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Estimation of concentration-independent rate-constant (CIRC) for esterification kinetics of biodiesel synthesis from high FFA containing low cost feed stocks

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The raw material accounts for 60–80% of the total cost of biodiesel fuel produced via transesterification of refined oil. The profitable biodiesel can be produced from low cost feed-stocks. But such feed-stocks generally contain large amounts of free fatty acids (FFA). A key challenge is cost-effective pretreatment of high FFA feed-stocks to reduce the FFA below the desired levels prior to the transesterification process. Kinetics of the esterification reaction cannot be computed unless the rate law and values of rate constant are known. Rate constants are determined usually by performing experiments at different reaction conditions. In this work, a novel method is proposed as shown in the Figure 1 for the estimation of rate constants for H_2SO_4-catalyzed esterification of FFA with methanol for the biodiesel synthesis from the low-cost feed-stocks. This method is based on the concept of concentration-independent rate-constant (CIRC) and equilibrium constant as a function of temperature only. The various steps involved in the method are shown in detail in the figure 2. Techniques of design of experiments (DOE) such as Taguchi method and full-factorial design are used to design the experiments and to perform statistical and regression analysis of the results using software MINITAB 15 to obtain mathematical models for the estimation of rate constants. Effects of catalyst loadings (0.5-2.0 wt %), temperature (40-60°C), and molar ratio (3-9) on the kinetics are studied. Mathematical models developed for the predictions of kinetics are statistically and kinetically tested through model adequacy check. Models are found to be suitable for kinetics predictions. The CIRCs are then estimated from the predicted kinetics of models. The estimated CIRCs are compared with the experimental values of CIRCs obtained from the validation experiments and most of them are found to be within ±10% deviation as shown in figure 3.

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