Chemical Engineering Thesis Defense

Depolymerization of Polypropylene Plastic Wastes under Solvothermal Liquefaction Conditions

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Abstract

"The coronavirus, which crippled the economy and killed many people, was the worst of the viruses that have been sweeping the world in recent years. Although numerous immunizations and treatments were developed to combat the spread of these diseases, personal protective equipment remained the most efficient strategy (PPE). Face masks were the first important PPE, and their popularity has risen because of their low cost and easy availability of three-layered masks. As a result, the use of facemasks has increased significantly and continues to increase. Further Polypropylene, a non-biodegradable plastic with a higher c-c bond disassociation energy than other convectional polymers like PE, is used to manufacture these three-layered masks. As a result, the amount of plastic pollution in the environment has grown tremendously, nearing million tons in a short period of time. As a result, the purpose of this study is to reduce the environmental damage caused by facemasks.

This M.S. thesis offers a concise overview of various thermochemical methods employed to depolymerize plastic waste materials. It emphasizes environmentally conscious and sustainable practices, with a specific focus on solvothermal processing. This innovative approach aims to convert discarded face masks into valuable resources, including hydrocarbons suitable for jet fuel, along with other useful products.

The thesis delves deeply into experimental investigations of solvothermal liquefaction techniques. Under conditions at 350°C and for 90-minute reaction duration, impressive results were achieved, including a remarkable conversion rate of 99.8%, an oil yield of 39.3%, and higher heating values (HHV) of 46.81 MJ/kg for the produced oil samples. Notably, the HHV of the oil samples obtained via the STL method, 46.82 MJ/kg, surpasses that of gasoline (HHV of 43.4 MJ/kg).

The significant role of the solvent in the depolymerization process primarily involves the dissolution and dispersion of the feedstock through solvation. This reduces the required thermal cracking temperature by enhancing mass and thermal energy transfer. While solvolysis reactions between the solvent and feedstock are limited in thermal liquefaction, the primary depolymerization process follows thermal cracking. This involves the random scission of polypropylene (PP) molecules during heat treatment, with minimal polymerization, cyclization, and radical recombination reactions occurring through free radical mechanisms.

Overall, this work demonstrates the feasibility of a highly promising technique for the effective chemical upcycling of polyethylene-based plastics into valuable resources, particularly in the context of jet fuel hydrocarbons, showcasing the comprehensive analytical methods employed to characterize the products of this innovative process."

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