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UV light absorption of reduced graphene oxide - titanium dioxide composite coating for sustainable UV protection

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The depletion of the ozone layer causes irreversible medical issues related to the increased fractions of Ultraviolet A (UV-A) and Ultraviolet B (UV-B) radiation reaching the Earth's surface. Therefore, introducing a material with a wide range of UV absorption capabilities is crucial. Recent studies show that both UV-A and UV-B can cause cancer in deep layer epidermis of keratinocyte cells. It is reported that titanium dioxide (TiO₂) nanoparticles (anatase phase, spherical shape) absorb UV-B light. Once doped with reduced graphene oxide (RGO), the composite material is observed to absorb both UV-A and UV-B radiation. The aim of this study was to utilize the shift from UV-B to UV-A to enhance the UV absorption of RGO - TiO₂ composite material for UV protection applications. The sun protecting factor (SPF) describes the ability of a material to absorb UV-B region. The UV-A protection factor (UVAPF) indicates the level of protection a material provides against UV-A radiation. In this study, indirect band gap, SPF and UVAPF values were studied for undoped, 1%, 2%, 3%, 4%, 5%, and 6% RGO doped TiO₂ composite coatings. According to the results, the indirect band gap value of the nano-composite material decreases from 3.38 eV to 2.98 eV, and the critical wavelength of the absorption spectrum shifts from 314 nm to 331 nm at room temperature when increasing the mass percentage of RGO in the composite material. From the Scanning Electron Microscope (SEM) measurements, the diameter of TiO₂ varies from 18.2 nm to 44.3 nm with an average diameter of TiO₂ is determined to be 71.3 nm. Undoped TiO₂ nanoparticles showed SPF and UVAPF values of 12.5±1.0 and 10.3±1.4, respectively. The UVAPF values for 1%, 2%, 3%, 4%, 5%, and 6% RGO doped TiO₂ composite coatings were determined, and the best UVAPF value of 18.3±1.4 was obtained for the 1% RGO doped TiO₂ composite coating. The UVAPF value decreases when increasing the mass percentage of RGO in the composite material. To develop a sun protection material, the RGO doped TiO₂ composite material was mixed with glycerin solution. The SPF values were evaluated for glycerin solution, TiO₂ mixed glycerin solution, and 1% RGO doped TiO₂ nano-composite mixed glycerin solution were determined to be 0.970±0.004, 4.01±0.08, and 10.5±1.3, respectively, at 25 °C. The UVAPF values were determined to be 1.13±0.09, 5.97±0.76, and 10.8±0.6, respectively, at 25 °C. This study demonstrated that 1% RGO doped TiO₂ composite showed higher UV light protection ability rather than using TiO₂ alone.

Keywords: Nanocomposite, Reduced Graphene Oxide, Sunscreen, Sun Protecting Factor, Ultraviolet A Protection Factor