

**UNIVERSITY TEKNOLOGI MARA**

**STRUCTURAL AND  
PHOTOLUMINESCENCE  
PROPERTIES OF Cr-DOPED AND  
Cr/Zn CO-DOPED Al<sub>2</sub>O<sub>3</sub>  
SYNTHESIZED USING SOLUTION  
COMBUSTION METHOD**

**NUR AZLIANA FTRI BINTI ABD  
HALIM**

Thesis submitted in fulfilment  
of the requirements for degree of  
**Master of Science**  
**(Physics)**

**Faculty of Applied Science**

**August 2022**

## ABSTRACT

The Cr-doped  $\text{Al}_2\text{O}_3$  is the foundation of advancement of modern laser technology. It is potentially can be applied as phosphor materials and photoluminescence (PL) bio-probe in bioimaging applications. For these applications, high PL intensity sample is required. In this work, samples were prepared using solution combustion (SC) method and their properties in terms of structural and PL properties were investigated. Characterization techniques including X-ray diffraction (XRD), scanning electron microscope (SEM), energy dispersive X-ray (EDX) spectroscopy, PL and Ultraviolet-visible (UV-Vis) spectroscopy were employed. Fuel is one of main component in solution combustion method for obtaining high PL intensity sample. Different fuels usage including urea, sorbitol, and glycine were used and analysed. From the result obtained, the samples synthesized using urea showed the formation of highly crystalline single phase  $\alpha$ - $\text{Al}_2\text{O}_3$  phase and produced highest PL intensity. While, the sample synthesized using sorbitol and glycine have lower PL intensity due to the existence of additional  $\text{Al}_2\text{O}_3$  phase crystalline structure which are  $\gamma$ - $\text{Al}_2\text{O}_3$  cubic phase and  $\theta$ - $\text{Al}_2\text{O}_3$  monoclinic phase. It can be concluded that, urea is the most suitable fuel which produced sample with high PL intensity. Next, the samples with different  $\text{Cr}^{3+}$  concentrations (0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 wt.%) were prepared in order to find the optimum  $\text{Cr}^{3+}$  concentration. The obtained results show that the optimum  $\text{Cr}^{3+}$  concentration is 0.8 wt.%. Moreover, the sample with optimum Cr concentration was found to have the smallest energy band gap (4.20 eV). This finding suggests, for this sample the electrons are easier to jump to the conduction band, which makes the photon releasing process more efficient. Rietveld refinement revealed the increases in lattice parameter due to the replacement of aluminium atoms with chromium atom which has larger ionic radius. The cell volume also found to increase at higher Cr concentration. Next, zinc was added in order to further increase the PL of the sample. After zinc addition, the energy band gap was reduced from 4.31 eV to 4.23 eV. This reduction leads to the PL intensity enhancement by 34%. Furthermore, the enhancement is believed due to the modification in the crystal field environment by  $\text{Zn}^{2+}$  ions. The modification will decrease the crystal symmetry around the  $\text{Cr}^{3+}$  ions which is beneficial for enhancing up-conversion luminescence. Thus, it is proved that the PL intensity of Cr-doped  $\text{Al}_2\text{O}_3$  can be enhanced by the addition of zinc elements.

## ACKNOWLEDGEMENT

First and foremost, I am very grateful to the almighty ALLAH S.W.T for granting me good health and giving me the opportunity to complete my research and thesis successfully.

Herein, I would like to express my sincere appreciation to my supervisor Dr. Wan Aizuddin bin W Razali for his guidance, support, suggestions, useful critiques and always patience for these two years of my study. Special thanks to my co-supervisor, Dr. Muhamad Kamil bin Yaacob who always provide a helpful advice, allocating time to guide me, sharing his knowledge and making it possible for me to complete my research. I am grateful to Universiti Teknologi MARA (UiTM), Ministry of Education/Ministry of Higher Education (MOE/MOHE) for supporting me financially under Fundamental Research Grant Scheme (FRGS) throughout my studies.

Thanks to my parents, Mr. Abd Halim bin Asnan and Madam Nor Sharifah binti Yacob, without them, none of this would have been possible. Their love, patience and support were vital to my success. Not to forget to all my siblings for their motivation and encouragements.

Thanks also to my close friends, Nur Shahirah binti Zaharuddin, Hanis Mastura binti Mohzan and Muhammad Najmi bin Zubairi who always helped me during this research and give the moral support until I completed my study with successful. Last but not least, I would like to thank to those who have contributed and assist through behind the scenes for the successful completion of this work.

Nur Azliana Fitri binti Abd Halim

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