

SYNTHESIS AND CHARACTERIZATION OF CALCIUM-DOPED BaO HETEROGENEOUS NANOCATALYST FOR BIODIESEL PRODUCTION FROM WASTE COOKING OIL: KINETIC STUDIES

1. INTRODUCTION

Biodiesel, a promising alternative to fossil fuels, is produced through transesterification of triglycerides (fats and oils) with an alcohol (typically methanol) using a catalyst. Waste cooking oil (WCO) serves as a readily available and inexpensive feedstock for biodiesel, but its utilization presents challenges due to the presence of free fatty acids (FFAs). Conventional homogeneous catalysts are effective but face drawbacks like separation difficulties, high production costs, and environmental concerns. Heterogeneous catalysts offer advantages like reusability, ease of separation, and the potential to handle FFAs. This research proposes the development of a novel calcium-doped BaO (barium oxide) heterogeneous nanocatalyst for efficient biodiesel production from WCO, alongside in-depth kinetic studies to understand the reaction mechanism.

2. LITERATURE REVIEW

Several studies explore heterogeneous catalysts for WCO transesterification, highlighting limitations like low activity, high costs, and complex synthesis. BaO, a promising material for heterogeneous catalysts due to its basicity, exhibits limitations like low surface area and activity. Doping BaO with other elements like calcium has been shown to improve its catalytic performance.

This research builds upon existing knowledge by:

- Developing calcium-doped BaO nanocatalysts with tailored properties for efficient WCO transesterification.
- Investigating the effect of calcium doping on the catalyst's activity, selectivity, and reusability.
- Optimizing reaction conditions for maximizing biodiesel yield and minimizing undesired byproducts.
- Conducting detailed kinetic studies to elucidate the reaction mechanism and rate-determining steps.

3. RESEARCH OBJECTIVES

- Synthesize calcium-doped BaO nanocatalysts with controlled morphologies and surface properties.
- Characterize the synthesized nanocatalysts using various techniques (e.g., XRD, SEM, TEM, BET) to understand their structural, textural, and morphological properties.
- Evaluate the catalytic activity of the synthesized materials for WCO transesterification under different reaction conditions (temperature, alcohol-to-oil ratio, catalyst loading).
- Optimize reaction parameters to achieve high biodiesel yield and conversion efficiency.
- Assess the reusability and stability of the synthesized catalysts.
- Conduct kinetic studies to determine the reaction rate constants, activation energy, and reaction order with respect to reactants.
- Propose a plausible reaction mechanism based on the kinetic data and catalyst characterization.

4. METHODOLOGY

- **Catalyst Synthesis:** Various synthesis methods (e.g., sol-gel, co-precipitation) will be employed to prepare calcium-doped BaO nanocatalysts with different doping levels. Synthesis parameters will be optimized for desired properties.
- **Catalyst Characterization:** The synthesized nanocatalysts will be characterized using techniques like X-ray diffraction (XRD) for crystal structure, scanning electron microscopy (SEM) and transmission electron microscopy (TEM) for morphology and particle size, and Brunauer-Emmett-Teller (BET) analysis for surface area and porosity.
- **Biodiesel Production:** Transesterification reactions will be conducted using the synthesized catalysts under different reaction conditions. Reaction progress will be monitored by analyzing the reaction mixture using gas chromatography (GC) and/or high-performance liquid chromatography (HPLC).
- **Kinetic Studies:** Kinetic data at various temperatures and reactant concentrations will be collected. Reaction rate constants will be determined using appropriate kinetic models.
- **Mechanism Proposal:** Based on the kinetic data, catalyst characterization, and literature knowledge, a plausible reaction mechanism for WCO transesterification over the calcium-doped BaO nanocatalyst will be proposed.

5. EXPECTED OUTCOMES

This research is expected to deliver the following outcomes:

- Development of novel calcium-doped BaO nanocatalysts with enhanced activity and selectivity for WCO transesterification.
- A comprehensive understanding of the relationship between calcium doping, catalyst properties, and catalytic performance.
- Optimized reaction conditions for efficient biodiesel production from WCO.
- In-depth kinetic studies elucidating the reaction mechanism and rate-determining steps for WCO transesterification using the developed nanocatalyst.

6. SIGNIFICANCE

This research contributes to developing sustainable and cost-effective biodiesel production processes utilizing waste resources like WCO. The successful development of a highly active and reusable calcium-doped BaO nanocatalyst coupled with detailed kinetic studies offers several benefits:

- Reduced reliance on fossil fuels and promotion of renewable energy sources.
- Mitigated environmental impact of waste cooking oil disposal.
- Cleaner and more efficient alternative to current biodiesel production methods.
- Improved understanding of the reaction mechanism, enabling further optimization and development of advanced catalysts.