Molybdate Coatings for Protecting Aluminum Against Corrosion

These coatings show promise, but further development is needed.

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Conversion coatings that comprise mixtures of molybdates and several additives have been subjected to a variety of tests to evaluate their effectiveness in protecting aluminum and alloys of aluminum against corrosion. Molybdate conversion coatings are under consideration as replacements for chromate conversion coatings, which have been used for more than 70 years. The chromate coatings are highly effective in protecting aluminum and its alloys against corrosion but are also toxic and carcinogenic. Hexavalent molybdenum and, hence, molybdates containing hexavalent molybdenum, have received attention recently as replacements for chromates because molybdates mimic chromates in a variety of applications but exhibit significantly lower toxicity.

The tests were performed on six proprietary formulations of molybdate conversion coatings, denoted formulations A through F, on panels of aluminum alloy 2024-T3. A bare alloy panel was also included in the tests. The tests included electrochemical impedance spectroscopy (EIS), measurements of corrosion potentials, scanning electron microscopy (SEM) with energy-dispersive spectroscopy (EDS), and x-ray photoelectron spectroscopy (XPS).

The corrosion-potential and EIS measurement data were gathered at several intervals during immersion in an aqueous NaCl solution for a total time of two weeks. Nyquist and Bode plots of the data were obtained. The corrosion potentials of the conversion-coated panels were found to increase during the first 24 hours and thereafter subside slightly, approaching steady values. The corrosion-potential measurements indicated that three of the proprietary formulations exerted a protective effect on the alloy. The EIS data on all the conversion-coated alloy specimens were characterized by impedance magnitudes greater than those of the bare alloy specimen at all frequencies and times for which measurements were performed (see figure). This characteristic indicates that the molybdate conversion coatings contribute some resistance to corrosion.

SEM images showed cracks in the coatings and cubic crystals believed to be calcium carbonate. EDS revealed high concentrations of aluminum, oxygen, and calcium but did not reveal any molybdenum on the panels. XPS indicated the presence of less than 0.01 atomic percent molybdenum on the surfaces of the coatings.

Overall, the test data have been interpreted as signifying that molybdate conversion coatings show promise for protecting aluminum and its alloys against corrosion, but that further development will be necessary to attain protection equal to that afforded by chromate conversion coatings.

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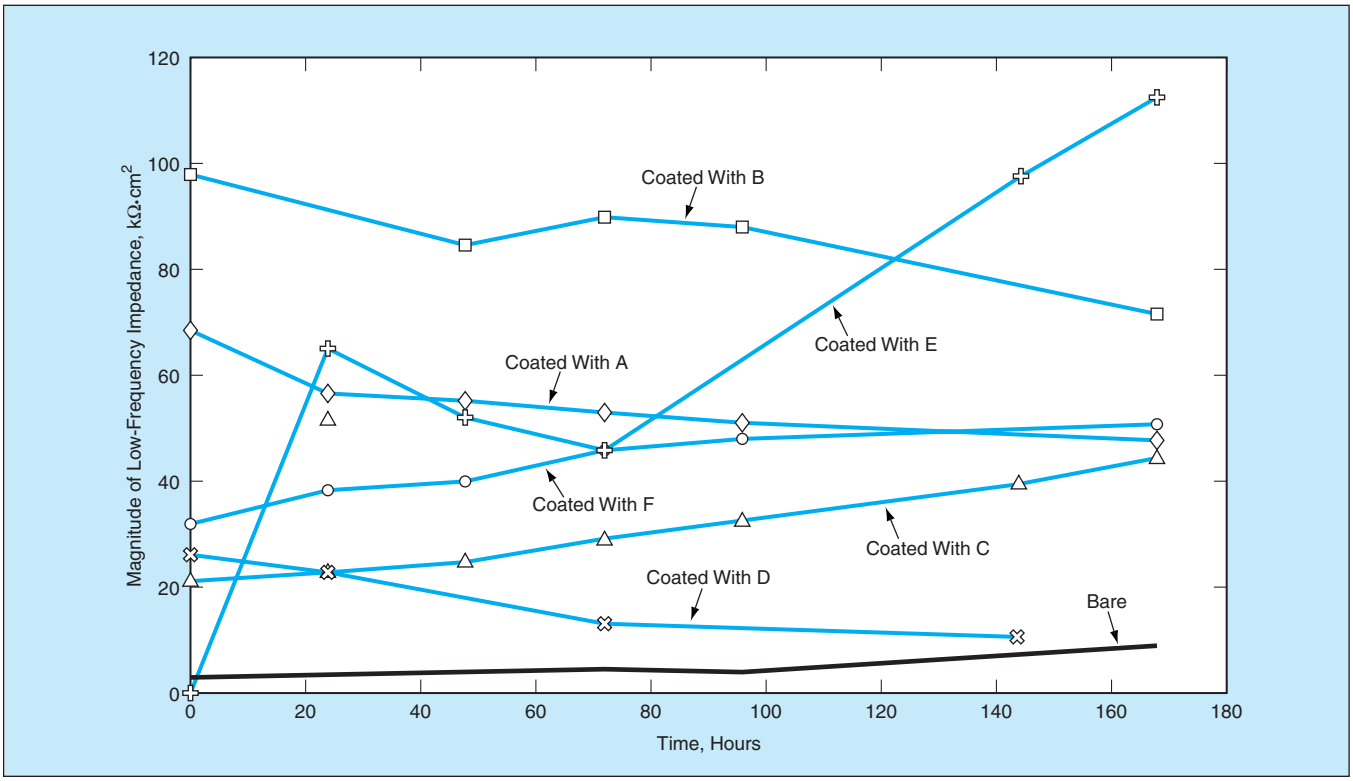

The **Magnitude of Impedance** at a frequency of 0.05 Hz was measured on each of the seven specimens as a function of immersion time.