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A Review on synthesis methods for Phosphor Material

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Abstract: Many techniques have been developed in recent years to synthesize phosphor material. In the research methodology, we explain the methods that have been used for the synthesis of phosphorous materials that can be applied to the synthesis of up-converting and down-converting phosphorous materials. In this paper, we have explained various synthetic routes, such as co-precipitation method, combustion method, sol-gel method, hydrothermal method, etc., which are used for thesynthesis of phosphoric material. We explain the synthesis methods such as the amorphous metal complex method, the combustion method and the complex base precursor solution method and the hydrothermal method, since these syntheses were used for the generation of the phosphoric materials studied in this work. . Search. Inthe present study, we have chosen the “complex-based precursor solution” route; "Co- precipitation technique" and "hydrothermal method" are used for up-conversion Nano phosphor synthesis.

1. Introduction:

Rare-earth-doped materials have received significant attention due to their wide range of applications in different fields such as new lasers, light-emitting diodes, display devices, plasma panels, solar panels, for bioimaging, as a sensor, etc. [1-4]. The upconversion (UC) emission from rare-earth-doped materials generated by the excitation in near-infrared (NIR) range is often utilized to receive important information in the field of Biological Science as the biomaterials do not degrade by weak NIR radiation. The hosts such as glass, polymer, inorganic or organic phosphor, composites, etc. are generally used for doping of rare-earth ions to get the upconversion emission. The host materials and their preparation method, purity and quality play a very important role in the photoluminescence intensity luminescence. The host material may be a self-activated host or non-self-activated host. Many techniques have been developed in recent years to synthesize phosphor material.

1.1Complex based precursor solution method

In the present study, we will apply a "complex-based precursor solution method using triethanolamine (TEA) as a complex agent" for the synthesis of YVO_4:Ho^{3+}, Yb^{3+} nano phosphorus by up conversion [1]. The manufacturing process involves the evaporation of aqueous precursor solutions consisting of stoichiometric amounts of the desired metalions complexed with TEA. TEA is an effective chelating agent that has good coordinationproperties with metal ions. Stoichiometrically, one to two moles of TEA per mole of total metal ions are required to form stable complexes with metal ions. However, the TEAmust be kept in the precursor solution in an amount greater than the required stoichiometric ratio. The reason for using the complexing agent, i. e.TEA in our synthesis procedure is its ability to form bonds with metal cations through its hydroxyl groups and nitrogen atom. TEA level must be properly maintained to control particle size.

1.1.1 Advantages of Complex Based Precursor solution Method using TEA

TEA is an effective chelating agent that has good coordination properties with metal ions[2].

1. Reduce processing temperature for synthesis, multipurpose.
2. Production of slightly agglomerated high purity particles.
3. Control of chemical homogeneity and stoichiometry.
4. Verification of the morphology of the TEA.
5. Cheap and readily available raw materials.
6. TEA is insensitive to moisture.

1.1.2 Mechanism of the Complexation Reaction

During the evaporation of the precursor solution, the TEA present in the system probably led to the formation of vinyl functions, which induce polymerization. As evidenced by FTIR investigation (Fig. 2.1(b)) of the resulting precursor solution, which was heated to 200 °C before decomposition. It presented a significant peak between 2900 and 3140 cm^{-1} due to polymerization due to the formation of vinyl groups during the thermal treatment of the precursor solution. But only the TEA without heat treatment showed no peaks as shown in Fig. 1.1(a) in the frequency range of 3000-3100 cm^{-1},confirming that the polymerization took place during the heat treatment of the complexes.

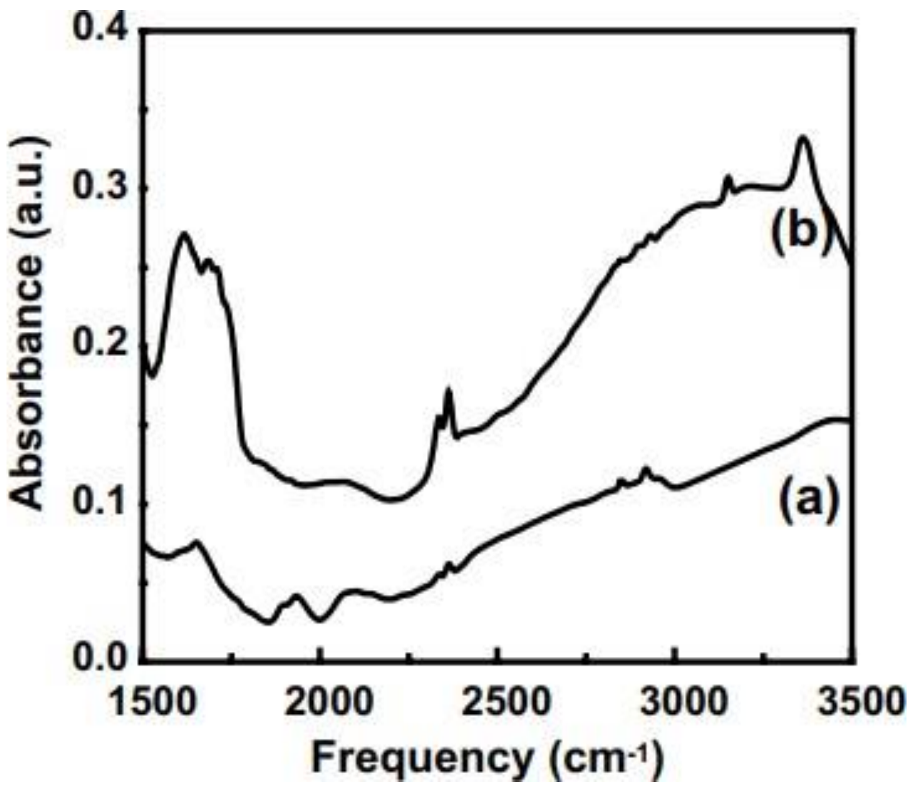

Fig. 1.1 FTIR of (a) TEA (triethanol amine) without heat treatment and (b) solution ofTEA complexed with metal ion just before decomposition.

1.1.3 Thermal Study

The DTA curves of FIG. 2 showed an exothermic thermal effect for all precursor materials with respective peaks between 380 and 500°C. The exothermic peak could be attributed to oxidation of carbon residues from decomposed metal complexes and TEA. The overall thermal effect was accompanied by the evolution of various gases (such as CO, CO_2, NH_3, water vapor, etc.), which was manifested by a single-step weight loss in the TG curves shown in Fig. 2. Above 500 ^{o}C, there was no significant thermal effect observed in theDTA curves and the corresponding TG curves did not show weight loss, which implies the complete volatilization of the carbonaceous compounds..

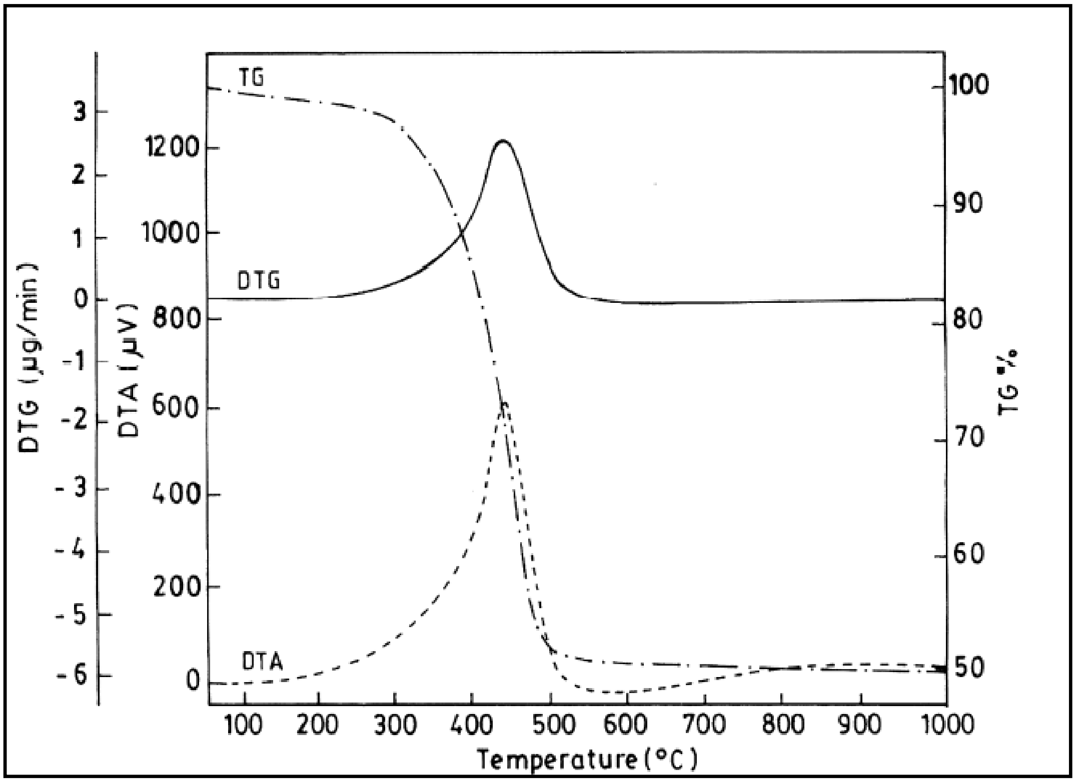

Fig. 1.2 simultaneously recorded DTA/TG of the precursor

1.2 Co-precipitation method

The required metal cations are co-precipitated in a common medium using the co- precipitation method, usually as hydroxides, carbonates, oxalates, or citrates. In fact, the precipitating reagent is added to the solution after the corresponding metal oxides or carbonates have been digested with an acid. The final product is obtained by heating the precipitate formed after drying to the required temperature. The temperatures used in the ceramic approach are generally lower than the decomposition temperatures of the precipitates. Control of stoichiometry is difficult unless all metal ions form insoluble precipitates [3].

Co-precipitation (CPT), also known as co-precipitation, occurs when a precipitate carries with it chemicals that are generally soluble under the conditions used. Similarly, in medicine, co-precipitation refers to the particular precipitation of an unbound antigen and an antigen-antibody combination. In chemical analysis, co-precipitation is a key issue thatcan be both a drawback and a useful difficulty, as unwanted impurities often co- precipitate with the analyte, leading to additional mass in gravimetric analysis, where the analyte precipitates out. and its mass is measured. and used to determine its concentration or purity. purer particles) or dissolving the sample and re-precipitating it often solves this problem; On the other hand, co-precipitation is often the only method to separate an element in trace element analysis, as is often the case in radiochemistry. The traceelement is often co-precipitated using a carrier, a substance of comparable crystal structure that may contain the target element in dilute form (sometimes less than one part per billion) be precipitated by conventional methods. For example, francium can beseparated from other radioactive elements by co-precipitating it with calcium salts such ascesium perchlorate. The use of co-precipitation in radiochemistry dates back to Otto Hahn.

1.2.1 Advantages of Co-precipitation technique

1. High performance
2. High product purity
3. No need to use organic solvents
4. Easily reproducible
5. Low cost

1.3 Hydrothermal Method

Important subfields of inorganic synthesis include hydrothermal and solvo thermal synthesis. In addition to being widely employed in the fields of waste treatment and imitating geothermal and bio-hydrothermal processes, hydrothermal and solvo thermal techniques also take on a very broad definition that spans numerous interdisciplinary scientific branches.

Hydrothermal synthesis, commonly known as the "hydrothermal process," is a special method for crystallizing compounds from hot aqueous solutions at high vapor pressures. Hydrothermal is a term with geological roots. A single crystal synthesis method that depends on the solubility of minerals in hot water under high pressure is known as hydrothermal synthesis. A device called an autoclave (see Figures 6.16 and 6.17) that contains a steel pressure vessel to which a nutrient is introduced in addition to water is used to develop crystals. There is a constant temperature difference between the growing chamber's two ends. The dissolved nutrient settles into a seed crystal at the cooler end while dissolving at the hotter end, causing the desired crystal to grow. The method is based on the observation that a lot of oxides can dissolve in an alkaline solution. The production of phosphorus has been the process's most effective application. The hydrothermal technique has the benefit of allowing for the re crystallization of the powder. It is also possible to regulate the grains' size and form. This approach takes a lot of time, though. A single crystal synthesis method that depends on the solubility of minerals in hot water under high pressure is known as hydrothermal synthesis. An autoclave, which is a steel pressure chamber where a nutrient and water are supplied, is where crystal formation occurs. The process is also exceptionally effective at producing massive, high-quality crystals while retaining strong compositional control. Theprocedure' drawbacks include the requirement for pricey autoclaves and the inability to watch the crystal grow [4].

1.3.1 Advantages of Hydrothermal Route

1. The ability to synthesize compounds of different morphology
2. The ability to synthesize large crystals of high quality

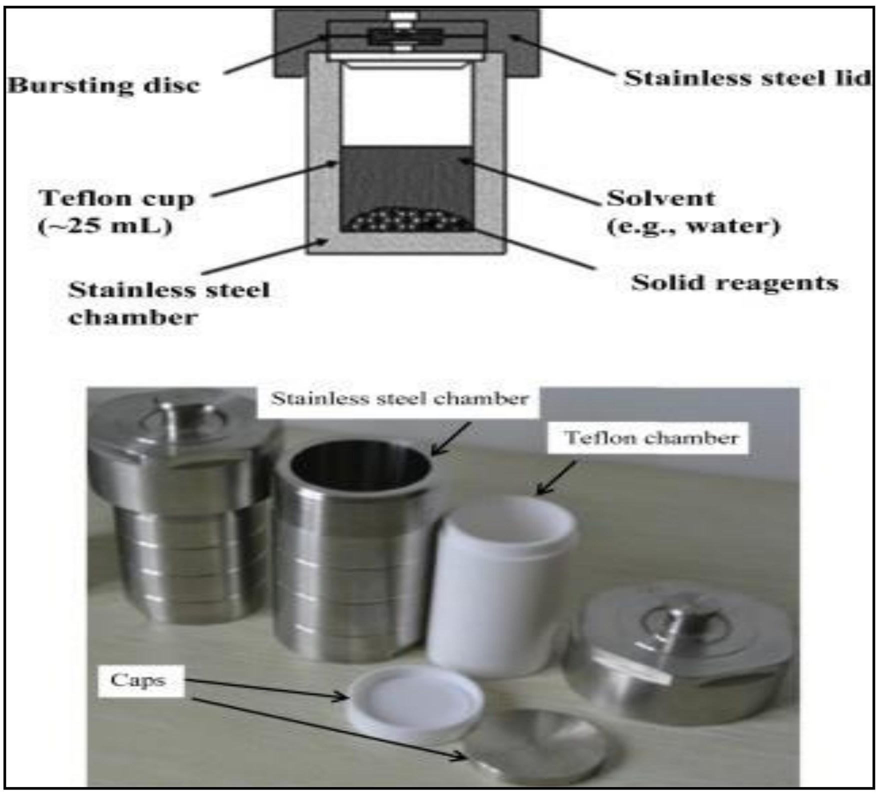

Fig. 2.3 Image of Teflon coated stainless steel autoclave

Hydrothermal autoclave reactors are those that carry out hydrothermal reaction processes but at high temperature and pressure. Two types of hydrothermal reactors have been developed, one is an autoclave with PPL tubes and the other is Teflon or PTFE. Both are coupled to each other by autoclave reactors.

Hydrothermal synthesis plays an extremely important role in the operation of autoclave reactors in order to carry out their applications in a more efficient and authentic way. Autoclaved hydrothermal reactors have become a success due to their specifications, adding value to these reactors and encouraging their use in our daily applications, promoting the prosperity of markets and industries at a higher level. The applications of this hydrothermal synthesis are numerous and validated, thus being able to increase the efficiency of hydrothermal autoclave reactors and their generalization in today's world.

The hydrothermal reaction is carried out by using the reactor in a high temperature and high pressure hydrothermal autoclave. Generally, there are two types of hydrothermal synthesis reactors; The PPL line autoclaves are the first, while the second are hydrothermal autoclave reactors lined with Teflon or polytetrafluoroethylene (PTFE). Mainly two parts make up the hydrothermal reactor; Teflon or Teflon coated innerchamber and high quality stainless steel outer shell.

1.4 References

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