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GREEN TRANSFORMER OIL: BIOBASED PRODUCTION AND CHARACTERIZATION FROM JATROPHA CURCAS SEEDS

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ABSTRACT

This study explores the production and characterization of green transformer oil derived from Jatropha Curcas seeds. As the demand for eco-friendly and sustainable alternatives to conventional transformer oils grows, Jatropha Curcas seed oil emerges as a promising candidate. The production process involves extraction, purification, and refining steps to transform Jatropha Curcas seed oil into a high-performance, biobased transformer oil. Comprehensive characterization techniques, including physicochemical, thermal, and electrical analyses, provide insights into the oil's suitability for electrical insulation applications. The results highlight the potential of Jatropha Curcas seed oil as a sustainable and environmentally friendly alternative for transformer oil applications.

KEYWORDS

Transformer oil; Jatropha Curcas seed oil; Biobased oil; Green energy; Sustainable materials; Characterization; Electrical insulation

INTRODUCTION

Transformer oil, traditionally derived from petroleum, serves a critical role in the efficient operation of electrical transformers and another high-voltage equipment. It provides electrical insulation, dissipates heat, and protects the transformer's internal components from oxidation and degradation. However, the

production and use of conventional petroleum-based transformer oils raise environmental concerns due to their non-renewable nature, potential toxicity, and carbon footprint.

In response to the global shift towards sustainability and environmental responsibility, there is growing interest in developing biobased transformer oils as eco-friendly alternatives. These biobased oils are derived from renewable sources and offer a more environmentally benign solution for transformer insulation and cooling. Jatropha Curcas, a hardy shrub native to tropical and subtropical regions, has gained prominence as a potential source of biobased transformer oil due to its abundant seeds and high oil content.

This study delves into the production and characterization of biobased transformer oil obtained from Jatropha Curcas seeds. The production process involves a series of steps, including seed extraction, oil purification, and refining, aimed at transforming Jatropha Curcas seed oil into a high-performance and environmentally friendly transformer oil. Through comprehensive characterization techniques, including physicochemical, thermal, and electrical analyses, this research assesses the oil's suitability for electrical insulation applications.

The investigation aims to shed light on the viability and advantages of Jatropha Curcas seed oil as a biobased transformer oil. As the world increasingly embraces sustainable energy and materials, this study contributes to the ongoing efforts to reduce the environmental impact of the electrical power industry while maintaining high-performance standards. The potential of Jatropha Curcas seed oil to meet the demands of the modern electrical infrastructure represents a significant step towards achieving greener and more sustainable energy technologies.

METHOD

Seed Collection and Extraction:

The process of producing biobased transformer oil from Jatropha Curcas seeds commenced with the collection of mature seeds from a reliable source. These seeds were meticulously cleaned and dried to remove any impurities. Subsequently, the seeds were dehulled to obtain the raw kernels, which are rich in

oil content. The oil extraction process utilized a mechanical cold-press method, which ensured that the oil was obtained with minimal heat generation, preserving its quality and preventing thermal degradation.

Oil Purification:

The crude Jatropha Curcas seed oil (JC oil) obtained from the extraction process contained impurities and undesirable components. To purify the oil, a multi-step process was employed. First, degumming was carried out to separate water and phospholipids from the oil. Following degumming, an acid treatment was applied to neutralize any free fatty acids present in the crude oil. To remove residual acids, the oil was thoroughly washed with water. These purification steps were crucial in enhancing the quality and stability of the oil.

Refining Process:

To further refine the oil and improve its quality, a refining process was implemented. This process involved bleaching the oil using activated clay, which effectively removed pigments and any remaining traces of unwanted substances. Deodorization was then carried out under controlled temperature and pressure conditions to eliminate odor and volatile components that might adversely affect the oil's performance and suitability for electrical insulation.

Transformer Oil Formulation:

The purified and refined Jatropha Curcas seed oil was used as the base for the transformer oil formulation. To enhance its performance in electrical insulation applications, the oil was carefully blended with suitable additives. These additives included antioxidants to protect against oxidation, anti-wear agents to minimize friction and wear in the transformer, and corrosion inhibitors to prevent damage to internal components. The formulation was meticulously prepared to ensure compatibility and optimal performance.

Characterization Techniques:

The produced transformer oil formulation underwent a series of characterization techniques to evaluate its suitability for electrical insulation:

Physicochemical Analysis: Key physicochemical properties such as density, viscosity, acidity, and flash point were determined. These properties were assessed to ensure that the oil met industry standards and specifications.

Thermal Analysis: Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) were conducted to investigate the oil's thermal stability, decomposition temperature, and heat capacity, crucial factors in electrical applications.

Electrical Properties: Dielectric breakdown strength and dissipation factor measurements were performed to assess the oil's electrical insulation capabilities, confirming its suitability for use in transformers and another high-voltage equipment.

This systematic process of seed collection, extraction, purification, refining, formulation, and thorough characterization aimed to explore the potential of Jatropha Curcas seed oil as a sustainable and environmentally friendly alternative for transformer oil. The comprehensive approach ensured that the produced oil met industry standards while also considering its environmental impact and performance in electrical applications.

RESULTS

The production and characterization of biobased transformer oil derived from Jatropha Curcas seeds yielded promising results:

Physicochemical Properties: The produced transformer oil exhibited physicochemical properties within industry standards. These included density, viscosity, acidity, and flash point, all of which met the required specifications for electrical insulating oils.

Thermal Stability: Thermal analysis, including thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC), demonstrated that the oil possessed excellent thermal stability. It exhibited a high decomposition temperature and a robust heat capacity, indicating its suitability for withstanding elevated temperatures within transformers.

Electrical Insulation: Electrical properties, such as dielectric breakdown strength and dissipation factor, revealed that the biobased transformer oil was an effective electrical insulator. Its dielectric strength met or exceeded industry standards, ensuring safe and reliable electrical insulation.

DISCUSSION

The results of this study confirm the feasibility of producing biobased transformer oil from Jatropha Curcas seeds. The physicochemical properties of the oil align with industry requirements, making it suitable for electrical insulation applications. Its thermal stability is particularly noteworthy, as it can withstand the high operating temperatures commonly encountered in transformers.

Furthermore, the excellent electrical insulation properties of the biobased transformer oil emphasize its potential as a green alternative to petroleum-based transformer oils. It meets or exceeds dielectric strength standards, ensuring the safe and reliable operation of electrical equipment.

The environmentally friendly aspect of using Jatropha Curcas seed oil as a base material for transformer oil is a significant advantage. It is derived from a renewable source, reducing the dependency on non-renewable petroleum resources. Additionally, the production process has the potential to have a lower environmental impact when compared to traditional oil refining methods.

CONCLUSION

In conclusion, the production and characterization of biobased transformer oil from Jatropha Curcas seeds offer a promising path toward sustainable and environmentally friendly electrical insulation solutions. The results of this study demonstrate that the produced oil meets critical industry standards, possesses excellent thermal stability, and exhibits superior electrical insulation properties.

As the world seeks greener and more sustainable energy solutions, biobased transformer oils like the one derived from Jatropha Curcas seeds have the potential to play a pivotal role in reducing the environmental impact of the electrical power industry. By embracing renewable resources and environmentally responsible production methods, this biobased transformer oil represents a significant step forward in the pursuit of a more sustainable and eco-friendly energy sector.

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