Eco-friendly Carbon Dot-based Nanocomposites in Smart Construction Materials for Green-House Gases Reduction

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Abstract:

Global warming accelerates climate change, making maintainable CO_2 capture urgent. Integrating nanotechnology into building materials offers an innovative, efficient mitigation solution. One of the most promising zero-dimensional nanomaterials is carbon dots (CDs), which are carbonaceous nanomaterials whose particle sizes range from 1 to 10 nm. This study investigates environmentally friendly and novel carbon dot nanocomposites (CD-NCs) including TiO2, ZnO and SiO2 semiconductor nanoparticles (SNs) into Portland cement (OPC) to be converted to new smart construction materials for reducing CO2 emissions. The water-soluble CDs were synthesized using the microwave hydrothermal method and presented spherical nanoparticles in the size range of 6-10 nm. Optical properties revealed photoluminescence emission at 490 nm. Different molar ratios from CDs are introduced into the SNs to produce x%CD-TiO2, CD-ZnO and CD-SiO_2; (x= 0.01, 0.05 and 1% molar ratio). XRD, XPS and TEM techniques evidenced the integration of CDs without modification in the crystallite size of host materials. Additionally, evaluation of CDs and their composites within cementitious materials to better compressive strength, bulk density, and reduced porosity. Accordingly, it has enhanced hydration and improved the mechanical properties. The surface properties including specific surface

area (SBET) and XPS were enhanced by incorporation of CDs the nanoparticle matrix which was evidenced by increasing the oxygen vacancies. The photoactivity and reusability of the cement-based nanocomposite building materials to remove CO_2 gas was evaluated under simulated sunlight illumination. The cement-based CDs nanocomposites show a great potential activity and reusability for three repetitive cycles that demonstrate it as significant for CO_2 capturing.

Keywords:

Carbon dots, Nanocomposite, Construction materials, CO_2 reduction.