Petroleum Research

Petroleum Research 2018 (December-January), Vol. 28, No. 102. 21-23

DOI: 10.22078/pr.2018.2905.2355

Thermochemical Synthesis of Mg-Al Ceramic Spinel as Support for MgO/ MgAl2O4 Nanocatalyst Toward Conversion of Vegetable Oil to Green Fuel

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DOI: 10.22078/pr.2018.2905.2355

Received: September/22/2017 Accepted: June/09/2018

INTRODUCTION

In the last decade, biodiesel has been one of the alternatives of fossil fuels. In addition, biodiesel is made from renewable sources such as vegetable oils and animal fats. Moreover, biodiesel is a biodegradable and environmentally friendly fuel [1]. Trasesterification is one of the most common ways to produce biodiesel. Different acidic and basic catalysts can be used for this purpose [2]. Ceramics have good properties such as high surface area and high thermal resistance. The properties of ceramics cause that ceramics can be used as catalyst support for the biodiesel production process [3]. In this way, the $MgAl_2O_4$ spinel (from the ceramic family) can be a catalyst for the biodiesel production reaction. The purpose of this paper is to investigate the thermochemical synthesis of spinel $MgAl_2O_4$ and deposition of the active phase of MgO on its surface and its use as catalyst in the biodiesel production reaction.

EXPERIMENTAL PROCEDURES

CATALYST PREPARATION

For the sample synthesis, the catalyst support ($MgAl_2O_4$) was first synthesized by thermochemical method. For this purpose, magnesium nitrate and aluminum nitrate precursors with Mg/Al molar ratio of 0.5 were dissolved in a certain amount of deionized water. After complete dissolution of the nitrate precursors in water, the solution temperature was increased to 60 °C, and it was stirred on hot plate until it was completely dried. The obtained mixture was placed at 110 °C for 24 hours for complete drying; then it was calcined

in a furnace at 800 °C for 4 hours. The resulting white powder ($MgAl_2O_4$) was used as the catalyst support. Impregnation was used to place the active phase of MgO on $MgAl_2O_4$ surface. For this purpose, the magnesium nitrate was dissolved at weight ratio of 10% (MgO to $MgAl_2O_4$) in a certain amount of deionized water. Then the synthesized $MgAl_2O_4$ was added to it, and stirred at 80 °C for 180 min on a hot plate. After it was completely dried on a hot plate, the sample was placed in an oven at 110 °C for 24 hours and finally the sample was calcined at 550 °C for 4 hours to obtain MgO/$MgAl_2O_4$ catalyst.

CATALYTIC ACTIVITY TEST

A 100 cm^3 stainless steel reactor with a Teflon layer was used for biodiesel production reaction. A controlled electric heater was used to create the required reaction temperature, and a magnetic stirrer was used to stir the reaction mixture. All reactions were carried out at 110 °C, alcohol to oil molar ratio of 12, catalyst to oil of 3 wt.% for 3 hours. To obtain the conversion of the transesterification reaction, the final reaction product was analyzed by a gas chromatographer equipped with Flame Ionization Detector (FID) and a SupraWax-280 column (Spain, Teknokroma). Injection of samples was performed in a split method (1:100) at 1 µl, while the temperature of FID and injector was 260 °C.

RESULTS AND DISCUSSION

XRD ANALYSIS

The XRD analysis of synthesized nanocatalyst is presented in Fig. 1. According to the analysis and the standard model of JCPDS (Cubic, 00-001-1157) related to $MgAl_2O_4$ with peaks at 2θ=66.2, 60.0, 45.3, 37.3, 31.6 and 19.22°, it was determined that $MgAl_2O_4$ sample was successfully synthesized. Also, small peaks at 2θ=78.7, 74.8, 62.4, 43.0 and 37° corresponding to the standard MgO model with JCPDS (Cubic, 01-077-2364), indicated that MgO crystals with small size and good dispersion are on $MgAl_2O_4$ support surface [4].

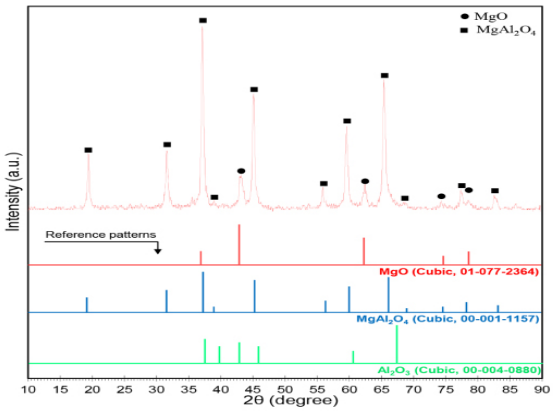

Figure 1: XRD patterns of synthesized sample.

CATALYTIC PERFORMANCES

The conversion of the sample in the biodiesel production reaction was very high and equal to 92.6%. The mentioned sample was also used six times in the biodiesel production reaction, and the conversion rate was obtained each time by the GC analysis whose results are shown in Fig. 2. In the second test, it decreased by about 17%, and in the third test, it showed 8% reduction in catalytic activity. However, in subsequent tests, the conversion remained almost constant with minor reduction. Regarding the mentioned discussions, it can be said that the synthesized catalyst of this paper has favorable conditions in terms of fabrication simplicity and cost-effectiveness which can be introduced as a heterogeneous catalyst for biodiesel production process.

CONCLUSIONS

In this study, MgO/$MgAl_2O_4$ catalyst was

synthesized for biodiesel production reaction by a simple and practical method. The results of the synthesized nanocatalyst analyses showed that this sample had a high potential for transesterification reaction, with biodiesel production conversion rate of 92.6%. The average diameter of the pores of this catalyst was found to be within the proper range for the biodiesel production reaction, which had a significant effect on its catalytic performance regarding its specific surface area of about 85 m^2/g. Accordingly, it can be said that the thermochemical method has the ability to create a catalyst with high crystallinity profile as well as proper morphology, specific surface and diameter for the biodiesel production. Overall, the expressed properties resulted in high stability of catalyst in the biodiesel production reaction, which further highlights the importance of using this synthesis method. Finally, it can be said that $MgO/MgAl_2O_4$ catalyst synthesized by a simple and inexpensive thermochemical method has a high industrialization capability due to its excellent performance in producing a green fuel.

REFERENCES

[1]. Liu H., Guo H. S., Wang X. j., Jiang J. Z., Lin H., Han S. and Pei S. P., *"Mixed and ground KBr-impregnated calcined snail shell and kaolin as solid base catalysts for biodiesel production,"* Renewable Energy, Vol. 93, pp. 648-657, 2016.

[2]. Torres-Rodríguez D. A., Romero-Ibarra I. C., Ibarra I. A. and Pfeiffer H., *"Biodiesel production from soybean and Jatropha oils using cesium impregnated sodium zirconate as a heterogeneous base catalyst,"* Renewable Energy, Vol. 93, pp. 323-331, 2016.

[3]. Keane M. A., *"Ceramics for catalysis,"* Journal of Materials Science, Vol. 38, No. 23, pp. 4661-4675, 2003.

[4]. Rahmani V.and Haghighi B. M., *"Biodiesel production from sunflower oil over $MgO/MgAl_2O_4$ nanocatalyst: Effect of fuel type on catalyst nanostructure and performance,"* Energy Conversion and Management, Vol. 134, pp. 290-300, 2017.