

## Process optimization and kinetic evaluation of Amberlite IR 120 and sulphamic acid catalyzed esterification of acetic acid and methanol

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The Box-Behnken design-based Response Surface Methodology (RSM) has been effectively utilized to optimize the parameters for operation in the amberlite IR 120 and sulphamic acid-catalyzed esterification of methanol and acetic acid. The impact of three process variables, temperature, catalyst loading, and the mole ratio of methanol to acetic acid on esterification has been evaluated. The esterification process exhibits excellent concordance between the predicted values and the experimental values ( $R^2 = 98.33\%$  and  $\text{Adj-}R^2 = 92.08\%$ ), which indicate the suitability of the Box-Behnken model employed. The interaction of the parameters is also studied based on its  $P$ -value with the help of ANOVA variance. The second-order kinetic rate equation is applied to correlate the experimental data. By employing the Arrhenius graph, the rate constants for the backward ( $12.727 \times 10^8 \text{ lit mol}^{-1} \text{ min}^{-1}$ ) and forward reactions ( $2.324 \times 10^4 \text{ lit mol}^{-1} \text{ min}^{-1}$ ), as well as the energy of activation using amberlite IR 120, have been determined. The statistical methodologies, including factorial design and Box-Behnken response, have been employed to model the conversion of acetic acid using various regression techniques for a quadratic equation. The result shows that the amberlite IR 120 catalyst is better than the sulphamic acid catalyst due to the more active catalyst surface area.

**Keywords:** Box-Behnken model, Response surface methodology, Esterification, Ion exchange, Amberlite IR 120, Sulphamic Acid