DAE-BRNS 6th Interdisciplinary Symposium on Materials Chemistry, December 6-10, 2016, Mumbai, India

Ionic Liquid Based Synthesis of Indium Sulphide Nanoparticles and their Photocatalytic Application

Rahul Kumar Sharma, Yogendra Nath Chouryal and Pushpal Ghosh*
Department of Chemistry, School of Chemical Science and Technology, Dr. Harisingh Gour University (A Central University) Sagar, 470003, M.P., India
pushpalghosh27@gmail.com.,9407265512, kumarrahulsharma592@gmail.com

Abstract

Herein, indium sulphide nanoparticles are synthesized using the ionic liquid based solvothermal method without using any further templating agent or surfactant. The ionic liquid and synthesis temperature has a crucial role on crystal phase tuning (i.e. from cubic to tetragonal). The nanoparticles are characterized by PXRD, SEM, TEM, BET Surface area analyzer and UV-vis spectrophotometer. The obtained nanoparticles have band gap ranging within 2.12-2.34 eV indicating their potential applications in photocatalysis and solar cell.

Owing to their size dependent tunable band gap, semiconductor nanomaterials have been attracting tremendous attention due to their potential applications in optoelectronic, magnetic, quantum dots, photocatalyst, solar cells, photovoltaic etc. [1-2]. Engineering of band gap can be possible by judicious designing of synthesis procedure. Some semiconductors which contains Cd, Hg, As have less band gap but are substantially toxic than the other contemporary chalcogenide semiconductors such as ZnS, ZnSe, $CuInS_2$, ZnO and In_2O_3 etc. But the major concern with them is having a high band gap that limits their application for example in case of solar cell etc. In this regard, indium sulphide which is non toxic and have band gap in the range of 2.0-2.3 eV can play a pivotal role in different applications.

On the other hand, "green synthesis" to prepare efficient nanomaterials is need of the hour. In this context, ionic liquids which are often described as "green" and "designer solvents" can play a pivotal role in materials synthesis.[3] As ILs are composed of distinct cations and anions, they are used as a widely tunable class of compounds with interesting properties. Useful properties like negligible vapor pressure, wide liquidus range, good thermal stabilities, considerable electrical conductivities and wide electrochemical window make them suitable for use in organic catalysis, electrochemistry, f-element separation and many other applications. Despite their versatility, their use in inorganic materials synthesis has just begun but holds great promises.[3]

Herein we have synthesized the indium sulphide nanoparticles solvothermally at 120°C, 150°C and 180°C, by using 1-ethyl-3-methyl imidazolium bromide ($[C_2mim]Br$) as templating agent. Keeping the other reaction parameters same, only reaction temperature is judiciously tuned. Indium chloride and thioacetamide are used as source for indium (In^{3+}) and sulphur respectively. It is seen that the rate of release of sulphur from thioacetamide is faster than the thiourea after thermal decomposition and sometimes thioacetamide releases sulphur even at ambient temperature which leads to high nucleation rate and smaller sized nanoparticles. Hence thioacetamide is used in present case for sulphur source.

It is observed from figure 1 that at reaction temperature 120°C, a cubic modification (JCPDS file -32-456) of In_2S_3 appears. The crystallite size is calculated using Debye Scherrer equation and it is 7.89 nm. There are three polymorphic forms of α-In_2S_3 (cubic, defective structure), β- In_2S_3 (defective spinel structure), γ- In_2S_3 (hexagonal layered structure) are present. β- In_2S_3 is n-type of semiconductor having band gap 2.0-2.3 eV. This cubic β-In_2S_3 presents for 150°C reaction temperature though crystallite size

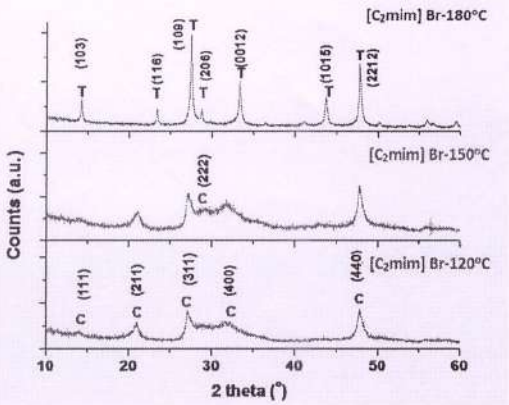

Figure 1-This PXRD pattern shows the as prepared indium sulphide using [C₂mim]Br IL, at different temperature (a) 120°C b) 150°C c) 180°C.

Pushpal Ghosh
15-07-2019