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Catalytic Deoxygenation of Palm Kernel Oil Into Sustainable Aviation Fuel Using Magnetite Based Catalysts

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Background: The growing demand for sustainable aviation fuel (SAF) has driven research into efficient catalytic processes for converting renewable feedstocks. This study focuses on developing and analyzing monometallic and bimetallic iron oxide-based catalysts for the deoxygenation of palm kernel oil (PKO) into SAF. Nickel (Ni) and cobalt (Co) were incorporated into iron oxide (Fe_3O_4) to enhance catalytic performance, aiming to improve hydrocarbon yield and fuel selectivity.

Methods: The catalysts were synthesized and characterized using various analytical techniques. X-ray diffraction (XRD) confirmed their crystalline nature, showing the presence of maghemite (Fe_2O_3) and magnetite (Fe_3O_4) phases. The Brunauer–Emmett–Teller (BET) method revealed that Ni incorporation reduced the surface area, while Co increased it. Field emission scanning electron microscopy (FESEM) showed that bimetallic catalysts exhibited less crystallite aggregation, leading to improved molecular diffusion. Energy dispersive X-ray spectroscopy (EDX) confirmed the presence of Fe, Ni, and Co, with compositions close to theoretical values, indicating successful synthesis. Vibrating sample magnetometer (VSM) analysis demonstrated enhanced magnetic properties with increasing Ni content. The catalysts were then evaluated in deoxygenation reactions, with hydrocarbon yield and SAF selectivity as key performance indicators.

Results: The results showed that the $Co_{0.5}/Fe_3O_4$ catalyst outperformed $Ni_{0.5}/Fe_3O_4$ in terms of total hydrocarbon yield and SAF selectivity. However, bimetallic $Ni_{0.5}$-$Co_{0.5}/Fe_3O_4$ exhibited superior catalytic performance, achieving 91% hydrocarbon yield and 77% SAF selectivity, highlighting the synergistic effect of Ni and Co in optimizing the acid-base properties essential for deoxygenation. Despite the absence of detailed acidity and basicity data, the findings suggest that bimetallic catalysts provide significant advantages in improving catalytic efficiency and product selectivity.

Conclusion: This study demonstrates that Ni-Co/Fe_3O_4-based bimetallic catalysts hold great potential for the efficient production of SAF from PKO, contributing to the advancement of sustainable energy solutions. The results highlight the importance of metal composition and catalyst design in enhancing deoxygenation reactions, paving the way for future improvements in renewable fuel technology.

Keywords: Palm Kernel Oil, Sustainable Aviation Fuel, Catalysts, Deoxygenation

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