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COS CATALYST FOR THE REPLACEMENT OF FOSSIL FUELS TO BIOFUELS

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ABSTRACT

One of the major factors of climate change is the increase in greenhouse gas emissions caused by the increased usage of fossil fuels. An alternate strategy for dealing with this issue is the conversion of biomass into useful compounds by a hydrogenolysis reaction, particularly through the catalytic hydrogenolysis of sorbitol. Its industrial application has, regrettably, been constrained by the catalyst's deactivation. Therefore, there is a lot of interest in developing new, attractive catalysts that could improve the performance of the hydrogenolysis reaction. Catalytic performance is greatly influenced by the effects of the metal (monometallic and bimetallic), the supporting material, and the acid/base characteristics. Chromium Oxide Silica (CoS) is a famous catalyst for polymerization of ethylene at relatively low pressures, hydrogenation-dehydrogenation, oxidation, isomerization and complete combustion. In this study, CoS catalyst with 15wt% Cr_2O_3 loadings was synthesized using impregnation method, to gain a better understanding on the nature of chromium oxide species on the silica. The samples (SiO_2 and 15wt%CoS) were analyzed using SEM, XRD, FTIR, TGA and DSC to confirm the formation of CoS. FTIR spectra and XRD pattern showed successful incorporation of Cr_2O_3 on SiO_2 support. SEM images indicated that the samples prepared have a uniform size and start to agglomerate when chromium oxide was introduced. Meanwhile, TGA analysis showed the stability of both samples even after they were calcined at high temperature. In summary, these catalyst properties can be used as the starting point for catalytic reactions and large-scale applications.

Keyword: sorbitol, catalyst, fossil fuels, biomass, impregnation

1. INTRODUCTION

Catalyst is a substance that can be introduced to a chemical reaction to speed up the reaction without being consumed or being created by itself. It can be a solid, liquid, or gas. Jöns Jakob Berzelius coined the word catalysis in 1835 to describe a new entity capable of facilitating the occurrence of a chemical reaction through a "catalytic contact," which means they create decomposition in bodies and generate a new compound into the composition of which they did not enter (Wisniak, 2010). Metals, oxides, sulphides, or carbons as bulk materials and silica, alumina, zirconia, or titania as supported are examples of solid catalysts with distinct chemical (acid-base, redox, oxidising, etc.) and physical properties (porosity, high surface area, thermal conductivity, etc.). Chromium oxide (Cr_2O_3) supported on silica (SiO_2) is one of the catalysts employed in several catalytic reactions throughout the last decade (Youssef et al., 2000; Ge et

al., 2002). While SiO_2 offers high mechanical stability, large surface area, high thermal stability, large pore size and volume (Zhang et al., 2020), Cr_2O_3 is believed to have specific applications including high-temperature resistant materials (Xiao et al., 2020), green pigment (Ai et al., 2020) and heterogeneous catalysts (Chen et al., 2020). In this study, 15wt% CoS was synthesized using impregnation method. The nature of the prepared catalyst was studied by various characterization techniques which are SEM, XRD, FTIR, TGA and DSC.

2. METHODOLOGY

The impregnation process was used to produce 15wt%CoS. In a volumetric flask, a solution of $Cr(NO_3)_3.9H_2O$ was initially made by dissolving a small amount of $Cr(NO_3)_3.9H_2O$ in distilled water. Simultaneously, a specified amount of SiO_2 was calcined in air for 1 hour in a vacuum furnace at 700 °C. The calcined SiO_2 was then added to the $Cr(NO_3)_3.9H_2O$ solution and heated to 80 °C while stirring continuously. The resultant solution was dried in an oven at 80 °C for 24 hours before being calcined in air at 570 °C for 6 hours, followed by 50 °C for 10 minutes with a nitrogen flow rate of 100 ml/min as an inert purge in a vacuum furnace. For catalyst characterization, the calcined catalysts were thermally analyzed using a Perkin Elmer Thermo Gravimetric Analyzer (TGA 8000). Bruker Fourier Transform Infrared Spectroscopy Vertex 70 (FTIR) study was performed to determine the chemical component and structure of the catalysts, as well as to investigate the primary absorption band. The analysis employs a spectral range of 650 cm-1 to 1500 cm^{-1}. XRD patterns were obtained at room temperature using a Siemens D5000 diffractometer set to 20 mA and 30 kV with Cu K radiation (= 0.15406 nm). Scanning electron micrographs (SEM, FEI Titan electron microscope) with a magnification of 1000 were used to evaluate the surface morphology of the samples.

3. FINDING

Based on SEM images, it can be seen that the surface of the samples was relatively smooth, but there were numerous flake particles adhering to the surface due to silica deposition. The particle size began to increase with the addition of Cr_2O_3. The increase of the size was mainly due to the agglomeration of particles and the successful incorporation of Cr_2O_3 on supported SiO_2. XRD patterns showed diffraction peaks observed at $2\theta = 21°, 26°, 36°, 39°, 50°, 60°$ and 68°, which were associated with (100), (011), (110), (102), (112), (121) and (031) planes of SiO_2, respectively. Low intensity of Cr_2O_3 phase was discovered at 33° and 55° with rhombohedral lattice system after the introduction of 15wt%CoS. FTIR spectra revealed two fundamental peaks at 789 cm^{-1} and 1050 cm^{-1} in both samples attributed to asymmetric stretching vibration of siloxane bond (Si-O-Si) while peak appeared at 1082 cm^{-1} was symmetric stretching of Si-O-Si. A shoulder at 1190 cm^{-1} indicated the presence of Si-O-Si stretching, where there was a decrease in their intensity with the impregnation of Cr_2O_3. The weak intensity band appeared at 676-695 cm^{-1} was also attributed to the presence of Si-O vibration (Memon et al., 2015). However, the 695 cm^{-1} band started to shift to the lower wavenumber at around 688 cm^{-1} when chromium oxide was added, due to the interaction with the Cr cation (Ricchiardi et al., 2001). The observed TGA curve exhibited 15% and 20% total weight loss for SiO_2 and 15wt%CoS

respectively. The first region of weight loss occurred from room temperature up to 100 °C and second temperature region was observed in the interval of 200 to 250 °C. Both regions were attributed to the removal of physically adsorbed water (Zangouei et al., 2010). 15wt%CoS showed more weight loss as compared to SiO_2. This was due to the higher mass of $Cr(NO_3)_3.9H_2O$ used during the impregnation method, which contributed to a higher amount of physisorbed water in the sample.

4. CONCLUSION

In this study, SiO_2 acted as the support material, while $Cr(NO_3)_3.9H_2O$ was used to generate a Cr_2O_3-SiO_2 catalyst as the precursor to Cr_2O_3. Using the impregnation method, the catalyst was created with 15wt% of Cr_2O_3. The produced catalyst was characterized using SEM, XRD, FTIR, TGA and DSC. The FTIR spectra and XRD patterns revealed the presence of functional groups in the catalyst and proved the successful integration of Cr_2O_3 on SiO_2 support. The samples were prepared with uniform particle sizes, according to SEM images, and they began to agglomerate as Cr_2O_3 was added. TGA analysis, meanwhile, provided an explanation of the thermal stability of the samples following high-temperature calcination. In general, these sample properties can be used as a starting point for the catalytic process and large-scale application.

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