Title of the project: Active protective coatings for aluminium based composites

The Eurocorr Young scientist grant 2016 allowed Dr. Beatriz Mingo to spent one month (Nov 19th – Dic 17th) at the Corrosion and Surface Technology Group at Helmholtz Zentrum Geesthacht. During that period she acquired knowledge and experience, under Prof. Mikhail Zheludkevich supervision, about active surface treatments for aluminium based composites. The work-plan was mostly followed on time and the obtained results will be soon published.

The used surface treatment is based on the growth of Zn-Al LDH (layered double hydroxide) on the material surface and its major interest lies on its layered structure that consists of stacks of positive charged mixed metals hydroxide layers between which solvent molecules and anionic species, such as corrosion inhibitors, are intercalated. These inhibitors can be released in a controlled manner in aggressive environments mitigating corrosion activity.

A380/SiC/10p material was used as substrate; this type of composites present excellent mechanical properties, although the presence of the reinforcement particles (SiC_p) compromises the corrosion resistance. The latter, is often attributed to the formation of galvanic couples and/or to the heterogeneity of the matrix/ SiC_p interface.

Zn-Al LDH coatings were grown over the substrates using a direct synthesis were the substrate served as source of aluminium ions. For that, an optimization of the synthesis parameters (concentration, temperature, time and pH) was carried out and the morphological and structural properties of the coating were characterized by SEM (Scanning Electron Microscopy)EDS (Energy-dispersive X-ray spectroscopy) and XRD (X-Ray diffraction). The pre-selection of the inhibitors was done taking into account the size of the anion, which should fit between the hydroxide interlayers which form the LDH coating. Although different inhibitors (organic and inorganic) were tried for intercalation, successful results were only obtained with the inorganic one ($NaVO_3$). The corrosion resistance was evaluated using electrochemical techniques (potentiodynamic curves and electrochemical impedance spectroscopy, EIS). Additionally, the self-healing properties of the coating were studied by scanning vibrating electrode technique (SVET).

LDH treated composites show flake-like particles (0.5 - 1 μm) covering the material surface unevenly. SiC rich areas were not completely covered, while on the Al matrix accumulation of flakes could be observed with a flower-shape (Figure 1). After the inhibitor intercalation the morphology of the flakes remains, which evidences that the anionic exchange reaction anions does not affect the integrity of LDH structure.

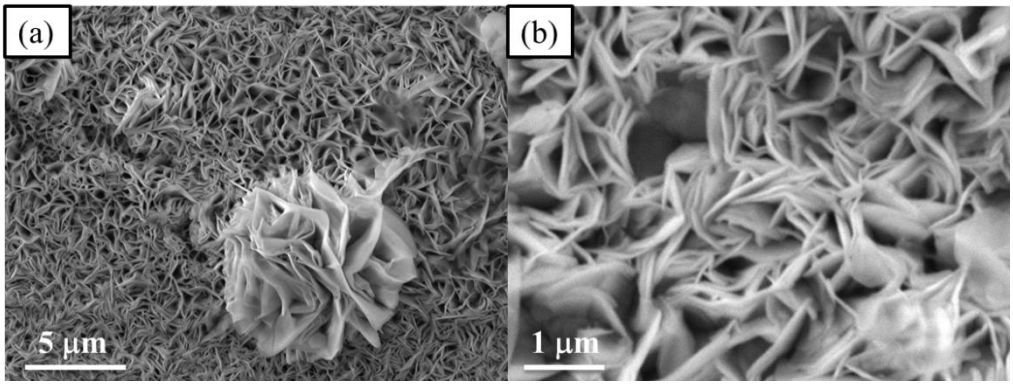

Figure 1 (a) SEM micrographs of LDH coatings form on A380/SiC/10p composite and (b) detail of LDH flakes.

Regarding the corrosion results, potentiodynamic test after 24 h immersion and EIS measurements up to 7 days of immersion in NaCl 0.05 M revealed that both LDH and LDH-VO_3 improve the corrosion resistance of the material, although the improvement is much more evident in case of LDH-VO_3, given the anti-corrosion properties of VO_3^- anions. The self-healing properties of the coatings were studied by SVET after 24 h of immersion in NaCl 0.05M and, although no self-healing effect was observed, the corrosion resistance was greatly improved with the surface treatment. Probably, longer immersion times are required to observe the self-healing behaviour. This will be carried out in the following weeks in order to complete the investigation.

These results evidence that LDH coatings on aluminium based composites improve the corrosion protection performance of this type of materials; however, this improvement would be probably more significant if a homogeneous coating was obtained, since on SiC_p-rich areas the formation of LDH flakes was impeded by the lack of aluminium ions required to form the hydroxide layers. The optimization could be achieved modifying the synthesis method using a co-precipitation of Zn-Al-LDH with an external source of Al cations. This approach could be developed in future collaborations.

Finally, I would like to express my gratitude to the European Federation of Corrosion not only for giving me the opportunity to work with such an exceptional research group, but for recognising my work and aspirations at an international level, which boosts the confident of any young researcher.