

# Conversion of Polymeric Waste into Hydrocarbon Fuels through Pyrolysis

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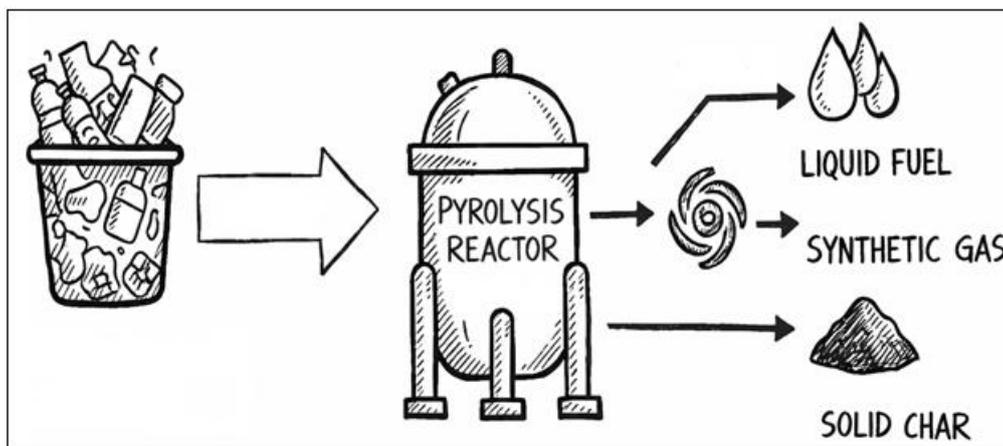
**Abstract:** *Plastics are both good and bad for modern society. Plastics are very useful because they are flexible and cheap. This article talks about how plastics have changed over time, sorts them by type, and looks at their hydrocarbon content and the possibility of getting energy from them through pyrolysis. Pyrolysis looks like a promising technology that can turn plastic waste that can't be recycled into useful fuels and materials. This is good for the environment. The study stresses how important it is to know the proximate and ultimate analysis of different types of plastic in order to make the pyrolysis process work better. To fight plastic pollution, we need to work together and come up with new ideas, change policies, and get more people to know about the problem. The purpose of this document is to give a complete picture of current efforts to deal with plastic waste and to show how pyrolysis technology could help us create a sustainable future.*

**Keywords:** Plastic, Environment pollution, Pyrolysis, Plastic waste, Hydrocarbon

## 1. Introduction

In the world of modern technology, plastic is thought to be a very flexible and innovative material. The use of it has grown along with the world's population and economy.

Plastic is one of the most important things that were made in the 20th century because it can be used for so many things, even though it hurts the environment. Plastic has evolved from bioplastic to eco-friendlier, recyclable, and durable variants [1].



People made things that looked like plastic out of natural materials like ivory, tortoiseshell, and cellulose from the 1600s to the 1800s. Later, Alexander Parkes made the first synthetic plastic, Parkesine, from cellulose, nitric acid, and camphor. Some of the later inventions that have made plastic better are celluloid, Bakelite, polyvinyl chloride, and nylon. People have begun to make safer, more advanced, and more environmentally friendly types of plastic that can be used again and again in the 21st century. Plastic is used for a lot of things because it has a lot of useful qualities [2]. For example, it is light, resistant to corrosion, long-lasting, flexible, waterproof, electrically and thermally insulating, colourable, mouldable, and cheap. Because of these different properties, plastics have been put into groups. Some common types are Polyethylene (PE), Polypropylene (PP),

Polyvinyl Chloride (PVC), and Polystyrene (PS) [3,4]. Ethylene monomer makes polyethylene, which is used in packaging films, plastic bags, bottles, and pipes. It makes up 34% of the global plastic market. Polypropylene is tough, heat-resistant, and cheap. It is used in packaging, car parts, textiles, and medical devices. It makes up 16% of the global plastic market and is expected to grow to nearly 104.99 million metric tons by 2030 [5]. Polystyrene is made from the styrene monomer and is light, stiff, and can be clear or opaque depending on its shape. It is often used in electronics, insulation, and disposable utensils. There are two types of polyethylene: high-density polyethylene (HDPE) and low-density polyethylene (LDPE). HDPE is stronger, lasts longer, and is less likely to break down in chemicals, while LDPE is more flexible, clear, and more

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likely to crack. PVC is another kind of plastic that is used to make things like pipes and window frames. It is popular because it is strong, flexible, and resistant to chemicals and the weather. This is why PVC pipes are so common in homes and on the road [4,6].

Plastic is now an important part of our daily lives, but its pollution is one of the worst problems for the environment. Plastic takes more than 1000 years to break down, so when it is thrown away, it stays in the environment until it becomes dangerous. This pollution is bad for your health, hurts fish and other marine animals, damages soil, and pollutes groundwater [5]. Since the middle of the 20th century, when mass production began, plastic has become a part of almost every part of modern life. Every year, 380 million tons of plastic are made, but only about 350 million tons are thrown away [2]. By 2060, the amount of plastic trash is expected to triple, reaching a shocking one billion metric tons. Ecosystems are greatly affected by plastic pollution. It hurts animals, messes up ecosystems, and puts chemicals in water and soil. These effects have the biggest impact on marine life. Plastic can look like food to fish, turtles, seabirds, and marine mammals, which can make them eat it and get sick, get blocked up, or die. People can also get hurt, drown, or even die if they get stuck in plastic trash.

It is important to cut down on plastic pollution to protect the environment and the ecosystem. To do this, we need to work with people, groups, businesses, and governments. Also, cleaning up plastic pollution is good for business. Pyrolysis is a new and exciting technology that could help reduce plastic waste a lot [1,3]. Pyrolysis can turn plastics that can't be recycled into useful fuels, chemicals, and carbon black. This helps reduce the amount of plastic waste that ends up in landfills. One of the best things about pyrolysis is that it can break down plastics that can't be recycled, like those that are mixed up or dirty and would normally end up in landfills or be burned, which lets out greenhouse gases. Another way to get rid of micro plastics, which are a major cause of plastic pollution in oceans and waterways [2], is through pyrolysis. To do this, it changes these plastics into useful things. Pyrolysis also helps make a closed-loop system in which plastic waste is turned into new products. This means that fewer new materials are needed. This technology is a big step forward in the fight against plastic waste [4].

## 2. Material selection

Modern society has come to know plastic as a flexible material with great durability, low cost, and simplicity of manufacturing. Plastics come in many varieties, each with unique qualities and uses. Among the common varieties are polystyrene, nylon, polypropylene, polyethylene, and PVC [5]. Usually depending on their composition, plastics fall into two basic groups: thermosets and thermoplastics. Thermoplastics can be formed, melted, and moulded; thermosets cannot be reprocessed once set. About 6.3 billion tonnes of plastic were produced worldwide between the 1950s and 2018; just about 9% were recycled and 12% were burned. Comprising 23% LDPE, 19% HDPE, 14% PP, 6% PVC, 9% PS, 10% PET, and various plastics, plastic trash makes up the remaining 19% [6]. India produces 3.4 million

tonnes of plastic garbage every year, of which only thirty percent are recycled.

**Table 1:** Proximate analysis

Type of plastic	Moisture (wt %)	Volatile (wt %)	Fixed carbon (wt %)	Calorific value (MJ/Kg)	Ash content
HDPE	0.00	99.81	0.01	46.81	0.18
LDPE	0.30	99.7	0.00	47.44	0.00
PP	0.15	95.08	1.22	46.40	3.55
PVC	0.8	93.70	6.30	18.00	0.00
PS	0.25	99.63	0.12	41.40	0.00
PET	0.46	91.75	7.77	24.13	0.02

**Table 2:** Ultimate analysis

Type of plastic	Carbon %	Hydrogen %	Nitrogen %	Sulphur %	Oxygen %
HDPE	88.7	15.2	0.21	-	0.88
LDPE	85.9	14.0	-	-	-
PP	83.7	14.3	0.01	0.84	1.14
PVC	38.2	4.94	-	-	-
PS	90.40	8.56	0.07	0.08	-
PET	64.2	4.65	0.05	0.55	30.5

Pyrolysis involves transforming plastics into solid, liquid, or gaseous fuels by breaking down long-chain polymers into simpler molecules without oxygen [3,7]. Plastics originate from natural organic sources like cellulose, coal, natural gas, salt, and crude oil, resulting in products closely resembling fossil fuels. The amount and quality of pyrolysis gas, oil, and char depend on things like the heating rate, temperature, time, type of waste, and size of the particles. High volatile matter and ash content are two important factors that affect the production of pyrolysis liquid oil. The more volatile matter there is, the more liquid oil is produced [8,9].

### Catalyst

A catalyst is something that changes how fast a reaction happens without actually taking part in it. Catalysts improve the quality of pyrolysis products, lower the temperature of the process, speed up the reaction rates, and use less energy [3,5]. Plastic pyrolysis uses a number of different catalysts, such as clay soil,  $\text{Fe}_2\text{O}_3$ ,  $\text{Ca}(\text{OH})_2$ , FCC (Fluid Catalytic Cracking), natural zeolite, synthetic zeolite, red mud, ZSM-5, HZSM-5, and Y-zeolite [10,11,12]. Clay catalysts possess a layered aluminosilicate structure, making them valuable due to their expandability, cation exchange capacity, small particle size, large surface area, diverse physical and chemical properties, as well as being natural, cost-effective, environmentally friendly, and readily available [13].  $\text{Fe}_2\text{O}_3$  catalyst is produced from iron sand through precipitation and calcination methods, serving as a crucial catalyst for high-temperature sulfuric acid decomposition [11,14]. FCC catalysts generate more gas due to their acidic nature, comprising 40-to-100-micron particles with 20% to 50% active zeolite content. Natural zeolite primarily contains silicon, aluminium, and oxygen, originating from zeolitic tuffs formed by volcanic eruptions and ash deposits [12].

In the current situation, LDPE and Polyethylene are two types of plastics that need to degrade for the benefit of the environment. LDPE is technically biodegradable, but it can take hundreds of years to break down since only 5% of the produced material is recycled. Additionally, carbon emissions occur during its production. Polyethylene

accounts for 34% of the total plastic market and is challenging to degrade in the environment, even when buried in landfills for extended periods. For instance, a sheet of polyethylene left in moist soil for 12-32 years exhibited only partial degradation and minimal weight loss. These characteristics of plastics make them suitable candidates for pyrolysis.

### 3. Conclusion

All things considered, plastic is indisputable as a flexible, reasonably priced, generally used substance that greatly supports current innovation and convenience. But given plastic waste's sluggish breakdown and pollution problems, clearly there are major ecological hazards from her. By turning non-recyclable plastics into valuable resources, technologies like pyrolysis present interesting alternatives that might help to reduce negative effects. Good plastic waste management calls for cooperation amongst people, businesses, communities, and governments. We will not only help the economy, but we will also greatly reduce the environmental impact of plastic waste by using creative recycling methods and supporting activities that are good for the environment.

Plastic is useful, but too much of it has caused big problems for the environment. This book makes it clear that we need to find better ways to deal with trash quickly, like pyrolysis, which turns plastic trash into useful things. By pushing for progress in material science, we can help lower pollution levels and make the world more sustainable. This will happen along with more cooperation and better regulations. Even though the widespread use of plastics is bad for the environment, solutions are starting to appear. Pyrolysis is a good way to turn trash into useful things and show that it is possible to get long-lasting results. We can lower the negative effects on the environment and encourage a culture of responsibility and efficiency by making the development and use of environmentally friendly technology our top priority.

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