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Abstract Submission

Intensification and scale-up of waste plastic upcycling to lubricants conversion

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Abstract.

Polyolefin packaging waste constitutes approximately 70–80% of all U.S. plastic waste, presenting a significant environmental challenge due to its accumulation in landfills and leakage into the biosphere. Conventionally practiced mechanical recycling, incineration, or pyrolysis do not address the issue of polyolefin waste. Novel solutions, like closed-loop chemical recycling of polyolefins to new polymers via ethylene and propylene intermediates, suffer from unfavorable economics due to stiff competition from fossil-derived incumbent polyolefins. Open loop catalytic processes offer to upcycle waste polyolefins into value-added lubricants, waxes, and surfactants with much more compelling economic incentives. Our research at NYU Tandon School of Engineering tackles the problem of chemical upcycling from a reaction engineering and process design standpoint.

One of the most prospective open-loop reactions is polyolefin hydroconversion to lubricants, which requires 200-300 °C and 30-50 bar H_2. Supported metal nanoparticles and sulfides catalyze hydrogenolysis in the melt phase, but the reaction rate and whole process scale-up are limited by the low thermal conductivity and diffusivity in polyolefin melt. This leads to significant thermal and mass transfer gradients, the development of hot spots, and coking. The batch or semi-batch operation studied so far exacerbates these issues, resulting in low activity and high selectivity for low-value by-products, like methane.

Our approach leverages a slurry bubble column reactor setup to induce vigorous mixing and convention within the plastic melt. We explore how gas holdup the correlation between engineering parameters, like column gas holdup, bubble size distribution, sparging intensity, and reactor performance. We add continuous operation capability, allowing simultaneous overhead product removal and feeding of fresh plastic from the bottom. Finally, we demonstrate process robustness using real-world packaging waste contaminated with antioxidants, fire retardants, and other additives. This work establishes a framework for scalable, economically viable polyolefin waste upcycling to lubricant base oil.