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Optimization of transesterification process for *Ceiba pentandra* oil: A comparative study between kernel-based extreme learning machine and artificial neural networks

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ABSTRACT

In this study, kernel-based extreme learning machine (K-ELM) and artificial neural network (ANN) models were developed in order to predict the conditions of an alkaline-catalysed transesterification process. The reliability of these models was assessed and compared based on the coefficient of determination (R^2), root mean squared error (RSME), mean average percent error (MAPE) and relative percent deviation (RPD). The K-ELM model had higher R^2 (0.991) and lower RSME, MAPE and RPD (0.688, 0.388 and 0.380) compared to the ANN model (0.984, 0.913, 0.640 and 0.634). Based on these results, the K-ELM model is a more reliable prediction model and it was integrated with ant colony optimization (ACO) in order to achieve the highest *Ceiba pentandra* methyl ester yield. The optimum molar ratio of methanol to oil, KOH catalyst weight, reaction temperature, reaction time and agitation speed predicted by the K-ELM model integrated with ACO was 10:1, 1 %wt, 60 °C, 108 min and 1100 rpm, respectively. The *Ceiba pentandra* methyl ester yield attained under these optimum conditions was 99.80%. This novel integrated model provides insight on the effect of parameters investigated on the methyl ester yield, which may be useful for industries involved in biodiesel production.

1. Introduction

Biodiesel has gained prominence throughout the world as alternative fuel for diesel engines. Biodiesels as alternative fuels in diesel engines is not new nowadays owing to their favourable physical and chemical properties that are comparable to those for diesel, but with lower engine emissions. There is a growing trend in the biodiesel production capacity not only in developed countries such as France, Germany, Italy and the United States, but also in developing countries such as Brazil, Argentina, Indonesia and Malaysia [1]. The production of alternative fuels from renewable sources have gained much interest from scientists, researchers and industrialists in the field due to concerns on the depletion of fossil fuels and the impact of fossil fuel emissions on the environment. More importantly, there is a critical need to ensure a sustainable supply of energy in order to fulfil the escalating energy demands, which is not possible with fossil fuels since these fuels are derived from non-renewable sources [2]. Concerns over food security have led to the development and enforcement of policies which emphasize the production biofuels from non-agricultural sources [3]. In response to this need, scientists and researchers actively search for ways to produce biodiesels from non-edible feedstocks as well as macroalgae and microalgae [4,5].

Ceiba pentandra (C. *pentandra*) is commonly known as silk-cotton tree. It is a tall plant which belongs to the *Malvaceae* family and it is typically found in tropical rainforests. The seeds of *Ceiba pentandra* contain a relatively high non-edible oil content (~40 %wt, dry basis) and thus, these seeds can be used as potential feedstocks to produce biodiesels. Several experimental have been conducted

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