UNIVERSITI TEKNOLOGI MARA

SYNTHESIS AND CHARACTERIZATION OF SULFONATED SnO_2 CATALYSTS FOR ESTERIFICATION OF LOW-COST PALM FATTY ACID DISTILLATE FOR BIODIESEL PRODUCTION

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MSc

February 2021

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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Thesis Title	:	Synthesis And Characterization of Sulfonated SnO2 Catalysts For Esterification of Low-Cost Palm Fatty Acid Distillate For Biodiesel Production
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ABSTRACT

Excessive use of non-renewable fuel in transportation and industry leads to the twin crises of fossil fuel depletion and environmental degradation. As fossil fuels are limited and it takes millions of years to be produced, their availability may be prolonged by decreasing overall consumption. Following this issue, various renewable sources of energy have successfully been tested to replace the dependency on fossil fuel consumption. Since Malaysia is the largest exporter of palm oil, biodiesel derived from palm fatty acid distillate (PFAD) was produced *via* catalytic esterification using sulfonated tin oxide (HSO_3^-/SnO_2) as a superacid solid catalysts. In this work, the SnO_2 catalysts were synthesized by different synthesis methods such as solid-state method, sol-gel method and self-propagating combustion method. After that, all the SnO_2 catalysts was further integrated with HSO_3^- ions by chlorosulfonic acid. The commercial SnO_2 was also sulfonated and used for comparison. Among all the synthesis methods, sulfonated SnO_2-SPC exhibited superior physicochemical properties in terms of homogeneous nano-sized particles that covalently anchored greater HSO_3^- ions which is important criteria for the esterification of PFAD. All SnO_2 based catalysts from non-sulfonated and sulfonated groups were preliminarily screened for the esterification of PFAD feedstock. Among them, the sulfonated SnO_2-SPC catalyst showed remarkable esterification activity. The used of the SPC method produced nano-sized particles with homogenous size and shape, that anchored many HSO_3^- ions resulted in greater acid properties that effectively esterified the PFAD feedstock into FAME (fatty acid methyl ester). At the optimized condition of 9:1 (methanol:PFAD molar ratio), 4 wt.% (catalyst loading), 100 °C (reaction temperature) and 3 h (reaction time), the FFA conversion and FAME yield were 98.9% and 93.8%, respectively. Besides, the sulfonated SnO_2-SPC catalyst could be reused up to five consecutive cycles with an acceptable esterification performance and minimal sulfur leaching. Additionally, the fuel properties of PFAD biodiesel were investigated and compared with both the American (ASTM D6751) and European (EN 14214) standards. Overall, the production of FAME from low value, cheaper, abundance, and non-edible PFAD feedstock assisted with non-transition metal oxide of sulfonated SnO_2 catalyst met all the requirement standards proposed by ASTM D6751, EN 14214 and diesel.

ACKNOWLEDGEMENT

All praises to Allah The Almighty, The Most Gracious and The Most Merciful for the strengths and His blessing in completing this research work. I would like to convey my deepest gratitude and appreciation to my supervisor, Dr. Mohd Sufri bin Mastuli for his supervision, constant support, guidance and suggestions throughout the project with patience and knowledge. Special thanks and appreciation goes to Dr. Mohd Lokman bin Ibrahim who has directly given guidance and assistance as a co-supervisor to accomplish this project.

I also want to express the deepest gratitude to Dr. Asikin Mijan from Universiti Kebangsaan Malaysia (UKM) who always giving her the best guidance and support during performing this research. Special thanks also dedicated to Prof Dr. Taufiq Yap from Catalysis Science and Technology Research Centre (PutraCAT) at Universiti Putra Malaysia (UPM) and Prof Suzana Yusup from Centre for Biofuel and Biochemical Research at Universiti Teknologi PETRONAS (UTP) for providing so many facilities to completing this study.

On the other hand, special gratitude to the Ministry of Higher Education of Malaysia for the financial support under the Fundamental Research Grant Scheme (No. Grant: 600-IRMI/FRGS 5/3 (036/2019)).

In addition, sincere thanks go to my colleagues and lab assistants, especially from the Centre of Functional Materials and Nanotechnology in the Institute of Science, staffs and technicians from Faculty of Applied Sciences for their kindness and moral support during my study.

Last but not least, my deepest gratitude goes to my beloved parents and family for their endless love, prayers and encouragement. To those who indirectly contributed to this project, that means a lot to me. Thank you so much.

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