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Simplistic surface active agents mediated morphological tweaking of CdS thin films for photoelectrochemical solar cell performance

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ABSTRACT

This study reports on the formation of cadmium sulfide (CdS) nanostructures with controlled morphology synthesized via a simple chemical route in surface active agent environment. The effect of organic surface active agents (surfactants) as sodium dodecyl sulfate (SDS), polyethylene glycol (PEG) and cetyltrimethylammonium bromide (CTAB) on structural, morphological, optical and photoelectrochemical properties of CdS thin films have been studied. Our results reveal that the organic surfactants play key roles in tweaking the surface morphology. A compact spongy ball like morphology was observed for the CdS samples grown without organic surfactants. The cauliflower's with nanopetals from the CTAB, whereas crowded star fish like morphology is observed in PEG-mediated growth. Water hyacinth like morphology is tweaked using SDS. Considering the importance of these nanostructures, the growth mechanism has been discussed in details. Additionally, the samples are photoelectrochemically (PEC) active and having a compact surface with a nanoporous structure twig helps in improved photoelectrochemical performance compared to that of CdS deposits from surfactant free solution. This is a simplistic way to tune the morphology using surfactants, which can be applied to other energy conversion applications.

1. Introduction

In recent years, great attention has been focused on the synthesis of complex micro/nanostructures, especially to three-dimensional (3D) hierarchical architectures that are assembled using 1D and 2D nanoscale structure slabs. To date, a wide assortment of functional materials with a hierarchical system can provide more opportunities for exploring novel properties and superior device performances, due to their higher specific area and peculiar characteristics than bulk structures. To organize the hierarchical architectures, various paths have been used successfully to assemble the structure slabs into 3D ordered superstructures. The solution-phase chemical method is one of the most auspicious paths due to its low cost, environmentally friendly, trivial condition, and the potential advantages for large-scale production. A variety of semiconductor nanomaterials especially metal chalcogenides with hierarchical structures have been successfully prepared using the chemical route in the past few years, such as PbS, CdS, ZnS, CdSe, CdTe, etc. [1–6].

Metal chalcogenides became an established versatile platform for multiple functional applications, including solar cell, photocatalysis, chemical sensing, thermo-electricity, etc. [7–13]. Among the metal chalcogenide compounds belonging to the II–VI family; cadmium sulfide (CdS) has received much attention due to the fact that it has a visible band gap of 2.42 eV at room temperature, and it exhibits excellent properties for various optoelectronic applications within the visible range of the solar spectrum [14,15]. It is well known that excellent properties of materials are clearly dependent on the morphology and structure. Because of these valuable properties, CdS were synthesized into diverse morphologies, including, spongy ball, nanorods, nanospheres, nanowires, nanotubes, nanobelts and nanoshuttles, etc. [3,16–20]. Several surface active agents/surfactants have been used to facilitate the self-

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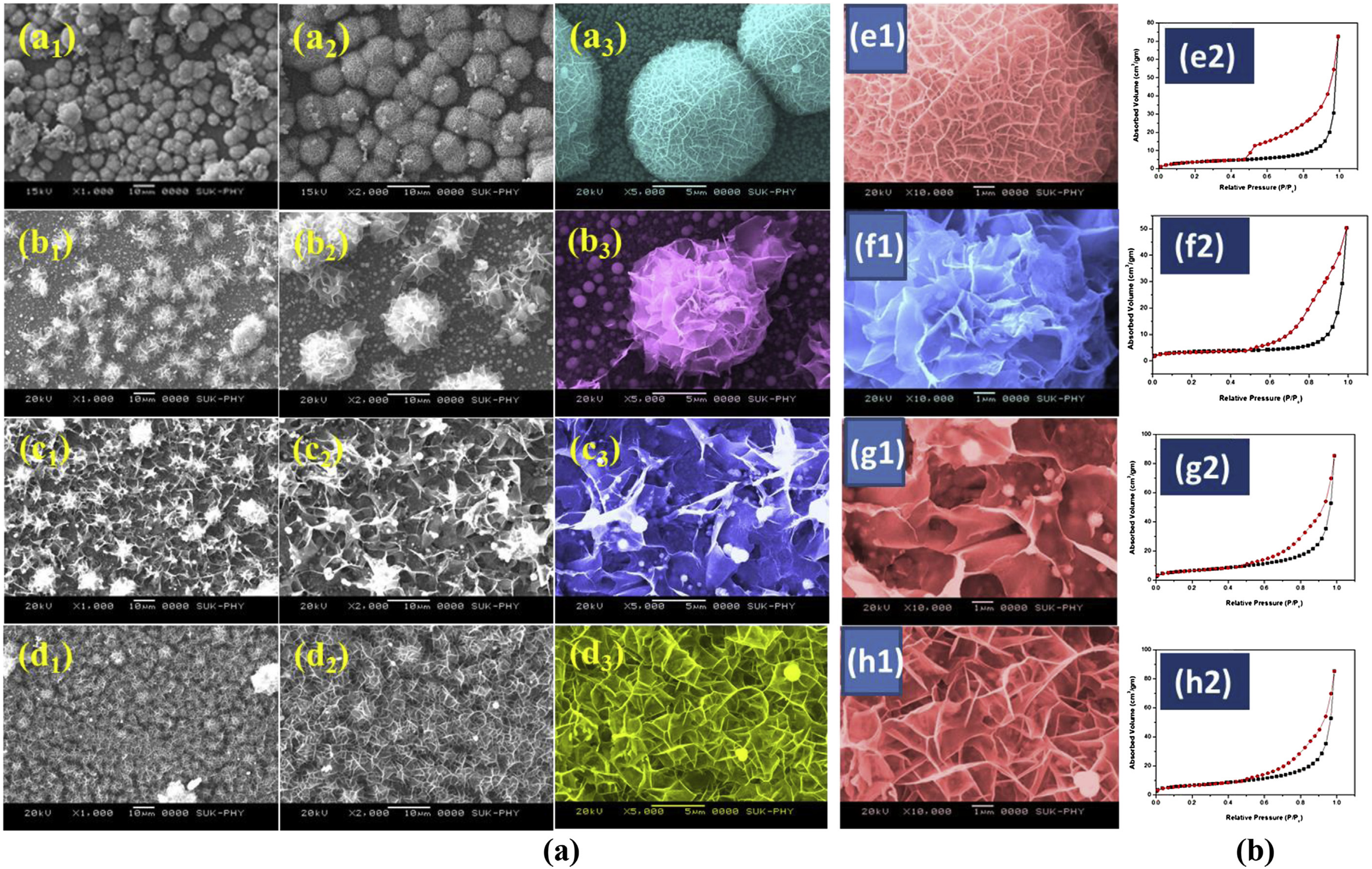

Fig. 1. a) Low-magnification SEM images of the CdS nanostructures synthesized with and without surface active agents (a_1, a_2 and a_3) CdS:bare, (b_1, b_2 and b_3) CdS:CTAB, (c_1, c_2 and c_3) CdS:PEG and (d_1, d_2 and d_3) CdS:SDS. b) high-magnification SEM images and the Nitrogen adsorption–desorption isotherms of the CdS nanostructures synthesized with and without surface active agents- (e1 and e2) CdS:Bare, (f1 and f2) CdS:CTAB, (g1 and g2) VdS:PEG and (h1 and h2) CdS:SDS.