It can take up to 8 hours to reach the desired amount of application onto the sample surface. One method to replace the salt spray method is to use a salt spray and exposed to corrosive gas and high temperatures to perform hot corrosion testing on small alloy samples. In this test, to deter hot corrosion, Rolls-Royce performs hot degradation called hot corrosion. This occurs when pollutants in the air, such as Na and S, which cause accelerated degradation, such as Na sulfate (Na\(_2\)SO\(_4\)) and D-xylose, are mixed together with a high-speed mixer, producing a flexible PVPX sheet with well-distributed Na\(_2\)SO\(_4\).

**Polymer Sheet Properties**

PVP sheets cast with only water and Na\(_2\)SO\(_4\) were found to be brittle and inhomogeneous. To remedy this issue, D-xylose, a plasticizer and compatibilizer, was added to the system. A study on the effect of the volume percent of D-xylose was performed, and it was found that optimal properties were obtained at a ratio of volume percent PVP to D-xylose of 3:1, producing a flexible PVPX sheet with well-distributed Na\(_2\)SO\(_4\).

**Polymer Decomposition**

To better understand what was happening during polymer degradation, a PVPX sample was heated up to 700°C at a rate of 10°C per minute, every 100°C, mass loss was measured and photos were taken. TGA data was collected and compared with the mass loss data. Ideally, once the temperature reaches 700°C, the PVPX sheet will be fully degraded and only the Na\(_2\)SO\(_4\) will be left on the substrate, distributed evenly on the surface.

**Hot Corrosion Test**

To investigate what materials in the polymer sheet caused uneven hot corrosion, Ni-allyl samples were prepared using the conventional salt spray method, the PVPX sheet method, pure D-xylose and neat PVP. Hot corrosion tests were performed at 700°C for 50 hours to investigate Type II hot corrosion.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Experimental Conc. Na(_2)SO(_4) (mg/cm(^2)) from Na test</th>
<th>Experimental Conc. Na(_2)SO(_4) (mg/cm(^2)) from S test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0818</td>
<td>0.0941</td>
</tr>
<tr>
<td>2</td>
<td>0.0787</td>
<td>0.1074</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0803</td>
<td>0.1008</td>
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</table>

To determine if the amount of Na\(_2\)SO\(_4\) was at the desired 0.075 mg/cm\(^2\) concentration, levels of Na and S were determined for two representative samples. The amount of S was determined using ion chromatography with Parr bomb preparation. The amount of Na was determined by ICP-MS with standard mineral acid digestion. Mean values had 7% and 34% error for Na and S tests, respectively.

**Conclusions & Future Work**

We were successful in creating a pliable PVPX sheet that degrades when heated to 700°C, leaving Na\(_2\)SO\(_4\) on the surface. However, further characterization of the remaining Na\(_2\)SO\(_4\) needs to be done to verify concentrations in different locations. Additionally, air bubbles that formed between the polymer sheet and substrate caused uneven hot corrosion. To have well-distributed Na\(_2\)SO\(_4\) on the surface, further study of the polymer decomposition is needed to prevent the bubbles from forming.

The PVPX sheet method has potential to replace the conventional salt application method for hot corrosion. Once it has been verified that the PVPX method produces the same hot corrosion results as the salt spray method, the method is ready for use in hot corrosion testing.

**Development of Na\(_2\)SO\(_4\) Application Technique for Hot Corrosion Testing**

Andrew Kim, Garrett Linville, Bo Pang, Xin Li Phuah and Hannah Woods

Faculty Advisor: Prof. Rodney Trice

Industrial Sponsors: Dr. Stephanie Gong and Linda Cook

This work is sponsored by Rolls-Royce North America, Indianapolis, IN

**Project Background**

Rolls-Royce is a leading manufacturer of turbine engines, which are a vital component in aircraft. In this study, these engines are exposed to fuel contaminants and pollutants in the air, such as Na and S, which cause accelerated degradation called hot corrosion. This causes a decline in mechanical properties that can be both costly and dangerous. To test the ability of the alloy to deter hot corrosion, Rolls-Royce performs hot corrosion testing on small alloy samples. In this test, Na\(_2\)SO\(_4\) contaminants are distributed on the alloy surface and exposed to corrosive gas and high temperatures to simulate hot corrosion. The current method for salt application onto the sample surface is to use a salt spray. It can take up to 8 hours to reach the desired amount of salt, even for a trained experimentalist.

**Experimental Procedure**

To make the polymer sheets, polyvinylpyrrolidone (PVP), water, and sodium sulfate (Na\(_2\)SO\(_4\)) were mixed together with a high-speed mixer. D-Xylose was added to the system. A study on the effect of the volume percent of D-Xylose was performed, and it was found that optimal properties were obtained at a ratio of volume percent PVP to D-Xylose of 3:1, producing a flexible PVPX sheet with well-distributed Na\(_2\)SO\(_4\).

**Polymer Sheet Properties**

To determine if the amount of Na\(_2\)SO\(_4\) was at the desired 0.075 mg/cm\(^2\) concentration, levels of Na and S were determined for two representative samples. The amount of S was determined using ion chromatography with Parr bomb preparation. The amount of Na was determined by ICP-MS with standard mineral acid digestion. Mean values had 7% and 34% error for Na and S tests, respectively.

**Table 1: Experimental concentrations of Na\(_2\)SO\(_4\) in cast PVPX sheets of 0.075 mg/cm\(^2\) concentration.**

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