Topics in Catalysis (2024) 67:785–809
https://doi.org/10.1007/s11244-024-01929-5

ORIGINAL PAPER

Biodiesel Synthesis Using Magnetizable Geopolymer as Heterogeneous Catalysts Nanocomposite Assisted by Artificial Intelligence

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Accepted: 5 February 2024 / Published online: 25 March 2024

Abstract

Biodiesel stands out as a promising contender in the quest for renewable energy solutions, offering a greener alternative to traditional fossil fuels. Derived primarily from the transesterification of vegetable oils or animal fats, biodiesel offers an eco-friendly energy avenue with a minimized carbon footprint. Catalysts are central to the success of this process, which significantly enhance yield rates. Geopolymers, traditionally associated with construction applications due to their inorganic nature, have been derived from aluminosilicate sources activated using alkaline solutions. However, recent advancements spotlight geopolymers in a new light, emphasizing their prospective role as nanocatalytic agents for biodiesel synthesis. This paradigm shift suggests improved production efficiency and an innovative method of repurposing industrial waste. This study centers on the pioneering application of geopolymers, fortified with magnetite, as potent heterogeneous catalysts for biodiesel generation from soybean and safflower oils. By leveraging a meticulously crafted geopolymer matrix—consisting of metakaolin, sodium hydroxide, and magnetite—this research replaced traditional catalysts with this advanced nanostructured geopolymer variant in the biodiesel methylation process. The research delved deep to ascertain the prime synthesis conditions. Furthermore, utilizing cutting-edge machine learning methodologies provided an analytical lens to navigate the extensive experimental data, thereby fine-tuning the optimization trajectory. One of the salient takeaways from this research is the validation that geopolymer catalysts, rooted in kaolinite, can be ingeniously tailored to ensure elevated biodiesel yields across a spectrum of oil sources, underscoring their unparalleled efficiency and versatility in the biofuel domain.

Keywords Biofuel · Biodiesel · Heterogeneous catalysis · Geopolymer · Magnetic particles

1 Introduction

The mounting concerns surrounding environmental degradation stemming from fossil fuels and looming resource depletion necessitate exploring alternative energy sources. Renewable energies are a cogent solution, given their abundant nature and lower environmental footprint. In this spectrum, biofuels [1] emerge as an environmentally responsible alternative to fossil fuels, primarily due to their reduced atmospheric pollutant emissions [2].

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