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Preparation and Properties of New Hybrid Material: $[CdCl_4]^{2-}[C_8H_9NO]^{2+}$

Research Article

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Abstract. An inorganic-organic hybrid material composed of tetrachlorocadmate as inorganic component and acetanilide as an organic moiety has been prepared by using solution growth through slow cooling process. The prepared material has been characterized by powder XRD peak profile pattern which results the existence of the material in monoclinic space group $P2_1/c$ with cell dimensions of $a = 7.571(2)$ Å, $b = 24.959(5)$ Å, $c = 19.666(4)$ Å, $\alpha = \gamma = 90°$, $\beta = 90.017(2)^o$. The surface functionalities were analyzed by FESEM image analysis which depicts the average particle size of 6.731 μm. The spatial agglomeration was observed through TEM image which predict that such materials has applications in energy storage devices.

Keywords. FESEM; Hybrids; Spatial agglomeration; TEM; XRD

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1. Introduction

The organic and inorganic derivatives had numerous applications as independent moieties but their composites had produced wonderful results. The new branch of solid-state materials came into existence as inorganic-organic hybrids or IO-functional materials. The properties of hybrids are quite enhanced as compared to the pure moieties and their application has revolutioned the modern materials science [1]. Looking upon the demand of energy storage devices in today's tech-savy world, the inorganic organic materials are fulfilling the requisite needs. The structural property analysis of inorganic-organic hybrids shows that the inorganic and organic components held together through non-covalent interactions [2]. Different type of such interactions such as hydrogen bonding, C–H... π, $\pi \ldots \pi$, metal... metal, halogen... halogen, etc. plays an important role in holding the inorganic and organic moieties into single hybrid composite [3]. The surface studies of hybrids presents that these materials have particle size ranging from μm to nm scale. The inorganic-organic hybrid materials have wide range of applications in super hydrophobic coatings, dental filling products, electric insulators, hybrid solar cell or fuel cells, biosensors, decorative coatings, automotive parts, etc. [4]. Since the organic components have conducting properties whereas the inorganics have photo-electro active characteristics and the combinations of such functional hybrid materials provide a wealth of opportunities for the development of smart materials with improved photovoltic properties. The hybrids have improved electro activity for energy storage applications as studied through the photo-electrochemical processes [5–7].

2. Experimental Preparation

The hybrid material of *acetanilide tetrachlorocadmate* (II) has been prepared by *solution growth* (SG) through instant heating and *slows cooling* (SC) method [8]. The inorganic component of $CdCl_2$ [0.105g] added with the organic compound of C_8H_9NO [1.5g] and 5 ml of HCl added into the mixture of inorganic and organic compounds. The solution is allowed to be heated up in the oil bath in the step up heating upto 100 °C in 24 hours to achieve the complete dissolution. The programmable apparatus has been fixed with step down cooling of the solution for 52 hours which results the preparation of hybrid material. The hybrid compound dried to get solidified and the powder XRD technique was used to characterize the structural pattern of the hybrid material. The surface functionality of the hybrid material was analyzed by FESEM and TEM image capturing devices.

3. Results and Discussion

The 3D X-ray diffraction data of the powder materials has been used to determine the peak profile which indicates that the prepared material is crystalline in nature. The peak profile analysis presents that the highest peak is obtained at 2θ of 18.215^o with intensity values of 5814.8.

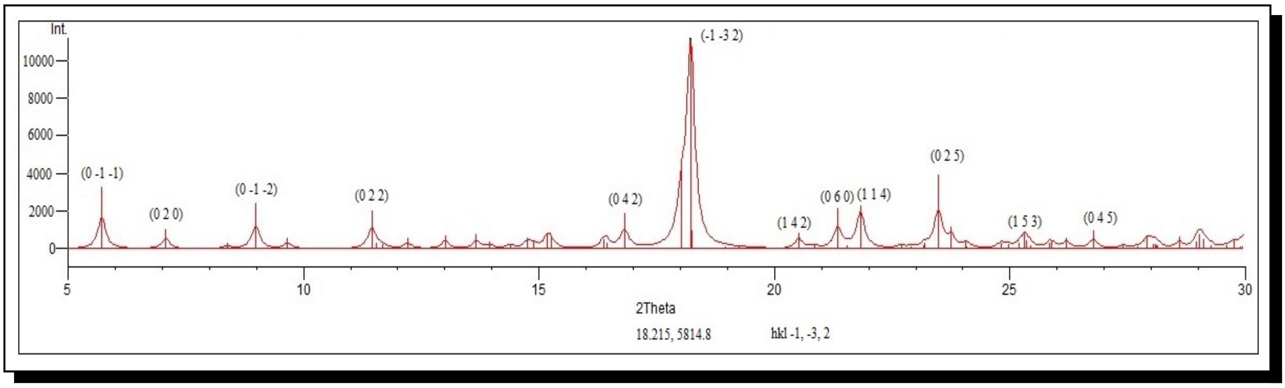

Figure 1. Powder XRD pattern with peak profile of $[CdCl_4]^{2-}$ $[C_8H_9NO]^{2+}$

The structural analysis of the XRD data results that the hybrid material exist in monoclinic space group $P2_1/c$ with lattice parameters; $a = 7.571(2)$ Å, $b = 24.959(5)$ Å, $c = 19.666(4)$ Å, $\alpha = 90°$, $\beta = 90.017°$, $\gamma = 90°$; unit cell volume $= 3716.6$ Å^3. The 3D powder XRD data shows that organic and inorganic moieties are crystallized together to form the hybrid material and these results are analogous with literature [9]. The Field Emission Scanning Electron Microscopic image analysis is used to analyze the morphological advanced features of inorganic organic hybrid material. FESEM image is shown in Figure 2 and as per the image analysis a needle shaped hybrid composites were observed rather than a rough or amorphous. The shape descriptor of the material indicates that the average particle size of 6.731 μm with circularity of 0.682. The solidity of the material is 78% was calculated by using IMAGEJ program [9].

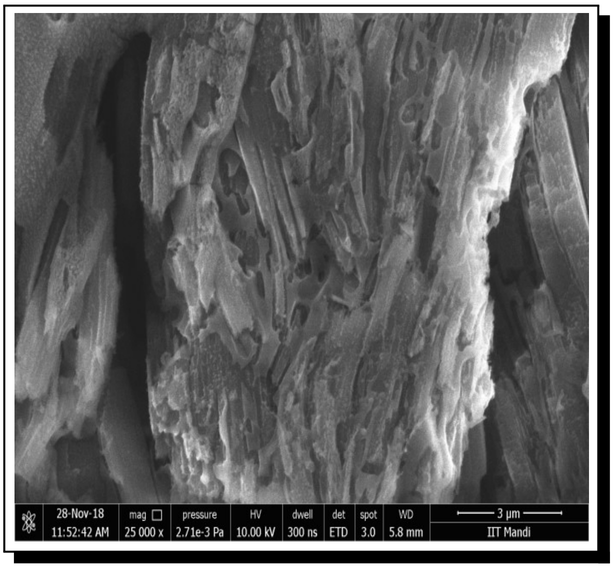

Figure 2. Surface analysis by FESEM image of acetanilide tetrachlorocadmate (II)

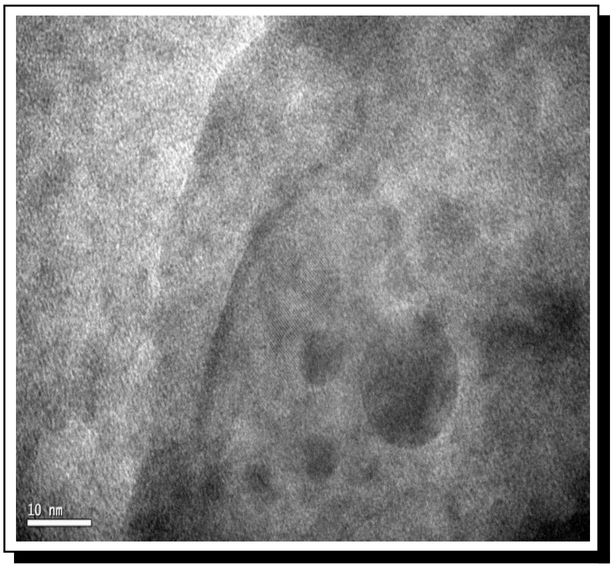

Figure 3. TEM image of the hybrid material with view field of 10 nm

Transmission Electron Microscopic image is shown in Figure 3 which presents the spatial agglomeration of the particles at the surface of hybrid material. The image depicts that the particles are narrowly distributed and agglomerated to some extent. The structural studies reviels that such materials can be used in energy storage devices [10, 11].

4. Conclusion

A composite material of tetrachlorocadmate and acetanilide has been prepared by solution growth through instant heating and slow cooling process. The powder XRD analysis concludes that the hybrid material exist in $P2_1/c$ space group at symmetry position –x, 0.5+y, 0.5-z with lattice parameters of $a = 7.571(2)$ Å, $b = 24.959(5)$ Å, $c = 19.666(4)$ Å, $\alpha = \gamma = 90°$, $\beta = 90.017^o$ and unit cell volume $= 3716.6$ Å^3. The surface functionality of the hybrid composite concludes that the material has particle size of 6.731 μm with solidity of 78%. The spatial agglomeration of the particle at the surface depicts that the particles are narrowly distributed with circularity of 0.682.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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