Plastics

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Background Information about Plastics

Plastic is a human-made material used everywhere in the world because of its unique properties. It's lightweight and malleable, which means that it can be molded into different shapes and sizes, making it very versatile and convenient. Its transparency, toughness, durability, hydrophobicity, and shock resistance also make plastic a one-of-a-kind material.

According to researchers, humans have produced more than 8.3 billion tons of plastic since the 1950s, and plastic production has increased rapidly over the past decade. In fact, the world has produced more plastic during the last decade than we produced during the last century. If plastic continues growing at the current rate, there could be more plastic than fish in the oceans by 2050, and plastic could require 20% of the world's total annual oil use.

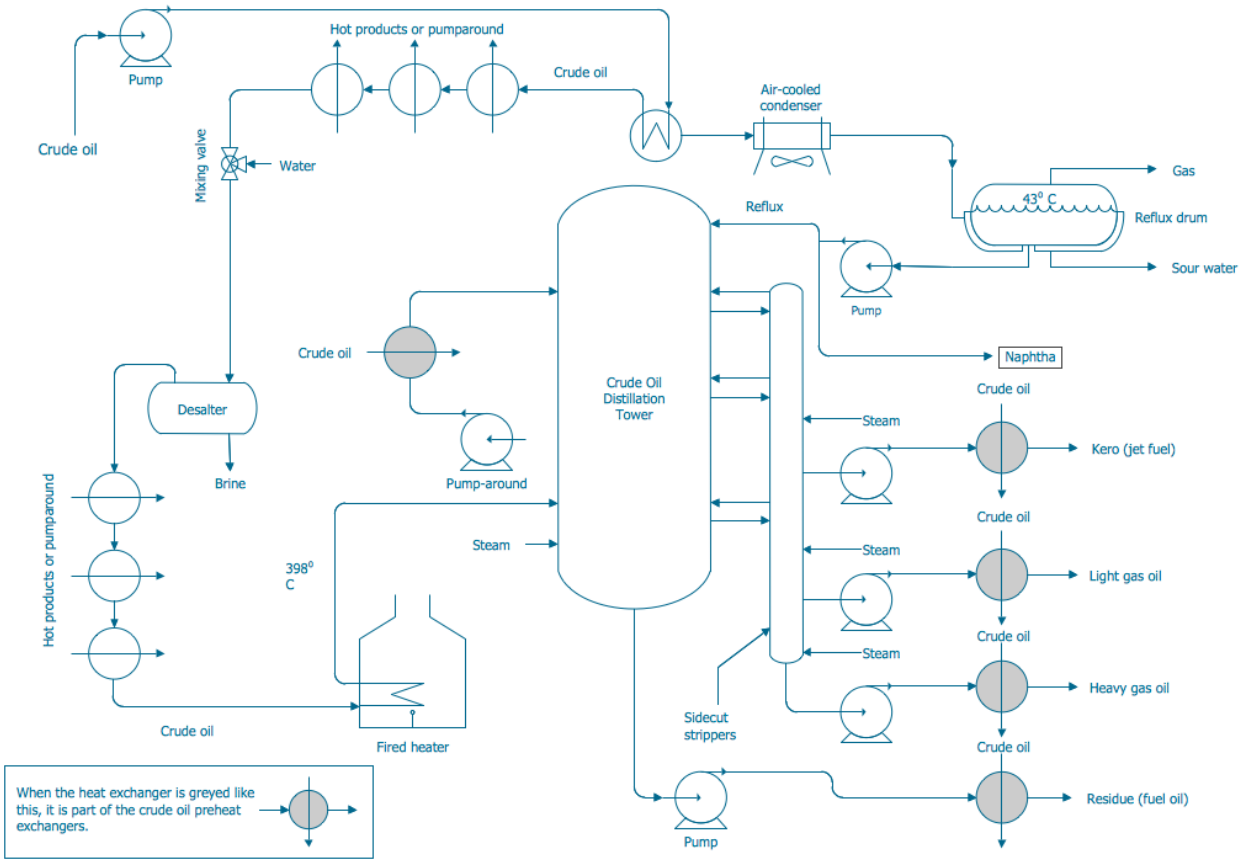
Around 50% of all plastics produced are single-use plastics, meaning that they are used once and then thrown away. Examples of single-use plastics include water bottles, plastic bags, shampoo bottles, snack bags, and the face masks that many of us have used during the COVID-19 pandemic.

Here are some more shocking facts about plastics: more than 99% of the plastics that humans produce comes from coal, natural gas, or crude oil, all of which are non-renewable forms of energy. And every piece of plastic ever made still exists in some form today, except for those plastics that have been incinerated.

Plastic Production

There are two main plastic categories: synthetic and biobased. Synthetic plastics are mainly created using natural gas, crude oil, and coal. They make up a majority of the produced plastics due to the ease of extracting and processing crude oil. Biobased plastics are created using renewable materials such as starch, vegetable oil, and carbohydrates. While they might seem better than synthetic plastics, they are actually just as toxic to the environment.

The first step in producing plastic is to extract raw materials like crude oil, natural gas, and coal. Crude oil needs to be refined before it can be used because it's a complex mixture of thousands of compounds. Crude oil is put into a furnace, where it becomes different gases and liquids, which are then transferred to distillation units. During the distillation process, the gases and liquids are separated into fractions, based on their melting point.



One of the fractions, naphtha, is an important component used to mass-produce plastic. Naphtha decomposes at a high temperature (1,472˚ F / 800˚ C) to produce aromatics (e.g., toluene, benzene, and xylene) and olefins (e.g., ethylene [2 carbons], propylene [3 carbons], butane, butadiene, and butylene [4 carbons]). These are all monomers, the building blocks for polymers when monomers are put together through chemical bonds.

These monomers are then connected into polymer chains through chemical bonding, a process called polymerization. There are two types of polymerization: addition polymerization and condensation polymerization. Addition polymerization involves a monomer connecting to another monomer (dimer), which then connects to another monomer (trimer), and so on and so on until the polymer is finished.

The polymers created through addition polymerization are chains of the same monomer. These polymers are usually catalyzed by a peroxide. Examples of plastics synthesized through addition polymerization include polystyrene and polyethylene.

Condensation polymerization, also known as polycondensation, is more complicated than addition polymerization and involves polymer chains of different monomers, created through dehydration synthesis, a process wherein a byproduct such as water is lost when two monomers are chemically bonded.

Condensation polymerization is also known as step growth because chains of monomers can be connected to other chains of monomers. Plastics synthesized through condensation polymerization include nylon and polyester.

At this point, the polymers look like powdered laundry detergent or sugar. This polymer "fluff" is put through an extruder, which melts it and sends it down a pipe, where the cooled plastic becomes a long tube. That tube is cut into small pellets and shipped to factories that mold them into whatever shape they want.

Plastic Pollution

Because plastic is so inexpensive to manufacture, companies mass-produce it all over the world. Plastic production is increasing exponentially, and it's expected to double by 2050.

Plastic's durability is a benefit when it's used as a construction material, but it also has serious environmental consequences. Plastic pollution harms humans, and it kills millions of animals each year, in the air, on land, or at sea. Despite this environmental destruction, around 300 million tons of plastic waste is still being produced every year.

The majority of that plastic ends up either in landfills or in the environment, especially the oceans. The problem with that plastic is that it's non-biodegradable and can last for centuries. The world is drowning in plastic, and we need to develop a better way to recycle used plastics so they don't damage the environment.

Microplastics

Microplastics are pieces of plastic that are less than five millimeters long. Scientists have found them everywhere they have looked, from the peak of Mount Everest to the depths of the Mariana Trench. In 2015, oceanographers estimated that there are anywhere from 15 trillion to 51 trillion pieces of microplastics in surface waters. Microplastics are in the air we breathe, the water we drink (both tap and bottled), and the food we eat.

In 1990, scientists found microplastics in the lungs of cancer patients who had inhaled microplastics found in the air. Those scientists believe that microplastics could potentially increase a person's risk of developing lung cancer.

Over the average lifetime, a person will eat more than 40 pounds of plastic. More than 10% of the plastics that humans ingest aren't excreted. These plastics inside the body are called nanoplastics, and they are small enough to penetrate cell walls and move into organs and living tissue, potentially disrupting and changing cell activity. But there hasn't been enough concrete research on nanoplastics to adequately determine what danger they pose to humans.

On average, people consume five grams of microplastics a week in drinking water. Bottled water has 22 times the amount of microplastics as tap water. Each year, people who primarily drink bottled water consume 90,000 extra plastic particles compared to people that primarily drink tap water. But even tap water isn't totally free from microplastics because they can pass through water filters.

Microplastics don't just harm humans; they also kill animals everywhere, but especially marine life. There are more than 20,000 species of fish, but only a very small percentage has been studied for microplastics. Microplastics have been found in nearly 400 marine fish species, which is more than two-thirds of the species studied. More than 200 of the species that consume microplastics are commercially fished.

Microplastics can block digestive tracts, preventing animals from consuming sufficient nutrients. The stomachs of some aquatic animals are so full of non-digestible plastic that they die of starvation.

Microplastics tend to stay in the stomachs of fish, whereas humans typically eat muscle tissue. But nanoplastics can move from the stomach of fish to the muscle tissue. Fish higher up on the food chain are more likely to have plastics in their bodies because they can eat other fish that have eaten plastic.

To address this problem, many countries have banned the use of microplastics in cosmetics, but so much damage has already been done to marine animals, birds, and turtles.

Plastics in the Ocean

Each year, 8 to 10 million tons of plastic end up in the oceans. All that plastic waste affects countless marine species. Some species mistake plastics for food and ingest them. Others get entangled in or lacerated by plastics. And as the plastics degrade, the chemicals that they contain harm marine life.

Gyres are large rotating ocean currents caused by the Earth's rotation, by wind patterns, and by Earth landmasses. There are five major ocean gyres: the North Pacific Gyre (the world's biggest gyre), the North Atlantic Gyre, the South Pacific Gyre, the South Atlantic Gyre, and the Indian Ocean Gyre. These gyres circle around large areas of calm, stationary water, sucking things toward the center, like a flushing toilet.

Because trash gets trapped inside the gyres, they are often called garbage patches. The most famous garbage patch is the Great Pacific Garbage Patch in the Great Pacific Gyre between Hawaii and California. Gyres are useful for marine life, but they also cause drifting plastic to slowly move toward the center. While in the gyre, the plastic breaks down into microplastics.

The surface area of the Great Pacific Garbage Patch is twice the size of Texas, but it is mostly made of microplastics. It isn't possible to clean these garbage patches through ocean cleanups because a majority of the waste is made of microplastics.

Recycled Plastics

Although plastic isn't biodegradable, thankfully some plastic can be recycled to create new products. Some of the plastics put in recycling bins are used to create other plastic products. Recyclables are collected and brought to a recycling center, where they are separated by type. The plastic is then made into bales, which are sold to companies to be made into new products.

Recycled plastics requires only a third of the energy needed to make new plastics, but because oil prices are relatively low, it's usually cheaper to create new plastic than to recycle used plastic. Around 9% of plastics get recycled, 12% are incinerated, and 79% end up in landfills or the environment. The EPA estimates that around 75% of the waste the US produces can be either composted or recycled, but the US only recycles or composts 34% of its plastic.

In the past, the US sold recycled plastics to China, but China has stopped accepting much of the recycled plastic due to contamination. Some US cities (e.g., San Francisco, Los Angeles, Seattle, and Portland) are pushing for recycling and zero waste. Here's an interesting fact: San Francisco has the highest composting and recycling rate in the US. We recycle more than 80% of the plastic we use.

The US uses single-stream recycling systems, meaning that all recyclables are put into the same bin, which is sorted out and cleaned at recycling centers. Trash usually ends up in recycling bins, and workers at recycling centers must remove the trash. Single-stream recycling is easier for consumers, but many mixed materials can't be recycled. Items like dirty pizza boxes, batteries, plastic bags, and electronics contaminate an entire batch of recyclables. These contaminated batches are usually thrown away or are sold for a lower price.

Innovations

Sorting garbage and other non-recyclables from recycling is a serious problem for recycling programs, but AI and robotic sorting could solve the problem. Cameras and advanced computer systems can guide robotic arms that sort plastics into appropriate bins. The robots can work twice as fast as humans can, and AI is much better than humans at sorting.

Price is the biggest downside for robotic sorting. AI systems are expensive, and many facilities might not be able to justify the cost. These systems also require a power source to operate, and the robots might also take jobs from humans.

Another option for reducing plastic waste is to use bacteria that can secrete enzymes that degrade plastics. Bacteria can break down polyethylene terephthalate (PET), which is commonly used for food packaging and water bottles, and polyurethane, which is commonly used as foam in furniture and automobile interiors. The bacteria break down the bonds in the plastics and use it as a fuel source. By degrading the bonds, the plastic polymer is turned back into individual monomers that can then be reused to create new plastic.

The main problem with using these bacteria is that they don't degrade plastics at a large enough scale to solve the problem of plastic pollution. These bacteria are still relatively new, but bioengineering could speed up the degradation process. In October of 2020, scientists combined two enzymes in plastic-eating bacteria to create a "super enzyme" that works six times faster than a normal enzyme. Scientists believe that combining plastic-eating enzymes with fiber-eating enzymes might allow the mixed enzyme to break down mixed materials.

Another problem is that there are seven major types of plastic, but plastic-eating enzymes can only digest one type: PET. The enzymes also don't completely get rid of plastic. Instead, they degrade the bonds connecting polymers and turn them back into individual monomers, which might release chemicals that are usually stored safely in plastic. Releasing genetically engineered organisms into the environment could also cause unintended consequences.

Depolymerization is another promising innovation for dealing with plastic waste. A company called Recycling Technologies is using thermal cracking to break plastic down into plaxx, which can be made into new plastics. A single Recycling Technologies machine can process 7,000 tons of plastic annually.

Increased Plastic Usage during the Pandemic

In 2020, plastic production increased by 0.9% compared to 1.2% in 2019. Although the plastic industry didn't grow as much in 2020 as 2019, Americans still used many plastic items to protect themselves from COVID-19. For example, Americans bought many single-use plastic products such as face masks, gloves, takeout food containers, and hand sanitizer bottles. The face masks and gloves that end up in oceans can endanger marine animals.

To avoid restaurants, many people ordered food for delivery, which required an increase in the manufacture of single-use food containers. Many of those containers weren't recyclable and ended up in landfills.

Hospitals also created more plastic medical waste. Face masks contain propylene, which can't be recycled through curbside recycling bins. Propylene is recyclable but not through the standard recycling. Face masks might also be contaminated, so they can't be recycled in curbside recycling bins.

What Can You Do?

You can do many things to reduce your own plastic waste and help protect the environment. Start by avoiding single-use plastics whenever possible and opt for reusable items like water bottles and bags. You can use glass jars rather than plastic containers and wooden clothespins instead of plastic clothespins. It's also a good idea to buy products with cardboard packaging rather than plastic packaging. Buying food in bulk can also reduce plastic packaging.

It's also essential that you recycle all the plastic you can possibly recycle rather than throwing it away in the garbage bin. But don't forget to make sure that you're not putting anything that would contaminate a recycling batch into the recycling bin.

If you're interested in playing a larger role in recycling efforts, you can volunteer at events such as beach cleanups. You can also raise awareness about plastic pollution so that others are also mindful of their plastic usage.

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