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Synthesizing Nano Phosphors With Varying Concentration Of Capping Agent

Sarita Kumari Satapathy Research Scholar, Department of Physics, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P, India.

Dr. Sanjay Rathore Research Supervisor, Department of Physics, Sri Satya Sai University of Technology & Medical Sciences, Sehore, M.P, India.

ABSTRACT

Nanophosphors, also known as nanoparticles with unique optical properties, have garnered significant attention in various fields due to their potential applications in optoelectronics, biomedical imaging, and solid-state lighting. The capping agent serves as a crucial component in controlling the size, stability, and luminescence efficiency of the nanophosphors. Optical absorption studies show that, as capping agent concentration is increased, the absorption edge shifts toward the blue region, indicating that the effective band gap energy increases with decreasing particle size, while no variation in the absorption spectra was observed with the change in doping concentration. X-ray diffraction was used to study the nano phosphors that were extracted. Particle size was observed to decrease with increasing capping agent content.

Keywords: Nanophosphors, Capping agent, Particle, Luminescence, Concentration.

I. INTRODUCTION

Nanophosphors, with their unique optical properties and diverse applications, have emerged as a promising class of materials in recent years. These nanoscale phosphor materials exhibit enhanced luminescent properties compared to their bulk counterparts, making them highly attractive for various fields such as optoelectronics, solid-state lighting, and biomedical imaging. The controlled synthesis of nanophosphors with tailored properties is essential for their successful integration into these applications.

The synthesis of nanophosphors involves a complex interplay of various parameters, including the choice of precursor materials, reaction conditions, and surface modifiers or capping agents. Among these parameters, the concentration of the capping agent has been identified as a critical factor that can significantly influence the synthesis process and the resulting properties of the nanophosphors.

Capping agents, also known as surface modifiers or stabilizers, are organic or inorganic molecules that interact with the surface of nanoparticles during their formation. These agents play a vital role in controlling the growth, size, shape, and surface chemistry of the nanoparticles. By adsorbing onto the nanoparticle surfaces, capping agents can effectively control the nucleation and growth processes, preventing particle aggregation and controlling the final properties of the nanophosphors.

The concentration of the capping agent used in the synthesis process has been shown to have a profound impact on the size, morphology, crystallinity, and luminescent properties of the resulting nanophosphors. Varying the concentration of the capping agent allows for precise control over the growth kinetics and surface interactions, leading to tunable properties of the nanophosphors. By systematically adjusting the concentration of the capping agent, it becomes possible to tailor the properties of the nanophosphors to meet specific requirements for different applications. By exploring the relationship between the capping agent concentration and the resulting properties of the nanophosphors, valuable insights can be gained into the optimization of this critical parameter for the controlled synthesis of nanophosphors with desired properties.

The following materials and methods are typically employed in the synthesis process:

- **Phosphor precursor:** A suitable phosphor precursor material is selected based on the desired luminescent properties of the nano phosphors. Common examples include rare-earth-doped phosphors, semiconductor quantum dots, and organic dyes.

- **Solvents:** High-purity organic solvents are used to dissolve the phosphor precursor and facilitate the reaction process.

- **Capping agent:** A capping agent or surface modifier is chosen to control the growth and surface properties of the nanoparticles. Common capping agents include surfactants, ligands, polymers, or inorganic compounds.

II. CAPPING AGENTS AND THEIR ROLE

The choice of capping agent is critical in the synthesis of nano phosphors, as it influences the size, shape, surface properties, and luminescent characteristics of the nanoparticles. The capping agent interacts with the growing nanoparticles, controlling their growth kinetics and surface chemistry. The key roles of the capping agent include:

- **Stabilization:** The capping agent forms a protective layer around the nanoparticles, preventing their agglomeration and maintaining a stable colloidal suspension.

- **Size control:** The concentration of the capping agent can influence the nucleation and growth rates of the nanoparticles, thereby affecting their final size and size distribution.

- **Surface passivation:** The capping agent can passivate the surface defects of the nanoparticles, reducing non-radiative recombination and enhancing their luminescence efficiency.

- **Surface functionalization:** Certain capping agents can introduce functional groups or surface ligands onto the nanoparticles, allowing for subsequent modifications or specific interactions with target molecules or substrates.

Different capping agents, such as surfactants, ligands, polymers, or inorganic compounds, have distinct properties and interactions with nanoparticles. The choice of capping agent depends on the specific requirements of the desired nano phosphors and the compatibility with the chosen phosphor precursor material.

III. EXPERIMENTAL METHOD

There was no further purification of the reactants and solvents utilized in this investigation because they were all of analytical quality. Water was used for the synthesis because of its inherent advantages of being easy to work with and gentle on the environment. The entire synthesis was carried out in a room temperature environment.

The present study utilizes a synthetic strategy based on the chemical pathway. In order to create ZnS nano phosphors, analar grade zinc salt, sodium sulphide, and mercaptoethanol are used in a chemical precipitation process in an aqueous media. After being centrifuged at 3500 rpm to remove them from the reaction liquid, the nano phosphors are air dried. Various samples were made by adjusting the amount of capping agent used. It is crucial that the samples' physical properties remain unchanged during the synthesis process.

Researchers looked at how well different capping agent and dopant concentrations were absorbed by the samples they generated. The absorption peak of ZnS nano phosphors was measured with a Perkin Elmer λ - 12 spectrometer. The optical design of the lambda-12 UV/VIS spectrometer is entirely reflective.

X-ray diffraction examinations using CuK radiation (λ = 1.5418 Ao) determined the morphologies and sizes of the mercaptoethanol-capped ZnS: Mn. The XRD measurements were taken at room temperature, which varied from 5o to 75o. The Bruk- er D8 Advance X- Ray diffractometer was used to obtain the diffraction patterns.

IV. RESULTS AND DISCUSSIONS

In this study, we looked at the absorption spectra of ZnS nano phosphors with different amounts of capping agent, as well as doped ZnS. Capping agent concentrations of 0.005 M, 0.01 M, 0.015 M, 0.02 M, and 0.025 M were used to make the samples. The spectra (Fig. 1) show that the visible range (800 nm - 390 nm) is almost completely absorbed.

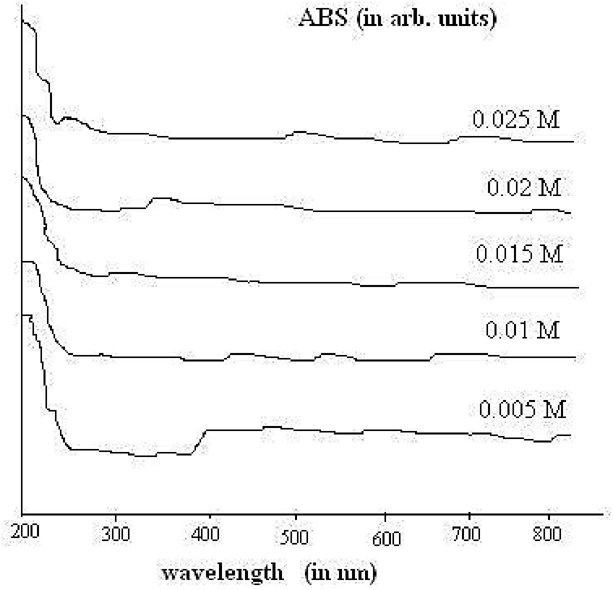

Figure 1: Absorption spectra of ZnS nano particles at various concentration of capping agent

ZnS and ZnS:Mn absorption spectra as a function of capping agent and doping concentration are shown in Figure 1.

There is an abrupt rise in visibility-range absorption. Absorption spiked suddenly at 240 nm, 235 nm, 230 nm, 225 nm, and 220 nm. As particle size decreased, a shorter wavelength was discovered to be the absorption edge.

Absorption edge calculations show that the optical band gap widens with increasing capping agent concentration. Surface states are found to not contribute to the absorption spectra because they do not undergo optical absorption.

Figure 2 shows an example of an X-ray diffractogram (XRD) for nanocrystalline ZnS that has been doped with Mn2+.The X-ray diffraction analysis shows that the crystal structure of ZnS nano phosphors is zinc- blende. There are three peaks seen for all samples, which can be attributed to diffraction in the (111), (220), and (311).

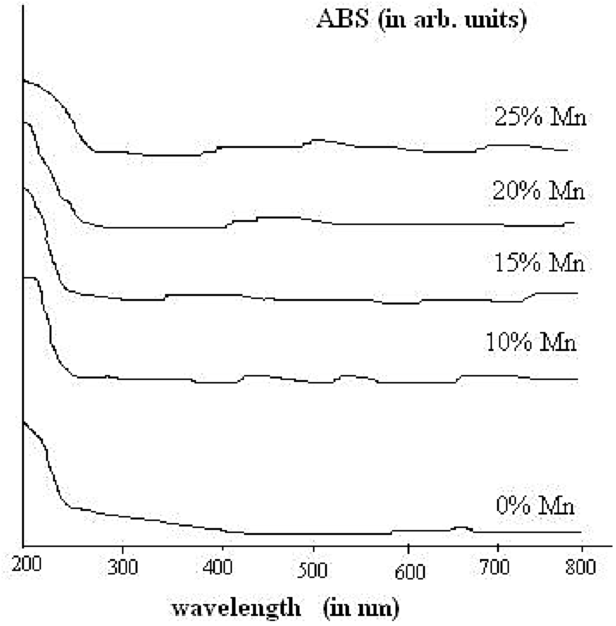

Figure 2: Absorption spectra of ZnS Mn nano particles

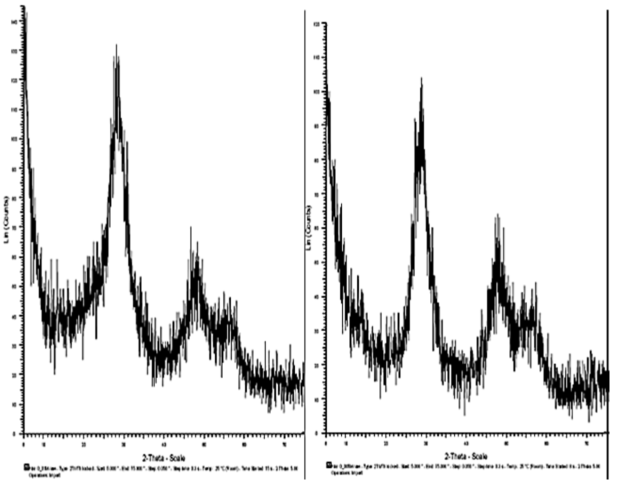

Figure 3: X-Ray Diffraction study of Mn 2+ doped ZnS na- nocrystalline

As the crystal shrinks in size, the size effect causes the XRD peaks to expand and their breadth to rise. The Debye-Scherrer formula was used to calculate the crystallite size from the widening of the first diffraction peak. It has been discovered that raising the capping agent concentration from 0.005M to 0.025M causes a precipitous drop in crystallite size, from 1.54 nm to 0.91 nm.

We can see that the addition of Mn causes a greater widening of peaks in the XRD patterns of both undoped and doped ZnS nano phosphors. A modest crys- tallite size may be inferred from the widening of peaks in Mn doped samples.

V. CONCLUSIONS

Research has shown that a capping agent may be used to control crystal development, and that tiny crystals can be created by increasing the concentration of the capping agent. The effective band gap energy rises with decreasing particle size, as shown by optical absorption experiments, which reveal that the absorption edge changes towards the blue area when the capping agent concentration is raised. The study of synthesizing nano phosphors with varying concentrations of a capping agent holds great potential for advancing the field of nanomaterials and enabling the design and optimization of nanophosphors for a wide range of applications. By understanding and controlling the capping agent concentration, researchers can harness the unique optical properties of nanophosphors and contribute to the development of innovative technologies and materials.

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