Synthesis and evaluation of hybrid SiO_2 coatings for high temperature corrosion protection

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Hybrid materials combine properties of several materials from molecular level in one only improved material. In this work a protective hybrid coating of amorphous SiO_2 is proposed for use as an alternative for protection of steels against different aggressive environments, such as oxidizing and carburizing atmospheres. The hybrid material was obtained by the Sol-Gel method by the use of tetraethyl orthosilicate (TEOS inorganic part) and poly-dimethylsiloxane (PDMS organic part) as precursor materials. The hybrid coatings were deposited on stainless (304L) and low carbon steels (1020 and T22), applying 6 layers by the Dip Coating method, creating bonds between silanol group (Si-OH) presents en the precursor solution and Me-OH group.

The behaviour of the hybrid material as well as the metal samples with the protective hybrid coating were evaluated in air, oxidizing and carburizing atmospheres at temperatures from 500 to 800 ˚C with exposure times from 3 to 300 hours and were characterized by mass change data and the mechanisms of surface deterioration using TGA, SEM, XRD and FT-IR techniques, showing that monolith and coating present compact and homogeneous surfaces, without appearance of new phases, as well as good thermal and chemical stability due to presence of amorphous structure even after 1200˚C. However the hybrid material shows decompositions after 300 hours exposition and a weight loss from 400 to 800ºC due to removal of solvents that not reacted during hydrolysis-condensation step and the removal of organic part due to the elimination of characteristic bands from hybrid material, however the hybrid coating shows a good protection against corrosive atmospheres, especially Metal Dusting, through entrapment carbon as SiC.

The hybrid SiO_2 film exhibited beneficial effects on the oxidation resistance of the alloy, especially at 500 °C due the oxidation rates of the silica-coated specimens decreased significantly. At higher temperatures a crack formation is observed, due to dissimilar expansion effects between the substrate and the coating. In these cases, the atmosphere penetrates the coating and beneath and above the silica film, formation an oxide scale of Fe_2O_3 occurred due to outward diffusion of metal and inward diffusion of oxygen through the coating layer.

Key words: Hybrid silica coating, high temperature corrosion, steels corrosion