Catalytic deoxygenation of palmitic acid using Co-Mo supported on carbon nanotubes

K. K. Ferreira[1,2], L. S. Ribeiro[1,2], M.F.R. Pereira[1,2,*]

[1] LSRE-LCM – Laboratory of Separation and Reaction Engineering - Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[2] ALiCE – Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

fpereira@fe.up.pt

The growing need for ecologically friendly aviation solutions is driving the development of renewable jet fuel. In this perspective, lipid sources are especially important since they include fatty acids with carbons in the aviation fuel range (C_8-C_{16}) [1]. However, their direct use as fuel is not feasible due to the elevated oxygen content, resulting in deterioration of the physical and chemical properties. Therefore, a catalytic hydrotreatment process is necessary [1,2]. In this context, this work focused on the evaluation of the catalytic performance of Co-Mo supported on carbon nanotubes (CNT) in the deoxygenation of palmitic acid (lipid-based feedstock model compound).

For this purpose, bimetallic catalysts (metal loadings of 2.5 and 10.5 % of Co and Mo, respectively) were prepared by incipient wetness impregnation. CNTs and oxidized CNTs (CNT_{ox}) were used as supports. After this procedure, the materials were thermally treated in a N_2 flow at 600 ºC for 3 h and reduced in H_2 at the same temperature and time. The prepared catalysts (Co-Mo/CNT and Co-Mo/CNT_{ox}) were characterized by N_2 adsorption, X-ray diffraction, temperature programmed reduction, elemental analysis, ICP-OES and point of zero charge. Reactions with 0.25 g of each catalyst were performed in a stainless steel batch reactor (100 mL) using 0.5 g of palmitic acid diluted in 50 mL of *n*-decane at 350 ºC, 30 bar of initial H_2 pressure, using a stirring rate of 150 rpm for 6 h. The final liquid products were analysed by GC-MS (Shimadzu TQ8040-NX). After that, the conversion of palmitic acid and the yields of hexadecane (C_{16}) and pentadecane (C_{15}) were determined. In addition, a reaction under the same conditions described above using a commercial catalyst (Co-Mo/Al_2O_3 , metal loadings of 2.5 and 10.5 % of Co and Mo, respectively) was carried out.

After 6 h of reaction, the carbon-supported metal catalysts were effective, with 67.7 and 81.8 % C_{16} yield over Co-Mo/CNT and Co-Mo/CNT_{ox}, respectively. The yields for C_{15} production were the same for both catalysts - 8.1 %. The addition of oxygenated groups to the surface of CNT improved the catalytic performance of Co-Mo/CNT_{ox} in the hydrodeoxygenation reaction, and a complete palmitic acid deoxygenation was achieved. Despite the commercial catalyst's lower acidity and the presence of micropores, the higher Co concentration in the material may have contributed to a larger C_{16} production (83.2 %) compared to Co-Mo/CNT. The high loads of Co and Mo oxides on the commercial catalyst and the high acidity of Co-Mo/CNT_{ox}, offered comparable performance in terms of C_{16} production after 6 h of reaction.

Acknowledgements

This work was supported by national funds through FCT/MCTES (PIDDAC): LSRE-LCM, UIDB/50020/2020 (DOI: 10.54499/UIDB/50020/2020) and UIDP/50020/2020 (DOI: 10.54499/UIDP/50020/2020); and ALiCE, LA/P/0045/2020 (DOI: 10.54499/LA/P/0045/2020). K. K. Ferreira acknowledges her Ph.D. scholarship (2022.12949.BD) from FCT.

References

[1] P. Mäki-Arvela, M. Martínez-Klimov, D.Y. Murzin, Fuel, 306 (2021) 121673.
[2] M. Zhang, Y. Hu, M. Wang, H. Li, X. Han, Y. Zeng, C. C. Xu, Molecular Catalysis, 504 (2021) 111438.