New technique for investigating the action of molybdate on carbon steel

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In the search for corrosion-resistant treatments for carbon steel that are non-toxic, A*STAR researchers have developed a technique for investigating the effectiveness of a corrosion inhibitor that is safer and environmentally friendly.

Carbon steel, an alloy made from iron and carbon, is the single largest class of alloys in use today. It's used to make a range of products from fences and springs to steel wires and pipelines, and for structural support in buildings, bridges, as well as nuclear power and fossil fuel power plants.

The corrosion of carbon steel, however, is a huge cost to industry and is of enormous practical importance. One common corrosion inhibitor used in the construction industry, calcium nitrite, is quite toxic to humans, impairing the ability of red blood cells to transport oxygen.

Seeking safer corrosion inhibitors, Yong Teck Tan and colleagues from the National University of Singapore and Singapore Institute of Manufacturing Technology investigated molybdate as a potential alternative and developed a technique to determine its suitability.

Molybdate is non-toxic, and protects the carbon steel from corrosion by competitive adsorption against chloride on the passive film surface, and, in the presence of calcium cations, can also deposit a layer of calcium molybdate.

"Our aim was to first determine the suitability of molybdate as a corrosion inhibitor for carbon steel in alkaline environments, and then to investigate its effect on the passivation of carbon steel," says Tan.

"Previous studies using electrochemical techniques have focused on corrosion inhibition efficiency at a particular time, which provides a snapshot of the level of corrosion at that instant," explains Tan. "Depending on whether it was assessed over short or long timescales, different conclusions were drawn."

So the research team took a longer look. They used an electrochemical method for estimating the extent of corrosion over the entire duration of the investigation, and could assess the overall effectiveness of molybdate.

"Even though molybdate resulted in a slightly higher passive current in the later stages, faster passivation in the early stages resulted in a lower overall level of corrosion," says Tan.

The researchers found that incomplete coverage of the carbon steel by the calcium molybdate led to slightly higher corrosion rates compared with untreated surfaces. By controlling the composition of the molybdate solution, however, the calcium molybdate film covered the entire surface, resulting in improved corrosion resistance.

"Overall, molybdate proved to be an effective corrosion inhibitor," says Tan. "We will now explore its effectiveness in solutions containing other ions."

More information: Yong Teck Tan et al. Effect of Molybdate on the Passivation of Carbon Steel in Alkaline Solutions under Open-Circuit Conditions, *Journal of The Electrochemical Society* (2016). DOI: 10.1149/2.0651610jes

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