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Ga doped SBA-15 as an active and stable catalyst for Friedel–Crafts liquid-phase acylation

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Abstract

Gallium containing SBA-15 mesoporous materials with different Si/Ga ratio were synthesized using a post-treatment procedure with an aqueous solution of $Ga(NO_3)_3$. The materials were characterised by means of elemental analysis, BET, XRD, TEM and H/D isotope exchange techniques. It appears that stable Ga-species were anchored to the siliceous matrix of SBA-15, thus generating acid properties in their host material.

The catalytic activity of Ga-SBA-15 materials has been evaluated in the Friedel–Crafts acylation of anisole with benzoyl chloride. The results were compared with nanoporous zeolite BEA to study the influence of the framework crystallinity, pore size, and acidity on the overall conversion and stability.

A conversion of 98% of benzoyl chloride over Ga-SBA-15 materials has been reached after 24 h of reaction with a 98% selectivity toward the desired para-methoxybenzophenone.

Nanoporous zeolite HBEA exhibited a higher activity, but a drastic decrease in the catalyst activity was observed after successive runs.

In contrast, Ga-SBA-15 samples present a higher stability during repeated runs. The observed results indicate that Ga-SBA-15 mesoporous materials can be used as versatile and stable acid catalysts for Friedel–Crafts reactions.

Keywords: Gallium; SBA-15; Nano-composites; Acid catalyst; Friedel–Crafts

1. Introduction

Mesoporous silica materials, MCM-41 and SBA-15, have received increasing scientific interest owing to their narrow pore size distribution, high surface area and pore volume which make them promising candidates for use as catalyst support in catalysis field [1–7]. SBA-15 material was synthesized in acidic medium with poly(alkylene oxide) tri-block copolymers under relatively mild synthesis conditions [8]. The pore size can be varied on a relatively large range between 5 and 20 nm depending on the synthesis conditions. The SBA-15 material also exhibits a higher stability due to the greater wall thickness compared to the MCM-41 material [8] which render it more suitable for use as catalyst support in catalytic processes where thermal treatments and repeated regeneration were frequently encountered. In the MCM-41 material, the wall thickness was only constituted by a few units of SiO_4 which render it extremely sensitive towards hydrolysis problems in the presence of boiling water or in aqueous solutions leading to the collapse of the pore walls with a concomitant destruction of the hexagonal network [9,10].

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