The Science of Plastic Recycling

Science Facts and Analysis from Science for Georgia

Plastic is durable, making it ideal for many products. It's durability also makes it an environmental hazard. Recycling is key but is expensive and not necessarily good for the environment.

Facts & Analysis

Over the past fifty years the growth of plastic production and use and shortcomings of recycling has left industries and governments desperate to solve the plastic problem. The majority of plastics are made from petrochemicals, and particularly shale gas, because of its durability and resistance. Ironically, these are the exact qualities that threaten the earth because plastics do not degrade.

More than 300 million tons of plastic are produced each year. Almost all commonly used plastic is not biodegradable or biologically derived and only 9% of plastic waste is recycled. The failure of plastic recycling to keep up with plastic use has led to an increase in research and development of technologies to recycle, reuse, or convert plastic waste.

Recommendations

Given the complex economic, operational, and environmental nature of plastic recycling, both mechanical and chemical methods are currently not seen to be a viable solution to the plastic waste problem. The most promising solutions to the plastic waste problem are to reduce and reuse your plastic use, and to support policies that reduce plastic use, such as plastic taxes or bans. More information on plastic policy in Georgia can be found here.

About Science for Georgia

Science for Georgia is a 501c3 dedicated to bridging the gap between scientists and the public through training, outreach opportunities, and direct contact with the public, policymakers, and the press. Science for Georgia highlights how science can impact people's lives and advocates for the responsible use of science in public policy.

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Mechanical Plastic Recycling

Mechanical plastic recycling refers the multistep process of turning plastic waste into other plastic products of similar quality. New plastic is not created from raw materials, but rather from existing plastic. This creates a closed material loop in plastic, minimizing plastic waste and extraction of new natural resources. This is the traditional recycling process, and the 9% of plastic that is recycled is typically done so through this method.

Mechanical recycling has been proven to work operationally, but not economically. The mechanical recycling process is more expensive than the creation of new plastic, which is one of the reasons it is sparsely used and the industry is rarely funds it anymore. Additionally, the variability in quality and transfer of contaminants make mechanical recycling impossible for some plastic waste, especially packaging.

Chemical Plastic Recycling

Chemical recycling of plastic is a relatively new process and refers to technologies of two categories: thermolysis and solvent-based processes. Both use a combination of heat, pressure, and/or other chemicals to break down old plastics to create new plastics and/or fuel. Chemical recycling has become more popular because it is inexpensive compared to mechanical recycling and can recycle almost any type of plastic.

The important distinction between mechanical recycling and chemical recycling is that mechanical recycling creates similar plastic products (i.e., old water bottles become new water bottles) and chemical recycling turns waste plastic into other products of less utility, such as fuel, which means it has relatively little environmental benefit. Mechanical recycling aims to preserve as much of the plastic chemical structure as possible (polymers), while chemical recycling aims to break down plastic into smaller molecules (polymers -> monomers).

Chemical recycling is more energy intensive than mechanical recycling. Chemical recycling of plastic into fuel often requires substantial upgrading of the product, which leads to greater quantities of pollutants, higher nitrogen oxides, soot, carbon monoxide and carbon dioxide emissions compared to that of traditional diesel fuel.

Environmental Impacts of Chemical Recycling

Chemical recycling is often framed as a solution for the plastic problem, but a majority of the research and support has been funded by those that support the major oil, gas, and petrochemical corporations. Based on predictions and industry estimates of chemical recycling technology viability provided in Global Alliance for Incinerator Alternatives report, the continued pursuit of chemical recycling does not offer a pathway towards sustainability but rather, due to the need to supplement with other petrochemicals, a high likelihood of enabling at least a decade of more fossil fuel extraction.

Most newly developed chemical recycling methods have not been proven to be environmentally beneficial or sustainable. Most research into chemical recycling focuses on design innovation rather than operational performance or environmental outcomes. There is minimal research on the proof of success or failure in practice, and existing research suggests that it will be a challenge to scale up from a laboratory to industrial setting while maintaining the desired result.

In fact, a strong argument exists that chemical recycling is more environmentally damaging than mechanical recycling, because of its higher energy cost, larger carbon footprint, and increased toxic byproducts.

To create plastics with the needed material properties, a variety of substances are added to plastics. Many of these additives are toxic, including, bisphenol-A (BPA), cadmium, benzene, brominated compounds, phthalates, lead, tin, antimony, and volatile organic compounds (VOCs). Many of these chemicals are that have been shown to cause cancer or harm bodily systems.

Chemical recycling that involves thermolysis breaks down the plastic molecules, making them even more harmful. For example, benzene and polycyclic aromatic hydrocarbons (PAHs), which are hazardous to human health, can be formed and released through this process. During the production process, these chemicals can enter the air the then migrate to water sources, where they can make their way into humans. This is of particular concern to the sites of chemical recycling plants. Facilities would need to be regulated and managed to avoid high risk situations on and off the site.

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