Four groups of catalysts have been tested for hydrodeoxygenation (HDO) of phenol as a model compound of bio-oil, including: oxide catalysts, methanol synthesis catalysts, reduced noble metal catalysts, and reduced non-noble metal catalysts. In total 23 different catalysts were tested at 100 bar H₂ and 275 °C in a batch reactor. The experiments showed that none of the tested oxides and methanol synthesis catalysts had any significant activity for phenol HDO at the given conditions, which were linked to their inability to hydrogenate the phenol. HDO of phenol over reduced metal catalysts could effectively be described by a kinetic model involving a two-step reaction where phenol initially was hydrogenated to cyclohexanol and then subsequently deoxygenated to cyclohexane. Among reduced noble metal catalysts ruthenium, palladium, and platinum were all found to be active, with decreasing activity in that order. Nickel was the only active non-noble metal catalyst. For nickel, also the effect of support was investigated and ZrO₂ was found to perform best. Pt/C, Ni/Co₂, and Ni/Co₂-ZrO₂ were the most active catalysts for the initial hydrogenation of phenol to cyclohexanol, but were not very active for the subsequent deoxygenation step. Overall, the order of activity of the best performing HDO catalysts was: Ni/ZrO₂ > Ni-V₂O₅/ZrO₂ > Ni-V₂O₅/SiO₂ > Ru/C > Ni/Al₂O₃ > Ni/SiO₂ >> Pd/C > Pt/C. The choice of support influenced the activity significantly. Nickel was found to be practically inactive for HDO of phenol on a carbon support, but more active than the carbon supported noble metal catalysts when supported on ZrO₂. This observation indicates that the nickel based catalysts require a metal oxide as carrier on which the activation of the phenol for the hydrogenation can take place through heterolytic dissociation of the O-H bond to facilitate the reaction.
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Web of Science (2011): Impact factor
ISI indexed (2011): ISI indexed no
Original language: English
Keywords: Bio-oil, Catalyst screening, Hydrodeoxygenation, Noble metals, Phenol, Oxides, Reduced metals
DOI:
10.1021/cs400266e
Source: dtu
Source-ID: n:oai:DTIC-ART:acs/388578627::30125
Research output: Research - peer-review • Journal article – Annual report year: 2014