MULTIPLE ACTION SELF-HEALING COATINGS FOR THE CORROSION PROTECTION OF METALS

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ABSTRACT

A polyurethane (PU) based segmented block copolymer with soft phases (figure 1) was deposited as a coating. This physically crosslinked polymer system shows a self-healing ability based on the fracture and reformation of thermally reversible physical bonds in the polymer matrix. Because heat is necessary to trigger and assist the healing process, these materials are classified as non-autonomic healing polymers. The investigated polymer system is generally not used for coatings, hence its potential as a coating material was explored. Additionally cerium nitrate was added to the coating formulation as corrosion inhibitor. As such a multiple action self-healing coating system (figure 1) was created based, on the one hand, on the inhibitor passivating the metal when the coating is damaged in a corrosive environment, and on the other hand, on the ability of the coating material itself to physically heal a sustained local damage.
The healing ability of this combined polymer system was studied in bulk and as a coating using various surface analyses, thermo-mechanical analyses and electrochemical techniques, such as Electrochemical Impedance Spectroscopy (EIS) for the evaluation of barrier properties [1], and local methods for the local healing activity with the Scanning Electrochemical Microscope (SECM) [2] and the Scanning Vibrating Electrode Technique (SVET) [3]. It is shown that when the coatings are locally damaged by scratching, a thermal treatment to a temperature above the melting point of the soft phase in the block copolymer and below the melting point of the hard PU phase, results in coating repair as observed using Atomic Force Microscopy (AFM) (figure 2) and in a regaining of its barrier properties as observed with EIS (figure 3). The additional effect of the incorporated inhibitor is also shown using the local electrochemical methods [2,3].

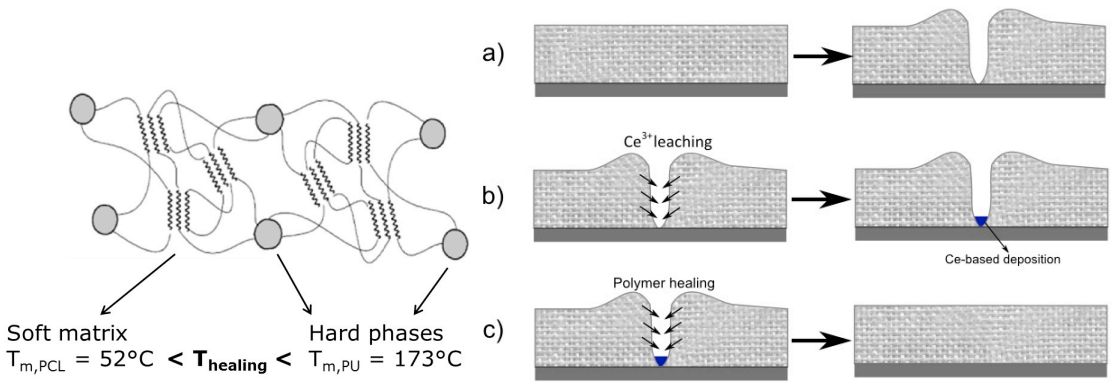

Figure 1: Physical structure of the cross-linked polymer network, and mechanism of multiple action self-healing: (a) Scratched coating, followed by (b) Ce^{3+} release and precipitation at defect site; (c) Thermally triggered healing of the scratch in the polymer material.

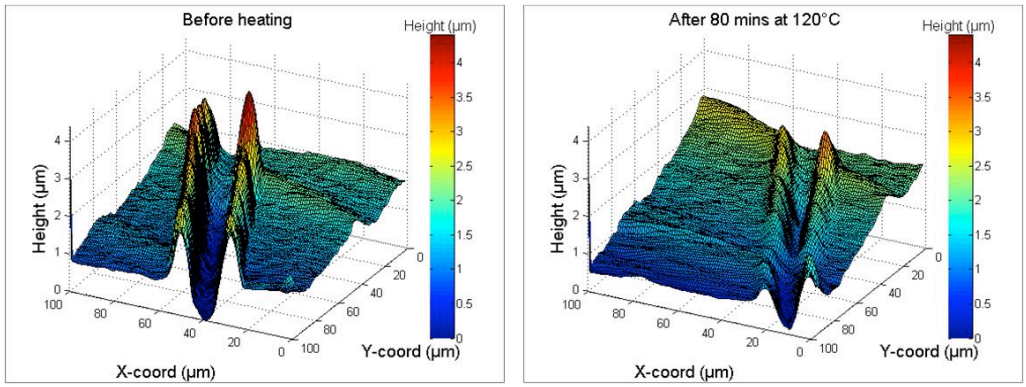

Figure 2: Healing of a scratch in a PU coating by hot-stage AFM analyses: 3D mapping across a scratch of about 15 µm width, exposing the underlying metal substrate, in a 500 nm thick coating, before and after induced healing at 120 °C for 80 minutes.

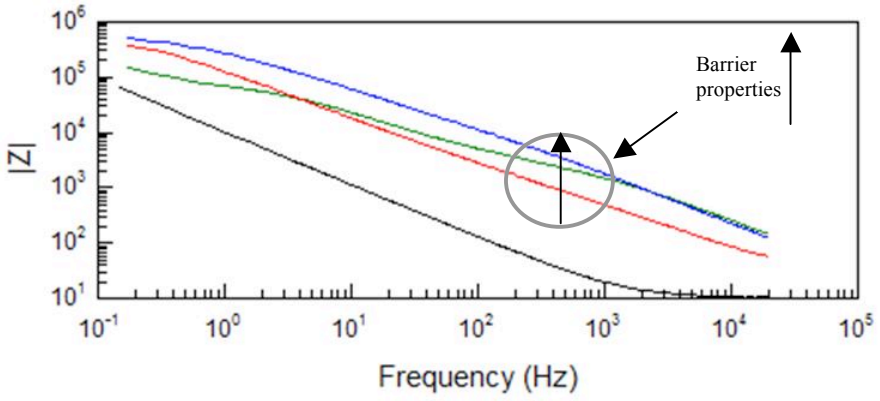

Figure 3: EIS impedance amplitude Bode plot of: Black: uncoated AA2024 substrate, Green: PU 12% coating doped with cerium on AA2024; Red: Scratched coating, Blue: Healed coating.

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