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Synthesis and TL glow analysis by Ce, Cu, Eu Dy and Mn doped $LiMgBO_3$ and $LiSrBO_3$Phosphor

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ABSTRACT

The present paper reports the combustion synthesis of $LiMgBO_3$ and $LiSrBO_3$ phosphor by various dopants Ce Cu, Eu, Dy and Mn and study their TL glow curve for TL dosimetry. During the combustion synthesis we have synthesized $LiMgBO_3$ and $LiSrBO_3$ phosphor by using various activators Ce, Cu, Eu, Dy and Mn so as to explore the possible compound for TL glow curve analysis and their application for TL dosimetry. The combustion synthesis method is very simple and time saving method. This work deals with detail procedure for synthesis $LiMgBO_3$ and $LiSrBO_3$ phosphor by various dopants Ce Cu, Eu, Dy and Mn and study of their TL glow curve analysis and luminescent characteristics for TL dosimetry.

Keywords : $LiMgBO_3$; LiSrBO3; combustion method; TL intensity; TL glow curve

I. INTRODUCTION

Borate compounds are known for their wide band gap. They are the best hosts for various activators. From the literature it is found that Borate compounds find several interesting applications. In borate compounds boron atom is coordinated by oxygen atoms to form a variety of atomic groups that affect the physical properties in general and optical properties in particular. In the past decades, much research interest has been focused on the synthesis and characterization of inorganic borates for exploring nonlinear optical materials. Several borate compounds find important application as TLD phosphors. However, they have not observed promising TL sensitivity in the phosphor so as to propose the same for TLD applications. Recently, a series of attempts have been made to investigate new borate materials as useful optical crystals in view of the demand for the nonlinear optical crystals in the deep UV band. The demand for such material is increasing consistently because of the development of optical communications and the semiconductor large-scale integrated circuit. Synthesis of luminescent materials specifically for borates by combustion method is found to be very useful. Since this method provides uniform and narrow distribution of the particle size of the product. Thus we have attempted combustion method for the synthesis of $LiMgBO_3$ and $LiSrBO_3$ (1-5).

II. SYNTHESIS OF $LiBaBO_3$ AND $LiSrBO_3$ PHOSPHORS

During the synthesis of $LiBaBO_3$ and $LiSrBO_3$ phosphors the stoichiometric amounts of high purity starting materials, Li_2CO_3, $Mg(NO_3)_2{\cdot}6H_2O$, H_3BO_3, $CO(NH_2)_2$, NH_4NO_3 were mixed thoroughly in agate mortar for about 30 minutes, so that the paste was formed. A stock solution of stoichiometric amount of dopant chloride $CuCl_2{\cdot}2H_2O$ was then mixed in paste. It was put in the pre-heated furnace (550°C) after warming it for 5 minutes. The self heat generating redox reaction was completed and the fine powder of $LiMgBO_3$ and $LiSrBO_3$ was obtained. The obtained raw powders were sintered for 1.5 hour at 700°C and quenched to room temperature on aluminum plate (6-10). The balanced chemical reactions for $LiMgBO_3$ and $LiSrBO_3$ phosphors are reported in the following balance chemical reactions:

Chemical reactions for synthesis of $LiMgBO_3$:Cu:

$0.5Li_2CO_3+Mg(NO_3)_2{\cdot}6H_2O+H_3BO_3+5CO(NH_2)_2+4NH_4NO_3+0.0001CuCl_2{\cdot}2H_2O + 4O_2 \rightarrow$ **$LiMgBO_3$:Cu** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiMgBO_3$:Ce:

$0.5Li_2CO_3 + Mg(NO_3)_2{\cdot}6H_2O + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001CeCl_3 + 4O_2 \rightarrow$ **$LiMgBO_3$:Ce** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiMgBO_3$:Eu:

$0.5Li_2CO_3 + Mg(NO_3)_2{\cdot}6H_2O + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001EuCl_3 + 4O_2 \rightarrow$ **$LiMgBO_3$:Eu** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiMgBO_3$: Dy:

$0.5Li_2CO_3 + Mg(NO_3)_2{\cdot}6H_2O + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001DyCl_3 + 4O_2 \rightarrow$ **$LiMgBO_3$:Dy** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiMgBO_3$:Mn:

$0.5Li_2CO_3+Mg(NO_3)_2{\cdot}6H_2O+H_3BO_3+5CO(NH_2)_2+4NH_4NO_3+0.001MnCl_2{\cdot}2H_2O + 4O_2 \rightarrow$ **$LiMgBO_3$:Mn** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 19.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiSrBO_3$:Cu:

$0.5Li_2CO_3 + Sr(NO_3)_2 + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.0001CuCl_2{\cdot}2H_2O + 4O_2 \rightarrow$ **$LiSrBO_3$:Cu** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 13.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiSrBO_3$:Ce:

$0.5Li_2CO_3 + Sr(NO_3)_2 + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001CeCl_3 + 4O_2 \rightarrow$ **$LiSrBO_3$:Ce** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 13.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiSrBO_3$:Eu:

$0.5Li_2CO_3 + Sr(NO_3)_2 + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001EuCl_3 + 4O_2 \rightarrow$ **$LiSrBO_3$:Eu** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 13.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiSrBO_3$: Dy:

$0.5Li_2CO_3 + Sr(NO_3)_2 + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001DyCl_3 + 4O_2 \rightarrow$ **$LiSrBO_3$:Dy** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 13.5H_2O + 6N_2)\uparrow$

Chemical reactions for synthesis of $LiSrBO_3$:Mn:

$0.5Li_2CO_3 + Sr(NO_3)_2 + H_3BO_3 + 5CO(NH_2)_2 + 4NH_4NO_3 + 0.001MnCl_2{\cdot}2H_2O + 4O_2 \rightarrow$ **$LiSrBO_3$:Mn** + $(5.5CO_2 + 4NH_3 + 4NO_2 + 13.5H_2O + 6N_2)\uparrow$

III. RESULTS AND DISCUSSION

Figure 1 shows the typical glow curves for $LiMgBO_3$ doped with various impurities exposed to γ ray (exposure of 5 Joule/Kg). Curve (a), (b), (c), (d), (e) are for Dy, Cu, Ce, Eu, Mn respectively. The intensity for the activator Dy was found to be more than 10 times than the other activators. Therefore the glow curve of $LiMgBO_3$:Dy is divided by 10 to fit in the scale. The main peak in this host for all activators is found

around 165°C which is close to the TL peak of most of the TLD phosphors currently used. Since the peak is single and simple and further moderate value of its full width at half maximum, it could be used for the dosimetric studies provided it satisfies the other requirements. In short, the activator Dy is found to be suitable dopant in $LiMgBO_3$ (11-15).

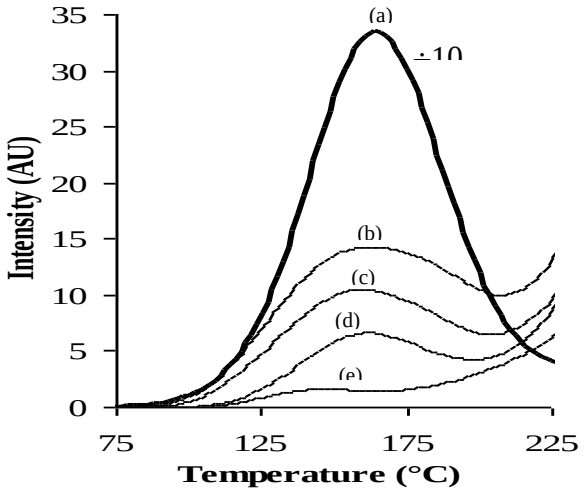

Fig.1: Typical glow curves for $LiMgBO_3$ doped with various impurities exposed to 5 Joule/kg. (a) Dy, (b) Cu, (c) Ce, (d) Eu (e) Mn. Curves (a) is divided by 10 fit the ordinate scale.

Figure 2 shows glow curves of $LiSrBO_3$ doped with various impurities exposed to γ ray of exposure 5 Joule / Kg. Curves (a), (b), (c), (d) and (e) are for Dy, Cu, Ce, Eu, and Mn respectively. In this case the highest intensity is found for the activator Ce. There are two peaks one at 185°C and the other at 265°C (16-18).

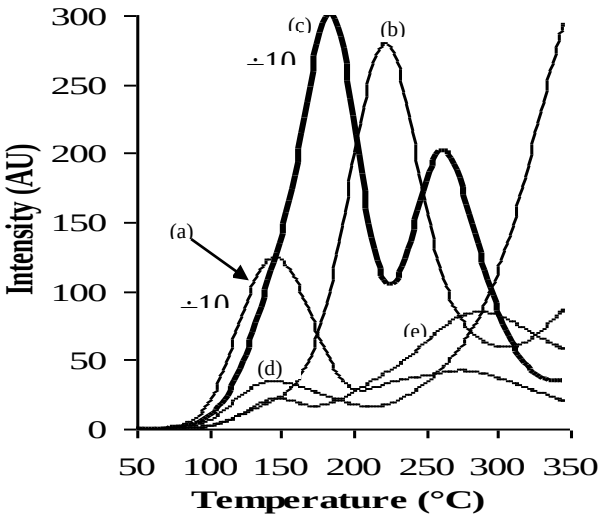

Fig.2: Typical glow curves for $LiSrBO_3$ doped with various dopants, exposed to 5 Joule/kg. (a) Dy, (b) Cu, (c) Ce, (d) Eu & (e) Mn. Curves (a) & (c) are divided by 10 to fit the ordinate scale

V. CONCLUSIONS

1. The combustion synthesis is successfully employed for the synthesis of $LiMgBO_3$ and $LiSrBO_3$ phosphors doped with the activators Cu, Ce, Eu, Dy and Mn.
2. Dy is the most suitable activator for $LiMgBO_3$
3. There are two peaks for $LiSrBO_3$ with activator Ce one at 185°C and the other at 265°C.
4. Typical glow curves for $LiMgBO_3$ and $LiSrBO_3$ doped with Dy and Ce respectively shows most ideal performance
5. The main peak of $LiMgBO_3$ for all activators is found around 165°C which is close to the TL peak of most of the TLD phosphors

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