A review on morphological studies of phosphors by combustion route synthesis: The role of fuels

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Abstract. There are several methods are developed for the synthesis of phosphor materials with different advantages like short reaction time and crystal lattice parameters. Solution combustion synthesis is one of the novel method for the synthesis of phosphor materials. In past few years, Solution combustion method has been used to develop novel nanostructured phosphor materials although there is special attention has been given to the morphological studies of the luminescent phosphors. Different kinds of fuels were employed for the synthesis of luminescent phosphors using fuels like triethylamine, aniline, urea, citric acid and hydrazine. This review focuses on the recent work on the phosphors prepared by solution combustion using different types of fuels.

Keywords: Combustion synthesis; phosphor; fuels; morphology; nanomaterials.

1. Introduction

Solution combustion synthesis paid its attention in the field of luminescence for their different morphological behavior depending on the fuel used in the synthesis[1–5]. Among different luminescent materials synthesized by combustion synthesis are broadly utilized in the new generation of lighting systems[6,7]. For instance the phosphors utilized in the lighting systems has specific characteristics like thermal conductivity, high resolution etc. Few outstanding investigations on the nano sized phosphors synthesized by combustion route has been studied and applied on the luminescent properties which shows its worth in applications of white light emitting diodes [8–12]. Although synthesizing nanoscale luminescent materials will improve the quality of characteristics of the white light emitting diodes. Aluminate based phosphors has been majorly investigated by the researchers for luminescent properties[13–15]. Aluminate phosphors Shows their superior characteristics among the recently investigated luminescent phosphors like high melting point, resistance properties and high strength at high temperature. Moreover it shows few more important characteristics like transparent materials, humidity sensors, solid state lightings and so on. There is several different synthesis techniques are reported for the preparation of aluminate based phosphors like sol-gel method, co-precipitation technique, wet chemical method, combustion technique, solid state diffusion method etc. Combustion synthesis is one of the most novel synthesis method among all the chemical route synthesis because of its easy preparation technique, suitable processing and time saving quality which shows unique characteristics of LEDs like color purity, high quantum efficiency. Phosphor
synthesized by combustion process acquired optimum process conditions plays a vital role in luminescence process. In this method, fuels are very determinative because they affect the particle size and the heat released during synthesis. Different types of fuels are used during combustion process like urea, citric acid, glycine, starch, hydrazine, triethylamine, aniline etc. are used during synthesis[16–22].

The subsequent features of solution combustion synthesis (SCS) promote to the sole belongings of the prepared products. Foremost, initial reaction exist in the liquid state allow mixing all the precursors and make constituent formulations and make desired composition of nanoscale. Subsequent, the high reaction temperatures (> 900 °C) make certain high product purity and crystallinity. Third one is short timing required for the synthesis of the phosphor using combustion route which helps in the growth in the particle size and promotes the synthesis of nano sized particles. All these characteristics of combustion route makes it emerging synthesis technology for the preparation of nanomaterials useful in different applications like fuel cells, biotechnology, luminescence and catalysts [23,24].

2. Different fuels
The nature of the precursors taken, fuels choosing for the synthesis to oxidizing parameters helps in make impactful structural properties in the combustion synthesis. Few researchers reported that combustion route are recognized in two categories i.e. flaming and non-flaming. Flaming reactions are recognized as emission of gaseous like NO, NO₂, NH₃, CO, CO₂ etc.

Among the all popular fuels glycine and urea are the most popular fuels for the synthesis of luminescent materials. Different fuels were utilized like citric acid, glycine, monoethiloamine, succinic acid and alanine etc. as an alternative[25]. Although the mixing of different kinds of fuels were employed for the synthesis of nanosized particles.

Synthesis of TiO₂ nanoparticles by solution combustion synthesis by using different fuels makes and influences of the photocatalysis properties of the prepared phosphors. Different types of fuels were employed during the synthesis of TiO₂ nano particles like glycine, urea, oxalyldihydrazide etc. these fuels used during the synthesis also make great impact on the surface morphology of the TiO₂ phosphors. Even though the spectroscopic investigations has not been disclose any electronic properties.

3. Effect of fuels
Different types of fuels were employed for the synthesis of aluminate phosphors by combustion route synthesis. MgAl₂O₄: Eu³⁺ nano phosphors were prepared by the combustion route using different fuels like urea, aniline, piperidine, glycine, hydrazine and starch. In first case of MgAl₂O₄: Eu³⁺ nanophosphors, the samples were prepared by combustion synthesis in which isobutyl nitrite, urea, aniline, piperidine, hydrazine, fuels were used for the synthesis while in second case of MgAl₂O₄: Eu³⁺ nanophosphors, sample were synthesized by combustion route synthesis in which glycine, starch and urea were selected as a fuels for check the effect of different fuels on aluminate phosphors. In combustion synthesis process, the largest size of the particles were observed by combustion route using aniline as a fuel and the smallest particle by using hydrazine as a fuel of size 35 nm for MgAl₂O₄: Eu³⁺ phosphors. In case combustion route synthesis, addition of starch markedly altered the combustion type from flame combustion to flaming combustion and lowered the combustion heat. In case of material prepared by combustion synthesis, particle size of the phosphor has been slightly decreased on enhancing the amount of starch used as a fuel in the synthesis process [26].

YVO₄:Eu³⁺ activated phosphors were prepared by combustion synthesis using urea (CH₄N₂O), aniline (C₆H₅NH₂), triethylamine N(CH₂CH₃)₃ and hydrazine(N₂H₄) as a fuels. All the precursors are mixed in the beaker and solution is then transferred into the muffle furnace and it was heated 500 °C for 10 min during the process a flame will arise and for combust the sample. This flame is then damped and the fluffy ash type powdered phosphors were found as a product. This obtained product is then collected in the mortar pistol
and it was crushed for 15 min each sample and the keep in the furnace for annealing process for further removing impurities in the prepared phosphor for the 8 hours at 600 °C and then it is cooled at the room temperature. This cooled phosphor is then crushed for 5 min and used for the further characterizations and investigations[27].

Due to removal of excess of gases as a byproduct, different type of morphology were observed for each fuels. It was observed that the phosphors were synthesized by combustion route shows exceptional photoluminescent properties of the phosphors when aniline were used as a fuel[28]. Kadam et al reported SrYAl3O7:Eu3+ activated phosphor by combustion route method using urea as fuel. Surface morphology of the SrYAl3O7 phosphor was investigated, as displayed in Figure 1. Morphology of the sample investigated by the SEM shows that the samples calcinated at 800°C for 24 h included non-uniform particles of a plate-like structure, As per the figure 1 (a, b, c, d), particles of the samples have cracks and pores in it. This pores and voids created in the phosphor are attributable to non-uniform allocation of temperature during the synthesis process. As shown in figure, the particle sizes were in the range submicrometres to a few micrometres. Solution combustion is a recognized method for preparation of fine powder samples in a comparatively short time[29].

![Figure 1. Morphology of SrYAl3O7 phosphors. (Reprinted with the permission from ref.[29] © 2019 John Wiley and Sons, Ltd).](image)

Kadam et al recently reported the RE3+ activated CaTiO3 phosphors by solution combustion synthesis was citric acid was employed in the form of fuel. Figure 2 shows the surface morphology of the prepared phosphors synthesized by solution combustion which confirms that the prepared phosphors were synthesized with a great particle density. Morphology of the proposed phosphor confirms that the particle sizes of the phosphors are in the range of 5 to 10 μm. Prepared phosphor forms in the fleecy structure due to improper allocation of temperature. [30].
4. Concluding remark

Combustion route synthesis is one of the novel technique among all the methods of preparation methods reported previously by the researchers due to its desired composition and easy synthesis approach. High quality of morphological behavior study of the sample is possible by this method. Our review focuses on the morphological behavior of phosphors synthesized by solution combustion method using different types of fuels. In the proposed article we reported different types of luminescent phosphor materials synthesized by combustion methods using variety of fuels. Here we report succinic acid, citric acid and glycine, urea, monoethilohamine, starch and alanine, etc. In this study we observed that the on using citric acid as a fuel in titanate samples, morphological behavior of the sample suddenly changes and the particle size of the sample is in sub-micrometer range. While use of other fuels it shows that particle size is smaller as compared to citric acid as a fuel synthesized by solution combustion method. There is still major concern about the morphological behavior of the different sample prepared by the combustion route synthesis using different fuels. Nevertheless, the conditions are definitely mature for penetrates in this area over the next upcoming years.

5. References

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