As such, when lightweighting of vehicles became a focus in the late 1970s to improve fuel efficiency, some steel parts were replaced by lighter metals such as aluminum which can be as much as three times lighter than steel. Since 2012, the amount of aluminum has risen from 8.8% of total vehicle weight to 10.6% while steel has fallen from 52.0% to 47.0%.

Other lightweight materials such as magnesium and plastics and polymer composites have also gained market share away from steel and other heavier materials such as iron and lead.

While steel still accounts for a significant portion of an automobile’s weight, mild (low-carbon) steel has increasingly been replaced by lighter grades, such as high-strength steel and advanced high-strength steel (AHSS). A decade ago, more than half of the steel in an automobile was mild steel, while high-strength steel and AHSS (combined) represented 39% of total steel. In 2021, two-thirds of an automobile’s steel content was high-strength or AHSS, while mild steel accounted for less than one-third.

In addition to 2,015 pounds of steel, the average automobile contains 456 pounds of aluminum and 311 pounds of iron, as well as other metals such as zinc, copper and copper alloys, and magnesium.

Table 4. Metals Content in an Average Automobile (lbs/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Mild Steel	1,055	969	912	828	774	737	709	665	633	604
High-Strength Steel	517	536	578	603	611	655	669	685	712	740
AHSS	435	474	499	509	530	532	544	564	554	584
Other Steels & Steel Alloys	62	82	102	118	122	123	81	101	79	81
Steel (Total)	2,069	2,062	2,091	2,058	2,038	2,047	2,027	2,016	1,979	2,015
Aluminum	350	359	372	381	399	416	427	433	443	456
Iron	318	319	322	314	312	315	313	313	307	311
Magnesium	11	11	12	14	20	27	31	31	33	36
Copper and Copper Alloys	33	35	37	37	37	38	38	39	41	44
Zinc	45	46	48	48	50	51	53	54	55	57
Lead	34	34	34	33	33	31	31	30	29	30
Platinum group metals	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Other metals/alloys	57	54	67	68	60	62	65	66	68	74
Metals/Alloys (Total)	**2,917**	**2,920**	**2,983**	**2,953**	**2,949**	**2,987**	**2,985**	**2,982**	**2,955**	**3,023**

Note. See *Data and Methodology* for data sources.

Table 5. Materials Content as a Percent of Total Vehicle Weight

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Steel	52.0%	51.5%	51.5%	51.0%	50.5%	50.0%	49.0%	48.5%	47.5%	47.0%
Aluminum	8.8%	9.0%	9.2%	9.4%	9.9%	10.2%	10.3%	10.4%	10.6%	10.6%
Plastics & Polymer Composites	8.9%	9.0%	8.9%	8.9%	9.0%	9.2%	9.3%	9.4%	9.4%	9.6%
Iron	8.0%	8.0%	7.9%	7.8%	7.7%	7.7%	7.6%	7.5%	7.4%	7.3%
Other Metals/Alloys	5.9%	5.7%	6.6%	6.7%	6.5%	6.6%	6.9%	7.0%	7.0%	7.3%
Synthetic Rubber/Elastomers	4.9%	4.8%	4.8%	4.8%	4.7%	4.8%	4.9%	5.0%	5.0%	5.1%
Fluids & Lubricants	4.8%	4.8%	4.9%	4.9%	4.8%	4.6%	4.6%	4.4%	4.5%	4.5%
Glass	2.1%	2.1%	2.2%	2.3%	2.3%	2.3%	2.4%	2.4%	2.4%	2.5%
Textiles	1.8%	1.8%	1.9%	2.0%	2.0%	2.1%	2.2%	2.2%	2.3%	2.3%
Natural rubber	2.2%	2.1%	2.1%	2.0%	2.0%	2.0%	2.0%	1.9%	1.9%	1.8%
Coatings	1.2%	1.1%	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%

Note. Due to rounding, figures may not add to 100%.
See *Data and Methodology* for data sources.

The Value of Chemistry in Automobiles

The value of the chemistry content in an average automobile was $4,069 in 2021, up 20% (or $669) compared to a decade ago. The chemistry content includes $710 in plastics and polymer composites, $651 in synthetic rubber and elastomers, $540 in semiconductors and other electronic chemicals, $324 in fluids and lubricants, and $241 in textiles, along with hundreds of dollars' worth of other products of chemistry.

Figure 4. Chemistry Value in Automobiles

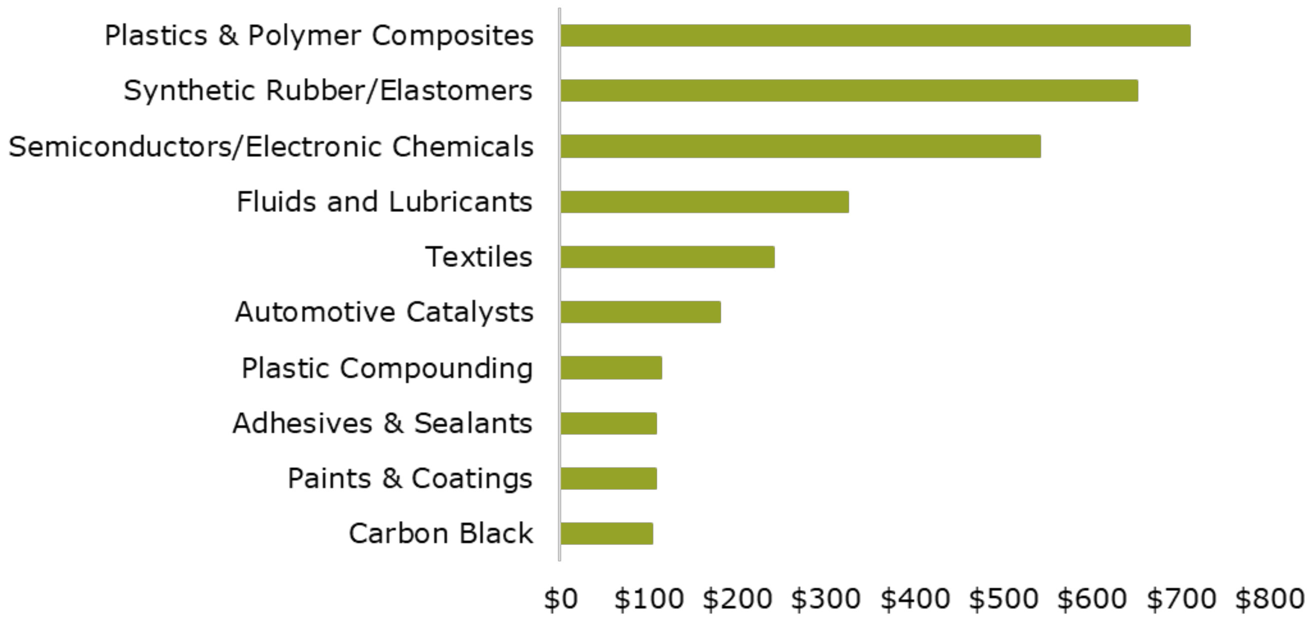


Table 6. Value of Chemistry in an Average Automobile ($/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Plastics & Polymer Composites	636	593	589	553	540	571	581	583	577	710
Synthetic Rubber/Elastomers	676	604	595	551	522	554	569	549	537	651
Semiconductors & Electronic Chemicals	379	388	422	413	433	396	450	480	504	540
Fluids & Lubricants	201	216	210	209	221	240	246	267	320	324
Textiles	221	224	226	219	214	221	235	237	229	241
Automotive Catalysts	162	163	164	167	168	170	171	173	175	180
Plastic Compounding	71	70	70	71	75	83	85	103	108	113
Paints & Coatings	111	110	108	93	92	94	93	92	96	107
Adhesives & Sealants	86	85	91	91	92	95	99	104	96	107
Carbon Black	82	74	73	67	63	74	79	82	77	103
Plastic Additives	80	78	79	77	77	78	80	82	81	86
Other Manufactured Fibers	74	75	75	73	71	74	78	79	76	80
Rubber Processing Chemicals	65	65	66	66	67	64	64	62	60	59
Solvents	20	19	19	18	18	19	20	20	21	24
Carbon Fiber	6	6	9	8	8	11	11	11	11	13
Other Processing Chemicals	488	472	463	429	465	501	518	534	514	593
Other Chemicals & Polymers	43	61	34	41	46	44	73	94	124	138
Total Chemistry Value ($)	**3,400**	**3,304**	**3,294**	**3,147**	**3,174**	**3,288**	**3,453**	**3,553**	**3,606**	**4,069**

Note. See *Data and Methodology* for data sources.

Value of Plastics & Polymer Composites

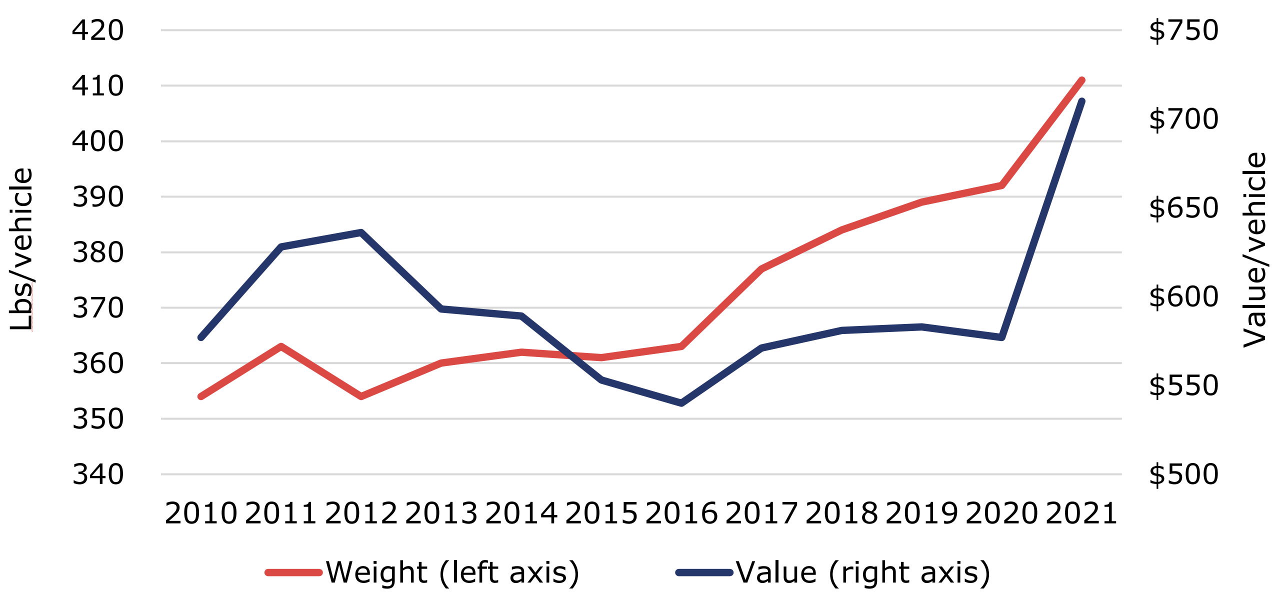
The value of plastics and polymer composites in an average automobile surpassed $700 per vehicle in 2021, an increase of 12% compared to 2012. This includes $75 of nylon, $74 of polyvinyl butyral, and $54 of polypropylene. Although the value of plastics and polymer composites generally increase as the cumulative weight of the products used in a vehicle increase, the pricing of plastics and polymer composites vary year to year and are based on various factors, including feedstock availability and cost, energy costs, labor rates, and currency exchange rates, among others. As such, the trends in value of plastics and polymer composites do not always mirror the trends in materials use, as shown in Figure 5.

Table 7. Average Value of Plastics & Polymer Composites ($/vehicle)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Nylon	62	61	60	52	48	54	65	68	63	75
Polyvinyl butyral	77	73	73	73	73	55	51	59	64	74
Polypropylene	19	22	25	32	41	44	51	45	40	54
Phenolic resins	65	71	62	55	43	50	50	49	46	53
Polycarbonate	38	33	35	30	30	25	28	27	29	35
PMMA	26	26	27	25	23	38	39	34	33	33
HDPE	25	27	28	18	19	22	26	25	17	26
PVC	14	16	19	18	19	18	20	21	21	25
ABS Resin	21	20	19	14	14	20	19	14	15	19
Polyacetal resin	10	10	11	11	11	12	13	13	13	15
Other Plastics	277	234	233	226	219	233	220	230	237	302
Total Plastics & Polymer Composites	$636	$593	$589	$553	$540	$571	$581	$583	$577	$710

Note. See *Data and Methodology* for data sources.

Figure 5. Plastics & Polymer Composites: Weight and Value



Value of Synthetic Rubber and Elastomers

The value of synthetic rubber and elastomers in an average automobile was $651 in 2021, including $239 of polyurethane elastomers and $143 of ethylene-propylene elastomers. As with other products, the value of synthetic rubber and elastomers in an average automobile is a function of volume as well as pricing for raw materials.

Table 8. Average Value of Synthetic Rubber/Elastomers (lbs/vehicle)

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Polyurethane Elastomers	224	216	212	209	208	209	217	218	213	239
Ethylene-Propylene Elastomers	172	157	142	142	120	117	125	120	115	143
Olefinic Thermoplastic Elastomers	98	90	98	98	100	108	102	104	120	128
Styrene Butadiene Rubber	59	44	47	30	27	38	40	33	26	42
Polybutadiene	33	26	25	17	18	23	24	19	17	27
Butyl Rubber	28	19	20	13	11	17	18	15	12	23
Other Synthetic Rubber	63	52	52	41	38	42	44	40	34	48
Total Synthetic Rubber/Elastomers	**$676**	**$604**	**$595**	**$551**	**$522**	**$554**	**$569**	**$549**	**$537**	**$651**

Note. See *Data and Methodology* for data sources.

Other Products of Chemistry

The automotive industry is one of the largest end users of semiconductors and other electronic chemicals, which enable a wide range of safety and performance functions in automobiles. Features which were recently limited to luxury vehicles, such as advanced driver assistance systems (ADAS), navigation systems, in-vehicle infotainment (IVI) systems, and keyless entry, are made possible by semiconductors and electronic chemicals. An average vehicle contained $540 in semiconductors and other electronic chemicals in 2021, a figure that will likely grow as vehicles become increasingly technology centered.

Processing Chemicals

Chemistry is a critical component to the processing of many of the materials that go into automobiles. In addition to $59 in rubber processing chemicals, other processing chemicals contribute $593 to the value of chemistry in an average automobile. This includes industrial gases, which are used in applications such as welding, cutting, and testing vehicle components; metalworking fluids; water treatment chemicals; and textile chemicals, among others.

Chemistry and Future of Automobiles

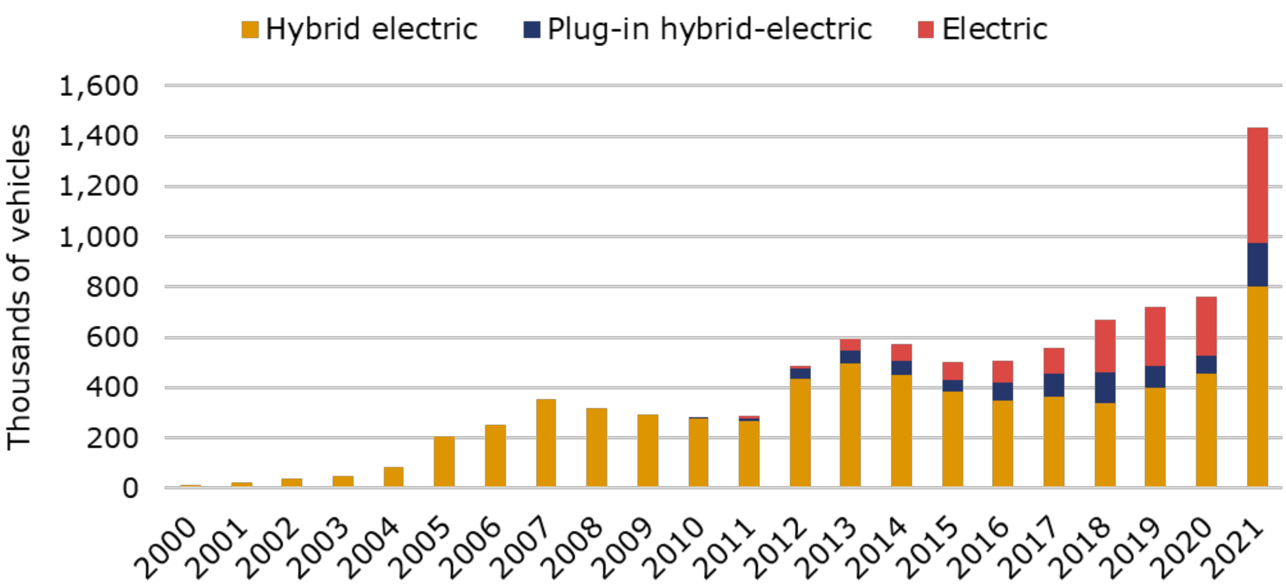
The Rise of Electric Vehicles

The rising popularity of hybrids, electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCVs) is another factor that influences statistics related to the weight and materials composition of an average automobile. In general, EVs are significantly heavier than their gasoline-powered counterparts, primarily due to the battery weight. As an example, the Ford F-150 Lightning's battery alone weighs around 1,800 pounds.[3]

However, given their light weight, plastics and polymer composites can help to offset added weight from the introduction of autonomous and advanced propulsion mechanisms, including batteries and hydrogen fuel cells. Additionally, the desirable conductive properties of plastics and polymer composites make them sought-after materials for various components of electric vehicle batteries, including battery casings and enclosures.

Since the launch of the Toyota Prius—the world's first mass-produced hybrid passenger vehicle—in 1997, the market for hybrid and electric vehicles has grown exponentially.[4] In 2000, just over 9,000 hybrid vehicles were sold in the U.S.; in 2021, 1.4 million hybrid, PHEVs, and EVs were sold, and accounting for 16% of total vehicle production.

Figure 6. Hybrid and Electric Vehicle Sales in the U.S.



Source: U.S. Department of Energy, Energy Vehicle Technologies Office, Oak Ridge National Laboratory, Transportation Energy Data Book, Edition 40, table 6.2, available at https://tedb.ornl.gov/data/ as of 6/21/22.

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[3] https://www.cnet.com/roadshow/news/americas-new-weight-problem-electric-cars/
[4] https://global.toyota/en/prius20th/evolution/

Electric vehicles as a share of total vehicle sales will continue to increase. In August 2021, President Biden signed an executive order "setting a goal that 50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles." As such, the market for critical chemistries such as polycarbonates, carbon fiber, flame retardants, and electronic chemicals, used in the operations and manufacture of hybrid, PHEVs, and EVs will likely increase. For example, according to data from USITC, "hybrid electric vehicles can contain up to $1,000" of semiconductor content.[5]

In addition to the chemistry used directly in electric vehicles, chemistry is a key component of the associated infrastructure needed to keep electric vehicles charged. Plastics and other products of chemistry can be used for a wide array of components within the larger structure of alternative fueling stations and electric vehicle charging ports, such as charger housings, covers over front displays or touchscreens, lenses, connectors, light guides, and other components.

Autonomous Vehicles

Autonomous vehicles are becoming an increasing reality. While fully autonomous vehicles have not yet infiltrated the automobile market, many of today's vehicles include semi-autonomous features, such as lane-keeping systems and adaptive cruise control. The cameras and sensors that enable these features use plastics in wiring, harnesses, and connectors – as well as in the cameras and sensors themselves.

Plastics contribute to enhanced safety in self-driving cars, enabling seat belts, airbags, side-curtain bags, windshield inner-layers, pedestrian collision protection safety features, and padded dashes. Brake boosters can be programmed to stop the vehicle and telematics, the coordination between cellular and GPS signals, will need weather resistant composite materials for connection harnesses, housings, and wiring.[6] Indeed, chemistry will remain a critical element in vehicles of the future.

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[5] The Automotive Semiconductor Market: Key Determinants of U.S. Firm Competitiveness (usitc.gov)
[6] https://www.automotiveplastics.com/mobility-trends/autonomy/

Conclusion

The chemistry value in an average automobile was $4,069 in 2021, up 20% since a decade ago. With over 13 million passenger automobiles and light-duty trucks manufactured for sale in the United States, Canada, and Mexico, the chemistry value in the North American automobile market reached nearly $53 billion in 2021.

For decades, plastics and other products of chemistry have helped to make automobiles safer, lighter and more fuel efficient. In today's automobile, plastics and polymer composites generally make up 50% or more of the volume of but less than 10% of the weight. As vehicles continue to become more like computers on wheels, the products of chemistry will play a key role in advanced features that are becoming commonplace, as well as innovations yet to be seen.

Data and Methodology

This report presents the results of updated data and methodology regarding the primary materials, particularly the products of chemistry, used in the manufacture of automobiles in North America (the United States, Canada, and Mexico). For the purposes of this analysis, the term "automobile" includes passenger automobiles and light-duty trucks. Since the size, components and features of automobiles vary significantly, this report presents statistics related to an average automobile.

For many years, the American Chemistry Council published an annual "Chemistry and Light Vehicles" report, built upon research on automotive high-tech materials initiated during the 1980s by Dr. TK Swift, who has since retired. This report is not an update to the previously published reports; rather, it is a new analysis of the chemistry and other materials used in the manufacture of automobiles using updated data sources and methodology. As such, the tables and figures in this report are not comparable to those in the Chemistry and Light Vehicles reports.

This report presents analyses of the materials volume and value in automobiles from 2010 through 2021. Production volumes are based on data from United States Department of Transportation's National Transportation Statistics (NTS), the Canadian Vehicle Manufacturers' Association, and the National Institute of Statistics and Geography (INEGI) supplemented by data and information from the Alliance for Automotive Innovation, the International Organization of Motor Vehicle Manufacturers (OICA), and S&P Global.

Data on materials composition and weight were developed from a range of industry sources including ACC's Plastics Industry Producers Statistics Group, the Aluminum Association, the American Coatings Association, the American Iron and Steel Institute (AISI), Fortune Business Insights, Glass.com, the Association of the Nonwoven Fabrics Industry (INDA), the International Copper Association, the International Organization of Motor Vehicle Manufacturers (OICA), Kloeckner Metals Corporation, Lenntech Water Treatment, Markham Metals, S&P Global, the U.S. Department of Energy, the U.S. Geological Survey (USGS), and the U.S. Tire Manufacturer Association.

Data on the value of chemistry per vehicle were developed based on data and information from sources including ChemAnalyst, Federal Reserve Economic Data, FocusEconomics, NexantECA, S&P Global, the Semiconductor Industry Association (SIA), the U.S. Geological Survey (USGS), and the U.S. International Trade Commission (USITC), as well as various industry and trade publications.

The methodology used to develop weights and values for individual components varied based on the available data. In some instances, there were existing data (or range of data) on the weight and value of a given material in an average automobile. In other instances, data was only available for one aspect (weight or value) and then that data was used to develop the other data point, often using supplemental data. For some materials, only data for the given industry as a whole was available; in those instances, the industry level data was compared to the automotive industry data to develop a per-vehicle figure. The final data includes reasonable assumptions and estimates.

ACC's Economics & Statistics Department

The Economics & Statistics Department provides a full range of statistical and economic analysis 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. The group functions as an in-house consultant, providing surveys, 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. The lead author of this report was Heather Rose-Glowacki, Senior Director, Industry Intelligence & Analysis.

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