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RESEARCH ARTICLE

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PET pyrolysis: Kinetics of a-graphite

Zinnia Chowdhury[1,3] | Sanjib Barma[1] | Dwaipayan Sen[2] | Aparna Ray Sarkar[2]

[1]Department of Chemical Technology, University of Calcutta, Kolkata, West Bengal, India

[2]Department of Chemical Engineering, Heritage Institute of Technology, Kolkata, West Bengal, India

[3]Department of Chemical Engineering, Calcutta Institute of Technology, Uluberia, West Bengal, India

Correspondence
Aparna Ray Sarkar, Department of Chemical Engineering, Heritage Institute of Technology, Kolkata, West Bengal 700107, India. Email: aparnaray.sarkar@heritageit.edu

Abstract

One of the primary issues nowadays is plastic waste management, where the low recycling rates and accumulation of waste plastic show an exponentially increasing trend with urbanization. Especially, the concern is high with the PET waste generated from food packaging industries. Thus, new technologies are required for waste refining. Pyrolysis is one such technique that will restrict the emission possibilities obvious with the incineration and convert plastic into some value-added end products. However, large scale implementation of pyrolysis technology for plastic waste management requires a thorough understanding of its degradation kinetics along with pyrolysis index (PI) calculation. Here a thorough analysis of the degradation kinetics of PET waste was done with established models to evaluate the activation energy for the reactions. Among all the conventional models discussed, Coats-Redfern shows a 0.95–0.98 R^2 value during model fitting. The activation energies were varied from 133.6 to 241.8 kJ/mol. PI value was evaluated at different temperatures to assess lower energy utilization during designing and scaling up the process. The value was found to be maximum at 500°C indicating the scalability of the process at this temperature with lower energy utilization. Qualitative predictions on the production of amorphous graphite oxide (a-graphite) were validated through FTIR, FESEM, Raman, XRD, and UV spectroscopy analyses.

KEYWORDS
activation energy, iso-conversion, kinetic model, pyrolysis, pyrolysis index

1 | INTRODUCTION

Since its invention in the 19th century, plastic materials have extensive applications in all our domestic and industrial activities. According to a recent report, global plastic consumption will raise to 1231 million tons by 2060 (Global Plastic, 2022) leading to the accumulation of huge plastic wastes in the environment due to its non-biodegradable nature (Thinking Sustainably, 2022). Among different varieties of plastics such as high-density polyethylene (HDPE), low density polyethylene (LDPE), polyvinyl chloride (PVC), polystyrene (PS), polypropylene (PP), etc., polyethylene terephthalate (PET) has maximum usages as drinking water packaging material. Starting from aquatic organisms to human beings, waste PET accumulation has adversely affected the entire ecosystem (Earth.org, 2022). Two primitive methods such as; landfilling and incineration are widely practiced so far to minimize the magnitude of waste PET (Pan et al., 2021). However, long term landfill practices may leach toxic pollutants in the land manifesting soil pollution (Yamamoto et al., 2001). Moreover, prolonged landfilling leads to a degradation of plastics into micro plastics that release pollutants like phthalates and bisphenol A into the soil. These pollutants may further percolate through different layers of soil contaminating underground water as well as surface water (Thakur et al., 2023). On the contrary, the incineration of PET increases global warming through the emission of toxic greenhouse gases and furans, dioxins, and polychlorinated biphenyls into the atmosphere (Verma et al., 2016). Hence, the exploration of eco-friendly technology for waste PET management is one of the utmost concerns nowadays (Sudeshkumar et al., 2022). One of the most important chemical recycling technologies is pyrolysis.

