

“Development Of Multilayer Coating Systems For Self-Healing Protection And Corrosion Mitigation In The Atmospheric Zone Of Offshore Wind Turbines.”

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ABSTRACT

Offshore wind turbines are subjected to harsh marine environment, which can cause detrimental problems to their integrity due to corrosion. Offshore wind energy is considered to play an important role on the net zero emissions by 2050, contributing to environmental protection, hence the long-term protection from corrosion of these offshore structures is of high importance. In this work the formation of microcapsules, loaded with corrosion inhibitor liquid is presented. More specifically the microcapsules consist of polystyrene shell and 3-octanoylthio-1-propyltriethoxysilane core. The formation of the microcapsules was achieved by testing different variables such as four agitation rates and three different emulsifiers. The experiments revealed that the optimum diameter size was achieved in agitation rates between 400 and 500 rpm and with sodium dodecylbenzene sulfonate (SDBS) as emulsifier. Agitation times were also tested. Hence, this work highlights the formation of microcapsules with self-healing properties, which can offer corrosion solution to offshore wind turbines when used as part of a coating system.

Key words: Corrosion, offshore wind turbines, corrosion inhibitor, TSZ-15Al sacrificial coating

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INTRODUCTION

Offshore metallic structures have an average life-time of 20-25 years. They consist of four different zones, the buried, the submerged, the tidal/splash and the atmospheric one. According to NACE 2013 the global corrosion cost is estimated to be US\$2.5 trillion [1], consisting a major economic problem. Hence, protection from corrosion is essential. Each zone is protected either with cathodic methods, or with a combination of cathodic methods and coatings. More specifically, the protection of the atmospheric zone, which is the aim of this research, due to the lack of continuous electrolyte (seawater) does not allow the application of cathodic protection. Due to this limitation, the application of protective coatings is chosen. As an additional protective coating, a sacrificial thermally sprayed Zn/Al coating is selected to protect the metallic substrate. The latter is a well-known and widely used technique in corrosive environments. It is noticeable that the combination of both Zn and Al provide greater corrosion resistance properties [2]. As a suggested solution to corrosion on the atmospheric zone, this research focuses on the development of a multilayer coating system. Thermally sprayed Zn/Al sacrificial coating in conjunction with an epoxy based marine coating enriched with self-healing microcapsules, will lead to a novel autonomous extrinsic self-healing anticorrosion system. Even if the idea of self-healing coatings is not new and there are a few studies on this topic, the industrial application of them in coatings is very limited or non-existing [3]. Silanes are used as corrosion inhibitors due to their chemistry, which protects the underlying substrate [4]. After the incorporation of the microcapsules in the selected paint, artificial scratches will be incorporated onto the coupons. As a result, once the microcapsules rupture and the core material is released, its contact with the environmental conditions will initiate the self-healing reaction. The development of novel coating systems with application on wind turbines will have a significant impact on the reduction of their maintenance and replacement costs, ensuring protection against corrosion, extension of their service life and reduction of catastrophic incidents that could have devastating social, environmental and financial consequences.

EXPERIMENTAL PROCEDURE

All the materials and reagents were used as received. Carbon steel (S355 J2+AR) commonly used in the offshore industry was used as a substrate and was coated with thermally spray TSZ-15Al. 3-Octanoylthio-1-propyltriethoxysilane, $\text{CH}_3\text{CH}_2\text{OH}$ (99.7%), HNO_3 (65%), Polyvinyl alcohol (PVA), $(\text{C}_2\text{H}_4\text{O})_n$, Polystyrene, Acacia gum, Sodium dodecylbenzene sulfonate (SDBS) and Silwet[†] were used as reagents.

Silicone polymers (polysiloxanes) are a product of polymerization. Hydrolysis is the initial step of this process, followed by condensation and lastly phase separation, from which sol or gel may appear. More specifically in the organoalkoxysilane (OAS) the alkoxy groups are replaced by hydroxyl groups in acidic conditions [5]. The formation of silane bridges (Si-O-Si) is the result from the condensation. Figure 1 represents these two consequent reactions.

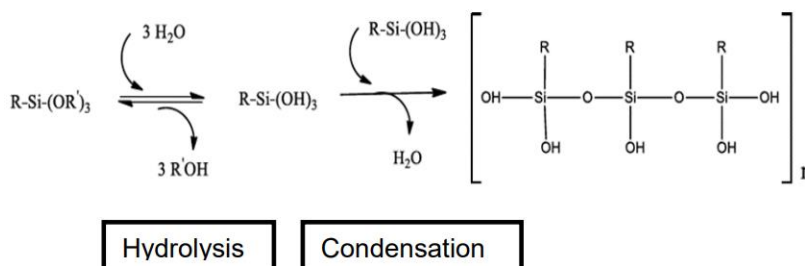


Figure 1: Hydrolysis and condensation reactions of silanes

[†] Trade name.