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Superhydrophobic Materials: A Promising Way to Enhance Resilience of Electric System

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Abstract : The increasing of extreme meteorological events represents the most important causes of damages and blackouts of the whole electric system. In particular, the icing on ground-wires and overheads lines, due to snowstorms or harsh winter conditions, very often gives rise to the collapse of cables and towers both in cold and warm climates. On the other hand, the high concentration of contaminants in the air, due to natural and/or antropic causes, is reflected in high levels of pollutants layered on glass and ceramic insulators, causing frequent and unpredictable flashover events. Overheads line and insulator failures lead to blackouts, dangerous and expensive maintenances and serious inefficiencies in the distribution service. Inducing superhydrophobic (SHP) properties to conductors, ground-wires and insulators, is one of the ways to face all these problems. Indeed, in some cases, the SHP surface can delay the ice nucleation time and decrease the ice nucleation temperature, preventing ice formation. Besides, thanks to the low surface energy, the adhesion force between ice and a superhydrophobic material are low and the ice can be easily detached from the surface. Moreover, it is well known that superhydrophobic surfaces can have self-cleaning properties: these hinder the deposition of pollution and decrease the probability of flashover phenomena. Here this study presents three different studies to impart superhydrophobicity to aluminum, zinc and glass specimens, which represent the main constituent materials of conductors, ground-wires and insulators, respectively. The route to impart the superhydrophobicity to the metallic surfaces can be summarized in a three-step process: 1) sandblasting treatment, 2) chemical-hydrothermal treatment and 3) coating deposition. The first step is required to create a micro-roughness. In the chemical-hydrothermal treatment a nano-scale metallic oxide (Al or Zn) is grown and, together with the sandblasting treatment, bring about a hierarchical micro-nano structure. By coating an alchilated or fluorinated siloxane coating, the surface energy decreases and gives rise to superhydrophobic surfaces. In order to functionalize the glass, different superhydrophobic powders, obtained by a sol-gel synthesis, were prepared. Further, the specimens were covered with a commercial primer and the powders were deposed on them. All the resulting metallic and glass surfaces showed a noticeable superhydrophobic behavior with a very high water contact angles (>150°) and a very low roll-off angles (<5°). The three optimized processes are fast, cheap and safe, and can be easily replicated on industrial scales. The anti-icing and self-cleaning properties of the surfaces were assessed with several indoor lab-tests that evidenced remarkable anti-icing properties and self-cleaning behavior with respect to the bare materials. Finally, to evaluate the anti-snow properties of the samples, some SHP specimens were exposed under real snow-fall events in the RSE outdoor test-facility located in Vinadio, western Alps: the coated samples delay the formation of the snow-sleeves and facilitate the detachment of the snow. The good results for both indoor and outdoor tests make these materials promising for further development in large scale applications.

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