Micro-scale Self-assembly of Long-range Ordered CuS Nanostructures

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Copper sulfide (CuS) due to its unique optical, electrical, and other physical and chemical properties, has been extensively studied in the areas of lithium batteries¹,² and solar cell²,³,⁴,⁵ sensing, photothermal therapy, imaging, supercapacitance, drug delivery, cathode materials, nonlinear optical materials, and catalysis. Currently, varies of 3-D CuS have been successfully synthesized by hydrothermal and solvothermal methods. In these studies, the controlled synthesis of CuS caved superstructures are very interesting due to its highly geometrical shape.⁵ However, long-range ordered structure of CuS has not been reported. In this study, a very simple, template-assistant solvothermal method was developed to synthesize micro-scale long-term orderly arrangement structure of CuS. This structure is self-assembled by a large number of hexagonal CuS nanoplates.

The synthesis of CuS was performed according to the following procedures: 0.4 mmol CuCl₂ was firstly dissolved in 50 mL deionized water with vigorous agitation to form a light green solution. Then, 1.2 g Polyvinylpyrrolidone (PVP) was added to the solution under magnetic stirring. 0.4 mmol thiourea was then added after all the substance was dissolved completely. The mixture was transferred into a 100 mL Teflon-lined stainless steel autoclave and heated at 100 °C for 15 h. After cooling to room temperature naturally, the product was collected by centrifugation, washed with deionized water and ethanol, and then dried in a vacuum oven at 60 °C for 10 h.

The structure and morphologies of the as-prepared CuS were recorded on a Hitachi S-4800 scanning electron microscope (SEM). XRD (X-ray powder diffraction) pattern was operated on a Japan RigakuD/Maxr-A X-ray diffractometer equipped with graphite monochromatized high-intensity Cu Kα radiation (λ= 1.54178 Å).

Fig. 1a displays typical SEM images of the as prepared hierarchical structure of CuS. X-ray diffraction was employed to understand the identity and phase purity of as-resulting products. As depicted in Fig. 1b, the entire diffraction pattern matches well with the standard data of covellite-type CuS with hexagonal lattice parameters of a = 3.7920 Å, b = 3.7920 Å and c = 16.3440 Å (covellite, syn, JCPDS no. 06-0464).

Further detailed investigations of crystallographic features of as prepared CuS sample were performed by SAED and DF-TEM, as shown in Fig. 2. It indicates that the CuS hierarchical structure composed by two different crystallographic oriented CuS nanocrystals. [5]

References:

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Figure 1. a) SEM image of the CuS sample, b) XRD pattern of the CuS sample, corresponding to JCPDS 06-0464.

Figure 2. (a) SAED pattern of a single hierarchical structure CuS; (b), (c) and (d) are dark-field TEM images, corresponding to spot 2, spot 1 and spot 3 respectively.