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Biomimicked Nano-Structured Coating Elaboration by Soft Chemistry Route for Self-Cleaning and Antibacterial Uses

Authors : Elodie Niemiec, Philippe Champagne, Jean-Francois Blach, Philippe Moreau, Anthony Thuault, Arnaud Tricoteaux

Abstract : Hygiene of equipment in contact with users is an important issue in the railroad industry. The numerous cleanings to eliminate bacteria and dirt cost a lot. Besides, mechanical solicitations on contact parts are observed daily. It should be interesting to elaborate on a self-cleaning and antibacterial coating with sufficient adhesion and good resistance against mechanical and chemical solicitations. Thus, a Hauts-de-France and Maubeuge Val-de-Sambre conurbation authority co-financed Ph.D. thesis has been set up since October 2017 based on anterior studies carried by the Laboratory of Ceramic Materials and Processing. To accomplish this task, a soft chemical route has been implemented to bring a lotus effect on metallic substrates. It involves nanometric liquid zinc oxide synthesis under 100°C. The originality here consists in a variation of surface texturing by modification of the synthesis time of the species in solution. This helps to adjust wettability. Nanostructured zinc oxide has been chosen because of the inherent photocatalytic effect, which can activate organic substance degradation. Two methods of heating have been compared: conventional and microwave assistance. Tested subtracts are made of stainless steel to conform to transport uses. Substrate preparation was the first step of this protocol: a meticulous cleaning of the samples is applied. The main goal of the elaboration protocol is to fix enough zinc-based seeds to make them grow during the next step as desired (nanorod shaped). To improve this adhesion, a silica gel has been formulated and optimized to ensure chemical bonding between substrate and zinc seeds. The last step consists of deposing a wide carbonated organosilane to improve the superhydrophobic property of the coating. The quasi-proportionality between the reaction time and the nanorod length will be demonstrated. Water Contact (superior to 150°) and Roll-off Angle at different steps of the process will be presented. The antibacterial effect has been proved with Escherichia Coli, Staphylococcus Aureus, and Bacillus Subtilis. The mortality rate is found to be four times superior to a non-treated substrate. Photocatalytic experiences were carried out from different dyed solutions in contact with treated samples under UV irradiation. Spectroscopic measurements allow to determinate times of degradation according to the zinc quantity available on the surface. The final coating obtained is, therefore, not a monolayer but rather a set of amorphous/crystalline/amorphous layers that have been characterized by spectroscopic ellipsometry. We will show that the thickness of the nanostructured oxide layer depends essentially on the synthesis time set in the hydrothermal growth step. A green, easy-to-process and control coating with self-cleaning and antibacterial properties has been synthesized with a satisfying surface structuration.

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