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SELF-HEALING COATINGS WITH MULTI-LEVEL PROTECTION BASED ON ACTIVE NANOCONTAINERS

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The destructive effect of environment and the corrosion induced degradation are the important problems which determine the service life of many metallic components. The application of organic coatings is the most common and cost effective method of improving protection and durability of metallic structures. However the degradation processes develop faster after disruption of the protective barrier. Therefore an active protection based on "self-healing" of defects in coatings is necessary to provide long-term effect.

The term "self-healing" in materials science means self-recovery of the initial properties of the material after destructive actions of external environment. The same definition can be applied to functional coatings. However, a partial recovery of the main functionality of the material can also be considered as a self-healing ability. Thus, in the case of corrosion protective coatings the term "self-healing" can be interpreted in different ways. The classical understanding of self-healing is based on the complete recovery of the functionalities of the coating due to a real healing of the defect based on the recovery of the coating integrity. However, the main function of anticorrosion coatings is the protection of an underlaid metallic substrate against an environment-induced corrosion attack. Thus, it is not obligatory to recuperate all the properties of the film in this case. The hindering of the corrosion activity in the defect by the coating itself employing any mechanisms can be already considered as self-healing, because the corrosion protective system recovers its main function, namely the corrosion protection, after being damaged.

Development of an active healing mechanism for the polymer coatings becomes an urgent issue for the respective industrial applications. Recently several attempts were made in this field using different protection/healing mechanisms for protective coatings. The first approach consists in introducing organic or inorganic inhibitors to the coating matrix in order to suppress the corrosion processes in the defects [1-3]. Another approach uses incorporation of the microcapsules containing a polymerizable component which is released forming polymer in the growing crack [4].

The present work suggests development of new active multi-level protective systems based on "smart" release nanocontainers incorporated into the polymer coating matrix. The nanocontainer (or nanoreservoir) is a nanosized volume filled with an active substance confined in a porous core and/or a shell which prevents direct contact of the active agent with the adjacent environment. A multi-level self-healing approach will combine - within one system - several damage prevention and reparation mechanisms, which will be activated depending on type and intensity of the environmental impact, as it shown in Figure 1.

Several types of nanoreservoirs of corrosion inhibitors were developed, introduced to the coating system and tested in terms of active corrosion protection. Different approaches of controllable delivery of corrosion inhibitors on demand are discussed here including the oxide and layered double hydroxide (LDH) nanoparticles, the titania nanostructured porous layer obtained by the templating synthesis, and finally "smart" nanocontainers developed using the polyelectrolyte layer-by-layer (LbL) assembled shells which can control the release of the inhibiting species.

The permeation of the polyelectrolyte layer used for creation of nanocontainers shells strongly depends on the different factors. Thus the release of the inhibitor from such a nanoreservoir can be controlled by selection of appropriate external stimuli. The release of inhibitor from polyelectrolyte covered nanocontainers can be triggered by local changes of pH in cathodic and anodic zones of corroding metal. Then the released inhibitor will react with metallic surface stopping the propagation of the corrosion and providing an "intelligent" self-healing effect.

The coatings with the LDH nanocontainers also reveal enhanced long-term corrosion protection in comparison with the undoped films. This effect is obtained due to regulated release of the corrosion inhibitor triggered by the presence of corrosive anions such as chlorides. Moreover LDH nanoparticles developed in this work were can play double-effect additionally absorbing aggressive chloride anions and working as nano-traps.

The development of nanocontainers for other levels of protection are in course and is main subject of new FP7 large scale collaborative project MUST.

References:

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Figures:

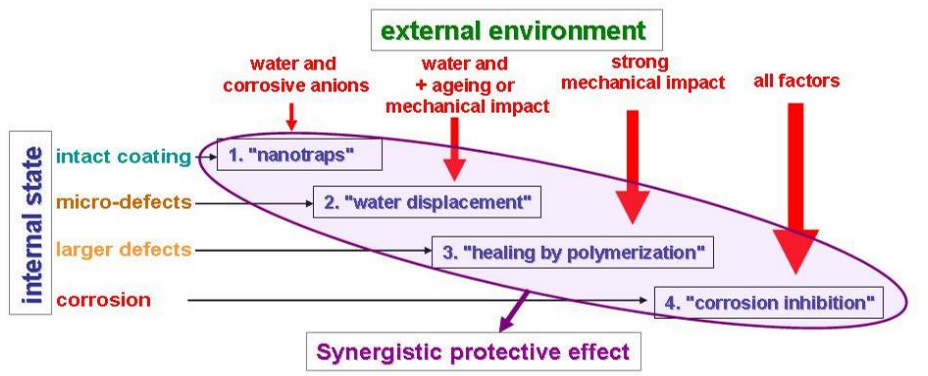

Figure 1. Illustration of the multi-level protection approach