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Moisture Resistant K-loaded ZIF-8 Catalyst for Glycerol Carbonate Production

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Abstract : Zeolitic imidazolate frameworks (ZIFs), a subclass of metal-organic frameworks (MOFs) with structures resembling aluminosilicate zeolites, are gaining significant attention due to their unique properties. ZIF-8, in particular, has shown high surface area and enhanced hydrophobicity, making it a promising candidate for catalytic applications. In this study, ZIF-8 was synthesized in an aqueous medium by mixing 2-methylimidazole (mIm) with zinc nitrate hexahydrate (Zn) in deionized water. To improve the basicity and catalytic performance of ZIF-8, a series of K-loaded ZIF-8 catalysts (K/ZIF-8) were prepared by varying the KOH content from 5 to 10 wt%. Characterization of the synthesized catalysts was conducted using powder X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), high-resolution transmission electron microscopy (HRTEM), and temperature-programmed desorption (TPD) techniques. The ZIF-8 and K/ZIF-8 catalysts were applied in the transesterification of glycerol (GL) and dimethyl carbonate (DMC) to form glycerol carbonate (GLC). Various reaction parameters, including DMC/GL molar ratio, KOH loading, catalyst amount, and reaction temperature, were systematically studied to optimize the GLC yield. Under optimized conditions, the 10 wt% KOH-loaded ZIF-8 catalyst (10-K/ZIF-8) demonstrated excellent catalytic activity, achieving up to 95% GLC yield at a DMC/GL molar ratio of 3:1 within 0.5 hours. Remarkably, despite the hygroscopic nature of potassium, the catalyst exhibited significant water resistance, maintaining performance with up to 5 wt% water in relation to GL. Furthermore, the catalyst retained its activity after three recycling cycles without any notable loss in catalytic efficiency. This study highlights the potential of K/ZIF-8 as an efficient, water-tolerant catalyst for the transesterification of GL with DMC, offering high GLC yields and recyclability.

Keywords : metal-organic frameworks (MOFs), zeolitic imidazolate frameworks (ZIFs), transesterification, sustainable catalytic
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