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Luminescent Properties of Sm^{3+}-Doped Silica Nanophosphor Synthesized from Highly Active Amorphous Nanosilica Derived from Rice Husk

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Abstract : Rice husk (RH) is a natural sheath that forms and covers the grain of rice. The husk composed of hard materials, including opaline silica and lignin. It separates from its grain during rice milling. RH also contains approximately 15 to 28 wt % of silica in hydrated amorphous form. Nanosilica was derived from the husk of different rice varieties after pre-treating the husk (RH) with HCl and calcination at 550°C. Nanosilica derived from the husk of Osi rice variety produced the highest silica yield, and further pretreatment with 0.8 M H_3PO_4 acid removed more mineral impurities. The silica obtained from this rice variety was selected as a host matrix for doping with Sm^{3+} ions. Rice husk silica (RH-SiO_2) doped with samarium (RH-SiO_2: xSm^{3+} (x=0.01, 0.05, and 0.1 molar ratios) nanophosphors were synthesized via the sol-gel method. The structural analysis by X-ray diffraction analysis (XRD) reveals amorphous structure while the surface morphology, as revealed by SEM and TEM, indicates agglomerates of nano-sized spherical particles with an average particle size measuring 21 nm. The nanophosphor has a large surface area measuring 198.0 m^2/g, and Fourier transform infrared spectroscopy (FT-IR) shows only a single absorption band which is strong and broad with a valley at 1063 cm^{-1}. Diffuse reflectance spectroscopy (DRS) shows strong absorptions at 319, 345, 362, 375, 401, and 474 nm, which can be exclusively assigned to the 6H5/2→4F11/2, 3H7/2, 4F9/2, 4D5/2, 4K11/2, and 4M15/2 + 4I11/2, transitions of Sm^{3+} respectively. The photoluminescence excitation spectra show that near UV and blue LEDs can effectively be used as excitation sources to produce red-orange and yellow-orange emission from Sm^{3+} ion-doped RH-SiO_2 nanophosphors. The photoluminescence (PL) of the nanophosphors gives three main lines; 568, 605, and 652 nm, which are attributed to the intra-4f shell transitions from the excited level to ground levels, respectively under excitation wavelengths of 365 and 400 nm. The result, as confirmed from the 1931 CIE coordinates diagram, indicates the emission of red-orange light by RH-SiO_2: xSm^{3+} (x=0.01 and 0.1 molar ratios) and yellow-orange light from RH-SiO_2: 0.05 Sm^{3+}. Finally, the result shows that RH-SiO_2 doped with samarium (Sm^{3+}) ions can be applicable in display applications.

Keywords : luminescence, nanosilica, nanophosphors, Sm^{3+}
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