

Development of Na_2SO_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

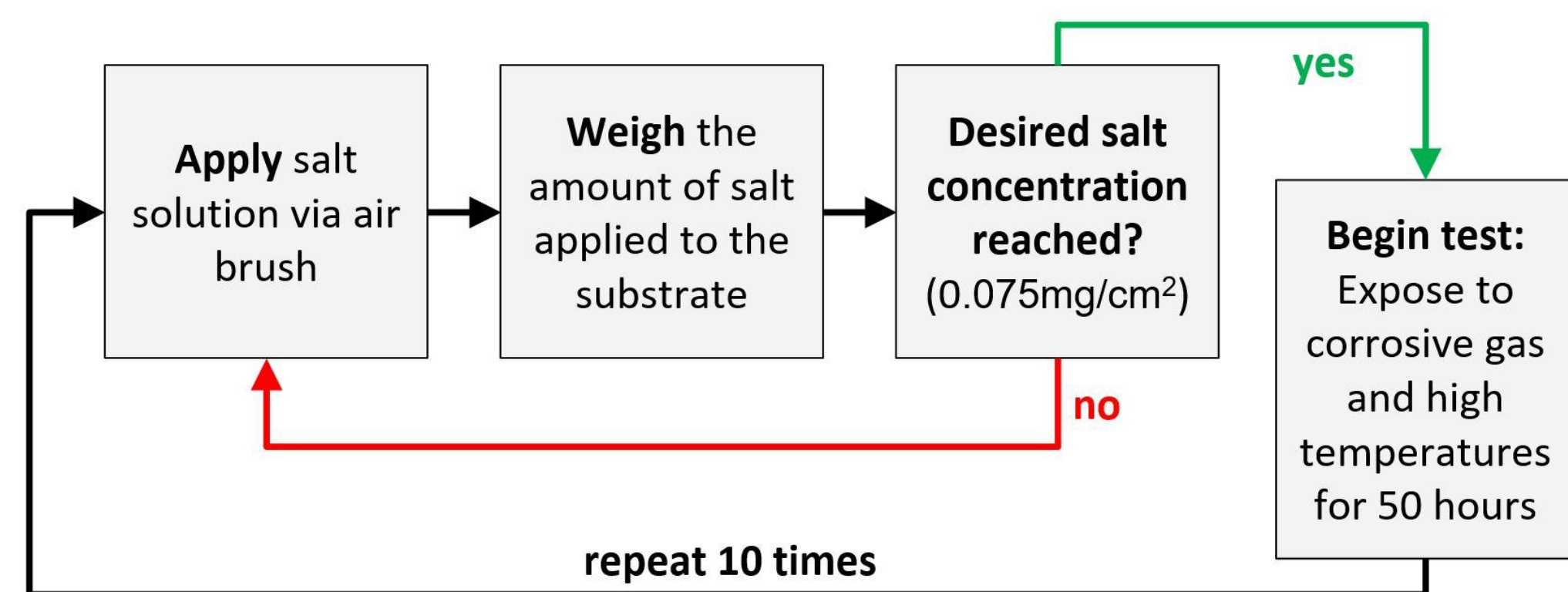
Rolls-Royce develops coatings to resist corrosion from Na_2SO_4 on their superalloy turbine blades. The preparation of samples for the hot corrosion testing can take upwards of 8 hours. There is a need to increase the efficiency of sample preparation to perform hot corrosion tests at a faster rate. Na_2SO_4 was dissolved in water along with PVP and D-xylose plasticizer and cast into a sheet, called a PVPX sheet. The sheet was cut to the sample size and placed on the substrate. Concentrations of 0.0803 mg/cm² from Na analysis and 0.1008 mg/cm² from S analysis were obtained with 7% and 34% error, respectively, from the goal concentration of 0.075 mg/cm² Na_2SO_4 . Na_2SO_4 remained on the surface after the polymer decomposed but was unevenly distributed due to bubbles forming as the polymer melted. For the PVPX method to feasibly replace the salt spray method, even distribution of Na_2SO_4 needs to be obtained.

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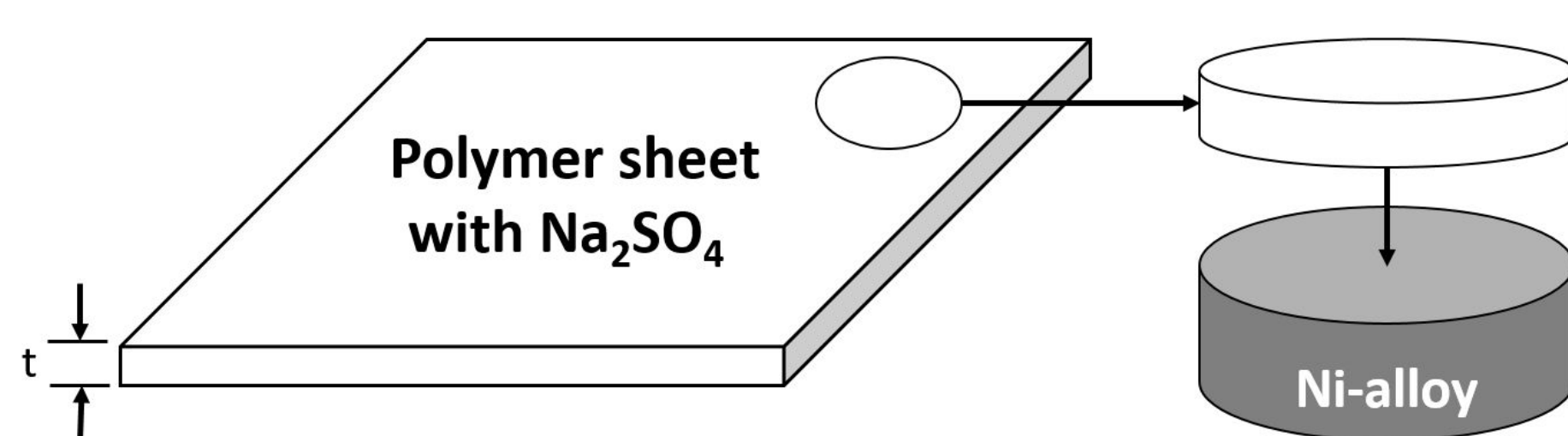


Project Background

Rolls-Royce is a leading manufacturer of turbine engines, which are a vital component in aircraft. When in use, 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_2SO_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.



Furthermore, there is no guarantee that the salt on the surface is evenly distributed. In order to reduce preparation time and to ensure an even salt distribution, we replaced the salt spray method with a novel polymer method. A polymer sheet of known concentration per unit area is placed directly on the sample surface. The polymer can be easily cut to a desired shape and will reduce the sample preparation time from approximately 8 hours to only a few minutes.



Polymer Sheet Properties

PVP sheets cast with only water and Na_2SO_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 3:1, producing a flexible PVPX sheet with well-distributed Na_2SO_4 .

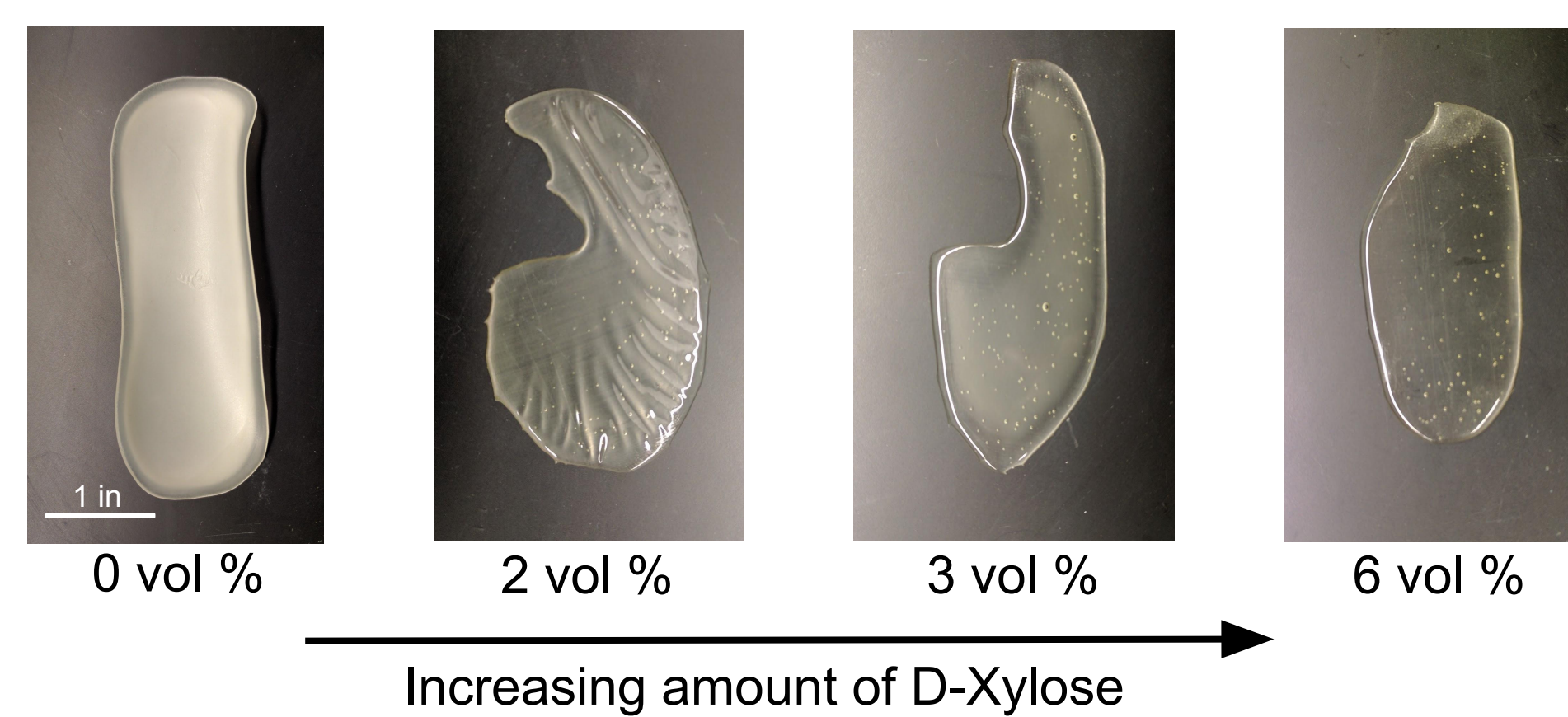


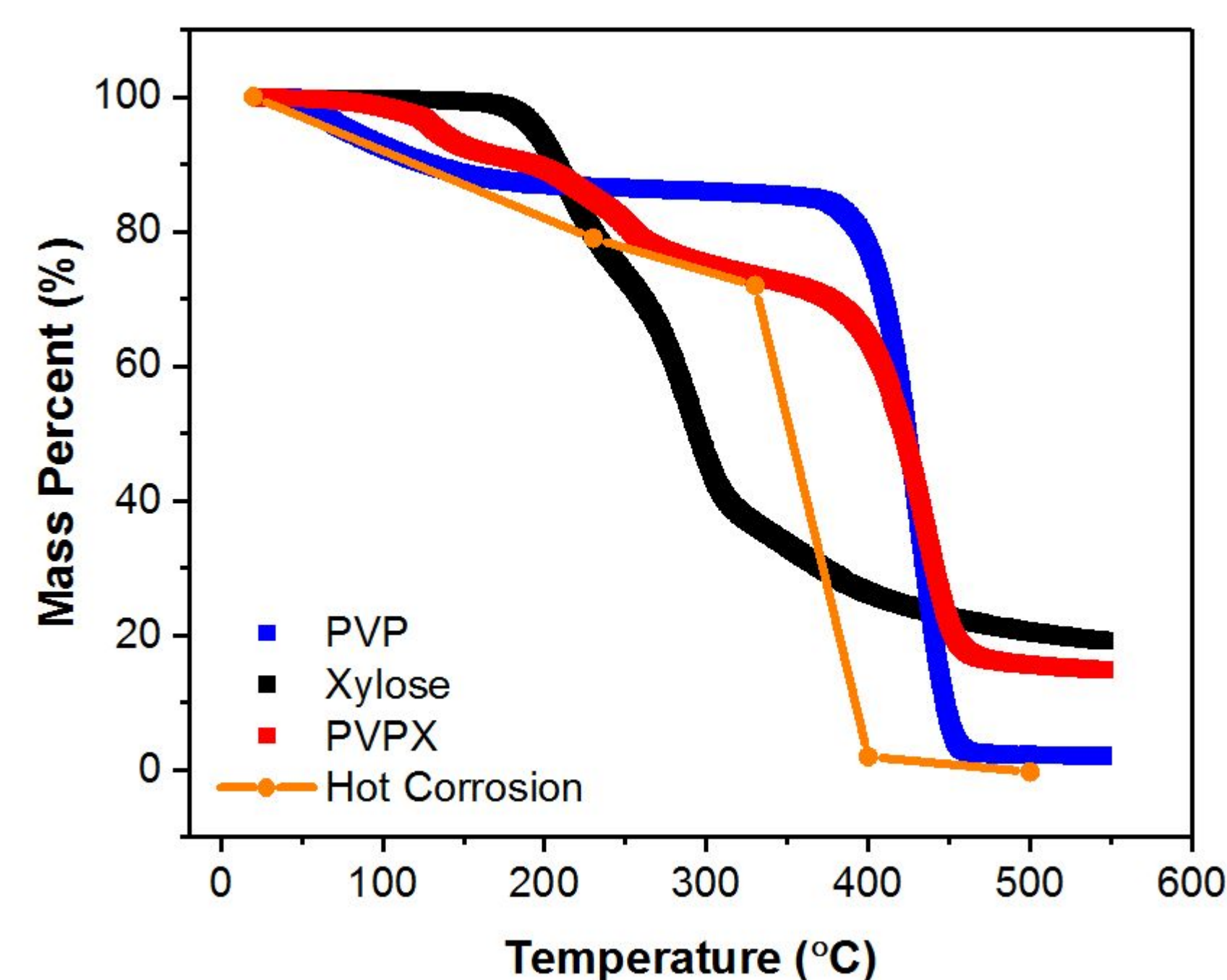
Table 1: Experimental concentrations of Na_2SO_4 in cast PVPX sheets of 0.075 mg/cm² concentration.

Sample	Experimental Conc. Na_2SO_4 (mg/cm ²) from Na test	Experimental Conc. Na_2SO_4 (mg/cm ²) from S test
1	0.0818	0.0941
2	0.0787	0.1074
Mean	0.0803	0.1008

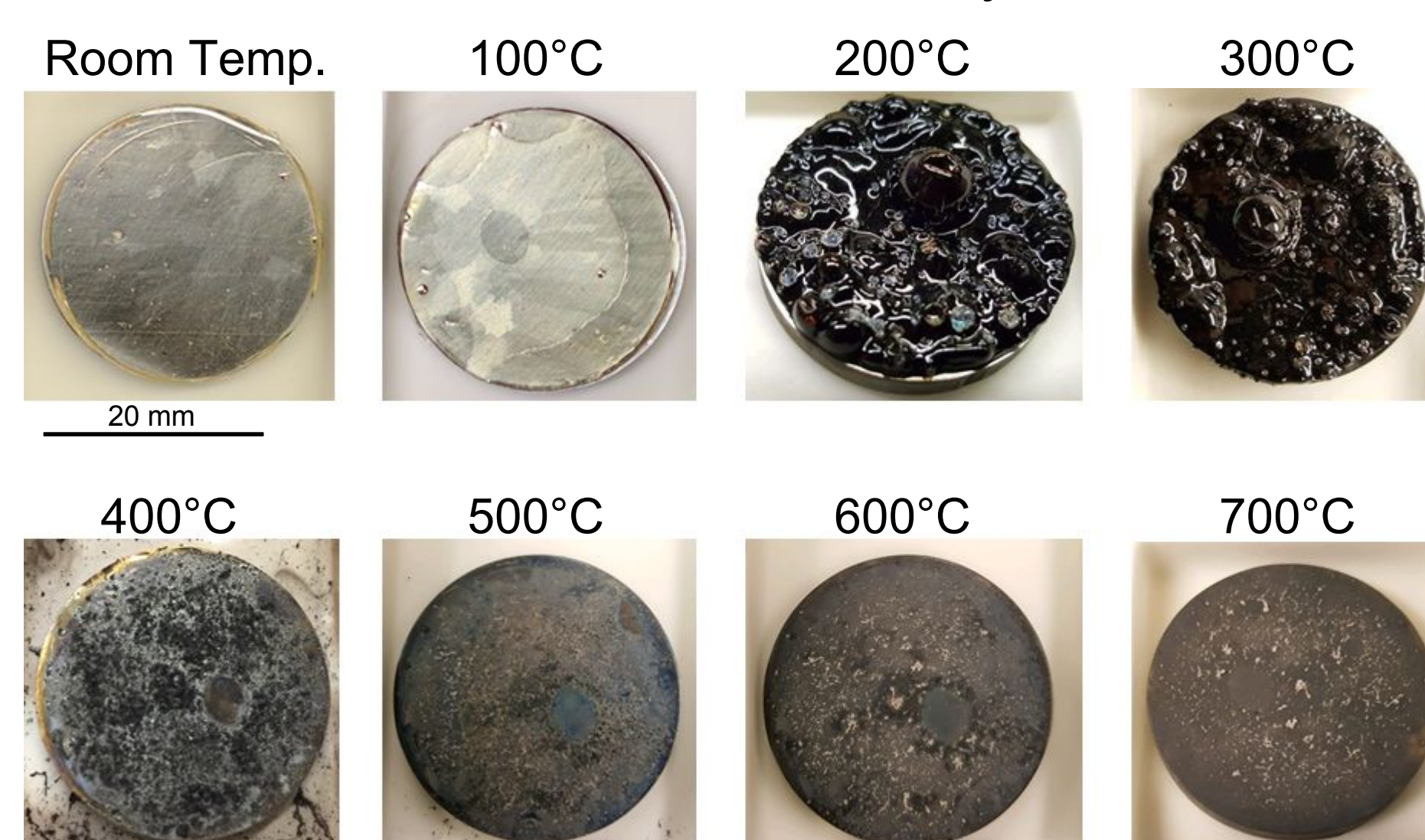
To determine if the amount of Na_2SO_4 was at the desired 0.075 mg/cm² concentration, levels of Na and S were determined for two representative samples. The amount of S was determined using ion chromatography with Parr bomb preparation. The amount of Na was determined by ICP-MS with standard mineral acid digestion. Mean values had 7% and 34% error for Na and S tests, respectively.

Polymer Decomposition

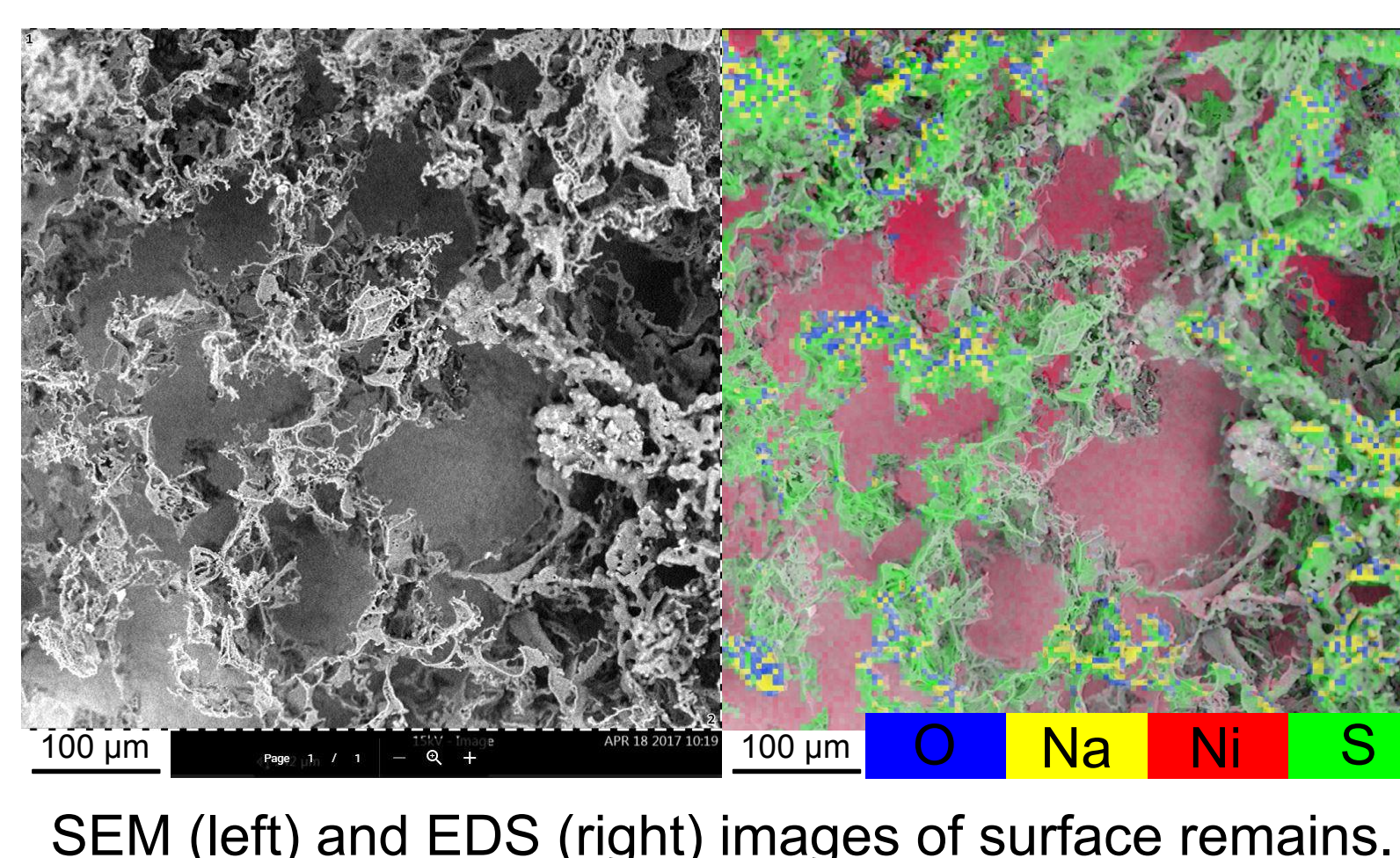
To better understand what was happening during polymer degradation, a PVPX sample was heated up to 700°C at a rate of 10°C per minute, every 100°C, mass loss was measured and photos were taken. TGA data was collected and compared with the mass loss data.



Ideally, once the temperature reaches 700°C, the PVPX sheet will be fully degraded and only the Na_2SO_4 will be left on the substrate, distributed evenly on the surface.

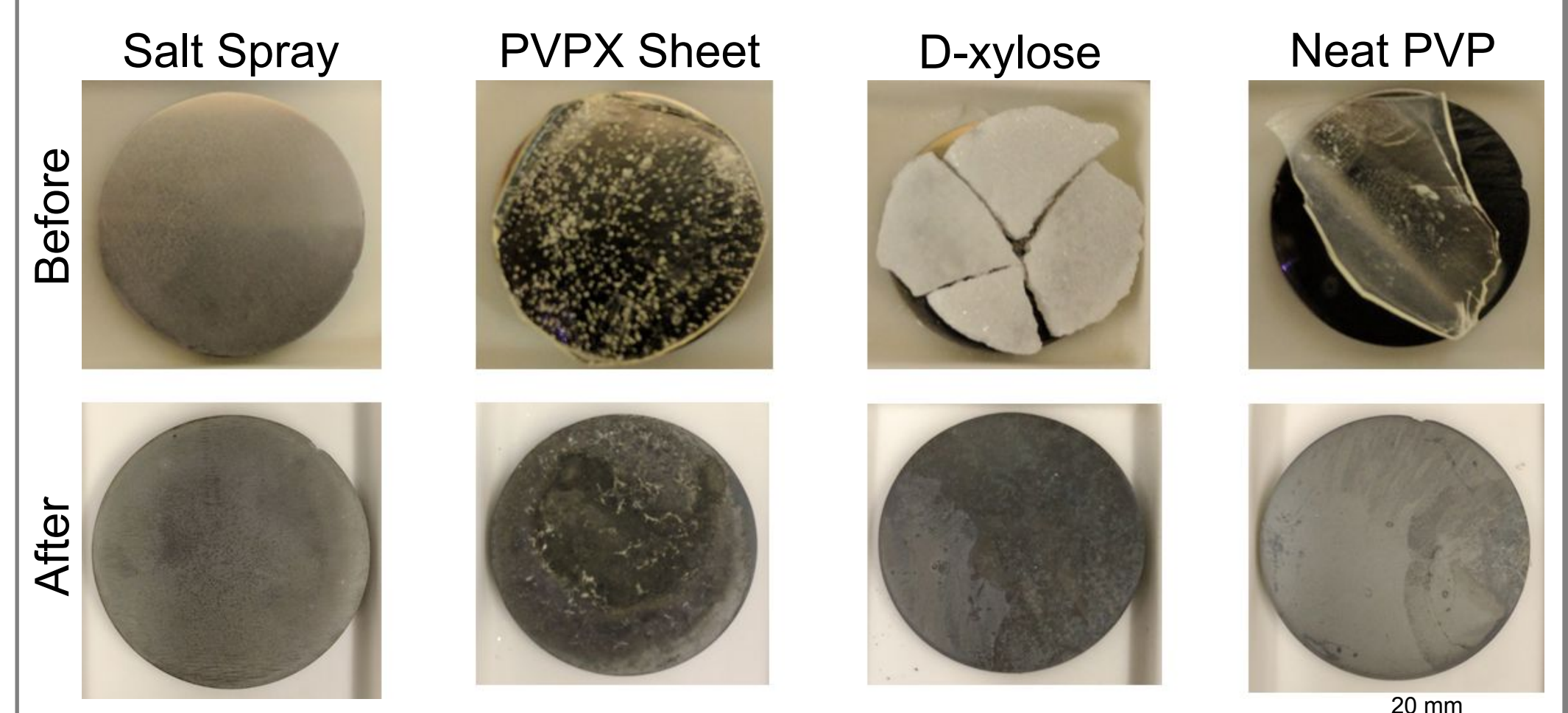


To examine the residue after the hot corrosion test, EDS analysis was done on the sample remains. It was found that the residue was Na, S, and O, indicating that the PVPX had fully degraded and the Na_2SO_4 remained unevenly distributed.

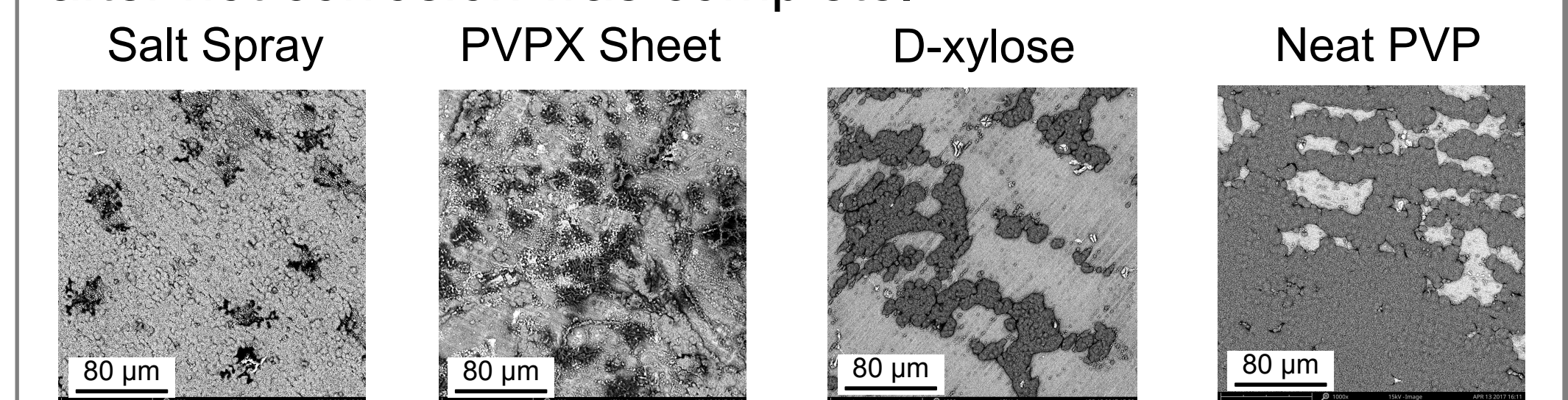


Hot Corrosion Test

To investigate what materials in the polymer sheet caused uneven hot corrosion, Ni-alloy 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.



SEM images were taken of the surfaces of each sample after hot corrosion was complete.



Similarities were noted between the salt spray method and the PVPX sheet method, but the salt spray sample was left with less corrosion and fewer surface remains compared to the PVPX sheet.

Experimental Procedure

To make the polymer sheets, polyvinylpyrrolidone (PVP), water, and sodium sulfate (Na_2SO_4), and D-Xylose were mixed together with a high speed mixer. The mix, henceforth called PVPX sheet, was then tape cast on a teflon substrate using a doctor blade and left to dry overnight. It was then punched into circles to fit on the samples for hot corrosion testing.

