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Feasibility of Varied Polyethylene Terephthalate Wastes as a Linker Source in Metal−Organic Framework UiO-66(Zr) Synthesis

Abstract
Polyethylene terephthalate (PET), a chemically stable polyester with multiple applications, has risen dramatically in manufacturing and consumption in the past decades. The increase in PET use has resulted in considerable volumes of waste PET pilling up and thus causing increased health and environmental concerns. Apart from the landfills and incineration solutions, the common waste PET recycling practices mainly focus on low-value downstream products. All the above mentioned factors have contributed to the lower waste PET recycling overall rate of less than 30% in South Africa and created a need for alternative treatment options. Our earlier work has proven the feasibility for converting clear PET bottles into high value-added metal−organic frameworks (MOFs) materials. The feedback from industries indicated that the colorful PET bottles and food trays are currently considered problematic to be recycled economically. In response, this work focuses on the use of various types of PET wastes as sources of benzene dicarboxylic acid (BDC) linker for the synthesis of the zirconium-based MOF UiO-66(Zr). The BDC linker was extracted from food trays, green bottles, brown bottles, and PETCO beads through glycolysis (depolymerization). Post-synthesis characterization revealed that textural properties of the waste PET-derived UiO-66(Zr) MOFs were comparable to those of the MOFs derived from commercial chemicals as exemplified in the scanning electron microscope images and X-ray diffraction patterns. The diffraction pattern peaks typically observed for commercial grade BDC positioned at 2θ = 17.21, 25.01, and 27.64° were observed for the PET-derived BDC samples, confirming the crystalline nature of samples. However, the MOFs synthesized from BDC derived from green and brown PET bottles measured lower Brunauer−Emmett−Teller surface areas in the range of 933−1085 m2/g compared to 1368 m2/g for MOFs synthesized from the commercial BDC linker. This phenomenon is attributed to the presence of organic dyes contained in the colored PET bottles residing in the MOF pores. This was further confirmed by the infrared spectra of the postconsumer PET-derived BDC showing a peak at 3158 cm−1 assigned to the amine N−H functional group, as well as the much stronger □C−H bend. This study complements the business case development model of “waste PET to value-added MOFs”.