Visualizing Corrosion Mechanisms on Galvanized Steel

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The understanding of corrosion mechanism is essential for the interpretation of corrosions tests as well as for the further development of materials with long lifetimes in corrosive environments. This work presents a simple approach using a universal pH-indicator-gel for visualisation of surface pH-values which allows the identification of anodic and cathodic regions to explain corrosion mechanisms and phenomena. In addition, these findings are compared with the corrosion potential as measured by scanning Kelvin probe (SKP).

In particular, durable adhesive joints are demanded in construction and automotive industry. Therefore, lap shear specimens of bare Zn-Al-Mg hot-dip galvanized steel were adhesively bonded according to DIN EN 1465 with a commercial epoxy adhesive. The samples were corroded in a NaCl cataplasma test, in which the middle part of the specimens were wrapped in cotton, then 5% NaCl solution was added, followed by ageing in a closed PP bag for 3 weeks at 70°C. A pH-gel was prepared by heating a solution of wide range indicator with agar-agar and poured over the samples after corrosion and tensile testing, and in response it changed its colour according to the pH value of the corrosion products. In addition, the samples were investigated scanning electron microscope (SEM) coupled with energy dispersive X-ray analysis (EDX).

The pH-gel showed alkaline areas (purple) on the outer part and acidic areas (red-orange) on the middle part of the lap shear specimens. In combination with SKP mappings this verified a separation of anode and cathode in the NaCl cataplasma test, whereas the alkaline regions were dominated by cathodic oxygen reduction and the acidic ones by anodic metal dissolution. In addition, SEM/EDX analysis showed different layers of corrosion products which were sodium doped in alkaline regions and chloride doped in acidic regions of the sample. This might be a result of ion migration in the electric field. Overall, chloride anions migrated towards the alkaline region and sodium cations migrated towards the acidic region. Thus, this work validates the pH-indicator-gel as a simple tool for the visualisation of surface pH-values and corrosion mechanisms.