

### Near Infrared Shielding Properties of Tungsten Bronze Nanoparticles $\text{Na}_x\text{Cs}_{0.33-x}\text{WO}_3$ Modulated by Sodium and Cesium Compositions

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There has been a growing demand in recent years to filter out the infrared waves of the solar spectrum from housing and automotive windows, in accordance with the worldwide energy-saving and environmental preservation movement. Reduced tungsten bronze nanoparticles of ternary and quaternary compounds were prepared by adding various levels of sodium and cesium to crystal structures of tungsten trioxides ( $\text{Na}_x\text{Cs}_{0.33-x}\text{WO}_3$ ,  $x = 0, 0.11, 0.22, 0.33$ ) while maintaining the overall alkali metal fraction at 0.33, in an attempt to control near infrared (NIR) shielding property in the particular wavelength range of 780 to 1200 nm. The NIR shielding property for  $\text{Na}_{0.11}\text{Cs}_{0.22}\text{WO}_3$  was remarkable, as this material demonstrated efficient transmittance of visible light up to 780 nm and enhancement in NIR shielding in the range of 780 ~ 1200 nm.

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