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Walnut shell-assisted synthesis of ceria nanoparticle

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ABSTRACT

Ceria (CeO_2) nanoparticles have been produced from cerium nitrate and walnut shell as a worthless agricultural waste by a thermal decomposition method followed by open air calcination. These nanoparticles further were characterized using powder X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy dispersive X-ray spectroscope (EDX) and fourier transform infrared spectroscopy (FT-IR). Moreover, the efficiency of CeO_2 nanoparticles as a support for palladium nanoparticles and subsequent use in aerobic oxidation of alcohols has been investigated. TEM image of a recovered catalyst indicates the formation of 12 nm sized palladium nanoparticles within the cerium oxide nanoparticles. The catalyst is quite effective for the oxidation of primary and secondary benzylic alcohols into their corresponding aldehydes and ketones under atmospheric pressure of air. Aerobic oxidation of secondary aliphatic alcohols is performed in an oxygen atmosphere.

Keywords: Thermal decomposition; Biomass; Textural properties; Green chemistry; Catalysis

1. INTRODUCTION

Cerium oxide or ceria (CeO_2) is a yellow-white cubic-fluorite type of oxide, which is known as the most famous oxide in oxides of the rare earth metals [1]. Although Cerium oxide has a large application in glass industry as a polishing agent [2] but it's principal use is as a support for heterogeneous catalyst [3] specially supported metal nanoparticle [4-6]. Many of chemists are interested in cerium oxide supported metal nanoparticle as an environmental catalyst for the oxidation of volatile organic compounds (VOCs) [7], nitrogen oxides (NOx) [8] and carbon monoxide (CO) [9].

Because of increase in surface to volume ratio of nanoparticles (NPs) and in the betterments redox and transport properties of ceria nanoparticles, synthesis of these nanoparticles has attracted increasing attention in last years [10]. However, green synthesis of nanoparticles is of major concern due to economical and environmentally friendly approach [11]. For example, Cetyltrimethylammonium bromide (CTAB) has been used as a cationic surfactant for the production of cerium oxide nanoparticles at room temperatures [12, 13]. Because of this surfactant (and other used chemicals such as monoethanolamine and ammonium hydroxide) are generally unfavorable to the environment, other greener routs for the production of chemical contaminant-free cerium oxide nanoparticles have been reported. Some of these routes have occurred in the presence of plants extracts. Recently, small ceria nanoparticles have been synthesized by extracts of Aloe vera leaf, Gloriosa superba L. leaf and Moringa oleifera peel that can be served as reductant or oxidant as well as stabilizer [14-16]. Along with this line, it was shown that food-based material such as Cassava-starch and gelatin can be employed in the synthesis of CeO_2-NPs [17, 18]. However, this method is limited by the cost, production of waste in the extraction process, the availability of restriction sites and nutritional value of these materials.