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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

SPENT COFFEE GROUNDS (SCG) WASTE VALORIZATION: WASTE TO WEALTH FUEL FEEDSTOCK

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Abstract: The increasing global energy demand requires a critical examination of our dependence on fossil fuels, prompting the exploration of sustainable and renewable energy alternatives. This study examines the transformation of spent coffee grounds (SCG) oil into biodiesel, presenting a cost-effective and environmentally friendly alternative by utilising sulfonated oil palm empty fruit bunch ash (EFBA) as a solid acid catalyst. The catalyst was characterised using Thermogravimetric Analysis (TGA) and Fourier Transform Infrared Spectrometer (FTIR). The SCG oil demonstrating its potential for biodiesel synthesis by transesterification. The ideal reaction conditions were established as a 7h reaction time with a catalyst loading of 30 wt.%. Under these conditions, the FFA value in coffee oil decreased significantly from 15.01 to 2.38, indicating an 84.14% conversion of FFA for the catalyst. The analysis using Gas Chromatography–Mass Spectrometry (GC–MS) validated the presence of significant fatty acid methyl esters (FAMEs), including methyl ester, methyl stearate, methyl linoleate, and methyl oleate. The findings indicate that SCG oil present a viable approach for transforming waste into valuable resources, supporting the principles of a circular economy and minimising reliance on non-renewable energy sources.

Keywords: *Biodiesel, domestic waste, empty fruit bunch, methyl ester*

INTRODUCTION

Nowadays, fossil fuels like coal, crude oil and natural gas are becoming more and more expensive, particularly petroleum products like gasoline and diesel. Furthermore, burning fossil fuels has several negative effects on the environment and society, such as the release of greenhouse gases, the health risks posed by toxic and dangerous species, the death of aquatic animals from crude oil leaks, currency inflation, and even international tensions that exacerbate fuel shortages. Economic and social issues have made energy and environmental safety a crucial concern for governments and scholars throughout the world, according to China's "Double Carbon & Double Control" strategy. Given the current global issues, such as the conflict between Russia and Ukraine and its negative effects on fuel and energy supply chains, it is especially beneficial to produce higher-generation biofuels from advanced platforms, such as those based on food wastes (FW), as opposed to first-generation biofuels. Because biofuels have significant environmental benefits over fossil fuels, they are a viable solution to the current energy problem and greenhouse effect (Xiong et al., 2023).

In recent years, biodiesel has gained traction as a sustainable, clean, and renewable energy source (Mandari & Devarai, 2022). However, the cost of generating biodiesel is greater, including the cost of feedstock and operating expenses. Hence, in this research, domestic waste which is SCG was utilized as a source of oil feedstock by using the transesterification process with the help of catalyst to produce high quality of biodiesel. In addition, minimizing the free fatty acid (FFA) content in spent coffee ground (SCG) oil is essential, as elevated FFA levels hinder the effectiveness of biodiesel production. When FFA levels exceed 2 mg KOH/g, they interact with alkaline catalysts such as NaOH or KOH, resulting in the formation of soap rather than biodiesel. This not only reduces the yield but also adds complexity to the separation and purification processes. Consequently, examining the reduction of free fatty acids is crucial to confirm that the oil derived from spent coffee grounds can serve as an appropriate and effective feedstock for biodiesel production, particularly in a two-step method that includes acid esterification followed by base transesterification. The most widely used catalyst in the commercial biodiesel production of biodiesel is the homogeneous base catalyst. However, there are issues with the current commercial biodiesel production process,

including the difficulty of separating the products and the requirement for irreversible homogenous base catalyst (Chua et al., 2020). In addition to providing energy, this waste product may turn into biodiesel. Additionally, by employing waste as an input, this technique improves environmental results while supporting global efforts to establish a circular economy (Ghasemi et al., 2024). Thus, to create a low-cost biodiesel, the domestic waste known as Spent coffee grounds (SCG) was utilized as feedstock in this study with the help of a heterogeneous acid catalyst. This study also endorses government policies and aligns with SDG 7: Affordable and Clean Energy by advocating for biodiesel as a renewable energy source, SDG 11: Sustainable Cities and Communities by utilizing local waste to mitigate urban pollution, and SDG 13: Climate Action by decreasing greenhouse gas emissions through sustainable fuel alternatives.

MATERIALS AND METHODS

Sample Preparation

Based on research by Khazaai et al. (2024), the oil content was assessed through the process of cold maceration in the meantime. A total of 15 g (on a dry basis) of the SCGs was combined with 50 mL of hexane in a conical flask, which is then sealed with a stopper and wrapped securely. The mixture, with a solid to solvent of 0.3, immersed in the solvent and permitted to remain at room temperature for a duration of 120 hours (5 days). The final extract underwent concentration utilizing a rotary evaporator. The subsequent step involved calculating the oil content as per Equation 1. Following the extraction process, the oil-solvent mixture underwent heating to facilitate the evaporation of the solvent, thereby recovering the extracted oil under vacuum conditions at 65 °C. The calculation of oil content was performed using Equation 1, where M_1 represents the mass of the accumulated oil and M_0 denotes the mass of SCGs in grammes. Eqn. 1: Oil Content (%) = (M_1/M_0) x 100.

Catalyst Preparation

Production of Activated Carbon (AC) from Oil Palm Empty Fruit Bunch Ash (EFBA)

Initially, the EFBA biomass was processed into powdered state to enhance carbonisation efficiency. The biomass underwent impregnation with 30 wt.% phosphoric acid at a weight ratio of 1:7 for a duration of 24 hours. After that, the pre-soaked biomass was cleaned and dried for 24 hours at 85 °C in a heating oven to get rid of any remaining moisture and phosphoric acid. The pre-soaked biomass underwent carbonisation in a Carbolite furnace at 400 °C, identified as the optimal calcination temperature from the total acid density test that indicates more acidic sites present on the surface. Consequently, the activated carbon (AC) that is calcined at 400 °C is known as AC400 (Lim et al., 2020).

Sulfonation through Sulphuric Acid (H_2SO_4)

The activated carbon (AC) that has been calcined at 400 °C (AC400) was combined with 2.0 M H_2SO_4 and subsequently agitated at 600 rpm for 6 hours. The solid precipitate is subjected to filtration and subsequently calcined at 500 °C for 4 hours with a heating rate 10 °C/min. (Embong et al., 2016).

Catalyst Characterization

The catalyst was characterized to determine physicochemical and morphological properties as used in this study. A range of sophisticated analytical techniques employed to perform a comprehensive evaluation of the catalyst's characteristics, including Fourier Transform Infrared Spectroscopy (FTIR) Analysis, to determine the functional group of the catalyst. The concentration and properties of biodiesel, as well as the structural organization noted in FAME, are assessed using FTIR analyses (Rozina et al., 2024). After washing the crystal and plate with acetone, the powder catalyst was placed into the germanium crystals. Following crystal placement, a background scan was performed to remove impurities such as water (H_2O) and carbon dioxide (CO_2). The instrument's spectrum has been set to cover a range from 4000 to 400 cm^{-1}. The analysis was refined through multiple iterations to achieve the best catalyst spectrum possible.

Esterification Reaction of Spent Coffee Grounds (SCG)

The reflux technique was used to heat coffee oil and methanol (MeOH), a condenser, thermometer, and a 50 mL rounded bottom flask that were submerged in an oil bath at 110 ± 3 °C. A molar ratio of 30:1 was maintained between refined oil and methanol during the esterification process. The catalyst amounts used were 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, 30 wt.% and 35 wt.% added into 50 mL round bottom flask with 5 g of coffee oil. Then, the reactions were stirred for 6 h, 7 h and 8 h. After the esterification process, the mixture was centrifuge at 4000 rpm for 15 min to separate the catalyst, which appeared at the bottom layer, the unreacted triglycerides (oil) at the middle layer, and the unreacted methanol at the top layer. The unreacted triglycerides (oil) in the middle layer need to be transesterified. First, eliminate the unreacted methanol from the centrifuge tube. Next, allow the oil to settle in fume hoods to evaporate the excess methanol. Evaluate the acid value of coffee oil using the titration method, performing the procedure in triplicates with a standard solution of isopropanol potassium hydroxide (0.1 M) as specified in AOCS;Cd 3a-63. Finally, compute the conversion rate using the established equations to understand the efficiency of the esterification process.

RESULTS AND DISCUSSION

Characterization of Spent Coffee Grounds (SCG)

The acid value of the spent coffee ground (SCG) oil was determined to be 30.02 mg KOH/g, suggesting a significant presence of free fatty acids (FFA). A high acid value can notably disrupt the transesterification process by encouraging soap formation when employing a base catalyst, which in turn decreases biodiesel yield. This highlights the necessity of implementing an esterification pre-treatment phase with a solid acid catalyst, like sulfonated EFBA, to lower FFA concentrations prior to advancing transesterification. The oil's moisture content was determined to be 0.24%, indicating a relatively low level that falls within the acceptable range for biodiesel feedstocks. Low moisture content is crucial because water may also lead to the hydrolysis of esters and the creation of soap, both of which reduce the effectiveness and purity of the biodiesel that is generated. The recorded density of the oil was 0.8615 g/cm³, aligning closely with the density range of conventional diesel, which typically falls between 0.820 and 0.845 g/cm³ (LearnMetrics, 2024). This indicates that biodiesel obtained from SCG oil may demonstrate comparable flow properties and combustion characteristics to petroleum diesel, positioning it as a viable alternative fuel regarding its physical attributes.

Thermogravimetric Analysis (TGA)

TGA was employed to assess the impact of elevated temperatures on uncalcined empty palm fruit bunch ashes (EFBA) to ascertain the thermal stability of the catalyst. Figure 1 illustrates the data analysis derived from the TGA of uncalcined EFBA. A slight reduction in weight of 4.12% is observed during the initial phase at temperatures between 30 °C and 100 °C. The graph illustrates the reduction of moisture, or the emission of low molecular weight components present in uncalcined EFBA. At intermediate temperatures ranging from 100 °C and 850 °C, a notable weight loss occurs, indicating the thermal decomposition or degradation of certain components within the sample. Alias et al. (2014) suggest that heating rates can affect the shape of the degradation peak. Consequently, the DTG curve of EFBA displays peaks within these temperature ranges, signifying the highest rates of weight loss. A weight loss 8.28% is observed between 850 °C and 1000 °C, likely resulting from the complete decomposition of organic matter or volatile components. The findings indicate that a significant segment of the sample maintains stability at elevated temperatures and possesses sufficient strength to endure thermal stress.

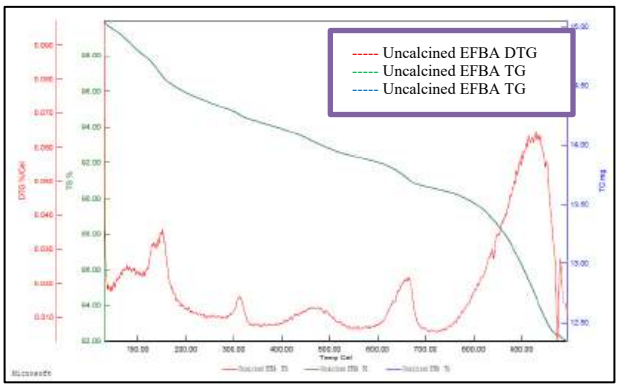


Figure 1. TGA curve of uncalcined EFBA

Optimization of Esterification Reaction

The reduction in FFA value following the esterification reaction, utilizing various reaction times ranging from 6 to 8 h of sulfonate oil palm empty fruit bunch catalyst (SO_4-EFBA). The lowest peak indicates that the maximum value of FFA reduction, which is 3.23 significant to AV:1.62, achieved after a reaction time of 7 h with the use of the catalyst. The proportion of FFA after 7 h was recorded at 78.48%. The FFA percentage for 6 and 8 hours were 13.06% and 69.15%, respectively. Consequently, a reaction time of 7 h was established as the ideal duration for the subsequent esterification reaction aimed at identifying the optimal catalyst loading. The results obtained were consistent with the earlier study conducted by Lim et al. in 2020, which identified 7 hours as the optimal reaction parameter, achieving would reduce the total amount of biodiesel produced.

CONCLUSIONS

The experiment effectively showed that spent coffee grounds (SCG) oil can be transformed into biodiesel using a sulfonated oil palm empty fruit bunch (SO_4-EFBA) as a solid acid catalyst. The ideal reaction conditions were determined to be 7 h for the reaction time and 30 wt.% for catalyst loading. The impressive conversion rate validates the efficacy of the waste-derived catalyst and the SCG oil as an economical and sustainable feedstock for biodiesel production. This approach enhances the value of two plentiful waste materials (SCG and EFBA) while providing a cost-effective and eco-friendly substitute for traditional biodiesel feedstocks. The findings indicate the promise of incorporating waste-to-wealth approaches in biodiesel production, enhancing the circular economy, and diminishing dependence on fossil fuels. While the catalyst demonstrated effectiveness as a heterogeneous catalyst that is both cost-effective and environmentally sustainable, contributing positively to biodiesel efficiency and enabling high conversion rates through the transesterification process, various external factors played a role, leading to a lower percent yield.

REFERENCES

Alias, N. B., Ibrahim, N., & Hamid, M. K. A. (2014). Pyrolysis of empty fruit bunch by thermogravimetric analysis. *Energy Procedia*, *61*, 2532-2536.

Chua, S. Y., Periasamy, L. A., Goh, C. M. H., Tan, Y. H., Mubarak, N. M., Kansedo, J., Khalid, M., Walvekar, R., & Abdullah, E. C. (2020). Biodiesel synthesis using natural solid catalyst derived from biomass waste — A review. *Journal of Industrial and Engineering Chemistry, 81*, 41–60.

Embong, N. H., Maniam, G. P., Mohd, M. H., Lee, K. T., & Huisingh, D. (2016). Utilization of palm fatty acid distillate in methyl esters preparation using $SO_4^{2-}/TiO_2–SiO_2$ as a solid acid catalyst. *Journal of Cleaner Production, 116*, 244–248.

Ghasemi, I., Haghighi, M., Bekhradinassab, E., & Ebrahimi, A. (2024). Ultrasound-assisted dispersion of bifunctional CaO-ZrO_2 nanocatalyst over acidified kaolin for production of biodiesel from waste cooking oil. *Renewable Energy, 225*, 120287.

Khazaai, S. N. M., Bhuyar, P., Strezov, V., Govindan, N., Rahim, M. H. A., & Maniam, G. P. (2024). Optimization of rubber seed oil extraction: adaptive neuro-fuzzy inference-based yield prediction model by studying polarity and moisture content. *BioEnergy Research*, *17*(1), 587-597.

LearnMetrics. (2024, October 23). Diesel Fuel Density In kg/m3, lb/gal, lb/ft3, g/cm3, kg/L (+ Chart). LearnMetrics.

Lim, S., Yap, C. Y., Pang, Y. L., & Wong, K. H. (2020). Biodiesel synthesis from oil palm empty fruit bunch biochar derived heterogeneous solid catalyst using 4-benzenediazonium sulfonate. *Journal of Hazardous Materials, 390*.

Mandari, V., & Devarai, S. K. (2022). Biodiesel production using homogeneous, heterogeneous, and enzyme catalysts via transesterification and esterification reactions: A critical review. *BioEnergy Research*, *15*(2), 935-961.

Rozina, Ahmad, M., Ezeji, T. C., Emmanuel, O., Qureshi, N., & Khan, A. (2024). Utilization of waste seed oil from Cestrum nocturnum as a novel source for cleaner production of biodiesel using green nano-catalyst of antimony oxide. *Fuel, 364*, 131124.

Xiong, X., Zhang, W., Ha, X., Li, N., Chen, S., Xing, H., & Yang, J. (2023). The preparation processes and influencing factors of biofuel production from kitchen waste. *Fermentation*, *9*(3), 247.

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Sekian, terima kasih.

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Setuju.

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