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Conventional vs. Microwave Heating in Combustion Synthesis of Ca-Mn Perovskite Used in MgO Nano catalyst for Biodiesel Production

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In the present article, MgO/Ca2Mn3O8 nanocatalyst was utilized in the transesterification process for engenderment of green fuel from sunflower oil. Besides, the synthesis of the layered nanostructured Ca2Mn3O8 support was carried out by combustion method. The effect of two heating approaches including muffle furnace and microwave irradiation was investigated on the characteristics of calcium-manganese commixed oxide utilized as the fortification of the MgO active phase. Both of the synthesized nanocatalysts were characterized by different techniques. The nanocatalyst engendered by the microwave irradiation combustion method scored the best performance. This nanocatalyst exhibited opportune morphology, higher porosity, and better distribution of particles compared to the synthesized sample in muffle furnace. This justified the positive influence of microwave irradiation on the catalytic properties.

Keywords:

MgO/Ca2Mn3O8, Microwave, Auto-Combustion, Green Fuel, Vegetable Oil.

INTRODUCTION

Renewable energies have been highlighted in recent years due to their potential to replace fossil fuels, especially for transportation. Renewable energies such as solar energy, wind energy, hydrogen energy and energy derived from biomass and waste have been successfully developed by various countries to limit the use of fossil fuels. Biodiesel is also highly regarded because of its environmental benefits as a biofuel. There are challenges to commercializing and reducing costs to produce this clean fuel. One of the most important challenges is finding the right catalyst for the biodiesel production reaction that has the best physical and chemical properties and the least disadvantage. Perovskite calcium-manganese oxide (Ca2Mn3O8) contained with Mn3O84- layers, which maintained with each other by Ca2+ cations alternatively. Due to the long time and high energy consumption synthesis methods such as sol-gel, hydrothermal and co-precipitation, it can be a major barrier to the industrialization of these types of catalysts. Besides, in the process of green fuel production using transesterification reaction, a synthetic method would be desirable that would produce the appropriate surface for surface reactions and create large meso and macropores for the penetration of feed molecules into the catalyst. Combustion synthesis is known as one of the important techniques and methods for the synthesis of nanomaterials for decades. This method using a suitable heat source can be a permissive and affordable by creating phenomenal morphology practically at any size and shape of catalysts in a short time and fast-growing heat rates.

MATERIALS AND METHODS

All materials and methods used in this work can be seen in Table 1.

Nanocatalyst	MgO (wt.%)	$Ca_2Mn_3O_8$ (wt.%)	Fuel	Synthesis Method	
				Support	Active Phase
$MgO/Ca_2Mn_3O_8$ (U-MF)	5	95	Urea	Muffle Furnace	Impregnation
$MgO/Ca_2Mn_3O_8$ (U-MW)	5	95	Urea	Microwave Irradiation	Impregnation

Table 1.Composition and heating approaches in fabrication of Ca-Mn Perovskite Used in MgO Nanocatalyst.

RESULTS

As shown in figure 1, comparing the XRD patterns of synthesized nanocatalysts shows that the higher crystallinity and the peak intensity of Ca2Mn3O8 is related to the muffle furnace with a slight difference. This is due to the onset of flame burning due to combustion of one heated section and then its propagation to the rest of the gel in the muffle furnace, which provides more combustion time than the microwave heating which heats the gel homogenously and its combustion takes place at once. The shorter duration of the microwave combustion process, all combustion gases are evacuated over a shorter time, which can lead to more and large pores inside the catalyst.

Note : This work is partly presented at Archives in Chemistry

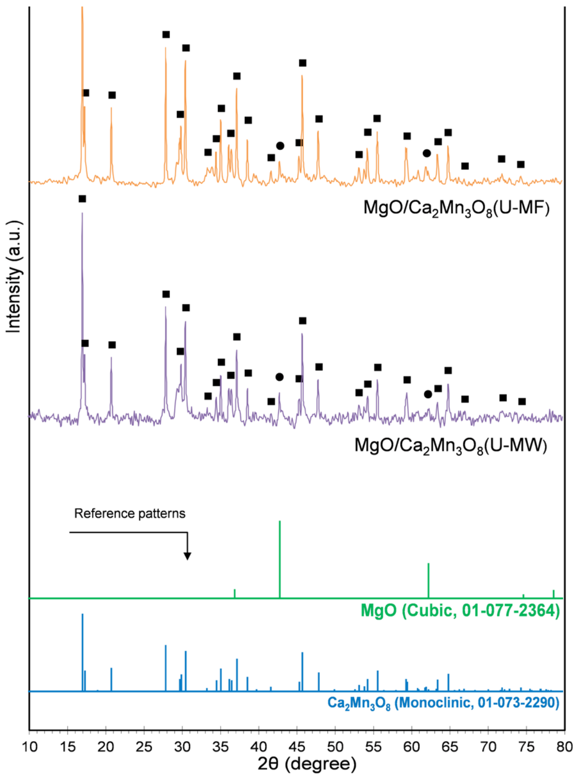

Figure 1. XRD patterns of Ca-Mn Perovskite Used in MgO Nanocatalyst: MgO/Ca2Mn3O8 (U-MF) and MgO/Ca2Mn3O8 (U-MW)

Comparing the two synthesized nanocatalysts FESEM images in figure 2 in the range of 500 nm, it can be perceived that microwave heating, due to the uniform heating of the initial gel and shorter combustion time and faster outflow of combustion gases, has resulted in the formation of more uniform surface morphology and a higher level of porosity.

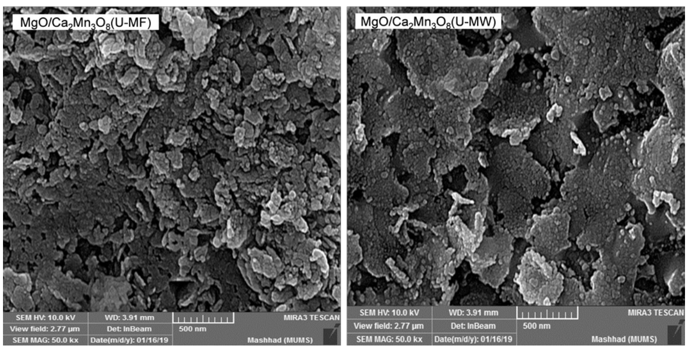

Figure 2. FESEM images of Ca-Mn Perovskite Used in MgO Nanocatalyst: MgO/Ca2Mn3O8 (U-MF) and MgO/Ca2Mn3O8 (U-MW)

SUMMARY

A series of Perovskite calcium-manganese oxide (Ca2Mn3O8) were synthesized via combustion method with two heating sources of microwave and muffle furnace, and then they were utilized as the support of the basic catalyst in biodiesel production via the transesterification reaction. The MgO active phase was impregnated on all of the synthesized supports. The presented results in terms of characterizations such as XRD and FESEM showed that different heating approaches can effect crystallization, morphology, and porosity which authenticated the diverse performances of nanostructured MgO/Ca2Mn3O8 catalysts.

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