Transesterification of used cooking oil over alkali metal (Li, Na, K) supported rice husk silica as potential solid base catalyst

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Abstract

Investigation was conducted on three alkali metals (Li, Na, and K) supported by rice husk silica as catalysts for methyl esters production. A simple pseudo-heterogeneous transesterification process of used cooking oil with methanol was conducted to produce methyl esters using calcined alkali metal supported rice husk silica as a solid catalyst. Alkali metal silicate catalysts showed longer lasting activity than the traditional alkali catalysts. The optimum conditions for the process were: alkali metals silicate calcination temperature 500 °C, time 3 h; catalyst amount 3%; methanol to oil molar ratio 9:1; and a reaction temperature of 65 °C. The process was able to transesterify oil to methyl esters in the range of 96.5–98.2% in 1 h for all series. The catalyst is able to tolerate free fatty acid and moisture up to 1.25% and 1.75%, respectively. The catalyst was easily separated from the reaction mixture by filtration and able to reuse six times. The final product met the selected biodiesel fuel properties in accordance with European Standard (EN) 14214.

1. Introduction

The global oil consumption in 2010 grew by 2.7 million barrels per day (b/d), or 3.1%, to reach a record level of 88 million b/d, while the fossil fuel reserve is depleting [3]. Furthermore, petroleum-based activities are one of the main causes of carbon dioxide (CO2) emission to the atmosphere. The transportation and industrial sector are almost entirely dependent on petroleum-derived fuels, which accounted for respectively 12.2 and 4.6 million b/d of oil consumption in January 2012 [8]. This scenario has driven the EU, the USA, Brazil, and parts of Asia to import renewable energy.

Biodiesel is one of the energy sources that can be used as an alternative fuel for diesel engines. Such data demonstrates the global awareness of the limitations of the fossil fuel and the quest for new energy alternatives. The common feedstocks for biodiesel are vegetable oils and animal fats. Thus, it can be said that the major lipid for biodiesel production comes from edible oils. However, as feedstock accounts for approximately 80% of the operational cost [9], the feedstock price has a huge effect on the overall production cost. In addition, consuming edible oil for biodiesel competes with food supply and has a definite impact on global food security and land.

One way to reduce the production cost is by utilizing used cooking oil (UCO). The source is abundant supply, relatively inexpensive and the utilization offers benefits on environmental conservation [25]. In addition, it is low in price in terms of its operational cost and feedstock, and recycling technology can be applied during the process. However, the UCO contains free fatty acid (FFA) and moisture. FFA content in waste oil should be as low as possible for alkali-catalysed transesterification and alkali catalysts will readily react with FFA to form soap if FFA content above 2.5% present in the reaction media [2]. This reaction is highly unfavourable because it will deactivate the catalyst from accelerating the transesterification reaction. Furthermore, too much soap in the product can drastically reduce the methyl esters (ME) yield and inhibit the subsequent purification process of biodiesel, including glycerol separation and water washing. Recently, the production of biodiesel by transesterification method using solid catalysts has become more favourable compared to others and has been scaled up to industrial level. Solid base catalysts bring several advantages, such as the catalyst can easily be separated from the reaction mixture, no washing is required, easy regeneration, less