UNIVERSITI TEKNOLOGI MARA

OPTIMIZATION STUDY OF SULFONATED IRON OXIDE CATALYST FOR BIODIESEL PRODUCTION FROM LOW-COST PALM FATTY ACID DISTILLATE FEEDSTOCK

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Biodiesel derived palm fatty acid distillate (PFAD) has successfully been produced to reduce the dependency on fossil fuel. Sulfonated iron oxide (Fe_2O_3) catalyst synthesized *via* self-propagating combustion method was found to render high free fatty acid (FFA) conversion of > 90%, indicating acidic sites play a key role during the esterification of the PFAD feedstock. The physicochemical properties of the sulfonated Fe_2O_3 catalysts were investigated using various characterization techniques such as thermogravimetric analysis (TGA), X-ray diffraction (XRD), field emission scanning electron microscopy coupled with energy dispersive X-ray (FESEM-EDX), Fourier-transform infrared spectroscopy (FTIR), Brunauer-Emmett-Teller (BET) and temperature-programmed desorption of ammonia (TPD-NH_3). Based on the results, the acidity of sulfonated Fe_2O_3 catalyst was proven increased after the sulfonation treatment. One-Variable-At-Time (OVAT) and Response Surface Methodology (RSM) were employed to determine the optimum reaction condition with maximum FFA conversion. By OVAT method, the reaction conditions were roughly estimated, resulting in 15:1 of methanol-to-PFAD molar ratio, 4 wt.% of catalyst loading, 80 °C of reaction temperature and 300 min of reaction time with 95.5% of FFA conversion and 92.5% of FAME yield. Next, the RSM with central composite design (CCD) was used to further optimize the reaction conditions, resulting in 15:1 of methanol-to-PFAD molar ratio, 4.9 wt.% of catalyst loading, 95 °C of reaction temperature and 183 min of reaction time were obtained with 97.3% of FFA conversion and 94.1% of FAME yield. The reusability of the catalyst was tested and found that it could be reused up to six consecutive cycles with an acceptable esterification performance. The fuel properties of PFAD biodiesel and their blends satisfied the standard biodiesel standard ASTM D6751. In conclusion, the sulfonated Fe_2O_3 showed outstanding performance as a heterogeneous solid acid catalyst for biodiesel production from high FFA based feedstock.

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