Multifunctional materials in indoor environments: air remediation and cooling properties

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ABSTRACT

In this work, a series of bismuth oxyiodide materials were synthesized using a coprecipitation method characterized by low energy demand and high phase tunability. By carefully controlling the synthesis parameters, materials with tailored crystal phases and morphologies were obtained, allowing the optimization of their optical, chemical, and electrochemical properties. Comprehensive characterization was carried out to establish clear correlations between material structure, light absorption, charge transfer behavior, surface chemistry, and functional performance.

Photocatalytic activity was systematically evaluated under ultraviolet and visible light for key indoor air pollutants, including nitrogen oxides, VOCs and microorganisms. Selected materials exhibited enhanced visible-light photocatalytic efficiency compared to conventional photocatalysts, achieving effective pollutant degradation and bacterial inactivation without relying on ultraviolet irradiation. Mechanistic studies revealed that superoxide radicals, singlet oxygen, and direct charge carrier interactions dominate the photocatalytic processes, while hydroxyl radicals play a negligible role. In addition to their photocatalytic performance, the synthesized materials exhibited high near-infrared reflectance and suitable thermal emissivity, key properties for passive cooling applications. Their thermal behaviour was systematically evaluated, demonstrating a reduced heat absorption under solar irradiation and a clear potential to mitigate indoor heat gain. Construction materials using cement, lime and gypsum, functionalised with the bismuth oxyiodide materials were cast. The positive cooling results confirm the multifunctional nature of the materials and support their suitability for combined air remediation and thermal management in indoor environments.

Overall, this study highlights the potential of bismuth oxyiodide-based materials as multifunctional candidates for indoor applications, combining visible-light-driven indoor air purification with energy-efficient cooling. The results indicate that these materials could serve as a basis for the development of advanced building materials, although further validation is required. Future work is focused on pilot-scale studies and the incorporation of these materials into indoor paint coatings, aiming to evaluate their performance, durability, and safety under realistic indoor conditions.

KEYWORDS

Indoor air remediation, visible-light photocatalysis, multifunctional coatings, bismuth oxyiodides, passive cooling