Statistical Prediction of Rate Constants for the Pyrolysis of High-Density Plastic Waste

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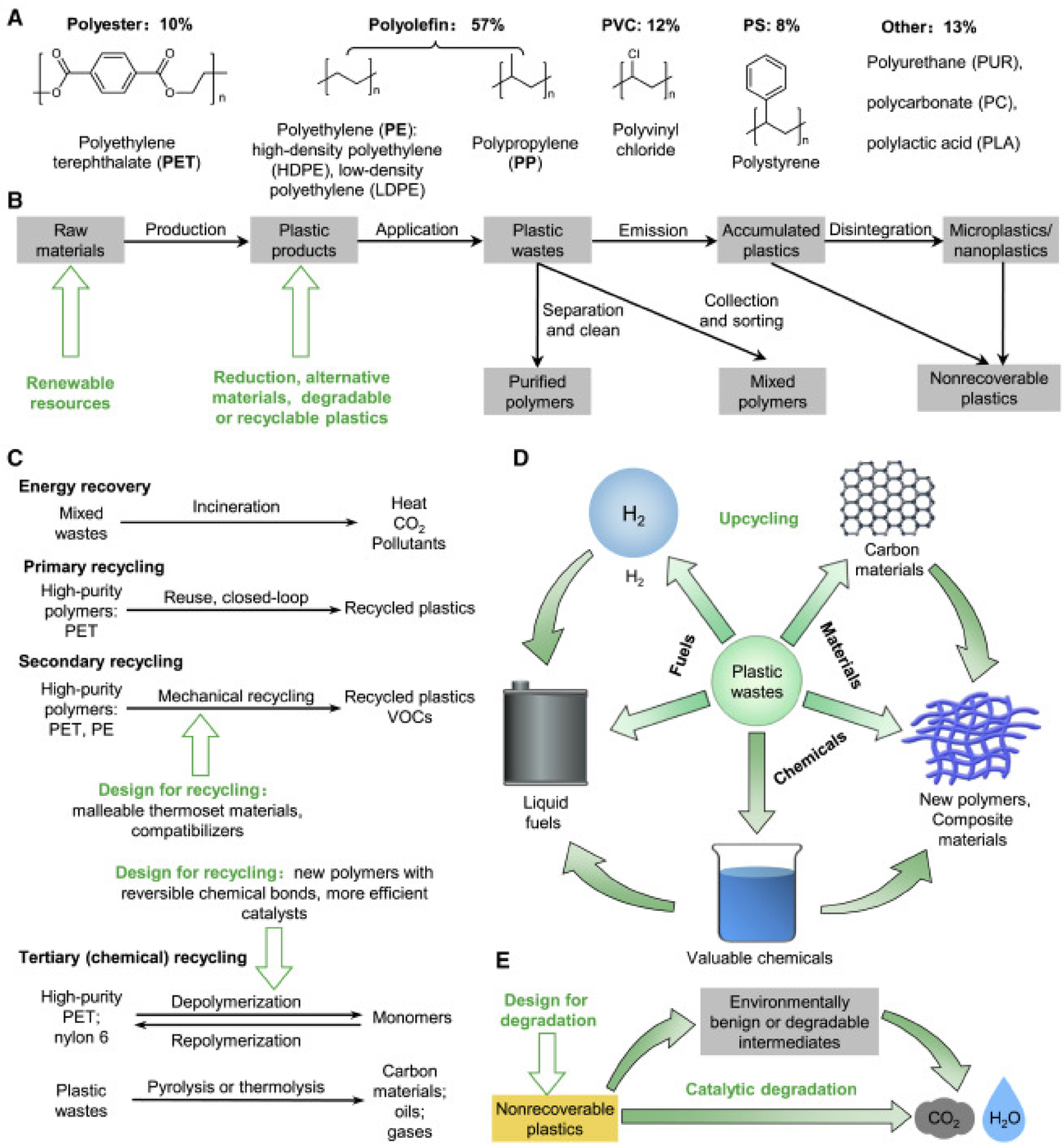
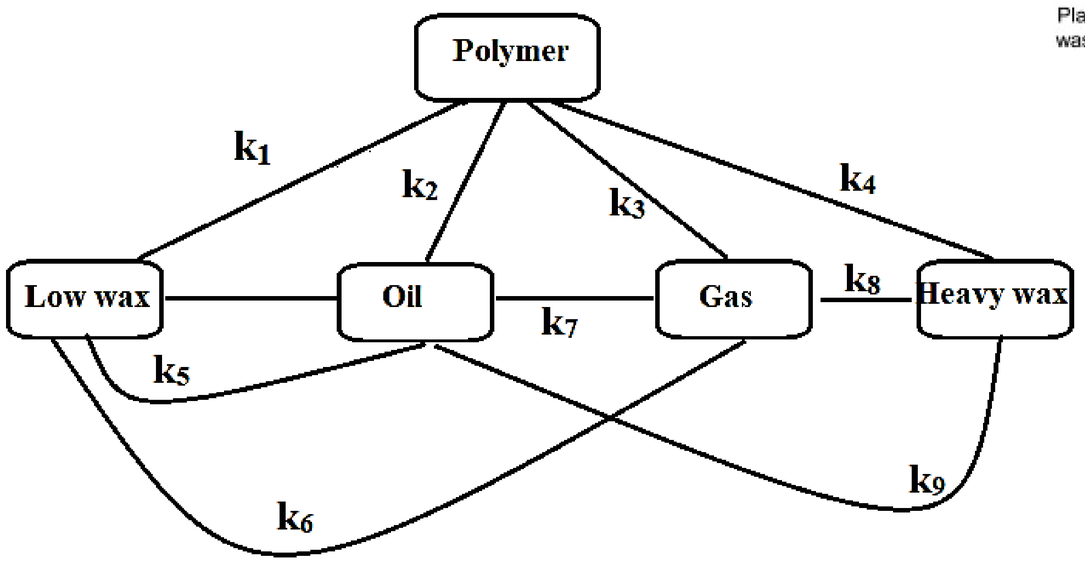
Abstract

The 400 million tons of waste plastic are disposed of around the world. A study reported by SINTEF estimates that the Norwegian fishing fleet dumps around 380 tons of plastic material in the ocean each year. This waste is increasing at an alarming rate, threatening aquatic life, polluting the environment, and causing serious diseases. Since this waste includes hydrocarbons and is a massive source for economically producing pyrolytic oil that can replace traditional fuels. To obtain Liquid fuels and gases from the thermal destruction of high-density plastic (HDP) pyrolysis using empirical rate constants is costly and time-consuming. A commercially sustainable quantity of liquid fuel is not achieved. As a result, predicting statistical rate constants (k) which are based on a suitable combination of activation energy (Ea) and frequency factor (Ao), and investigating their sensitivity is a need of time that has not been documented. This study can provide a better insight into the reaction mechanism of HDP and assess the suitable combination of Ea, Ao, and k that can play a significant role in the effectiveness of liquid fuels and gases at a commercial scale.

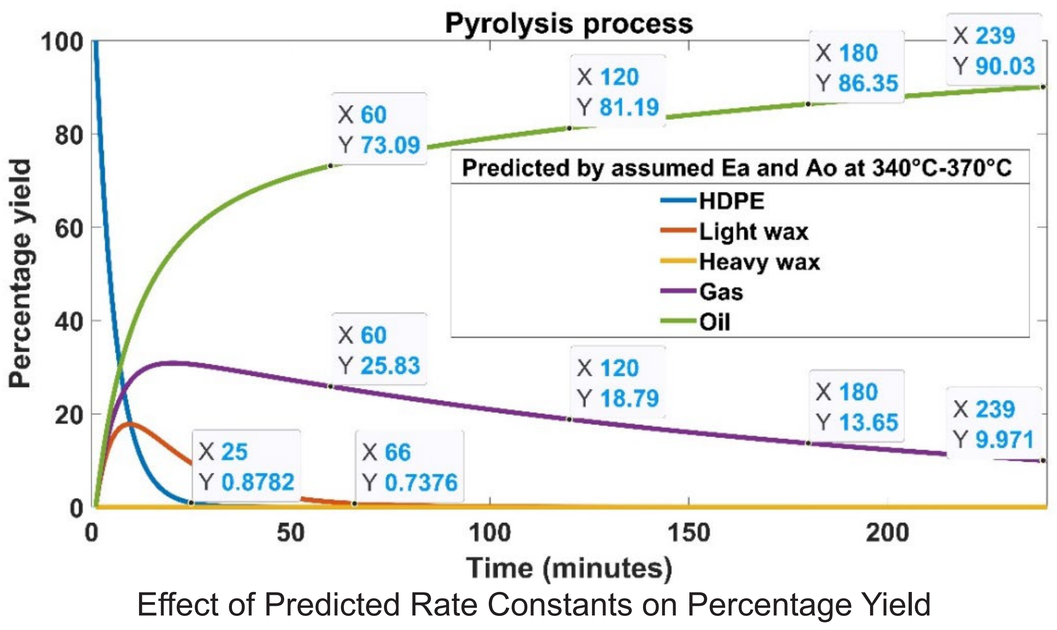
In this study, H-abstraction, chain fission, polymerization, and β-scission reactions have been chosen from literature due to the majority of free radicals. The Arrhenius equation is implemented in R software to predict temperature-dependent rate constants at a fixed temperature (340°C to 370°C). In MATLAB (R2020a) the second-order differential equation solver has been employed to assess how changes in temperature, Ea, and Ao affected the efficiency of species such as oil, gas, and waxes.



Management of Waste based on Types



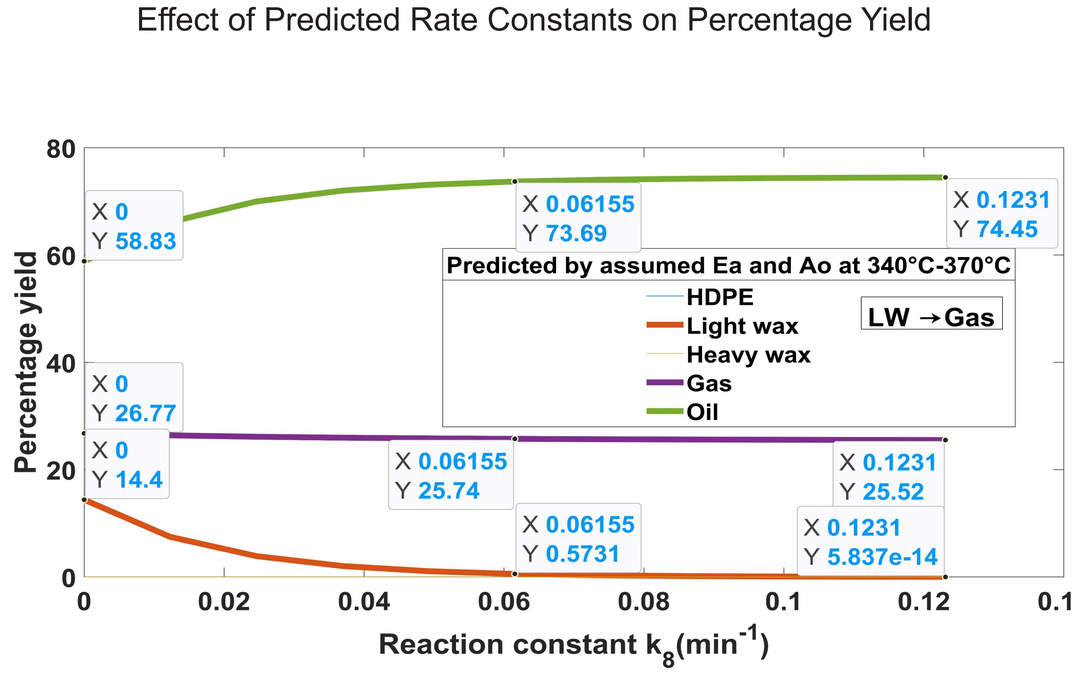
Model Pathway



Effect of Predicted Rate Constants on Percentage Yield

Conclusion

The oil recovery rate increased dramatically to 90% at the end of processing time, while the byproducts produced gradually decreased. A 74% improvement in oil yield and a 14% improvement in light wax enable the k(8) rate reaction to remain commercially efficient during sensitivity analysis since an increase in the light wax yield has commercial applications. These predicted rate constants are dominant over empirical findings; however, experimental validation is required.



Sensitivity of k(8) Rate Constant

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