

NiMo-sulfide supported on activated carbon to produce renewable diesel

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Abstract

Due to their weak polarity and large surface area, activated carbon supports have the potential to enhance the dispersion of metal-sulfides. It is expected that the absence of a strong metal-support interaction can result in the formation of a very active and stable Ni-Mo-S phase. In this study, catalysts with different amounts of nickel and molybdenum supported on a commercial activated carbon were prepared by a co-impregnation method and characterized by BET, XRF, and SEM techniques. The catalytic activity for hydroprocessing of Jatropha oil was evaluated in a batch reactor, and the composition of the liquid and gaseous products were determined. Results showed that gaseous products are mainly composed of high amounts of propane and small amounts of other light hydrocarbons (C1 to C5). Liquid hydrocarbon products consisted of a mixture containing mainly n-paraffins of C₁₅-C₁₈ and some oxygenated compounds. The catalysts with a mass fraction of 3 % Ni, 15 % Mo (Ni3Mo15/AC) presented the highest selectivity toward C₁₇-C₁₈ hydrocarbons, with a product distribution similar to a commercial alumina-supported Ni-Mo-S catalyst.

Keywords: hydroprocessing; NiMo; activated carbon; n-paraffin; Jatropha oil.

Introduction

Jatropha curcas L. plant is resistant and easily adaptable to adverse environmental conditions. Therefore, this plant could be cultivated in extensive areas without competing for arable land. This species does not compete with edible oils due to its content of phorbol and lecithin, which makes it toxic for human consumption. Moreover, the amount of oil produced per kilogram of seed is about 40 %, making it a suitable alternative for biofuels production (Martinez-Herrera et al., 2006; Mukherjee et al., 2011).



Many researchers have investigated the hydrotreatment of vegetable oils such as palm oil (Srifa et al., 2014), rapeseed oil (Sotelo-boy et al., 2011), sunflower oil (Sankaranarayanan et al., 2011), and Jatropha oil (García-Dávila et al., 2014; Liu et al., 2012) over conventional hydrodesulfurization catalysts. Hydroprocessing of vegetable oils leads to the production of hydrocarbons in the boiling range of diesel, commonly called green diesel or renewable diesel (Nikulshin et al., 2014). Depending on the reaction conditions (i.e. temperature, pressure, type of catalyst), a series of complex reactions occurs during the hydroprocessing. These include the saturation of double bonds, heteroatom (sulphur, nitrogen, or oxygen) removal and, breakage and reorganization of C – C bonds (Breysse M. et al., 2008). In the case of the hydroprocessing of vegetable oils, the liquid products consist of straight chain n-alkanes with 15 – 20 carbons, which are formed via three different reaction pathways: decarbonylation, decarboxylation, and hydrodeoxygenation (Sotelo-boy et al., 2011).

Operating conditions and catalysts activity have significant effects on the quality of the reactions pathways and the liquid product. Chen et al., (2013) investigated the catalytic activities in the hydroconversion of Jatropha oil of reduced NiMo catalysts supported by Al_2O_3 , $\text{SiO}_2\text{-}\text{Al}_2\text{O}_3$, SAPO-11, and Al-SBA-15. They found that the catalytic performance was influenced by the acidity of the support, resulting in significantly different hydrocarbon distribution products. In another investigation, Verma et al. (2015) studied the hydroprocessing of Jatropha oil over the hierarchical SAPO-11 zeolite with different acidities (i.e. type, strength, and number). It was found that variations of Si content in the support SAPO-11 did not have significant impact on the product yields, but aromatics formation indicates that, in addition to deoxygenation, mild cracking and isomerization occurred. This suggests that unexpected aromatization reaction was also taking place over this catalyst. A significant advantage of this process is the reduction in hydrogen consumption by as much as 10 %. Therefore, the choice of catalyst is crucial for the composition and desired fuel properties of hydroprocessed triglycerides. Moreover, the nature of the support plays an essential role on the morphology of active phase particles (Nikulshin et al., 2014), which in turn is strongly related with the catalytic activity and stability.

Supports (i.e. alumina, zeolites, SBA-15 and MCM-41, and silica-alumina) are found to possess high cracking activity due to their acidity, and therefore are less favourable for the hydrotreating process. Alumina is by far the most common support for hydrotreating catalysts containing nickel (or cobalt) and molybdenum (or tungsten) due to its relatively large surface area, easily controlled pore structure, high packing density, thermal stability, physical strength, and recoverability (Breysse M. et al., 2008). However, alumina develops strong interactions with metal oxide precursors which could favor the formation of undesired phases under certain reaction conditions. In addition, its surface contains acid and basic sites that cause undesirable transformations of precursors and coke formation (Nikulshin et al., 2014). On the other hand, a carbonaceous support such as activated carbon has been reported to have some potential for enhancing the dispersion of the catalytic metal-sulphide because of the weak polarity and higher surface area. The weak polarity of the surface reduces interaction between the active phase and the support, and the high surface area provides much more anchor sites for the active component (Kouzu et al., 2004). Additionally, the low cost and the possibility of recovering the active

metals from spent catalysts by burning off carbon are advantages of carbon over alumina-based catalysts (Furimsky, 1983; Kukushkin et al., 2015). Although the effect of active metal sites on selectivity of the catalysts in deoxygenation reaction have been investigated (Sotelo-boy et al., 2011; Wang et al., 2015), there is little information about the influence of the Ni:Mo ratio in deoxygenation pathways and selectivity. In this study, catalysts with different amount of nickel and molybdenum supported on commercial activated carbon were prepared using co-impregnation methods. The different catalysts were evaluated in the hydroprocessing of Jatropha oil.

Experimental

2.1 Preparation and characterization of catalysts

A commercial activated carbon (from Anderson Development Company) was used as catalytic support. The activated carbon (diameter particle size between 0.3 and 0.5 mm) was impregnated with aqueous solutions of ammonium heptamolybdate ($(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$) and nickel nitrate ($\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$), both from Panreac (analytical grade). An appropriate volume of aqueous solution of the salts was selected to reach the desired concentration in the catalysts. Catalysts were prepared by a wetness co-impregnation method using different Ni 1 %, 3 % and 5 % and Mo 5 %, 10 % and 15 % amounts. Chemical analysis was carried out by X-ray fluorescence, XRF (Thermo Optim'x). BET surface areas were measured by N_2 adsorption at -196 °C using a sorptometer (Micromeritics®, ASAP 2020) and the morphology was analyzed using scanning electron microscopy, SEM-EDS (Philips, Model 505). Hydrogen temperature-programmed reduction (H_2 -TPR) studies were carried out using a Micromeritics® Autochem II 2920 instrument. The calcined samples were placed in a U-shaped quartz reactor and pretreated in helium at 350 °C before reduction in order to remove humidity and clean the surface. After cooling down the sample to room temperature and introducing the reduction mixture of 10 % H_2/Ar (50 mL/min), the sample was heated at a rate of 10 °C min⁻¹ from room temperature to 600 °C. The hydrogen consumption was estimated from the area under the peak; taking into account the calibration of TCD signal.

2.2 Catalytic activity and products analysis

Hydrotreating by hydrodeoxygenation (HDO) of Jatropha oil was performed using 4.75 g Jatropha oil and 0.25 g catalyst in a 50 mL batch reactor at 350 °C and under a hydrogen pressure of 90 bar during three hours. The catalysts were *in-situ* sulfided by the addition of elemental sulphur (S_8) in a S:Mo ratio of 2:1. A commercial catalyst of $\text{NiMo}/\text{Al}_2\text{O}_3$ (with 4.2 % Ni and 11 % Mo) was used for comparison. The products consisted on a solid and a liquid phase. 2-propanol (analytical grade) was added to solubilize oily products. The solid (catalyst) was separated by filtration, afterwards, the liquid phase consisting in a mixture of 2-propanol, water and oily products was separated by rotaevaporation. The oily products were characterized by FTIR (Nicolet 6700) and gas chromatography (GCMS-QP2010 Ultra, Shimadzu Corporation) with a flame ionization detector (FID) and a DB-5 capillary column (30 m x 0.25 mm x 0.10 µm). Quantitative results were obtained using octadecane as an internal standard. The gaseous products were analyzed using a micro-GC (Varian, CP 4900 model) with a thermal conductivity detector (TCD).

Results and discussion

3.1 Raw material and catalysts characterization

Fatty acid composition of Jatropha oil is presented in **Table 1**. Similarly to other vegetable oils, triglycerides are the main components of Jatropha oil. They can be hydrolyzed into three fatty acid molecules and a glycerol molecule. From these results, the largest fatty acid component consisted of C₁₈ species with a percentage of 86.5 % (C₁₈:0, oleic acid; C₁₈:1, linoleic acid; linolenic acid C₁₈:2), while the second largest fatty acid component was palmitic acid (C₁₆:0), 12.2 %. This composition is typical for Jatropha oil as reported by other authors (Kumar et al., 2007).

Table 1. Fatty acid composition of Jatropha oil

| Fatty acid | | Composition (wt %) |
|------------|----------------------|--------------------|
| Oleic | (C ₁₈ :1) | 44.9 |
| Linoleic | (C ₁₈ :2) | 34.1 |
| Palmitic | (C ₁₆ :0) | 12.2 |
| Stearic | (C ₁₈ :0) | 7.33 |
| Linolenic | (C ₁₈ :3) | 0.17 |

Table 2 shows the metal loading of the catalysts. The theoretical ratio loadings of Ni:Mo in NiMo/AC catalysts were 0.33, 0.20, 0.50, and 0.33 for Ni3Mo10/AC, Ni3Mo15/AC, Ni5Mo10/AC, and Ni5Mo15/AC, respectively. The X-ray fluorescence results showed an experimental ratio of 0.36, 0.25, 0.57, and 0.38 for the catalysts, respectively. According to these results, the theoretical and experimental values are highly correlated, indicating that co-impregnation is an appropriate method to prepare NiMo/AC catalyst.

Table 2. Chemical composition of different NiMo/AC catalysts. ^aOn dry ash free basis, ^bObtained by x-ray fluorescence.

| Catalysts | Nominal (wt.%) | | | Chemical analysis (wt.%) | | |
|------------|------------------|-------------------|-------|--------------------------|------|-------|
| | Ni | Mo | Ni:Mo | Ni | Mo | Ni:Mo |
| Commercial | 4.2 ^b | 10.9 ^b | 0.38 | - | - | - |
| Ni3Mo10/AC | 3 | 10 | 0.30 | 4.5 | 12.4 | 0.36 |
| Ni3Mo15/AC | 3 | 15 | 0.20 | 4.4 | 17.4 | 0.25 |
| Ni5Mo10/AC | 5 | 10 | 0.50 | 6.9 | 12.0 | 0.57 |
| Ni5Mo15/AC | 5 | 15 | 0.33 | 6.1 | 16.0 | 0.38 |

The specific surface area of activated carbon was measured as 1800 m²/g. It was observed that for the catalysts the specific surface area decreased to about 1500 m²/g, probably due to the relatively high nickel and molybdenum loading.

SEM micrographs in **Figure 1** show the surface morphology of fresh catalysts. It can be observed that the increase in Mo concentration in the catalysts do not modify the morphology of the particles and merely causes agglomeration of Mo-containing particles on the surface (Figure 1: Ni3Mo15/AC and Ni5Mo15/AC).

TPR results are shown in **Figure 2** and the derived data are presented in **Table 3**. The activated carbon support (AC) observed in Figure 2 has no defined reduction peak, but a progressive consumption of hydrogen is observed above 400 °C which could be associated with a slight gasification of the active carbon. This slight gasification process is also evident from the H₂-TPR profiles for solids containing Ni-Mo.

All samples showed one reduction peak (Figure 2). This suggests the presence of highly homogeneous reducible species, where Ni is probably forming a mixed or binary oxide of the type of nickel molybdate. Moreover, it can also be observed from Figure 2 that increasing Ni amount causes a decrease of the temperature at the maximum reduction peak. This shift to low temperature is more important for catalysts with low amounts of Mo. Particularly, for the sample Ni5Mo10/AC, the reduction peak occurs at the lowest temperature (i.e. 357 °C Vs. 380-398 °C for other samples), indicating that at higher Ni/Mo molar ratio the reducibility process is favoured (see Table 2 and Table 3). This is consistent with some reports indicating that Ni species are easier to reduce than Mo species (Laniecki et al., 2006).

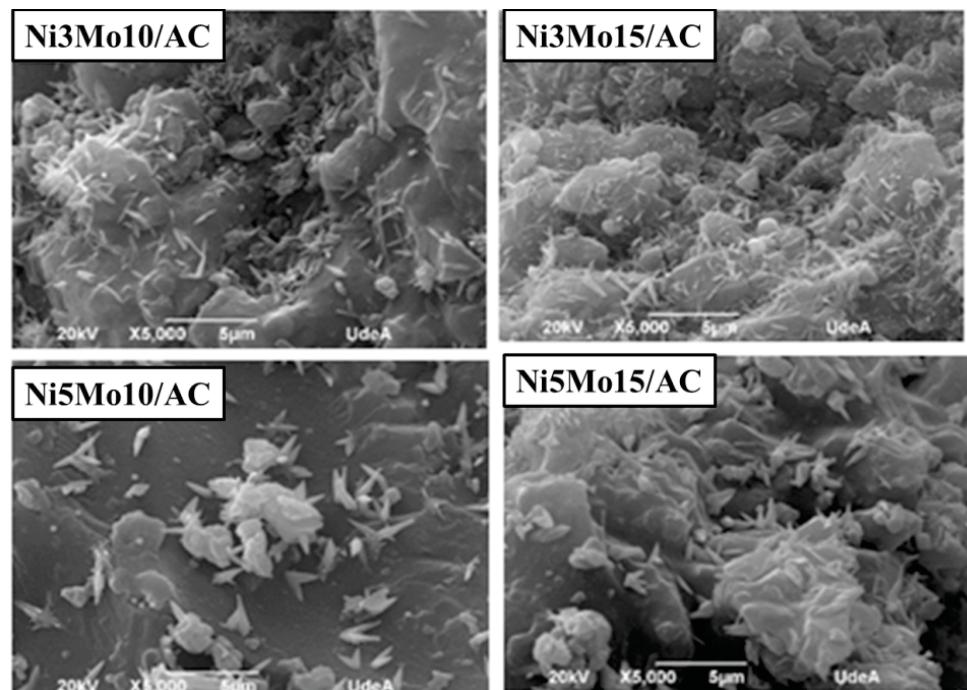


Fig. 1. SEM micrographs of variable concentration of NiMo/AC catalysts.

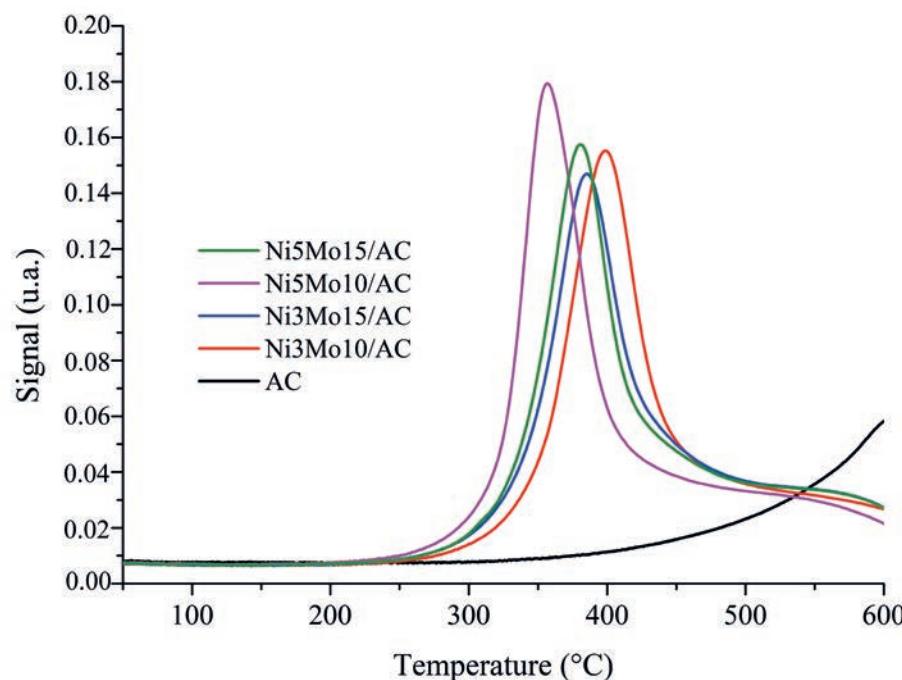


Fig. 2. TPR-H₂ for the different catalysts used and compared with support.

On the other hand, no reduction events were observed at high temperatures (above 500 °C), which is in contrast to metal oxide type supports. The fact that the main reduction event occurs at low temperature (below 400 °C) indicates that a low strength interaction between the activated carbon support occurred and reducible species of Ni-Mo. This result shows an advantage since this means that Ni-Mo species would be more available to phidation processes. consequently, it would be easier to form the Ni-Mo-S active phase. The results of H₂ consumption normalized by metal content ($\mu\text{mol H}_2/\mu\text{mol Ni} + \text{Mo}$), except for the sample Ni5Mo10/AC (Table 3), suggest that hydrogen consumption is proportional to the quantity of reducible species in the surface of the activated carbon support. Therefore, these results would suggest that reducible species in the catalyst are prone to form the active phase of sulphided Ni-Mo species; constituting an indirect evidence of the high dispersion of metal species on the surface.

Table 3. Quantity and Temperatures obtained from TPR-H₂ for different NiMo/AC catalysts.

| Sample | T _{max.} Reduc. | H ₂ consumption ($\mu\text{mol/g}$) * 10 ³ | $\frac{(\mu\text{mol H}_2)}{(\mu\text{mol Ni+Mo})}$ | (Ni / Mo) Chem. Anal. |
|------------|-----------------------------|---|---|--------------------------|
| Ni3Mo10/AC | 397.8 | 3.08 | 1.50 | 0.59 |
| Ni3Mo15/AC | 384.6 | 3.44 | 1.34 | 0.41 |
| Ni5Mo10/AC | 356.5 | 5.21 | 2.15 | 0.94 |
| Ni5Mo15/AC | 380.7 | 3.59 | 1.33 | 0.62 |

3.2 Analysis of products in HDO of Jatropha oil

For Ni3Mo15/AC and commercial catalysts, liquid products presented two clear and colourless phases of oily products and water. For the rest of the catalysts under study, liquid products became cloudy and contained a suspension of water and paraffinic oil that solidifies at room temperature depending on the reaction progress. The oily phase, which corresponds to liquid hydrocarbon products, was separated from the aqueous phase and characterized using FTIR and GC-MS techniques.

Figure 3 illustrates the IR spectra of Jatropha oil and liquid hydrocarbons obtained during the HDO process using the synthesized and commercial catalysts. An approximate analysis of the product composition and residual oxygen content in the liquids, in particular, can be obtained by FTIR spectroscopy (Romero et al., 2015). For the products after reaction, the disappearance of the band at 1230 cm^{-1} , which corresponds to C – O – C stretching mode, suggests that conversion of triglycerides was essentially complete for all tested catalysts. The band in the range of $1680 - 1750\text{ cm}^{-1}$ is due to the C = O stretching mode of compounds containing carbonyl group, i.e. esters, acids and carbonyl compounds. The lower intensity of this band indicates a reduced amount of such compounds. It is evident that the intensity of this band decreased strongly when commercial catalyst, Ni3Mo15/AC, and Ni5Mo15/AC were used, which is an indicative that deoxygenation reactions took place. The disappearance of the band around 3010 cm^{-1} , associated to the C – H stretching band in olefinic carbons, showed that all catalysts were effective for hydrogenation reactions,

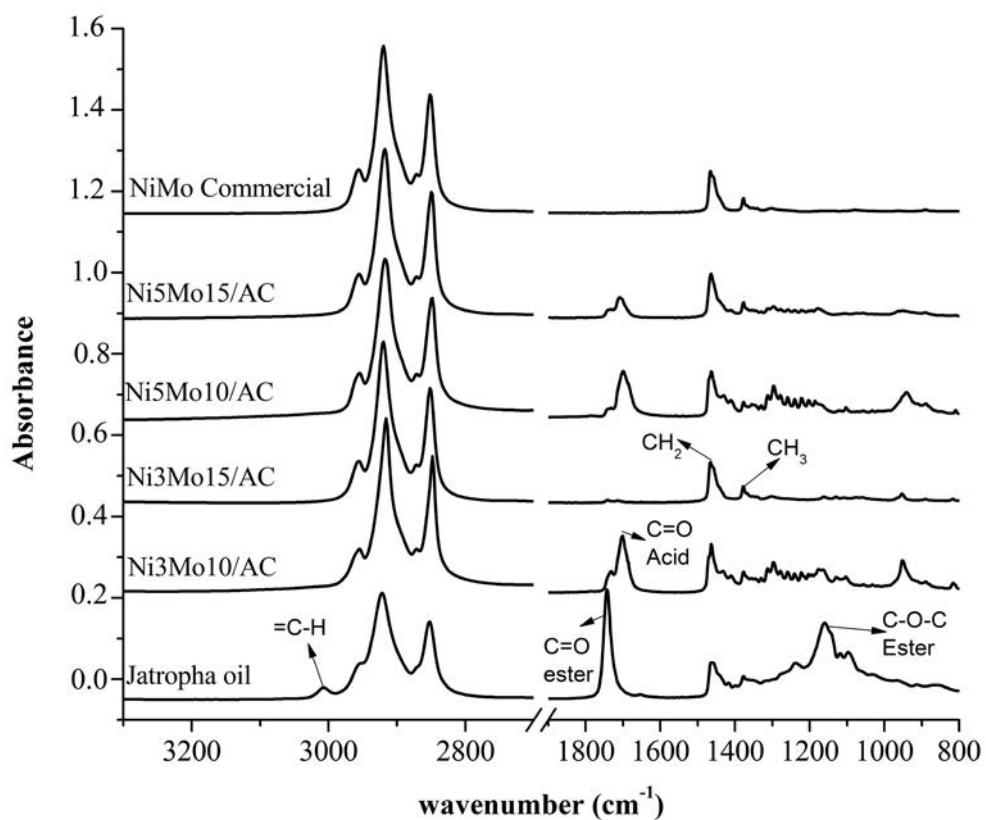


Fig. 3. FT-IR spectra of Jatropha oil and products.

therefore forming paraffinic hydrocarbons. In general, IR analysis provided evidence of substantial deoxygenation of Jatropha oil in all experiments, with an increased degree of deoxygenation in the presence of catalysts Ni3Mo15/AC and Ni5Mo15/AC.

Figure 4 presents the selectivity to liquid hydrocarbon products obtained during HDO process of Jatropha oil after 3 h over different catalysts. The products distribution was comparable for Ni3Mo15/AC, Ni5Mo15/AC, and commercial catalysts. For these materials, a significantly higher selectivity toward C₁₈ hydrocarbon was observed, with 47 %, 40 %, and 48 % respectively; which may indicate that HDO mechanism is the main oxygen elimination pathway.

In order to verify the importance of the presence of metal sulphide, a control reaction under the same conditions were carried out using activated carbon as catalyst. The results of this reaction showed a yield of 2 % and a 2 % of selectivity to hydrocarbons. The limited yield is associated to thermal conversion from triglycerides to fatty acids. Moreover, the microporosity of the active carbon support and the lack of Ni-Mo sulphide species prevent the formation of hydrocarbon products.

Three possible reaction pathways are usually considered for the removal of oxygen during the hydrotreatment of triglycerides: hydrodeoxygenation, decarboxylation, and decarbonylation. During the hydrodeoxygenation, the triglycerides are converted into

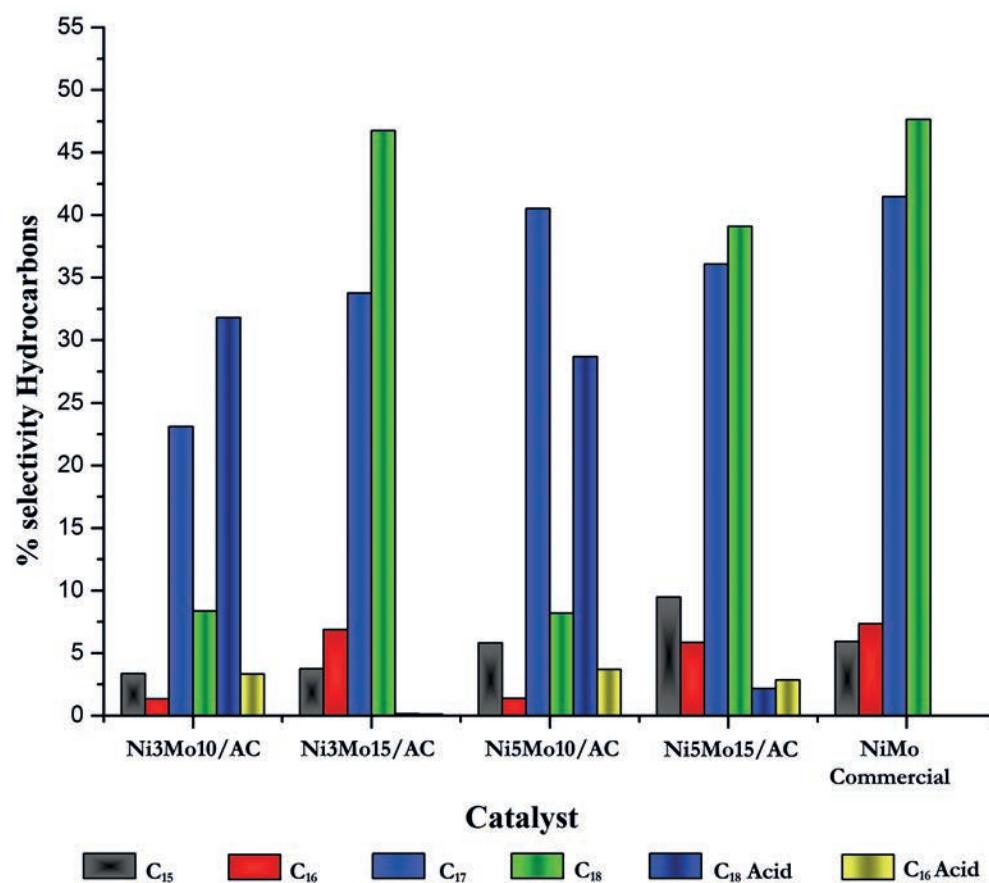


Fig. 4. Selectivity of catalysts toward various fractions of hydrocarbons obtained in the HDO process of Jatropha oil.

n-paraffins which have the same carbon number as the fatty acid of the triglyceride; furthermore during the decarboxylation and decarbonylation the carbon number of the produced paraffins is one carbon lower with respect to the fatty acid of the triglyceride molecule (Satyarthi et al. 2013). It was found that Ni3Mo15/AC, Ni5Mo15/AC, and commercial catalysts have relatively high selectivity toward C_{17} hydrocarbon with 34, 36, and 41 % respectively. As Jatropha oil does not have C_{17} fatty acids in its composition (see Table 1), the only way to produce C_{17} hydrocarbon is through decarboxylation or decarbonylation of C_{18} . However, to determine if decarboxylation or decarbonylation took place, it is not sufficient to use the analysis of the carbon number distribution of the target fraction. It is necessary to know the amount of formed gases (CO and CO_2) as by-products and the exact amount of water. However, this is difficult because, besides the main deoxygenation reactions, other gaseous reactions, such as water gas shift or methanation, could take place on the investigated catalyst. Catalysts Ni3Mo10/AC and Ni5Mo10/AC have a higher selectivity to C_{17} hydrocarbon; 23 % and 40 % respectively. However, their liquid products still have fatty acids, indicating a lower progress of the reaction. The yield to hydrocarbons was 50.7 %, 99.7 %, 63.3 %, 94.7 %, and 100 % for Ni3Mo10/AC, Ni3Mo15/AC, Ni5Mo10/AC, Ni5Mo15/AC, and commercial catalyst respectively. According to these results, it can be safely concluded that catalyst Ni3Mo15/AC is as active as the commercial one and it has the best yield and selectivity to these target products.

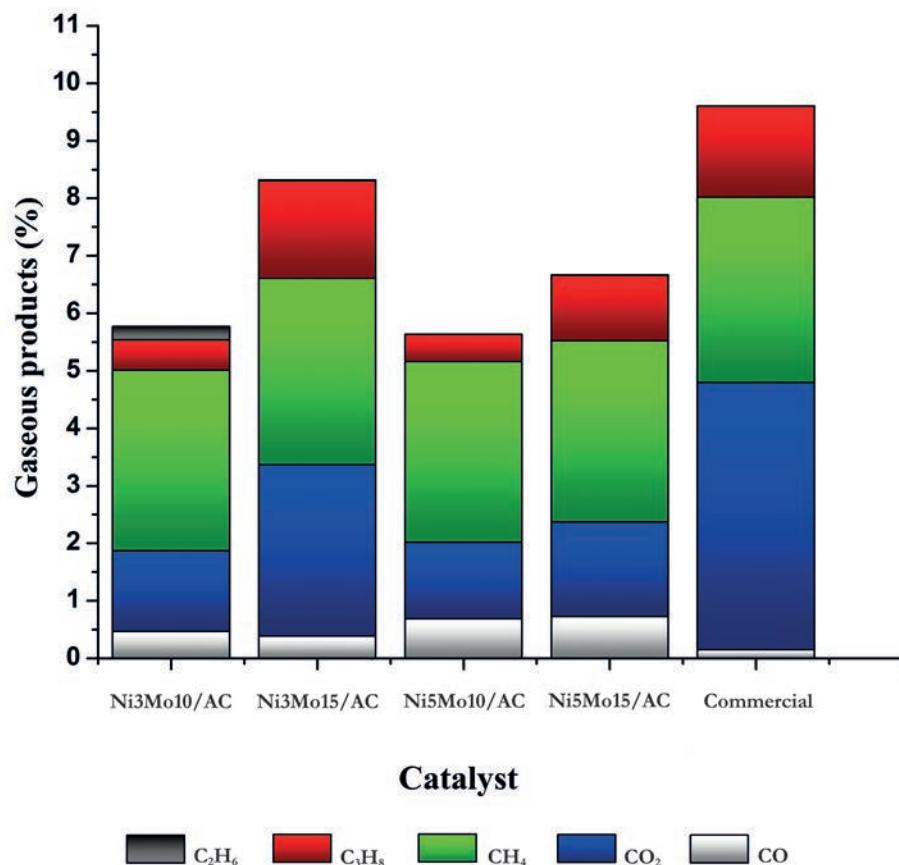
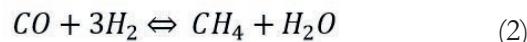
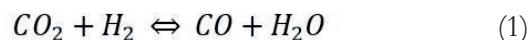


Fig. 5. Composition of the gaseous products after the HDO of Jatropha oil for the different catalysts (H₂ balance).

To obtain a better understanding of the way by which oxygen is eliminated from Jatropha oil, the gaseous products were subjected to gas chromatography analysis. The gas composition obtained using the Ni3Mo10/AC, Ni3Mo15/AC, Ni5Mo10/AC, Ni5Mo15/AC, and commercial catalysts is presented in **Figure 5**.

The gaseous products for all studied catalysts were mainly composed of CO₂, CO, CH₄, C₂H₆, and C₃H₈. It was not possible to determine the quantity of water because of the loss of this product during the sampling process, which leads to a lack of reproducibility. The presence of CO₂ and CO as the main gaseous compounds confirmed that decarboxylation and decarbonylation reactions were occurring. Water gas shift (equation 1) and methanation (equation 2) reactions are other probable side-reactions during the hydroprocessing. They lead to an increase in hydrogen consumption and may explain the high amount of methane.



The low formation of CO may imply that the water-gas shift reaction occurs and the formation of methane is a consequence of the consumption of this CO through equation 2. At the initial stage of the hydrocracking reaction, each triglyceride molecule is expected to break down into three hydrocarbon molecules and one propane molecule. For Ni3Mo15/AC and commercial catalyst, the yield of propane was around 1.5 %, which was mainly generated from the hydrogenation of the C₃-backbone in the triglyceride of Jatropha oil.

To study the effect of the nickel and molybdenum content in NiMo/AC catalysts during the hydrotreatment of Jatropha oil, six catalysts with the following weight percent ratio of Ni:Mo were evaluated: 1:15, 3:15, 5:15, 3:5, 3:10, and 3:15. The selectivity of these catalysts towards C₁₇ and C₁₈ hydrocarbons are shown in **Figure 6**.

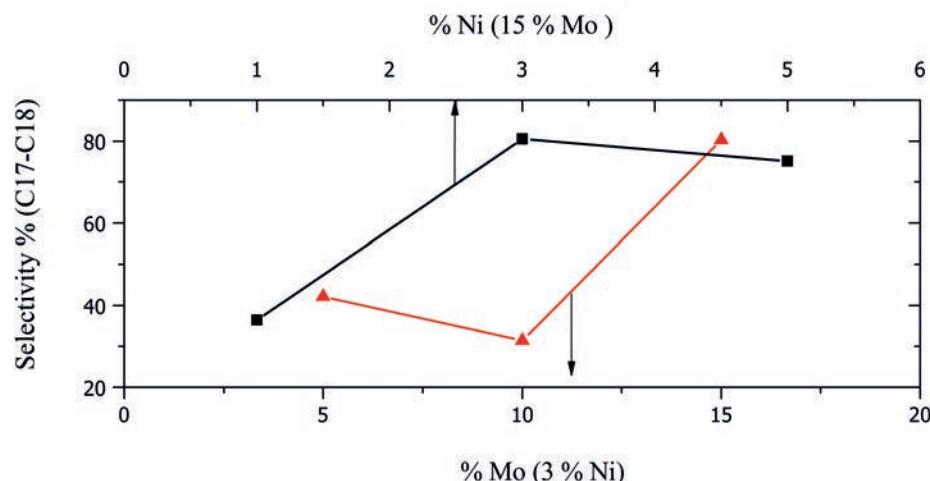


Fig. 6. Effect of Ni and Mo concentration (wt. %) in their selectivity toward C₁₇ and C₁₈ hydrocarbons.

It can be seen from Figure 6, that an increase in Mo content from 10 % to 15 % in the NiMo/AC catalysts caused an increase in the selectivity of C₁₇ and C₁₈ hydrocarbons. On the contrary, an increase of Ni content, from 3 % to 5 %, led to a slight decrease on the yield of these hydrocarbons. The extent of the HDO reactions(i.e. hydrogenation/dehydration versus decarboxylation/decarbonylation) is highly dependent on the promoter metal (Ni) concentration and the dispersion of sulphided phases (Furimsky, 1983). Ni is well known as a promoter in MoS₂/Al₂O₃ catalysts to increase the catalytic activity in hydrogenation (Kubicka et al., 2010). In the present work, this promoting activity of Ni was evident in the ability of efficiently obtaining a high selectivity to hydrocarbons C₁₅-C₁₈. It could be proposed that a small load of Ni over the active phase provides enough hydrogenation ability to transform oxygenated compounds into hydrocarbons; hence 3 % of Ni in NiMo/AC catalysts seems to be appropriate to reach the adequate activity in the HDO of Jatropha oil. Ni-Mo mixed sulfides are known to have higher chemical resistance to acids compared to monometallic nickel catalysts (Kukushkin et al., 2015). On the other hand, the study of the influence of molybdenum as a modifying metal on the activity and selectivity of nickel-based catalysts showed the increase from 30 % to 80 % in the yield of C₁₇-C₁₈ with the Mo content (from 10 % to 15 %) in the NiMo/AC catalysts. This result indicated that the catalyst with 15 % Mo and promoted with 3 % Ni was the most appropriate combination to generate the active phase on activated carbon supported catalysts for the hydrodeoxygenation of Jatropha oil.

Conclusions

The results of the present work clearly demonstrate that activated carbon is a suitable support for the preparation of Ni-Mo sulfided catalysts for the hydroconversion of Jatropha oil to hydrocarbon mixture in the range of diesel (green diesel). Catalyst Ni3Mo15/AC, which has a composition of 3 % Ni and 15 % Mo showed a yield of 99.7 % and a selectivity to C₁₈ of 47 %, comparable to those reached using commercial alumina supported catalyst. This indicates that , as for the alumina supported catalysts, a Ni:Mo weight ratio of 3:15 was the most appropriate combination to prepare activated carbon-supported Ni-Mo sulfided catalysts for the hydrotreatment of Jatropha oil. Because of the similar performance of the alumina and activated carbon-supported catalysts, it can be concluded that the support does not have a significant effect during the hydrotreatment of Jatropha oil. This observation is probably related to the microporosity of the used activated carbon, which could limit the accessibility of the triglycerides molecules, affecting their catalytic performance.

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Conflicts of interest

The authors state that their sole interest in the results of this research is scientific.

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NiMo-sulfuro soportado en carbón activado para producir diesel renovable

Resumen. Gracias a su débil polaridad y gran área superficial, los soportes de carbón activado tienen el potencial de aumentar la dispersión de los sulfuros metálicos. La ausencia de una interacción fuerte metal-soporte puede conducir a la formación de una fase Ni-Mo-S muy activa y estable. En este estudio se prepararon catalizadores por el método de co-impregnación, con diferentes cantidades de níquel y molibdeno y soportados sobre carbón activado comercial, y se caracterizaron por técnicas BET, XRF y SEM. Se evaluó su actividad catalítica para el hidroprocesamiento de aceite de Jatropha utilizando un reactor por lotes, y se determinó la composición de los productos líquidos y gaseosos. Los resultados mostraron que los productos gaseosos están compuestos principalmente de grandes cantidades de propano y pequeñas cantidades de otros hidrocarburos livianos (C1 a C5). Los hidrocarburos líquidos fueron principalmente una mezcla de n-parafinas de C₁₅-C₁₈ y de algunos compuestos oxigenados. Los catalizadores presentaron una fracción de masa de 3 % Ni, 15 % Mo (Ni3Mo15/AC) y mayor selectividad hacia hidrocarburos C₁₇-C₁₈, con una distribución de productos similar al catalizador Ni-Mo-S soportado en alúmina comercial.

Palabras clave: hidroprocesamiento; NiMo; carbón activado; n-parafina; aceite de Jatropha.

NiMo-sulfeto suportado em carvão ativado para produzir diesel renovável

Resumo. Devido a sua baixa polaridade e ampla área superficial, os suportes de carvão ativado possuem o potencial de aumentar a dispersão de sulfetos metálicos. A ausência de uma forte interação suporte-metal pode levar a formação de uma fase Ni-Mo-S muito ativa e estável. Neste estudo, foram preparados catalisadores com diferentes teores de níquel e molibdênio suportados em carvão ativado comercial por um método de co-impregnação e caracterizados pelas técnicas BET, XRF e SEM. A atividade catalítica foi avaliada para o hidroprocessamento do óleo de Jatropha em um reator por lotes, e se determinou a composição dos produtos líquidos e gasosos. Os resultados mostraram que os produtos gasosos são compostos principalmente por altos teores de propano e pequenos teores de outros hidrocarbonos leves (C1-C5). Os hidrocarbonos líquidos consistiram de uma mistura contendo principalmente n-parafinas de C₁₅-C₁₈ e alguns compostos oxigenados. Os catalisadores apresentaram uma fração de massa de 3 % Ni, 15 % Mo (Ni3Mo15/AC) e uma maior seletividade em relação aos hidrocarbonos C₁₇-C₁₈, com uma distribuição de produtos similar ao catalizador comercial Ni-Mo-S suportado em alumina.

Palavras-chave: hidroprocessamento; NiMo; carvão ativado; n-parafina; óleo de Jatropha.

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