Performance of novel Polymer Derived Ceramic (PDC) coatings developed for refinery piping systems and in-situ corrosion monitoring by EIS-based sensor

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Novel protective *Polymer Derived Ceramic* (PDC) coatings with improved corrosion resistance was developed in the context of the European project ACHIEF. This project is aiming to introduce innovative materials to improve the energy performance of Energy Intensive Industries (EIIs) and reduce CO_2 emissions in the industrial processes.

A specific use case was identified in refinery pipes carrying corrosive fluids aiming for a reduction of the corrosion and/or erosion damage by 40%. Novel coatings with increased durability could increase service life of equipment and components, leading to a reduction of O&M operations (by 20%) and improving the overall performance and efficiency of the plant.

In this scenario, a novel PDC coating, containing polymer derived ceramic and ceramic charges, was developed to protect the inside of a stainless steel pipe (AISI 321) against corrosion in acidic environment (HCl 2mol/L at 60°C). PDC are organic/inorganic materials formed by the pyrolysis of silicon containing polymer precursor (preceramic polymer precursor). Their properties (chemical composition, density) can be tailored at the molecular scale using suitable precursor and applying adequate thermal treatments. The processability techniques (spray, dip coating, brush etc.) lead to a relatively low cost and easy approach to produce ceramic coatings, which provide excellent corrosion protection in high temperature and/or harsh environment.

In order to find the optimal composition for this particular case, analysis of the thermal conversion of suitable preceramic precursors and the addition of ceramic charges were assessed together with the integrity and morphology of coatings (by SEM) and the adhesion of the coating on substrates. Electrochemical Impedance Spectroscopy (EIS) was applied to select the best corrosion performance composition in the defined acidic conditions. Results encourage the development of these coatings for the next steps of the project.

Advances on upscaling the selected coating for pilot testing in industry will be showed. Besides, a novel corrosion probe was also integrated in the refinery piping installation for in-situ and on-line monitoring using electrochemical techniques. The novel corrosion probe relies on the utilization of EIS method to determine the corrosion performance of the coated pipe. EIS is introduced as a useful tool not only at lab-scale but also for in-situ and real time estimation of the service life of components, corrosion resistance of novel coatings and prediction of failures in critical units, by correlating the process events to corrosion evolution.

The new EIS-based sensor system will facilitate the decision making and contribute to optimize the operation conditions, the coating/material selection and the maintenance costs of the plant.