Carbon Nanofiber Supported Ru Catalyst for Sorbitol Hydrogenolysis

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Hydrogenolysis of sorbitol aiming at the production of glycols and glycerol provide an opportunity to sustainable biomass utilization in current and foreseeable chemical industry. Over the past decades, Ru catalysts based on different metals such as SiO$_2$, Al$_2$O$_3$ and activated carbon have been investigated for polyols hydrogenolysis by academe and industrial circles. However, in spite of all efforts, to obtain desired pro ducts at high conversion still need harsh operation conditions. One of the reasons accounting for this issue is the fact that mass transfer limitation is a considerable challenge in biomass conversion$^{(1)}$.

Recently, carbon nanofiber (CNF) supported catalysts have displayed competitive performance in many liquid phase reactions thanks to their mesoporous texture and special electronic properties$^{(2)}$. Therefore, the objective of this work is to develop an effective Ru catalyst supported on CNF for sorbitol hydrogenolysis under more moderate conditions, which, to the best of authors’s knowledge, has not been reported so far.

The CNF is synthesized in our lab by catalytic chemical vapor deposition (CCVD) using Fe$_3$O$_4$ as catalyst and purified in diluted HCl solution for times to remove residue metal. For comparison purpose, the hydrogenolysis reaction is also carried out over microporous activated carbon (AC) supported catalyst. Both CNF and AC were oxidized in 4 M HNO$_3$ at 40 °C for 5 hours. Ru catalysts on 160 mesh supports were prepared by incipient wetness impregnation with an aqueous solution of RuCl$_3$·3H$_2$O, and reduced by hydrogen gas before use. Experiments were carried out in a batch autoclave with addition of 1.0 g 3.0 wt% catalyst and 10.0 g CaO as promoter at 220 °C and 8.0 MPa hydrogen pressure for 4 hours.

A comparison of catalytic performance shows that Ru/CNF catalyst displays a significant increase in sorbitol conversion but a slight decrease in selectivity to desired polyols as compared to Ru/AC catalyst. This is rationalized by the fact that mesoporous CNF could increase the accessibility of the active sites for reactants while enhances the diffusion of intermediates away from the active sites. Moreover, it is indicated that the oxidation treatment of both activated carbon and CNF deteriorate the activity of supported Ru catalysts, though the oxidation treatment introduced a large amount of oxygen groups on support surface$^{(3)}$.

References

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