Advanced Porous Materials
Vol. 5, 1–6, 2017

Hydroxylation and Oxidation of *p*-Cresol to *p*-Hydroxybenzylalcohol and *p*-Hydroxybenzaldehyde by Using Zeolite-Y and Cerium-Containing Zeolite-Y Catalysts

P. Salma, A. Sreenavya†, K. Anjali†, P. Sahu†, P. Silpa, and A. Sakthivel*

Department of Chemistry, School of Physical Sciences, Inorganic Materials and Catalysis Laboratory, Central University of Kerala, Padnakkad 671314, Kerala, India

A series of zeolite-Y was prepared and subsequently cerium ions were incorporated into the framework of zeolite-Y through the wet-impregnation method. FT-IR spectra of cerium ion containing zeolite-Y showed a vibration band at 460 cm^{-1}. This band can be attributed to the bending vibration of Ce–O–T bond (where T = Si or Al). The well-resolved reflections in the powder XRD patterns of zeolite Y (parent) and the cerium ion containing zeolite-Y corresponds to faujasite-type structure. The crystallinity of zeolite-Y remained unaltered even after loading of 10% cerium ion. The incorporation of cerium ions in the zeolite Y framework enhanced the surface basicity. Diffuse reflection UV-Vis spectra of cerium ion containing zeolite-Y indicated a broad band around 300 nm; the presence of this band supported the presence of Ce^{4+} in a tetrahedral environment. The major product of the zeolite-Y sample was *p*-hydroxybenzylalcohol. The presence of cerium ion facilitated generation of the secondary oxidized product viz, *p*-hydroxybenzaldehyde.

Keywords: Hydroxylation, Oxidation, *p*-Hydroxy Benzyl Alcohol, *p*-Hydroxy Benzaldehyde, Zeolite, Cerium Ions, Faujasite.

RESEARCH ARTICLE

1. INTRODUCTION

Heterogeneous catalytic processes are crucial tools in industrial processes, which influence the environment and green processes.[1–5] Heterogeneous catalysts such as mixed oxide, metal oxide, pure metal, and dispersed metal on metal oxide are crucial in industrial processes such as synthesis of fine chemicals, pharmaceutical manufacturing, and petroleum refining.[6–9] Aluminosilicate-based materials have high stability and are environment friendly, hence they are used as solid acid catalysts in several petrochemical processes.[10–15] In particular, zeolite and zeolite-like molecular sieve materials are widely used in petroleum and petrochemical processes.[12–15] Zeolite Y belongs to the faujasite (FAU) family and comprises four- and six-membered secondary building units that contain large voids of α-cage. Zeolite Y has proved to be very effective for the fluidized catalytic cracking (FCC) processes in its rare-earth exchanged ultra-stable form.[16–18] Moreover, many studies were conducted on the utilization of acid-base functionalities and redox properties of zeolite-based materials in several organic transformations such as alkylation of aromatic compounds, dehydration of alcohols, and biomass conversion.[19–28]

Note that lanthanide-containing zeolite materials sustain their catalytic activity in extreme conditions and thus are used for controlling coke deposition.[29–34] Cerium-based materials are widely used as support and catalytic materials because these materials possess redox properties and acid-base functionalities.[35] Ceria has been extensively used in catalytic processes due to its high redox potential Ce^{4+}/Ce^{3+} of approximately 1.62 eV. For example, ceria is used as catalyst in catalytic converters for the exhaust gas in automobiles[36] and is also a powerful oxidant used for many applications including the glycol cleavage oxidation of vic-diols (e.g., carbohydrate, cellulose). The acid-base property of ceria is due to the presence of Ce^{4+}, which acts as a Lewis acid, in the crystal lattice and due to the presence of O^{2-} ion, which acts as a Lewis base.[35,37] The direct synthesis of cerium-containing zeolite causes the formation of poorly crystallized CeO_2 and Ce_2O_3, which are not in the active phase. Moreover, it is essential to form cerium

*Author to whom correspondence should be addressed.
†These three authors contributed equally to this work.