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Kinetic study of methanol dehydration to DME on Zr-loaded P-containing mesoporous activated carbon catalyst

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Abstract

Fossil fuels depletion, together with an increasingly stringent in the environmental regulations, are the driving force in seeking for alternative clean energy resources. Thanks to its physical and chemical properties, similar to liquified petroleum gases (LPG) and conventional diesel, plus the clean combustion achieved when used as fuel, dimethyl ether (DME) is considered as one of the most promising alternatives to petroleum derived fuel and, thus, its production is the object of different researches [1]. Currently, DME production is carried out via methanol dehydration on solid acid catalysts [2]. The use of activated carbons as catalysts for this aim has been little studied to date. In this work, we examined the selective methanol dehydration to DME using a Zr-loaded P-containing activated carbon catalysts.

The activated carbon was prepared by chemical activation of olive stones with phosphoric acid, with an impregnation mass ratio value (H_3PO_4/carbon precursor) of 2 and an activation temperature of 800 ºC. Then, the resulting activated carbon was loaded with a 5 % (wt) of Zr by incipient wetness impregnation.

The results highlighted the presence of zirconium phosphate species bonded to the activated carbon surface. These species were responsible for the high steady-state methanol dehydration achieved when using the activated carbon as catalyst, keeping a selectivity to DME higher than 97 % at a reaction temperature of 400 ºC. A kinetic study for the selective methanol dehydration to DME was carried out and the corresponding kinetic and thermodynamic parameters were calculated. Three reaction mechanisms were proposed. A Langmuir-Hinshelwood like mechanism was the one that better reproduced the experimental data. Fig. 1 displays the experimental methanol conversion (dots) and the results predicted by the model (solid lines). The model here presented reproduced the experimental data with a high accuracy.

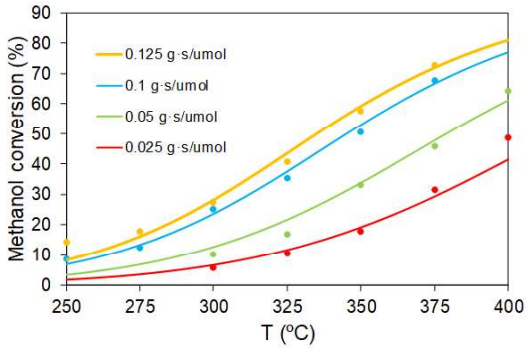

Fig. 1. Experimental (dot) and simulated (solid line) steady-state methanol conversion as a function of the reaction temperature at different W_{cat}/F_{MeOH} with a constant partial pressure of methanol P_{MeOH} = 0.04 atm

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