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SYNTHESIS AND CHARACTERIZATION OF MIXED OXIDES CATALYST TO PRODUCE FAME

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Abstract:

Biodiesel known chemically as fatty acid methyl esters (FAME) is an alternative to fossil fuels. The process of transforming cooking palm oil into biodiesel is called transesterification reaction. Transesterification is the chemical reaction between a triglyceride and alcohol in the presence of the catalyst, producing a mixture of fatty acid esters and glycerol. Heterogenous catalyst is the preferred catalyst in this research due to the least problem to the overall reaction compared to homogenous catalyst and enzyme. The Mn-Al mixed oxides catalyst was synthesized via sol-gel method at different metal ratio and tested in the transesterification of FAME. The reactions were conducted in a batch reactor at temperature 55^{o}C, methanol to oil molar ratio of 15:1 and catalyst loading of 2wt%. The thermal stability and presence of surface functional group were investigated using thermal gravimetric analysis (TGA) and Fourier-transform infrared spectroscopy (FTIR). The synthesis catalyst is also used for determination of FAME density by Micromeritic Pycnometer model AccuPyc II 1340. The result shows that catalyst with metal ratio 1:0 obtained FAME density of 864.9 kg/m^3 which is the closest to the standard palm oil density. However, based on TGA analysis, metal ratio 1:2 has stable weight change at temperature 500 ^{o}C with the second closest FAME density of 861.4 kg/m3. Thus, the best catalyst based on this research is metal ratio 1:2 according to TGA analysis and FAME density. Thereby, this research highlights the recent effective investigation in prepare and characterize Mn-Al mixed oxides catalyst.

***Keywords*:**

Biodiesel, Metal Oxide, Fatty Acid Methyl Ester, Catalyst, Transesterification

Objectives:

- To synthesis the Mn-Al mixed oxides catalyst via sol-gel method at difference metal ratio for transesterification of FAME.
- To characterize the Mn-Al mixed oxides catalyst in terms of thermal stability and surface functional group using TGA and FTIR.

Methodology:

Figure 1 illustrates the process flow on the synthesis and characterization of mixed oxides catalyst to produce FAME.

Sample preparation of Mn-Al catalyst by sol-gel method

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Characterization of catalyst sample

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Fresh catalyst sample

Fourier-Transform Infrared Spectroscopy (FTIR) analysis
Thermal Gravimetric Analysis (TGA) analysis

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Transesterification and analysis of FAME

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FAME sample

Micromeritic Pycnometer model AccuPyc II 1340 analysis

Figure 1 Process flow of project

Results:

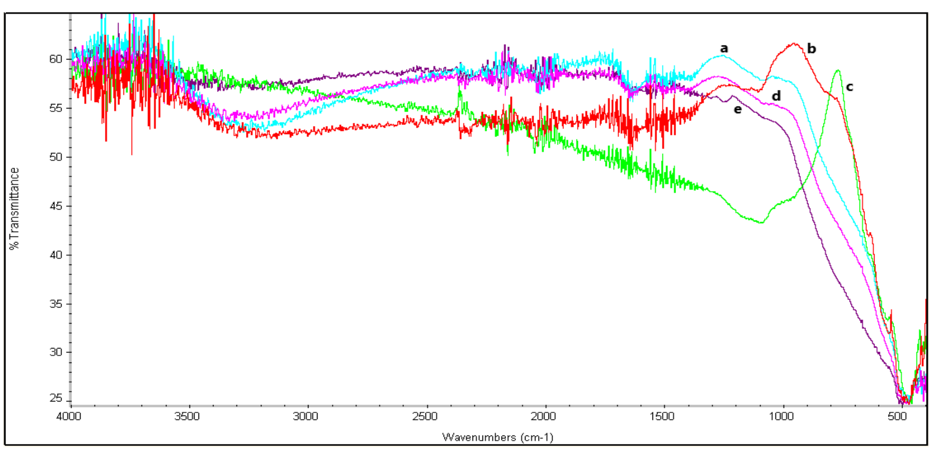

Figure 2 FTIR spectra of metal ratio (a) 1:1 (b) 2:1 (c) 1:0 (d) 1:2 (e) 0:1

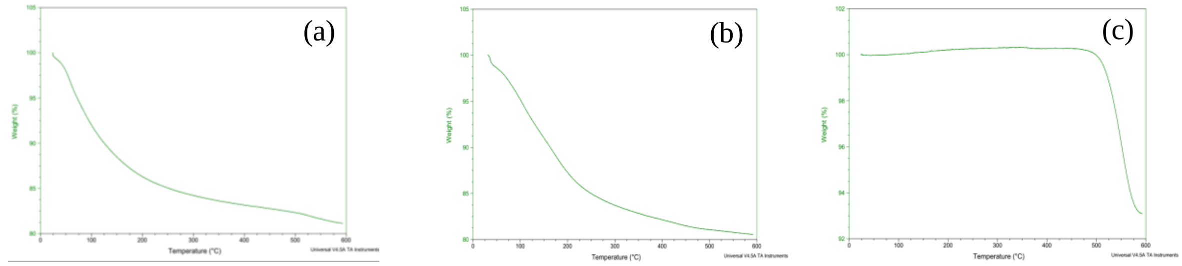

Figure 3 TGA profile of metal ratio (a) 1:2 (b) 1:0 (c) 0:1

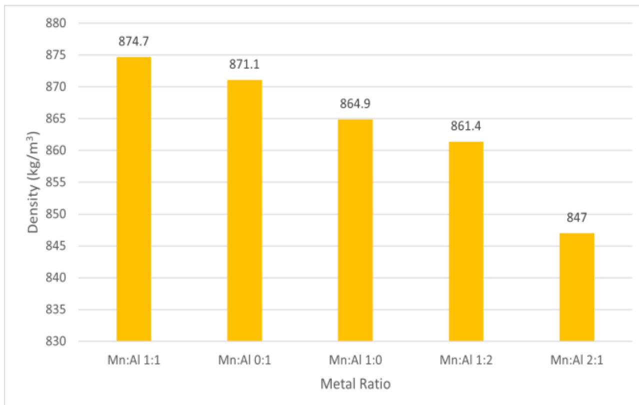

Figure 4 FAME density for different metal ratio of Mn-Al mixed oxides catalyst

Conclusion:

The Mn-Al mixed oxides catalyst with different metal ratio 1:1, 1:0, 0:1, 2:1 and 1:2 successfully prepared by using sol-gel method. The FTIR spectra of different metal ratio catalyst samples in the region of 500-4000 cm^{-1} are presented in Figure 2. The spectra of the catalysts showed some identical functional groups detected on their surfaces, which revealed a similar pattern. The most obvious are the peaks at 500-600 cm^{-1} assignable to the stretching vibration of C-l group attached to the surface of the metal. Another prominent peak at 1600-1650 cm^{-1} can be observed in all samples, which assigned to C=C bending vibrations. However, the peak at the metal ratio of Mn-Al 1:0 is less intensified compared to the other samples. The samples of metal ratio 1:0 has a peak at 1087-1124 cm^{-1} which indicated C-O stretching vibration. The TGA profiles of metal ratio (a) 1:2, (b) 0:1 and (c) 1:0 was shown in Figure 3. The TGA profile for the Mn-Al catalyst sample metal ratio of (a) 1:2 and (b) 0:1 shows that the weight loss from room temperature to 100 ^{o}C due to the evaporation of moisture content, which indicates that the catalyst is hygroscopic. Then, the temperature between 100 ^{o}C to 300 ^{o}C shows the weight loss due to decomposition of precursors material such as nitrate compound. The weight change is small after 450 ^{o}C indicating a stable metal oxide. The TGA profile for catalyst sample of metal ratio (c) 1:0 shows no weight loss from room temperature to 500 ^{o}C. The major weight loss was observed at the temperatures between 500 ^{o}C to 600 ^{o}C. The decomposition was completed at 600 ^{o}C after that the weight of the catalyst remained almost constant indicating that 600 ^{o}C should be the maximum calcination temperature for the metal ratio. Thus, based on the characterization of the catalyst using TGA shows that a stable catalyst can be achieved using the metal ratio (a) 1:2 and (b) 0:1 and calcination temperature at 500 ^{o}C. Figure 4 shows the FAME density obtained from the transesterification reaction using different metal ratio of Mn-Al mixed oxides catalyst. The transesterification of different metal ratio shows different FAME density. The standard palm oil biodiesel density is 864 kg/m^3. The mixed oxide catalyst of metal ratio 1:1 shows the higher FAME density of 874.7 kg/m^3 than the standard density. The catalyst of metal ratio 1:0 and 1:2 obtained the FAME density of 864.9 kg/m^3 and 861.4 kg/ m^3 respectively which is the nearest to the standard palm oil biodiesel density. This indicated that catalyst with metal ratio 1:0 and 1:2 has a good catalytic activity among the synthesis catalysts. Therefore, it can be concluded that based on the research on the synthesis and characterization of mixed oxides catalyst, the best catalyst is metal ratio 1:2 because the density is very close to the standard palm oil biodiesel density. The TGA analysis also shows that this catalyst has good thermal stability.