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Roles of Pore Geometry of Calcium–Lanthanum Oxide Supported on MCM-41 as an Ordered Mesoporous Basic Catalyst in the Etherification of Glycerol to Diglycerol Isomers

Glycerol is now excessively produced from oleochemical and biodiesel industry and efforts to convert it to value-added substances are worthwhile. The catalytic etherification of glycerol using mixed calcium–lanthanum oxide supported on MCM-41 as a stable heterogeneous basic catalyst with an ordered pore system was investigated in this study. Particular focus was given on the roles of pore geometry on governing the formation of the desired products i.e. diglycerol isomers. The heterogeneous mesoporous basic catalysts were synthesized by wet impregnation of MCM-41 with calcium nitrate and lanthanum nitrate as precursors. The surface and structural properties of the prepared catalysts were then elucidated using SEM, EDX, XRD and FTIR methods and correlated with their catalytic activities. MCM-41 and modified MCM-41 were then used in the solventless etherification of glycerol to selectively produce diglycerol as the desired product. The reaction was performed at 250 °C for 8 h and catalyst activity was evaluated and correlated with the properties of the catalysts. The conversion of glycerol managed to reach 91.3% and the corresponding diglycerol yield was 42.6%. The high activity was successfully correlated with basicity properties and the pore geometry of the catalysts. The distribution of diglycerol isomer in the etherification of glycerol was also elucidated and the value of the sum of two dimers ($\beta\beta' + \alpha\beta = 67\%$) was found to be higher than that of $\alpha\alpha'$ dimer (33%) after 8 h of reaction. Thus, the major reaction was deemed to have occurred mainly inside the internal ordered mesoporous pores instead of on the external surface area when 20% CaLa/MCM-41 was used to catalyze the reaction. The more selective formations of $\beta\beta'$ and $\alpha\beta$ dimers were ascribed to the internal pore geometry of the ordered mesoporous catalyst.

Keywords: Glycerol, Catalytic etherification, MCM-41, Calcium, Lanthanum, Pore Geometry, Diglycerol isomer.

Biography

Prof Dr. Ahmad Zuhairi Abdullah received his PhD in 2004 in chemical engineering. His research works involve the use of functionalized nanoporous materials in generating renewable energy sources, oleochemical conversions and waste treatment. He used to be involved the environmental impact assessment of oil refinery, petrochemical complex, sanitary landfill, smelting plant, used acid lead battery, paper mill etc. Many international invitations have been received to share his research experience. He has published more than 200 refereed articles in journals. He is one of the recipients of the Top Research Scientists Malaysia 2014 award. His h-index (Scopus) currently stands at 47.