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Magnetic and electrochemical behaviour of cobalt doped tungsten oxide (WO_3) nanomaterials by microwave irradiation method

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ABSTRACT

Nanocrystalline $WO_3 \cdot H_2O$ nanopowders, doped with cobalt (2 and 5 wt%) have been synthesized using $CoCl_2 \cdot 6H_2O$ and $Na_2WO_4 \cdot 2H_2O$ in a facile microwave irradiation process, followed by the annealing process. The samples were characterized with powder X-ray diffraction, field emission scanning electron microscopy, UV-VIS diffusion reflectance spectroscopy, photoluminescence spectroscopy and cyclic voltammetry (CV). X-ray diffraction patterns showed both undoped and Co doped $WO_3 \cdot H_2O$ crystallized with orthorhombic phase. Annealing h-WO_3 at 600 °C 6 h in air resulted in the different products, $W_{17}O_{47}$ (monoclinic) for undoped, WO_3 orthorhombic for 2 wt% Co doped and WO_3 (monoclinic) for 5 wt % Co doped. FE-SEM micrographs suggested that the dopants are able to influence the growth rate and morphology of the prepared nanopowders. UV-VIS-DRS spectra revealed that the dopant (Co ion) is incorporated in the intermediate energy level. Blue emissions (450–550 nm) were verified using PL at room temperature for the annealed samples ($W_{17}O_{47}$ and WO_3) with excitation wavelength 390 nm. The difference in peak intensity observed through PL spectra attributed to the possible distortions in WO_4^{2-} tetrahedron group during microwave irradiation process. Electrochemical studies showed the possible enhanced catalytic behaviour of cobalt doped (5 wt%) as prepared samples than that of others. The temperature dependent magnetic susceptibility (300 K–2 K) and isothermal magnetization measurements showed the enhancement in magnetic behaviour of the samples for diamagnetic to antiferromagnetic nature which is clearly shows the incorporation of Cobalt ion at tungsten lattice site and in determining the resultant magnetic behaviour of the samples.

1. Introduction

Nanosized materials have attracted great attention as a result of exhibiting unique surface to volume ratio. In particular, high surface area materials have been of great interest in a wide range of applications such as catalysis, chemical and biosensors, fuel cell electrodes and so on [1]. As a well known inorganic oxide, WO_3 is a promising candidate for many applications such as electrochromic [2], photocatalytic [3], photoluminescent [4] and as a gas sensor device [5] due to their existence of various structural polymorphs and easily tunable oxygen content of the end product by varying the growth atmosphere. In fact, the optical and electrical properties of this compound strongly depend on size and morphology of the corresponding end product. Accordingly, the recent scenario for many practical applications is mainly based on morphology and size distribution of the nanoparticles. This can be done by varying the synthesis procedure and growth atmosphere which influence the morphology and size distribution of the nanoparticles.

On the other hand, dopants have offered relatively better morphology and high surface to volume ratio of the nanoscale materials. To date, the following methods have been adopted to synthesis pure and doped WO_3 in the form of powders; vapour deposition [6], hydrothermal route [7], sol-gel [8], acidification method [9], electro spinning method [10], electro deposition method [11] etc. However, the above mentioned techniques are more time consuming and cost effective. Great efforts are being

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