

Development of LDH-MOF-5-Based Tunable Active Sites of Metal Nodes (Mo|Mn|Sn|Ag) for the Efficient Transesterification of *Picochlorum oklahomense* Lipids for Biodiesel Production

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Abstract

The structural properties of metal-organic frameworks (MOFs) enhance the catalytic activity of the metal centers, which interact effectively with lipid molecules during transesterification. In this research, sustainable LDH-MOFs with tunable active sites at the metal nodes (Mo|Mn|Sn|Ag) were synthesized using terephthalic acid as the organic ligand and Zn-Co LDH. XRD revealed the presence of dominant, highly crystalline phases that preserved MOF structures. UV-visible spectra showed ligand-to-metal charge transfer accompanied by weak d-d transitions at the metal centers. FE-SEM micrographs revealed micro-flower, needles, and flake-like structures in the MOFs. The optimized conditions were employed to investigate the catalytic performance of the prepared MOFs in the transesterification of *Picochlorum oklahomense* lipids. Biodiesel conversion efficiencies are to be 89.2% (MOF-BL-Mo), 88.0% (MOF-BL-Mn), 80.0% (MOF-BL-Sn), 73.7% (MOF-BL-Ag), and 60.0% (pristine LDH), with major composition of FAMES of palmitic acid (C16:0) and oleic acid (C18:1). The enhanced activity could be attributed to the synergistic effect of the MOF's porous structure, the Zn-Co LDH layers, and the catalytically active sites at the metal nodes, which enable stronger interactions between the catalyst and the lipid molecules. Therefore, the key findings demonstrate the potential of LDH-MOFs with green metal nodes as effective heterogeneous catalysts for the sustainable, high-yield production of microalgal biodiesel.

Keywords: FAMES; LDH-MOFs catalysts; microalgal lipids; *Picochlorum oklahomense*; transesterification