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Temperature dependent growth of cadmium(II) oxide nanocrystals: studies on morphology based optical, electrical and dielectric properties

Shyamapada Shit[1] · **Animesh Layek**[2]

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Abstract Nanocrystalline cadmium(II) oxide were obtained by calcining a hydrated cadmium-organic hybrid precursor, $(C_{10}H_2O_8)Cd_2{\cdot}xH_2O$, obtained by a chemical reduction method using cadmium acetate dihydrate, 1,2,4,5-benzenetetracarboxylic acid, and triethylamine. Calcined CdO at different temperature possess different morphology, revealed by field emission scanning electron microscope analysis. In this article, the photosensitivity, dielectric behavior, frequency dependant loss-tangent and complex impedance spectra of the morphology driven CdO nanoparticles were studied aptly.

1 Introduction

Nanocrystalline materials have paid special attention in the recent years for their inimitable and remarkable physical and chemical properties in comparison to their bulk properties or single atom [1, 2]. Nanocrystalline cadmium oxide (CdO) is a well-known n-type semiconductor metal oxide having a rock-salt crystal structure (FCC) with direct and indirect band gap within the range of 2.2–2.7 and 1.36–1.98 eV [3, 4], respectively. However, variations in the magnitude of these band gaps were reported in the literature due to the variations of the experimental conditions [5]. Nano-dimensional CdO bearing different morphologies such as nanoparticles, nanowires [6], nanoneedles, nanotubes [7], nanorods [8] etc. were reported in the literature. Due to its high band gap and large linear refractive index ($n_o = 2.49$) it finds wide range of applications in solar cells, gas sensors, transparent electrodes and photodiodes, photocatalysts, optoelectronic devices [9–12], chemical sensors and liquid crystal display [13, 14], and many more. Numbers of methods including sonochemical, micro-emulsion, hydrothermal/solvothermal methods and mechanochemical processes [15–21] have been employed to get such fascinating CdO nano-structures. However, controlled growth of spherical CdO nanoparticles is still a challenging task. There are few reports on growing spherical CdO in the literature. Solvothermal method [4, 22] is cost effective and usually used in growing CdO nanoparticles. Sonochemical method using cadmium-organic precursors was also explored for growing spherical CdO nanoparticles [23, 24]. However, wet chemical reduction of cadmium-organic precursor for growing CdO nanoparticles was not well-explored [25–27]. Herein, we have successfully employed a chemical reduction method [28] of growing nano-crystalline CdO for the first time, using cadmium(II)-1,2,4,5-benzenetetracraboxylate hydrate precursor $[(C_{10}H_2O_8)Cd_2{\cdot}xH_2O]$, obtained by the reaction of cadmium acetate dihydrate, 1,2,4,5-benzenetetracarboxylic acid, and triethylamine. The method is very simple, cost effective and does not require any special apparatus or techniques usually adopted in other methods of the synthesis of CdO nanoparticles. This method explores triethylamine ($(C_2H_5)_3N$), an unconventional base instead of conventional hydroxide bases. The base is mild compared to hydroxide and generates hydroxide ions through hydrolysis in water. Thus modulate the concentration of OH^- in the medium and avoid the precipitation of $Cd(OH)_2$. Its volatility also suggests that a little bit excess will not affect the overall

✉ Animesh Layek
layekanimesh@gmail.com

[1] Department of Chemistry, Jalpaiguri Government Engineering College, Jalpaiguri 735102, West Bengal, India

[2] Department of Physics, Bejoy Narayan Mahavidyalaya, Itachuna, Hooghly 712147, West Bengal, India

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