CHEMICAL ENGINEERING COMMUNICATIONS
https://doi.org/10.1080/00986445.2018.1538973

Statistical optimization and kinetic study on biodiesel production from a potential non-edible bio-oil of wild radish

Q3 C. Senthilkumar[a], C. Krishnaraj[b], P. Sivakumar[c], and Anirbid Sircar[c]

[a]Department of Mechanical Engineering, RVS College of Engineering and Technology, Coimbatore, India; [b]Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India; [c]School of Petroleum Technology, Pandit Deendayal Petroleum University, Gandhinagar, India

ABSTRACT

The bio-oil extracted from wild radish seeds is non-edible and it still remains an unexplored area in terms of its use as a feedstock for biodiesel. It was extracted from the seeds using mechanical expeller and the oil yield was found to be 46.2 ± 2 wt%. The physical and chemical properties of the extracted oil were analyzed as per AOAC official methods. In this current study, biodiesel was derived by catalytic transesterification reaction. The parameters that influence the processes like methanol to oil molar ratio, catalyst concentration, reaction temperature, and reaction time were optimized. Taguchi statistical method and Analysis of Variance (ANOVA) table were used to understand the effects of the influencing parameters and to optimize the biodiesel yield. Further, it was compared with Box-Behnken Design (BBD) using Response Surface Methodology (RSM). It shows that Taguchi method gave similar results of RSM within a limited number of runs. At the optimized condition, the yield of biodiesel was 94.58 wt%. Kinetic studies were also performed for transesterification reaction and it was observed that the reaction follows pseudo-first-order kinetics. The reaction rate constants and activation energy were determined. The physical and chemical properties of the biodiesel were analyzed as per ASTM test methods and compared with ASTM D6751 standard.

KEYWORDS

ANOVA; Biodiesel; Kinetic Study; optimization; Taguchi Method; Wild Radish

Introduction

Petroleum fuels were the dominant energy source in the last 55 years and later petroleum diesel was used as the primary fuel for diesel engines due to its easy availability and low cost. The dwindling of petroleum resources gives way to the quest for alternative energy sources. In this context vegetable oil is one of the potential alternative sources. But, the main disadvantageous properties of vegetable oils are its high viscosity, low volatility, and the several problems caused during their long time usage in compression ignition engines (Corsini et al., 2015; Mohan et al., 2016). Converting these vegetable oils to alkyl esters can solve these problems. Biodiesel is also a low-emission substitute fuel for petroleum diesel made from renewable resources (Silva et al., 2017).

Recently, biodiesel derived from vegetable oil and animal fats has become a great concern for researchers because they compete with food materials (Qin et al., 2010; Sivakumar et al., 2014; Rashid et al., 2016; Carvalho et al., 2017). In the past few years the demand for vegetable oils for human consumption has increased tremendously and it is impossible to justify the use of these oils for fuel. Moreover, these oils could be more expensive to be used as fuels (Demirbas, 2008; Demirbas, 2009). This crisis increases the thrust on researchers to search for a new non-edible plant oil as a source of biodiesel (Qin et al., 2012). Hence, the contribution of non-edible oils such as jatropha, pongamia, neem, mahua, rubber seed, kusum, pistachio etc., is unfathomable and these oils are some of the significant sources for biodiesel production (Balaji and Cheralathan,

CONTACT P. Sivakumar sivakumarhap@rediffmail.com School of Petroleum Technology, Pandit Deendayal Petroleum University, Gandhinagar 382007, India.
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/gcec.