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Study of Pitting Corrosion of Stainless Steel by MOS under Simulated Dynamic Clean-in-Place Conditions

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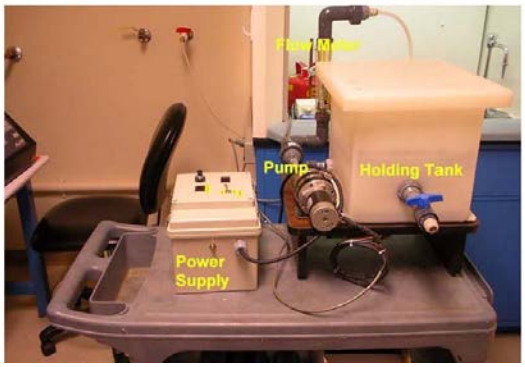
Summary

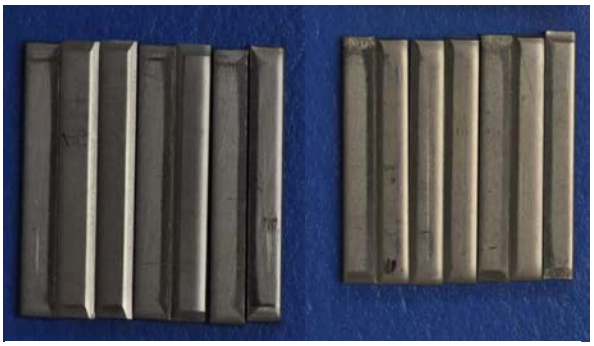
MIOX Mixed Oxidant Solution (MOS) is a more effective cleaner and sanitizer for Clean-in-Place (CIP) applications. As part of MIOX's application research to quantify MOS effectiveness, extensive studies were performed to demonstrate that MOS will not cause harm to production equipment infrastructure when used in CIP applications. There are many different types of corrosion studies documented by ASTM standards, and this briefing describes just one type of corrosion study specifically designed to simulate the CIP environment that stainless steel surfaces are exposed to over an extended period of time. While this precise method is not described by ASTM, ASTM methods G1, G31, and G46 were used to help design these tests. Experiments and analyses with high resolution electron microscopy to detect sub-microscopic pits were conducted entirely by a third party laboratory (Analytical Solutions Inc., Albuquerque, NM).

Procedure

Polished coupons of both stainless steel 304 and stainless steel 316 were placed inside ¼" diameter PVC tubes. The PVC tubes were submerged in a tank containing MOS at the target free available chlorine (FAC) concentration of 70 mg/L. MOS was then circulated through the tube system at a flow velocity of ~ 6 ft/s, mimicking the typical fluid flow conditions present during CIP. The coupons were exposed to MOS continuously for a period of 8 weeks. This time represents just less than 5,400 15-minute CIP cycles. MOS was changed out twice a week during this test to ensure the solutions remained fresh throughout the study. The chemical properties of the MOS (including FAC concentration and chloride ion concentration) were measured each time MOS was exchanged. In these tests, the average FAC concentration of the MOS was 74 ppm (range of 68 – 81 ppm) and the average chloride ion concentration was 254 ppm (range of 240 – 260 ppm).



Photograph showing the test apparatus used to simulate flow in a CIP system.



Photographs showing (left) SS 304 and (right) SS 316 coupons used in this study.

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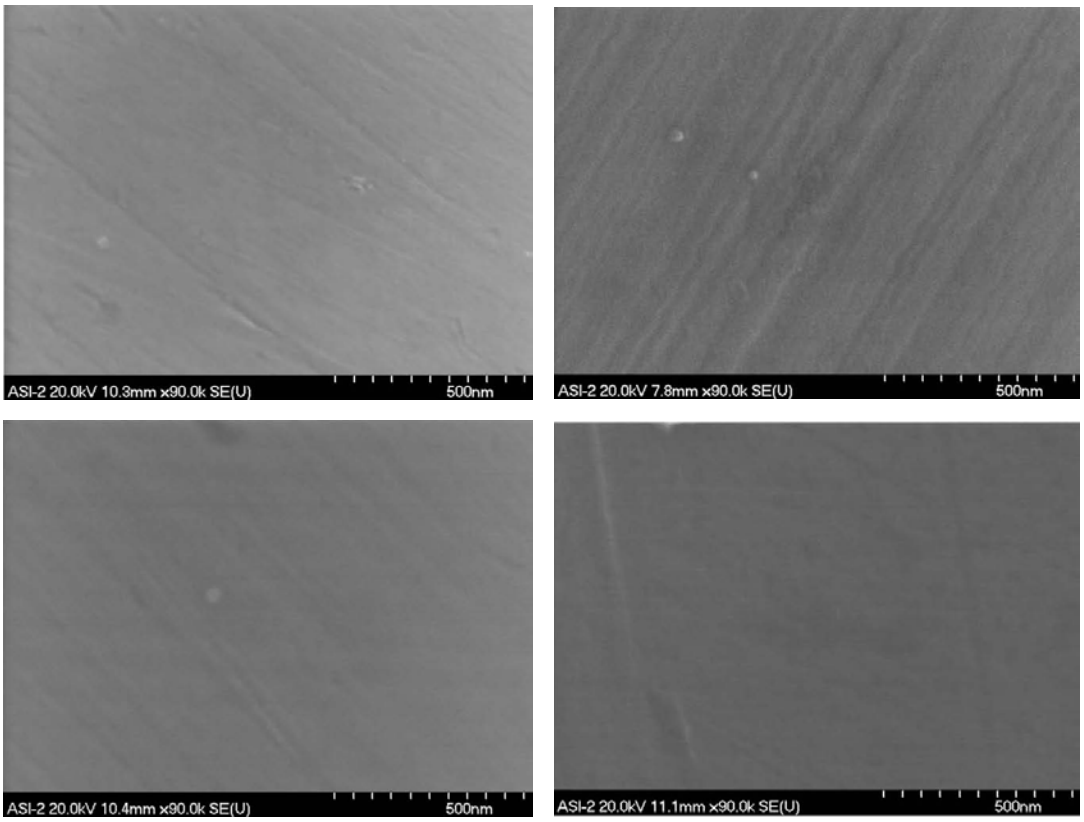
Coupons were removed periodically and examined with Field Emission Electron Microscopy (FESEM). FESEM can easily detect sub-microscopic pits that may escape detection using optical microscopy.

Results

The micrographs of stainless steel 304 obtained during this study shown below are representative of all the data obtained. **At no point during any of these tests was pitting observed using either optical or electron microscopic investigation**. Since FESEM has the ability to resolve surface features on the order of 10 nm (10 nm = 0.01 μm), these data conclusively demonstrate that, under typical CIP conditions, pitting corrosion of stainless steels is not expected to occur. Similar results, not shown here, were observed for stainless steel 316.



FESEM micrographs of Stainless Steel 304 coupons (top left) after polishing and before MOS exposure and after being exposed to MOS for (top right) two, (bottom left) three, and (bottom right) six weeks.

MIOX's applied research team has also conducted numerous studies on the corrosivity of aqueous chlorine solutions towards metals under static exposure conditions. To learn more about these studies, please visit our website, www.miox.com.

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