Annealing Temperature Effect on the Hydrophilic Coating Film for the Cover Glass of the PV Module

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The optical and mechanical characteristics of a novel hydrophilic coating material are introduced according to the annealing temperature. As a water-based SiO₂-abundant material has perfect transparency, as does glass, and a hydrophilic property, it can be applied to the protective glass for a PV module. After the coating process on the glass substrate, the film was cured at different annealing temperatures of 200–500 °C in 100 °C increments. A UV-visible spectrometer was utilized to measure the optical transmittance of the film. To verify the mechanical properties, the hardness and adhesion of the film were tested using ASTM standard methods. 9H hardness and 5B adhesion were achieved. Self-cleaning characterization was performed with artificial pollutants and with simple watering of the samples. Moreover, the self-cleaning experiment was conducted on a real-sized 40 × 40 cm² solar panel cover glass with successful results.

Keywords: Cover Glass, PV Module, Anti-Pollution, Surface Cleaning, Hydrophilic.

1. INTRODUCTION

As global energy consumption is increasing with the growing population, industrial development, and higher mobility, conventional energy sources such as coal, oil, and gas are quickly being exhausted. Moreover, carbon-related energy sources have caused environmental pollution. To reduce the pollution and to protect the environment, new and renewable energy sources are good candidates for meeting the global energy demand. Among the new and renewable energy sources, solar energy is the most promising and abundant energy source. Academic studies and industrial investments have led to a low-cost and high-efficiency solar energy system, and the energy source has become an important energy supplier in the world. A market report estimated that solar energy will provide about 345 GW by 2020 and 1,081 GW by 2030.¹-³

With the remarkable progress in solar technology, recent studies on solar energy have focused on external variables such as self-cleaning, solar panel area enlargement, and cooling systems to achieve better efficiency.⁴-⁶ In most cases, a solar module is installed outdoors and is exposed to natural environmental conditions such as dust and bird excrement. A report states that the efficiency of a solar module covered by opaque elements deteriorates by up to 80% within a period of 6 months.⁷ To solve the contamination issues, many researchers have studied coating materials with a self-cleaning property in natural rain conditions. Furthermore, the coating material requires temperature stability and anti-corrosion to endure a harsh environment, in addition to high optical transparency (over 95%) to absorb sunlight well.⁸ ⁹

Among the existing coating materials, the TiO₂ film, which has a photocatalysis function, has been broadly studied. The film, however, has lower adhesion and hardness, high cost, installation difficulties, energy source requirements for chemical catalysis, and low yield rate issues.¹⁰-¹² There are many other technologies for realizing self-cleaning or anti-pollution properties for solar panels, along with anti-fogging, anti-frost, and electric static repellant properties, but the results are insignificant with regard to efficiency improvement.

In this paper, a novel coating material that enables a solar module to have self-cleaning ability is presented.