E-PROCEEDINGS

INTERNATIONAL TINKER INNOVATION & ENTREPRENEURSHIP CHALLENGE (i-TIEC 2025)

"Fostering a Culture of Innovation and Entrepreneurial Excellence"

23 January 2025
PTDI, UiTM Cawangan Johor
Kampus Pasir Gudang

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A-ST022: REVOLUTIONIZING EPOXIDE SYNTHESIS: CATALYTIC INNOVATIONS IN WASTE COOKING OIL EPOXIDATION

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ABSTRACT

This study presents an innovative catalytic process for the epoxidation of waste cooking oil to provide a sustainable and efficient approach to generating high-value epoxide compounds. The process employs eco-friendly oxidizing agents and recyclable catalysts to minimize waste, decrease energy consumption, and improve reaction selectivity and yield. By comparing the traditional methods, this method offers catalyst stability and will reduce side reactions regarding cost-effectiveness and environmental sustainability. The innovation tackles socio-economic issues by converting waste or low-value cooking oil into valuable industrial products, bolstering local industries and diminishing reliance on petrochemical materials, stabilisers and lubricants are used to synthesize polymers. This process is the increasing demand for bio-based materials across various industries. This advancement illustrates a more sustainable and efficient method for epoxide synthesis, yielding significant socio-economic and environmental advantages. In addition, the substantial amount of waste cooking oil produced worldwide presents major challenges for waste management. Poor handling contributes to environmental pollution, blocked drainage systems, health hazards, and heightened greenhouse gas emissions, while also overlooking its potential as a renewable resource for biodiesel production and other valuable uses.

Keywords: Waste cooking oil, epoxide, sustainable

1. Product Description

Epoxides waste cooking oil are reactive organic compounds with a three-membered cyclic ether structure, making them essential intermediates in chemical synthesis. Derived from unsaturated oils like cooking oil through the epoxidation process, they are produced by reacting the oil's double bonds with oxidizing agents, often in the presence of a catalyst. This transforms the oil into epoxidized derivatives by introducing epoxy groups at the double bond sites. Epoxidized oils find wide industrial applications, including use as plasticizers and stabilizers in PVC, components in eco-friendly coatings and adhesives, and precursors for biodegradable polymers. They also serve as additives and lubricants in industrial processes. These products offer significant environmental and economic benefits by converting renewable and low-value oils into high-value materials. Their sustainability reduced environmental impact, and alignment with circular economy principles make them attractive alternatives to petroleum-based products in diverse industries

2. Schematic Representation of the Epoxidation Process for Waste Cooking Oil

Figure 1 illustrates the steps in the waste cooking oil epoxidation process. It started with determining and optimizing critical process parameters for epoxidation, including temperature, reaction time, reactant molar ratio, and stirring speed. During the catalyst selection stage, a suitable catalyst is selected to improve the rate of the epoxidation reaction. Heterogeneous or homogeneous catalysts are assessed for activity, stability, and environmental impact. Waste cooking oil undergoes epoxidation, converting double bonds in triglycerides into epoxy groups. This requires an oxidizing agent, like hydrogen peroxide, and an acid catalyst. The conversion of double bonds into epoxy groups was quantified by calculating the percentage of Relative Conversion of Oxirane (RCO) after the reaction. The final step, characterization, involved analyzing the epoxidized oil using FTIR to confirm the production of epoxy groups.

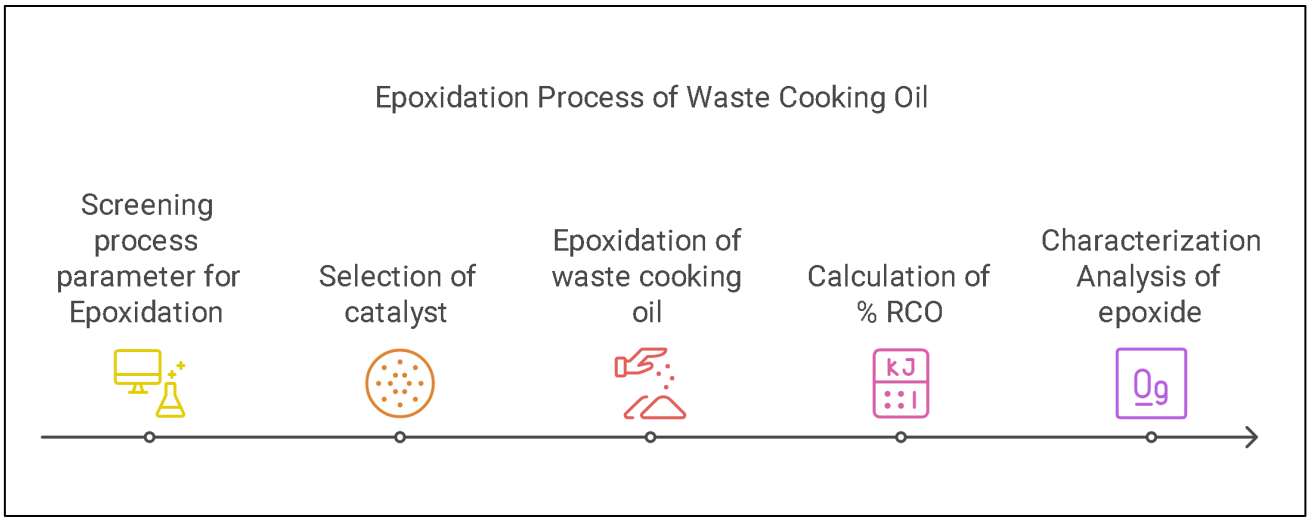

Figure 1. Epoxidation Process of Waste Cooking Oil.

3. Novelty and uniqueness

The novelty of this project lies in its innovative approach to epoxidizing waste cooking oil using advanced catalytic mechanisms. Unlike conventional methods that rely on hazardous chemicals or require harsh conditions, this process utilizes eco-friendly oxidizing agents and recyclable catalysts, which significantly reduce environmental impact by lowering waste and energy consumption. The use of sustainable catalysts ensures higher stability and selectivity, minimizing side reactions and improving the overall sustainability of the process. Additionally, the project introduces a novel catalytic system that can be adapted to different feedstocks, making it versatile for a range of industrial applications. By converting waste or low-value cooking oil into high-value products like biopolymers, lubricants, and stabilizers, this innovation opens up new opportunities for commercialization in the bio-based materials industry. It not only enhances the economic viability of sustainable technologies but also aligns with global goals for reducing environmental footprints and promoting a circular economy

4. Benefit to mankind

This innovative process allows for the conversion of waste cooking oil into valuable products, reducing environmental impact and promoting a circular economy. It helps mitigate the reliance on non-renewable petrochemical resources by providing bio-based alternatives in various industrial applications such as polymers, lubricants, and coatings. Additionally, it supports economic development by creating opportunities for local industries and small businesses. Ultimately, this process contributes to improved environmental health, economic stability, and societal well-being by fostering sustainable practices and reducing the carbon footprint.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by developing an advanced catalytic process for epoxidizing waste cooking oil, transforming waste materials into high-value industrial products through sustainable green chemistry. It fosters entrepreneurship by enabling scalable, locally adaptable production systems for small and medium enterprises, supporting applications like biopolymers and lubricants. Integrating findings into academic programs inspires students and researchers to explore eco-friendly chemical processes, cultivating a culture of innovation. The project bridges scientific advancements with entrepreneurial opportunities, driving socio-economic growth while aligning with circular economy principles and demonstrating the economic viability of sustainable technologies for community and industry benefit

6. Potential commercialization

The commercialization potential of the epoxidation process for cooking oil is significant. This scalable, sustainable method can be adopted by SMEs and larger industries to produce high-value products like polymers, lubricants, and coatings. As the market for bio-based materials grows, this process meets demand for eco-friendly alternatives, aligning with sustainability goals and opening up new business opportunities.

7. Acknowledgment

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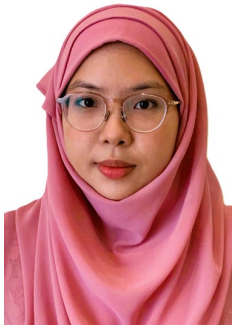
8. Authors' Biography



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Mrs. Norhafini Hambali is a Lecturer at the UiTM Pasir Gudang, Johor, specializing in bioprocess engineering, particularly in biopolymer production. Her current research area focuses on catalyst modification to produce biopolymers from epoxide groups. With over 5 years of experience, she has been involved in natural products extraction, enhancing extraction yield through co-solvent systems and optimization simulations. She has also contributed actively to environmental engineering, particularly in developing natural coagulants and creating natural filtration systems from waste materials. She has several publications in reputable journals highlighting her work in bioprocess engineering, sustainable biopolymer production, and environmental particularly in fish cage farming areas.

Mr. Mohamad Zarqani Yeop is a Lecturer at the UiTM Pasir Gudang, Johor, specializing in chemical engineering in hydrothermal process & technology and wastewater treatment. His current research area focuses on formation of bio-polyols via hybrid process from epoxidized rice bran oil. He has several publications in reputable journals highlighting his work in each related area of research.