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Preparation and characterization of hydroquinone aggregate-TiO_2 composite produced by copper(ii) catalyzed reaction, a promising material for application in solar cell

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Abstract:
Preparation and characterization of Hydroquinone aggregate-TiO2 composite material through a copper (II) catalyzed reaction have been presented with discussion on the probable scope of utility of such materials in the fields like electronic, optoelectronic, LED, Plastic laser as well as for solar cell application. Methodology reported in literature for preparation of hydroquinone aggregate was used with minor modification. The products are soluble in organic solvents like ethanol indicating well inclusion of TiO2 particles within the matrix of hydroquinone aggregate. Characterization of the composite materials is performed using spectroscopic techniques such as IR spectroscopy and UV-Vis spectroscopy which supports the formation of the composite material. Thermal stability of the products was ascertained by using Differential Scanning Calorimetry (DSC). Product shows appreciable thermal stability. Since hydroquinone aggregate has already been reported as promising to have thermoelectric switching behavior therefore the composite material is likely to have potential utility in the fields like electronics, opto-electronics as well as for solar cell application.

Keywords: *Composite material, Hydroquinone aggregate, Nanostructured TiO_2, Solar cell*

Introduction

Development of advanced 'smart materials' for applications towards electronic, opto-electronic, solar cells etc. is an interesting research objective and significant progress has been attained in this field[Yuan, Y. & Kruger, M. (2012)]. The application prospect of such materials has greatly been increased by the introduction of the concept of obtaining hybrid materials from organic and inorganic compounds. Such type materials are being used to develop solar cells [Zeng, T. W. et. al.(2009)], for sensor application [Sanchez, C. et. al. (2005)], to design advanced dielectric materials [Zhang, Y. –H et. al. (2005)]and so on. Advantage of using hybrid materials containing inorganic semiconductors and organic polymers is that inorganic semiconductors often possess excellent, well established electronic properties and they are very well suited as solar cell materials. For self-assembled organic-inorganic hybrid materials, self-assembled nanostructured organic system can control the subsequent synthesis or behavior of inorganic component. Hydroquinone aggregate which is known to possess interesting thermoelectric switching behavior [Puzari, A. et. al. (2000)], can be considered to be promising for developing such type of hybrid materials. TiO_2 exists naturally as n-type semiconductor. TiO_2 layers with high refractive index and high photocatalytic activity are suitable for electronic application and for production of architectural windows, working electrode in electrochromic device, in semiconductor devices, solar cell applications etc. Therefore the materials described herein can be considered as promising material for electronic applications including solar cell.

Experimental

Synthesis of composite materials were performed by dissolving 6.0 mmol of hydroquinone in 2.0 ml of 2.0 M HCl at room temperature followed by 0.1 mmol of cis-bis-glycinato Copper (II) monohydrate. Strength of the acid was varied for other members of this series and the range of acid strength employed was from 0.1 M to 2.0 M.3.0 mmol of TiO_2 was added to the solution followed by addition of 1.0ml of 30% Hydrogen peroxide. An exothermic reaction takes place to produce a brown coloured solution and the colour intensified with time to produce finally ablack coloured crystalline material. Yield of products obtained was estimated as 70 %. The material obtained was washed with 3x10.0ml of petroleum spirit and dried under vacuum.

IR spectra of the products were recorded on a Shimadzu Prestidge-21 FT-IR and UV-Visible spectra were recorded on a Shimadzu UV-Visible spectrometer (UV-1601). Differential scanning Calorimetry(DSC) for the sample was recorded on Shimadzu Differential scanning calorimeter (DSC-60).

Results And Discussion

Formation of Hydroquinone aggregate at room temperature,using hydrogen peroxide as the reactant along with catalytic amount of cis-bis-glycinato copper(II) monohydrate, has already been reported in literature [Puzari, A. et. al. (2000)]. Reported aggregate was demonstrated to be promising for using as thermoelectric switch. For the reported aggregate, the IR spectra show a broad sharp signal at 3297cm^{-1} due to O-H stretching. The characteristic frequency of p-substituted aromatic ring for the compound was observed at 1593cm^{-1}& 1357cm^{-1} while the C=C frequency appeared at 1618 cm^{-1}. Incorporation of TiO_2 into the aggregate matrix causes a marked change in the IR spectra. For the hybrid composites in all cases a broad sharp absorption was observed at around 2983 cm^{-1} to 2986cm^{-1} which can be attributed to enolic O-H stretch. Characteristic signal for aromatic C-H stretching was observed at around 3192 cm^{-1}. Similarly characteristic absorption for p-substituted aromatic ring was observed at around 1362^{-1}to 1365cm^{-1}.

UV-Visible study of the compound also reveals the incorporation of TiO_2 into the matrix of the hydroquinone aggregate and an absorption peak was observed around 295 nm. UV-Visible spectra recorded for the composite material synthesized is shown in figure-1. Thermal study carried out on the composite materials indicated appreciable stability of the material up to 200^{0}C.

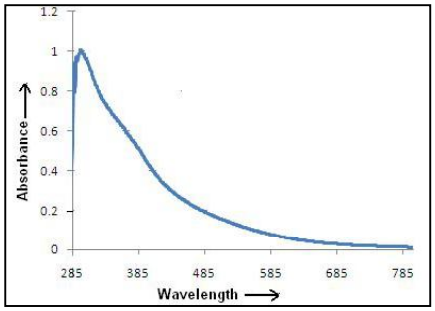

Figure-1:UV-Visible spectra of a composite material

Differential Scanning Calorimetry obtained for the composite is shown in figure-2 below. The DSC curve ensures significant improvement of thermal stability due to the presence of TiO_2 molecules in the matrix. The initial small spike observed at around 79^0C can be attributed to trace amount of Hydroquinone impurity in the composite material.

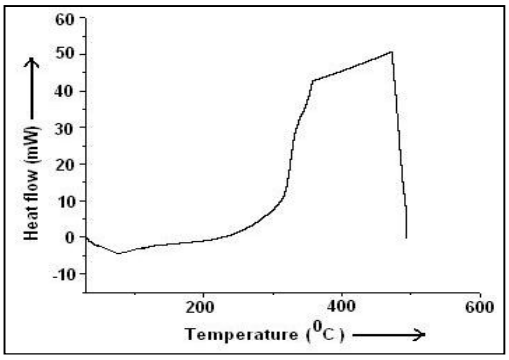

Figure 2: DSC trace of the composite material (heating rate of 5^0C / min.)

Keeping in view the application prospect of reported hydroquinone aggregate, it can be concluded that the composite material synthesized can be a potential precursor material for application in electronics, especially for application in solar cells.

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