Bentonite, as a natural zeolite enhanced biodiesel production through trans-esterification of waste oil

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Abstract
Waste oils are becoming increasingly more important as feedstock for the production of fuels and chemicals. The influence of bentonite on the KOH-catalyzed methanolysis of waste cooking oil was investigated. It was found that an appropriate introduction of bentonite can promote the methanolysis. By the rapidly removal of the water from the system, bentonite enhances the transformation of KOH to the catalytically active methoxide species. Further, the main side reactions are significantly inhibited. The methanolysis of triglycerides took place in the liquid phase rather than in the solid phase. The introduction of bentonite also lowered the soap concentration in crude biodiesel, which was beneficial for the post-treatment to generate refined biodiesel.

Keywords: Biodiesel, Trans-esterification, Bentonite, Heterogeneous Catalyst

Introduction

Depleting fossil fuel reserves and an increasing awareness of the impact of energy production on society and the environment has catalyzed the search for cleaner energy resources [1, 2]. The most significant advantages of using biodiesel as replacement for or in blends with fossil-based diesel is reduced greenhouse gas emissions due to recycling of carbon dioxide [3, 4] better lubricating properties with lower sulfur content due to the presence of free fatty acids and mono glycerides and lower environmental impact due to the biodegradability of biodiesel [4].
Biodiesel is produced through the trans-esterification reaction of triglycerides with a short chain alcohol (mostly methanol) in the presence of a suitable catalyst. The alkali catalysts like sodium or potassium hydroxide are the most common due to the high productivity yield [5, 6]. Homogeneous catalysts have some drawbacks, e.g. they produce large amount of waste water [7]. On the other hand, heterogeneous catalysts are less corrosive, more environmentally friendly, safer, cheaper and they can be easily recovered, regenerated and reused. Bentonite is a kind of silicate layered structural material. The main component of bentonite is montmorillonite which has small particle size, large specific surface area and strong water adsorption capacity [8]. The bentonite ore resources are abundant and cheap, which has made it an ideal adsorption material. Bentonite has been reported to have been applied to the production of biodiesel [9]. The final product of the trans-esterification reaction contains two major crude phases in an emulsion form, i.e. the biodiesel (non-polar phase) as the continuous phase and the glycerol (polar phase) as the dispersed phase. This mixture is unstable and glycerol droplets start to decant immediately after mixing has stopped [10]. Having a good and complete reaction is not enough for the obtained biodiesel contains several impurities such as soap, catalyst residue, glycerol droplets, alcohol etc. Inefficient separation of these impurities can lead to off-spec product, increase in production cost and time, and also damage of the engine system [11]. Therefore, purification of biodiesel prior to any application is inevitable. Industrially, there are two generally accepted methods to purify biodiesel, wet washing using water (mostly using hot distilled water) and dry washing using proper adsorbents [12].
To assess whether the KOH/bentonite catalysts perform well in the trans-esterification of waste cooking oil with methanol, we tested a series of KOH/bentonite catalysts in the reaction and we evaluated the effect of active phase loading on the yield of biodiesel production. This paper discusses the influence of active phase content in KOH/bentonite catalysts, the catalyst to oil ratio and the reaction time on the biodiesel production yield. The catalyst reusability is also investigated for several consecutive runs as it represents a key advantage for biodiesel production.

Materials

Waste cooking oil was purchased from a restaurant in Tehran. Bentonite zeolite was obtained from Negin pooder Company. Methanol (purity: 99.8%), n-hexane, potassium hydroxide (purity: 85%) were supplied by Merck.