The Effect of Additives in Hybrid Zr-based Chemical Conversion Coating on the Surface Morphology, Chemical Compositions and Corrosion Resistance

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Introduction

Conversion coating of metal substrates is an important technology for a wide range of industrial applications to prevent corrosion and to enhance adhesion of decorative paints to treated metal parts. To avoid using conventional toxic coatings, a zirconium-based coatings have been developed as a new greener conversion coating technology. In this work, we studied the effect of additives’ concentration on the formation of zirconium-based coatings containing hybrid organic-inorganic additives, which helped advance our knowledge concerning organic-inorganic additives in the surface conversion coating for the development of future green technology.

Experimental setup

Hybrid coating thickness

< Cold rolled steel >

Surface morphology

- The surface clusters increased with the increasing of Cu2+ concentration.
- Cu00 sample showed agglomerations on the surface without clusters.

Corrosion performance

- The test was done with a resting period to stabilize the open circuit potential.
- Cu40 sample showed a better corrosion resistance.

Result and Discussion

Cu compounds in the coating - X-ray absorption near edge structure

< Fe thin film on Si substrate >

Surface morphology

- Larger clusters with less density formed on the coatings of Fe thin films. Defects may influence the nucleation and growth rates of the clusters.
- Cu clusters may be the sites for further Cu2+ reduction.

Hybrid coating thickness

- Voids were formed in the Fe layer.
- The thickness of the coating is about 20 nm. It requires TEM analysis to quantify thickness accurately.

CuX X is the Cu ion concentration in ppm in the coating solution

Conclusion

- Based on the surface SEM analysis, the hybrid coatings with different Cu2+ concentrations were prepared on both cold rolled steel and Fe thin film substrate.
- From the cross-sectional FIB-SEM analysis, with the increasing of the Cu2+, the thickness of the coatings does not change obviously.
- From synchrotron XANES analysis, with the increasing of the Cu2+, the ratio of the Cu and CuO in the coatings increases, but the ratio of CuO decreases.
- The electrochemical tests show the coatings with higher Cu2+ concentrations (40 ppm) has a better corrosion resistance.

Future work

- Post characterization (Synchrotron X-ray absorption, XPS, TEM, Raman) on the coatings after the potentiodynamic test, especially with chemical and morphological analysis will be utilized to further correlate the corrosion behaviors with the Cu concentration and the morphology of the coatings.

Reference

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[5] This research used resources on Beamline for Materials Measurements (BM), 6-BM of the National Synchrotron Light Source II, a U.S. Department of Energy (DOE) office of Science User Facility operated by the DOE office of Science by Brookhaven National Laboratory under Contract DE-SC0012704.
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Acknowledgment

- The intensity of pre-edge increased, and the intensity of post-edge decreased as the Cu ion concentration increased in the solution.

Linear combination fitting

- Linear combination fitting showed more Cu, CuO and less Cu2O, as the Cu ion concentration increased in the solution.

Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Condition</th>
<th>Uncoated</th>
<th>Cu10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (eV)</td>
<td>Uncoated-1</td>
<td>-0.563 V</td>
<td>-0.557 V</td>
</tr>
<tr>
<td></td>
<td>Cu05-1</td>
<td>-0.717 V</td>
<td>-0.627 V</td>
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<tr>
<td></td>
<td>Cu10-1</td>
<td>10 μA/cm²</td>
<td>4.38 μA/cm²</td>
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<tr>
<td></td>
<td>Cu20-1</td>
<td>0.402 μA/cm²</td>
<td>2.23 μA/cm²</td>
</tr>
</tbody>
</table>

- The rest changed the Ecorr and Δcorr of the Cu10 coating less than the uncoated one.