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Biodiesel synthesis from used frying oils: Synergistic effect study using central composite design (CCD)

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ABSTRACT

Growing global energy demands, particularly in developing economies heavily reliant on oil, exacerbate concerns about fossil fuel dependence, air pollution, and climate change. The urgent need to transition towards sustainable energy sources has spurred research into renewable alternatives, such as waste vegetable oils, for second-generation biofuel production. This eco-friendly approach aims to repurpose organic waste, specifically used cooking oils, into valuable fuels. This study focuses on biodiesel synthesis via transesterification of used frying oils, along with a comprehensive analysis of the physicochemical properties of both the raw oil and the synthesized biodiesel. The results demonstrate that the synthesized biodiesel aligns with European standards, making it suitable for use in diesel engines. The biodiesel synthesis conditions were optimized using Response Surface Methodology (RSM) based on a Central Composite Design (CCD), with agitation time and temperature as input variables. A second-order model, validated through Analysis of Variance (ANOVA), was developed to relate biodiesel yield (output response) to the aforementioned input variables. The second-order regression model accurately described the process. The effects of these variables on biodiesel yield were investigated, including a discussion of the interactive effects between the various influencing factors.

Keywords: Biodiesel; Waste vegetable oil (WVO); Transesterification; Green technology; Response surface methodology