Corrosion Protection by Conducting Polymers - Controlled Inhibitor Release (CIR) Mechanism

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Until recently, the anodic protection (AP) model has dominated discussion of the mechanism by which inherently conducting polymer (ICP) coatings inhibit corrosion. DeBerry demonstrated the AP mechanism for the material/environment combination of stainless steel in dilute sulfuric acid, where anodic protection clearly occurs (1). However, the AP mechanism seems impossible for mild steel or aluminum in chloride environments, and particularly for mild steel in a dilute hydrochloric acid environment. The demonstration by Kinlen et al. (2) that the anion dopant in an ICP coating plays an important role for corrosion protection of mild steel in acid chloride provides an important clue for the controlled inhibitor release (CIR) mechanism as described in this paper. Additional motivation for this model comes from the work of Pineaud and Reynolds who showed how ICPs can provide for controlled release of model biophysiological anions (3).

The CIR model suggests that the oxidized and doped form of certain ICPs, such as polyaniline (PANI), when applied to a base metal substrate, release the anion dopant upon reduction resulting from coupling to the base metal through defects in the coating. Figure 1 shows this mechanism schematically. Hence, defects in the coating drive release of the inhibitor and constitutes a 'smart' corrosion inhibiting coating. Kinlen and Silverman (4) showed that the release of organo-phosphonates by a PANI coating on steel in an acid chloride environment dramatically improves the corrosion protection of the substrate. Likewise, Toressi and coworkers (5) maintain that a PANI/acrylic blend promoted corrosion inhibition of steel by the release of the camphor sulfonate anion dopant.

Recently, we have doped a PANI material, with a particular corrosion-inhibiting anion. A local region of the coating on AA 2024-T3 was doped with the inhibiting anion and exposed to a 48-hour salt fog environment (ASTM B117). Before exposure, a scribe was drawn through both the doped and un-doped region of the coated material. After 48 hours, the portion of the scribe that was drawn through the doped region showed dramatically less corrosion as compared to that portion of the scribe that traversed the un-doped region. Recent developments of releasable inhibitor-containing ICP coatings will be described in another paper in this symposium.

Experiments have been initiated using a Cu RDE to determine the effectiveness of the release of inhibitors from ICP coatings. These results will be presented.

An alternative path by which the CIR mechanism can operate entails build up of alkali at the surface of conducting PANI as cathodic reduction of oxygen occurs. The alkaline build-up will also drive release of any inhibiting anion dopant.

The implications of the CIR model are as follows:

- The AP model may apply only to cases where a metal can be anodically protected.
- Future development of protective ICP coatings must focus on the dopant.
- Selection of an anion dopant for protective ICP coatings is critical for corrosion protection and may be alloy sensitive.
- The CIR model suggest that protective ICP coatings can be 'smart' in that they release the inhibiting anions only in the presence of a defect that leads to galvanic reduction of the ICP or alkalinization of the ICP.
- Release of other protective species such as biocides and fungicides by ICPs might also be considered.

References

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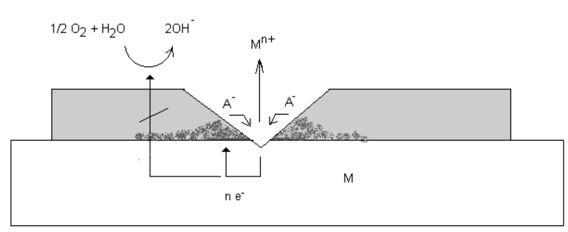

Figure 1. Schematic illustrating the corrosion inhibitor release (CIR) mechanism.