Characterization of Geopolymer to Use as Heterogeneous Catalyst in the Biodiesel Production

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Highlights

- Geopolymers were synthetized based on a mixture of Na and K alkaline activators.
- The feasibility geopolymer as heterogeneous catalysts for biodiesel processing was assessed.
- A high conversion of soybean oil into methyl esters was achieved with 3 wt% geopolymer.
- Biodiesel conversion was affected by the calcination temperature of geopolymers.

1. Introduction

Diesel fuel plays an essential role in a country's economy, even though serious environmental problems are caused when such fossil fuels are used. The best alternative is the use of renewable energy sources, including biodiesel, a promising substitute for diesel due to its similar properties [1].

Biodiesel comprises methyl or ethyl monoesters obtained by the transesterification of edible and non-edible vegetable oils, waste cooking oil, algae oil or animal fats with a short chain alcohol (methanol or ethanol) in the presence of a strong acid or basic catalyst, which may be homogeneous or heterogeneous. Homogeneous catalysts are still the most used in industrial biodiesel production. However, these catalysts present some problems in relation to non-reuse and cleaning of final products. In order to minimize these problems, the use of heterogeneous catalysts has been investigated [2-3].

Geopolymer is a synthetic material with a chemical composition comparable to that of a zeolite; it is obtained by synthesizing an aluminosilicate with a highly concentrated alkali hydroxide or silicate solution providing the formation of a three-dimensional continuous network that can consolidate at low and uniform temperature [4].

This work investigates the processing and characterization of geopolymers in order to act as catalysts to produce biodiesel by transesterification of soybean oil with methanol.

2. Methods

Geopolymers were prepared by mixing metakaolin with an activating alkaline solution. The heterogeneous catalyst was prepared in powder form: (Na+K)-based geopolymer. The characterization of the material was made by measurements of X-ray diffraction (XRD), thermal analysis (DTA-TGA), density by pycnometry, granulometry, BET surface area, total pore volume and average pore diameter. The influence of geopolymer heat treatment was also evaluated, as four temperatures were tested: 110, 300, 500 and 700°C.

The biodiesel was obtained in the following reaction conditions: methanol:oil ratio of 7.5:1; catalyst amount of 3% of oil (w/w); reaction temperature of 70°C; reaction time of 2 h. The reaction yield was

calculated by gas chromatography measurements. Atomic absorption spectrometry analysis was done to quantify the sodium and potassium leached into the biodiesel in different calcination temperatures.

3. Results and discussion

With XRD graphs it could be observed that no new crystalline phases are formed during the processing of the geopolymers. The particle size of the geopolymer powders was between 40 and 125 µm. The density of the geopolymer powder at the different heat treatment temperatures remained approximately 2.4 g/cm³.

The biodiesel yield decreased with the heat treatment temperatures, but it still kept a high value (approximately 95%). Atomic absorption spectrometry analysis showed that there was leaching of sodium and potassium in the biodiesel but the geopolymer had high activity as heterogeneous catalyst.

4. Conclusions

This work demonstrates that the geopolymer made with a mixed composition (Na+K) can be used as catalyst in the transesterification reaction of soybean oil by methyl route.

The properties of the material decrease with the increasing heat treatment temperature ranging from 110 to 700°C. The geopolymer is amorphous even with the different heat treatment temperatures.

There was a loss of material leached in the biodiesel, however, the geopolymer had high values for biodiesel yield.

New processing and characterization tests are in progress to optimize the production of biodiesel and further increase the conversion values.

References

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Keywords
Biodiesel; geopolymer; heterogeneous catalyst.