

Response Surface Methodology Approach for Optimization of Reaction Time and Temperature for Glycerol Esterification Reaction

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Structured Abstract

Background: Crude glycerol, a by-product of biodiesel production, presents both a disposal challenge and an opportunity for valorization into industrially valuable compounds. This study explores the conversion of glycerol into acetins which are monoacetin, diacetin, and triacetin via esterification with acetic acid using a sulfonated polydivinylbenzene (PDVB-SO₃H) catalyst.

Methods: The catalyst was synthesized and sulfonated, followed by characterization using FTIR, XRD, CHNS, BET, TGA, and acid-base titration. High acidity (7.18 mmol/g) and sulfur incorporation (2.54 mmol/g) confirmed successful sulfonation. Esterification was carried out in a batch reactor using a Box-Behnken Design under Response Surface Methodology (RSM) to evaluate the influence of temperature and reaction time on acetin selectivity.

Results: Regression models revealed that increasing temperature and reaction time favored triacetin formation, while monoacetin and diacetin were more prominent under milder conditions. The optimal conditions significantly improved triacetin yield. Characterization results confirmed the mesoporous nature and thermal stability of the catalyst, making it suitable for reuse.

Conclusion: This study demonstrated an effective approach to converting biodiesel-derived glycerol into high-value acetins using a green, reusable catalyst. The integration of sulfonated PDVB and RSM optimization supports clean energy practices (SDG 7) and industrial innovation (SDG 9).

Keywords: Glycerol esterification, polydivinylbenzene, sulfonation, response surface methodology, triacetin

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