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Investigating the influence of metallic bismuth nanoparticles on europium luminescence in phosphate glasses

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Glasses, with their versatile shapes and numerous applications in photonics such as laser amplification and light emission, owe their tunable properties to their composition and manufacturing methods. Incorporating elements like rare earth elements and metallic nanoparticles allows glasses to exhibit luminescence and color through surface plasmon resonance or interactions with other elements. While the interaction of europium with silver and gold nanoparticles in glass has been extensively studied, the interaction between elemental bismuth nanoparticles (NP-Bi^0) and Eu^{3+} remains underexplored, likely due to the highly sensitive and variable oxidation states of bismuth. This study aims to elucidate the influence of elemental bismuth nanoparticles on the luminescent properties of Eu^{3+} in a bismuth-rich phosphate glass, as well as its effect on the glass matrix. Glass samples with the composition xEu_2O_3-(100-x)[80$Bi(PO_3)_3$-10Bi_2O_3-10Na_2O] were prepared by melting-quenching, with varying concentrations of Eu^{3+}. Additionally, glasses with the same composition were synthesized under different conditions to vary the concentration of NP-Bi^0. Raman scattering and thermal analyses showed no significant changes in structural parameters up to 8 mol% of Eu_2O_3, with crystallization occurring at 16 mol%. UV-vis spectra of samples with varying Eu^{3+} concentrations indicated a correlation between europium addition and the formation of bismuth nanoparticles. Eu^{3+} was found to promote nanoparticle formation, as evidenced by an increase in the SPR absorption band at 455 nm with the addition of Eu_2O_3. UV-Vis spectra of glasses produced under different melting conditions indicated that bismuth nanoparticles cause luminescence quenching, with more transparent glasses (lacking metallic nanoparticles) exhibiting more intense emission. These findings are supported by a reduction in relative intensities in the excitation spectra of the $^7F_0 \rightarrow {}^5D_2$ transition. In conclusion, this study investigated the interaction between Eu^{3+} and bismuth nanoparticles in glass. Through optical and structural characterizations, we observed deactivation of Eu^{3+} luminescence in the presence of NP-Bi^0 and found that Eu^{3+} influences the nanoparticles formation. These findings contribute to understanding the oxidation states of bismuth in the glasses and its interaction with luminescent centers. Future work is required to determine the bismuth species present in the glasses using X-ray Photoemission Spectroscopy (XPS) for a better understanding of the luminescent processes.

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References

[1] O. Sanz González et al, J. Non-Cryst. Solids, **vol. 352**, no. 8, pp. 761-768, 2006.
[2] L. R. P. Kassab et al., Appl. Phys. Lett. **94**, 101902 (2009).