Designing Self-Healing Lubricant-Impregnated Surfaces for Corrosion Protection

Authors : Sami Khan, Kripa Varanasi

Abstract : Corrosion is a widespread problem in several industries and developing surfaces that resist corrosion has been an area of interest since the last several decades. Superhydrophobic surfaces that combine hydrophobic coatings along with surface texture have been shown to improve corrosion resistance by creating voids filled with air that minimize the contact area between the corrosive liquid and the solid surface. However, these air voids can incorporate corrosive liquids over time, and any mechanical faults such as cracks can compromise the coating and provide pathways for corrosion. As such, there is a need for self-healing corrosion-resistance surfaces. In this work, the anti-corrosion properties of textured surfaces impregnated with a lubricant have been systematically studied. Since corrosion resistance depends on the area and physico-chemical properties of the material exposed to the corrosive medium, lubricant-impregnated surfaces (LIS) have been designed based on the surface tension, viscosity and chemistry of the lubricant and its spreading coefficient on the solid. All corrosion experiments were performed in a standard three-electrode cell using iron, which readily corrodes in a 3.5% sodium chloride solution. In order to obtain textured iron surfaces, thin films (~500 nm) of iron were sputter-coated on silicon wafers textured using photolithography, and subsequently impregnated with lubricants. Results show that the corrosion rate on LIS is greatly reduced, and offers an over hundred-fold improvement in corrosion protection. Furthermore, it is found that the spreading characteristics of the lubricant are significant in ensuring corrosion protection: a spreading lubricant (e.g., Krytox 1506) that covers both inside the texture, as well as the top of the texture, provides a two-fold improvement in corrosion protection as compared to a non-spreading lubricant (e.g., Silicone oil) that does not cover texture tops. To enhance corrosion protection of surfaces coated with a non-spreading lubricant, pyramid-shaped textures have been developed that minimize exposure to the corrosive solution, and a consequent twenty-fold increased in corrosion protection is observed. An increase in viscosity of the lubricant scales with greater corrosion protection. Finally, an equivalent cell-circuit model is developed for the lubricant-impregnated systems using electrochemical impedance spectroscopy. Lubricant-impregnated surfaces find attractive applications in harsh corrosive environments, especially where the ability to self-heal is advantageous.

Keywords : lubricant-impregnated surfaces, self-healing surfaces, wettability, nano-engineered surfaces
Conference Title : ICCEM 2018 : International Conference on Corrosion Engineering and Materials
Conference Location : Vancouver, Canada
Conference Dates : September 17-18, 2018