Cr(VI)-free Pre-treatment and Coating Technology for Aerospace Applications

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For many decades, hexavalent chromium, Cr(VI), based compounds have been the key component in effective surface treatment processes, such as anodizing, and corrosion protection of aluminium aircraft structures. Unfortunately, these Cr(VI)-based chemistries are recognized to be toxic and carcinogenic and to comply with the new international health and safety regulations, the Cr(VI) era will soon have to come to an end.

Anodizing aluminium in acid electrolytes produces a self-ordered nanoporous oxide layer. Although different acids can be used to create this type of structure, the excellent adhesion and corrosion resistance that is currently achieved by the complete Cr(VI)-based process is not easily duplicated. This has lead to a large amount of studies in search for suitable replacements. One part of the presentation will comprise an overview of the relation between anodic oxide properties and interfacial bonding strength and durability, as affected by systematic variation of different parameters such as the electrolyte, the anodizing conditions and organic resin chemistry. It is well known that two fundamental characteristics are critical for bonding: the oxide chemistry and morphology. To separate between these two contributions, either adhesively bonded barrier-type or porous-type oxide specimens were studied. These results provide the first experimental validation and quantification of the cooperative action of physio-chemical and mechanical adhesion mechanisms on nanoporous anodic oxides based on Cr(VI)-free electrolytes.

Furthermore, many different compounds have been studied to find a non-toxic and environmentally friendly alternative for Cr(VI)-based corrosion inhibitors in active protective coatings for aerospace industry by rapid screening techniques and more in-depth mechanistic studies. Amongst other approaches, over the recent years lithium-salts have become of interest as a potential alternative for chromates as leaching corrosion inhibitor in organic coatings and demonstrated active protective properties on AA2024-T3. Further insights into the active protective mechanism of the lithium-based inhibitor coating technology will be presented. The results show the mechanistically different behavior of the lithium inhibitor doped coating technology compared to other inhibitors and demonstrate the key characteristics that are essential for active protective coatings, providing fast leaching, effective inhibition and formation of an irreversible protective layer in the defect area.