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Emerging Catalysts and Techniques in Microalgae-Based Biodiesel Production

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INTRODUCTION & AIM

Microalgae offer a sustainable feedstock for biodiesel, with catalysts playing a key role in transesterification. This study includes various catalyst types homogeneous, heterogeneous, enzymatic, and ionic liquids—by analyzing FAME yields, reaction times, and separation ease from multiple research works on species like Nannochloropsis oculata and Chlorella vulgaris.

METHOD

•Conducted a comparative review of published research on catalysts used in microalgae-based biodiesel production.
•Collected data from experimental studies focusing on FAME yield using various catalysts:
•Sulfuric acid
•Sodium hydroxide
•NaOH/Zeolite
•KF/CaO
•Ionic liquids
•Catalysts were tested under different conditions with microalgae species like:
•*Nannochloropsis oculata*
•*Chlorella vulgaris*
•*Chlorella sp.*
•Key performance metrics analyzed:
•FAME yield percentage
•Reaction time
•Catalyst separation and reusability
•Environmental and economic impacts of each catalyst were evaluated for practical scalability.

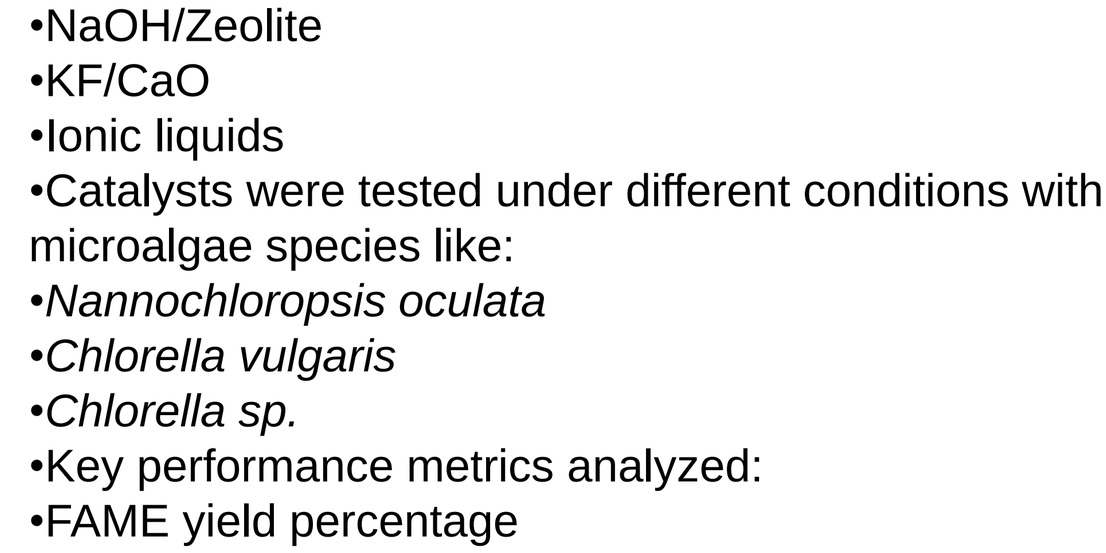

Figure 1: Catalysts in Microalgae-Based Biodiesel Production

RESULTS & DISCUSSION

Homogeneous catalysts like sulfuric acid and sodium hydroxide are highly efficient, achieving FAME yields up to 92%, but pose challenges in separation and environmental impact.
Heterogeneous catalysts, such as NaOH/Zeolite and KF/CaO, offer high yields (up to 98%) with easier separation and reusability, making them ideal for industrial use.
Metal oxides on zeolite (e.g., CuO/Zeolite) and **ZnAl LDH** also show strong performance, with yields up to 98%.
Enzymatic catalysts, particularly immobilized ones, produce over 90% yield under mild conditions but are limited by high cost and stability.

CONCLUSION

•**Homogeneous Catalysts (Sulfuric Acid, NaOH)**:
•**Sulfuric Acid**: 73% FAME from *Nannochloropsis oculata*, 92% from *Chlorella sp.*
•**Challenges**: Hard to separate from biodiesel; high operational costs, environmental impact.
•**Heterogeneous Catalysts**:
•**NaOH/Zeolite**: 83.5% FAME from *N. oculata*, 98% from *C. vulgaris*.
•**Other Catalysts**:
  •**CuO/Zeolite**: 69% yield.
  •**KF/CaO**: 93.07% yield.
  •**ZnAl LDH**: >98% yield.
•**Advantages**: Easy separation, reusability, suitable for large-scale production.
•**Enzymatic Catalysts**:
•**Immobilized Enzymes**: Over 90% ester yield, mild reaction conditions.

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