WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Production of Biofuel from Industrial Waste Using a Novel Nano-Catalyst Synthesized from Natural Biomass

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ABSTRACT

The global depletion of fossil fuels and increasing environmental concerns have intensified the need for renewable alternative fuels. Biodiesel, derived from biological and industrial waste sources, offers a promising solution due to its biodegradability, lower emissions, and compatibility with diesel engines. This study investigates biodiesel production from various industrial bio-wastes—including tannery scum, dairy scum, fishery waste, and microalgal biomass—using heterogeneous catalytic transesterification. The work includes a literature review, feedstock evaluation, catalyst techniques, and experimental biodiesel production from tannery scum. Produced biodiesel met ASTM fuel standards, confirming industrial wastes as sustainable feedstocks for circular energy systems.

Keywords: Biodiesel, Transesterification, Industrial waste, Tannery scum, Heterogeneous catalyst, Renewable fuels.

1. Introduction

The global energy demand continues to rise due to population growth, transportation needs, and industrial expansion. Biodiesel is a renewable, biodegradable alternative to fossil diesel with reduced emissions. Although edible oils have traditionally been used to produce biodiesel, concerns about food security have shifted focus toward non-edible and waste-derived sources. Industrial bio-wastes such as tannery scum, dairy scum, fish waste, and microalgae provide abundant, low-cost lipid resources. This paper reviews biodiesel from industrial waste sources and presents a condensed experimental study using tannery scum as feedstock.

Nomenclature

FAME – Fatty Acid Methyl Ester

FFA – Free Fatty Acid

TSO – Tannery Scum Oil

RTSO – Refined Tannery Scum Oil

ASTM – American Society for Testing and Materials

2. Literature Review

Biofuel feedstocks are classified into edible, non-edible, and waste-derived categories. Edible sources increase food scarcity issues, while non-edible sources require land and water. Industrial waste feedstocks such as tannery scum, dairy scum, fish viscera, and microalgae offer environmentally friendly, cost-effective alternatives. Studies show that these waste materials produce biodiesel comparable to conventional diesel while minimizing disposal problems.

3. Materials and Methods

Tannery scum was collected, dried, ground, and screened. Oil extraction was performed using Soxhlet apparatus with hexane. The extracted TSO was refined through fractional crystallization. High FFA levels required two-step biodiesel production: acid esterification followed by base transesterification. Biodiesel was tested using NMR, GC, ICP-OES, and ASTM D6751 standard methods.

4. Results and Discussion

Tannery scum demonstrated high lipid content suitable for biodiesel production. Acid esterification significantly reduced FFA, enabling successful transesterification. Biodiesel produced met ASTM standards for viscosity, density, flash point, and heating value. Waste-derived biodiesel reduces production cost and environmental impacts, making it suitable for large-scale applications.

5. Conclusion

Industrial bio-wastes provide sustainable feedstocks for biodiesel production. Tannery scum oil (TSO) was successfully converted to biodiesel with properties meeting ASTM D6751 fuel standards. Waste-to-energy approaches reduce environmental pollution and enhance circular economy practices.

Acknowledgements

The authors thank the Department of Chemical Engineering for facilities and academic support.

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