Development of Nanoparticle Coatings for Self-Cleaning Applications: Case Studies on Solar Cell Panels, Mirrors and Concrete Surfaces of Places of Worship

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Abstract

Self-cleaning coatings play a crucial role in maintaining surface cleanliness and performance in various applications. They are generally categorized into two main types: superhydrophobic and superhydrophilic coatings. In this study, we developed and evaluated a superhydrophilic coating based on colloidal silica nanoparticles for self-cleaning applications on solar cell panels, architectural mirrors, and concrete surfaces of religious buildings. The coating aims to minimize dust accumulation on solar panels, thereby enhancing light transmittance and energy conversion efficiency. For mirrors, the coating provides anti-fogging and stain-resistant properties, ensuring long-term clarity with reduced maintenance. On concrete surfaces, especially those of cultural or religious significance, the coating protects against weathering, biological growth, and pollution-induced discoloration while preserving structural and aesthetic integrity. The film thickness was measured using a nano-surface profiler, and surface morphology was examined via scanning electron microscopy. The coating exhibited an average thickness of 2.0 µm and a water contact angle of 13.0°, confirming its excellent hydrophilicity. These results demonstrate the effectiveness of colloidal silica nanoparticle coatings in improving surface properties and enabling sustainable self-cleaning functions for solar and architectural applications.

Keywords:

Self-Cleaning; Hydrophilic; Contact Angle; Solar Cell Panels