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Optimization of ultrasound-assisted base-catalyzed methanolysis of sunflower oil using response surface and artifical neural network methodologies

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HIGHLIGHTS

- Four operational factors included in optimization of methanolysis under sonication.
- Comparing the performances of RSM and ANN in optimizing biodiesel production process.
- ANN predictions of FAME yield (±3.4%) were much better than those of RSM (±24.2%).
- The generalization ability of the developed ANN model was well documented.

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ABSTRACT

The sunflower oil transesterification, catalyzed by KOH in the presence of ultrasound, was optimized by combining a 3^4 full factorial design of experiments with either a back-propagation artificial neural network (ANN) with the topology 4–10–1 or the response surface methodology (RSM). Four input factors, methanol/oil molar ratio, reaction temperature, catalyst loading and time and one output response, FAME yield, were included into the optimization study. The main goals were to test how accurately these two combinations predict and simulate the FAME yield achieved by the base-catalyzed methanolysis of sunflower oil under ultrasonication. Another aim was to compare the performances of the developed two models as a tool assisting decision making during the investigated methanolysis process. The ANN is shown to be a powerful tool for modeling and optimizing FAME production. Its predictions of FAME yield are very good all through the methanolysis process studied in wide ranges of the process factors. This is proved by a low value (±3.4%) of the mean MRPD between the experimental and simulated values of FAME yield, suggesting that they are almost the same. The ANN predictions were much better than those (±24.2%) obtained by the second-order polynomial equation from the RSM. The generalization ability of the developed ANN model for the base-catalyzed methanolysis optimization was well documented for different feedstocks and operational variables in the presence and absence of the ultrasound. The maximum FAME yield of 89.9% predicted by the ANN model could be achieved in 60 min at the reaction temperature of 30 °C, the initial methanol/oil molar ratio of 7.5:1 and the catalyst loading of 0.7%.

1. Introduction

Biodiesel, an alternative to fossil fuels, is obtained from natural sources of triacylglycerols (vegetable, algal and waste cooking oils as well as animal fats) by the transesterification reaction (or more accurately alcoholysis) of triacylglycerols with a low aliphatic alcohol (usually ethanol or methanol), which is usually catalyzed by a catalyst. The results of this reaction are monoalkyl esters, commercially known as biodiesel, and glycerol. The major obstacle to industrial biodiesel production processes is their economic viability. Therefore, recent research work has been aimed to the development of novel methods leading to the decrease of the biodiesel production cost.

The use of ultrasound in biodiesel production is a promising, novel method solving the problem related to the immiscibility of oily feedstocks and alcohol. This method has several advantages over the classical synthesis employing mechanical agitation. Ultrasound improves the interfacial area between the immiscible reactants which accelerates the reaction and shortens the reaction time [1,2]. Application of ultrasound is also economically acceptable

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