

Development of Co-Mo Catalysts on CNT-Zeolite Composites for Efficient Production of Sustainable Aviation Fuel

AUTHORS

Karoline Kaiser Ferreira / LSRE-LCM/ALiCE

Bruno Filipe O. Magalhães / LSRE-LCM/ALiCE

Lucília S. Ribeiro / LSRE-LCM/ALiCE

M. Fernando R. Pereira / LSRE-LCM/ALiCE

PURPOSE OF THE ABSTRACT

The aviation sector, a major emitter of pollutants from petrochemical jet fuel combustion, is exploring sustainable aviation fuel (SAF) solutions from renewable sources like waste cooking oil. While several technologies are advancing, they currently do not attend the required industry demand. A key challenge is efficiently converting feedstocks, especially lipids, to SAF. Catalysts are crucial in maximizing SAF hydrocarbon (C8-C16) yields for ASTM D7566 quality standards, as they contribute to heteroatom removal, cracking, and isomerization to enhance product quality [1]. Bifunctional catalysts are applied to these reactions, being the metal phase responsible for deoxygenating ions, and the acidic support necessary for cracking and isomerization. A moderate level of acidity is required to prevent excessive cracking of the resulting compounds [2]. In this context, the present study aimed to develop Co-Mo catalysts supported on a composite of carbon nanotubes (CNT) and zeolite (H-ZSM-5) to evaluate the deoxygenation of palmitic acid (a model compound for oil sources), as well as the cracking and isomerization of the resulting hydrocarbons. The combination of CNT's textural properties and H-ZSM-5's acidity was a primary motivation to synthesize a material with the desired physicochemical properties for the direct conversion of oils into SAF. Ammonium type ZSM-5 was first calcined at 600 °C in air for 3 h to obtain its acid form. The composites were synthesized by ball-milling varying the milling time (30, 60, 90 min), the frequency (5, 10 and 15 s⁻¹) and the CNT:H-ZSM-5 ratio (1:1, 1:2, 2:1, 3:1 and 4:1). Co (metal loading of 2.5 wt.%) and Mo (metal loading of 10.5 wt.%) were impregnated over CNT:H-ZSM-5 composites by incipient wetness impregnation method, dried in an oven at 110 °C overnight and subsequently thermally treated in furnaces with N₂ followed by a reduction under H₂ at the same temperature (600 °C). The produced composites and catalysts (CoMo/xCNyHZ, where x = 1- 4 and y = 1- 2) were characterized by Raman spectroscopy, scanning electron microscopy (SEM), nitrogen adsorption at -196 °C and inductively coupled plasma-optical emission spectroscopy. In a typical run, 100 mg of catalyst, 500 mg of palmitic acid and 50 mL of n-decane were loaded into a 100 mL stainless steel Parr batch reactor. After purging the reactor with N₂ and then H₂, an initial 20 bar of H₂ was adjusted. The reactions were carried out at 325 °C and 300 rpm for 3 h. The liquid products were analyzed by gas chromatography-mass spectrometry using a ZB-5MSPlus column and docosane as internal standard. According to the results, the composites were mesoporous, with a slight contribution of micropores from zeolite. No significant differences in the textural properties were observed,

however, the total pore volume was the smallest using a frequency of 15 s⁻¹. In Raman results, this frequency promoted the formation of defects in the CNT's structure, probably allowing the anchor of H-ZSM-5 or severe damaging the CNT. Taking these into account, for preliminary reaction studies, the composite ball-milled for 60 min at 10 s⁻¹ was first chosen as support for presenting a higher homogeneity according to SEM images, compared to the one ball-milled for 30 min and 5 s⁻¹. The catalytic results showed a higher selectivity for n-C₈-C₁₆ (15 %) using CoMo/1CN1HZ, while a higher cracking in naphtha components and more aromatic compounds was achieved using CoMo/1CN2HZ. On the other hand, more iso-C₈-C₁₆ compounds and less aromatics were obtained with CoMo/2CN1HZ.

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FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Carbon Nanotubes (CNT) and Zeolite Composites | Bifunctional Catalysts | Deoxygenation and Isomerization | Sustainable Aviation Fuel (SAF)

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