Calcium Phytate:
A Treatment for Degraded Tacking Margins

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Background

Paintings constructed of canvas and with uncoated iron nails in the tacking margins are susceptible to degrading tacking margins due to migrating corrosion products (i.e. Fe^{2+} ions) from the nail heads. As the tacks continue to age, Fe^{2+} ions migrate and accumulate in the surrounding canvas resulting in an acidic and weakened canvas. This kind of weakness in a painting is problematic as the tacking margins hold the painting under tension and ensure that the painting remains attached to its strainer or stretcher. Currently, there are no intermediate treatments for paintings suffering from degrading tacking margins except for strip lining; however, this treatment is usually reserved for those paintings which have become detached from their supports. Paper conservation uses a two-step aqueous treatment of calcium phytate (a natural anti-oxidant) and calcium bicarbonate to reduce the corrosive products of iron gall ink (i.e. Fe^{2+} ions) in documents. The present study investigates the use of these solutions as a possible intermediate conservation measure for corroded tacking margins.

Table I. Samples and Analysis Methods.

Group	Subgroups	Test to be Preformed
A – Control (untreated & not rusted)	1. Not Aged (AU) 2. Aged (AA)	1. Bathophenanthroline Test Strips 2. Tensile Strength 3. Mandrel Test
B – Rusted (not treated) Control	1. Not Aged (BU) 2. Aged (BA)	1. Bathophenanthroline Test Strips 2. Tensile Strength 3. Mandrel Test
C – Control (untreated & not rusted) with Water Soak	1. Not Aged (CU) 2. Aged (CA)	1. Bathophenanthroline Test Strips 2. The pH 3. Tensile Strength 4. Mandrel Test
D – Rusted (untreated) with Water Soak	1. Not Aged (DU) 2. Aged (DA)	1. Bathophenanthroline Test Strips 2. The pH 3. Tensile Strength 4. Mandrel Test
E – Control (not rusted) with Calcium Phytate & Calcium Bicarbonate	1. Not Aged (EU) 2. Aged (EA)	1. Bathophenanthroline Test Strips 2. Tensile Strength 3. Mandrel Test
F – Rusted with Calcium Phytate & Calcium Bicarbonate	1. Not Aged (FU) 2. Aged (FA)	1. Bathophenanthroline Test Strips 2. Tensile Strength 3. Mandrel Test

Experimental

- 720 linen threads were cut and divided into groups half of which were not rusted, while the rest were rusted (see Table I).
- Rust was imparted using a two-step chemical process by first soaking the threads in 5% w/v $FeSO_4$ for 10 minutes followed by air drying, and then submerging in 10% v/v NH_4OH for 20 minutes followed by oven drying at 50°C for two days.
- Half of the total rusted and not rusted samples were placed in an environmental test chamber for 14.5 weeks (80˚C and 65% RH for 12.5 weeks, and then 100˚C and 0% RH for 2 weeks).
- Group C and D were soaked in distilled water for 40 minutes followed by air drying.
- Group E and F were treated for 20 minutes in each of the calcium phytate and calcium bicarbonate solutions followed by air drying.
- The samples were evaluated for Fe^{2+} ion concentration using bathophenanthroline test strips compared to the Canadian Conservation Institute (CCI) Iron (II) Test Strip Colour Chart (see Figure 1), the pH, tensile strength using an Instron Tensometer Universal Testing Instrument, and flexibility using the Mandrel test.

Results

Overall the aged and rusted threads not treated with calcium phytate and calcium bicarbonate had increased concentrations of Fe^{2+} ions according to the bathophenanthroline test strips, more acidic pH values, less tensile strength, and less flexibility according to the Mandrel Test. After these threads had been treated with calcium phytate and calcium bicarbonate, their concentrations of Fe^{2+} ions decreased; however, their tensile strength was not able to be determined and their flexibility increased.

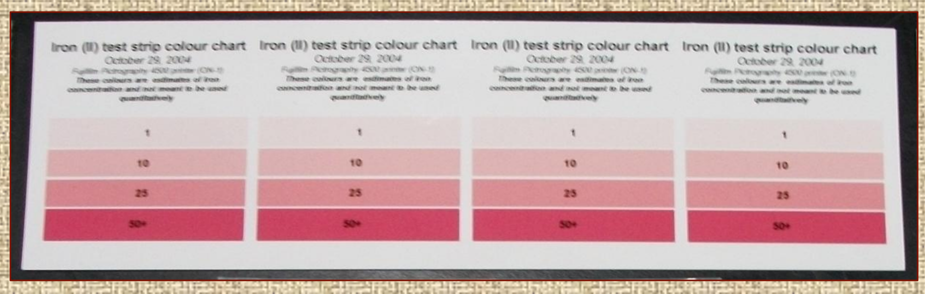

Figure 1. CCI Colour Chart for Determining Fe^{2+} Concentrations.

1. Bathophenanthroline Test Strips

- Groups not artificially rusted had an Fe^{2+} ion concentration of 0.0 +/- 0.0, both before and after being placed in the environmental test chamber. For rusted samples before exposure, their overall Fe^{2+} concentration was 1.0 +/- 0.0.
- After the rusted samples had been placed in the environmental test chamber, their Fe^{2+} concentration increased, but this was not even across the threads; however, on average the threads had an Fe^{2+} concentration of 15.0 +/- 8.12.
- After being treated with calcium phytate and calcium bicarbonate, the rusted thread's Fe^{2+} concentration decreased to an average of 0.42 +/- 0.29.

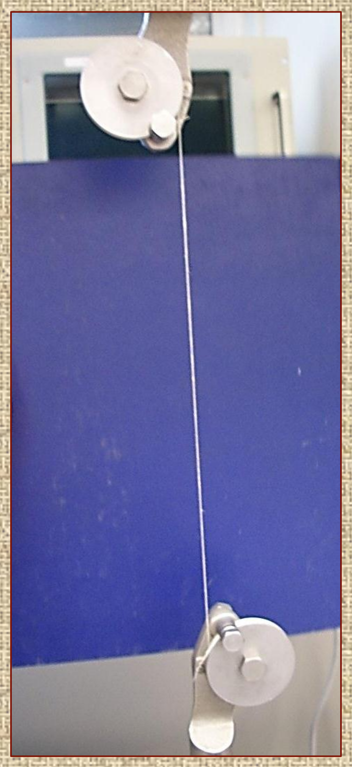

Figure 2. Thread during Tensile Strength Test.

2. The pH

- All samples in group C had slightly acidic pH values (see Table II); however, the aged threads had a more yellowish colour suggesting the samples had become degraded in the environmental test chamber.
- In group D, the not aged and aged samples had a more acidic pH; however the aged threads had the most acidic pH, which was expected.

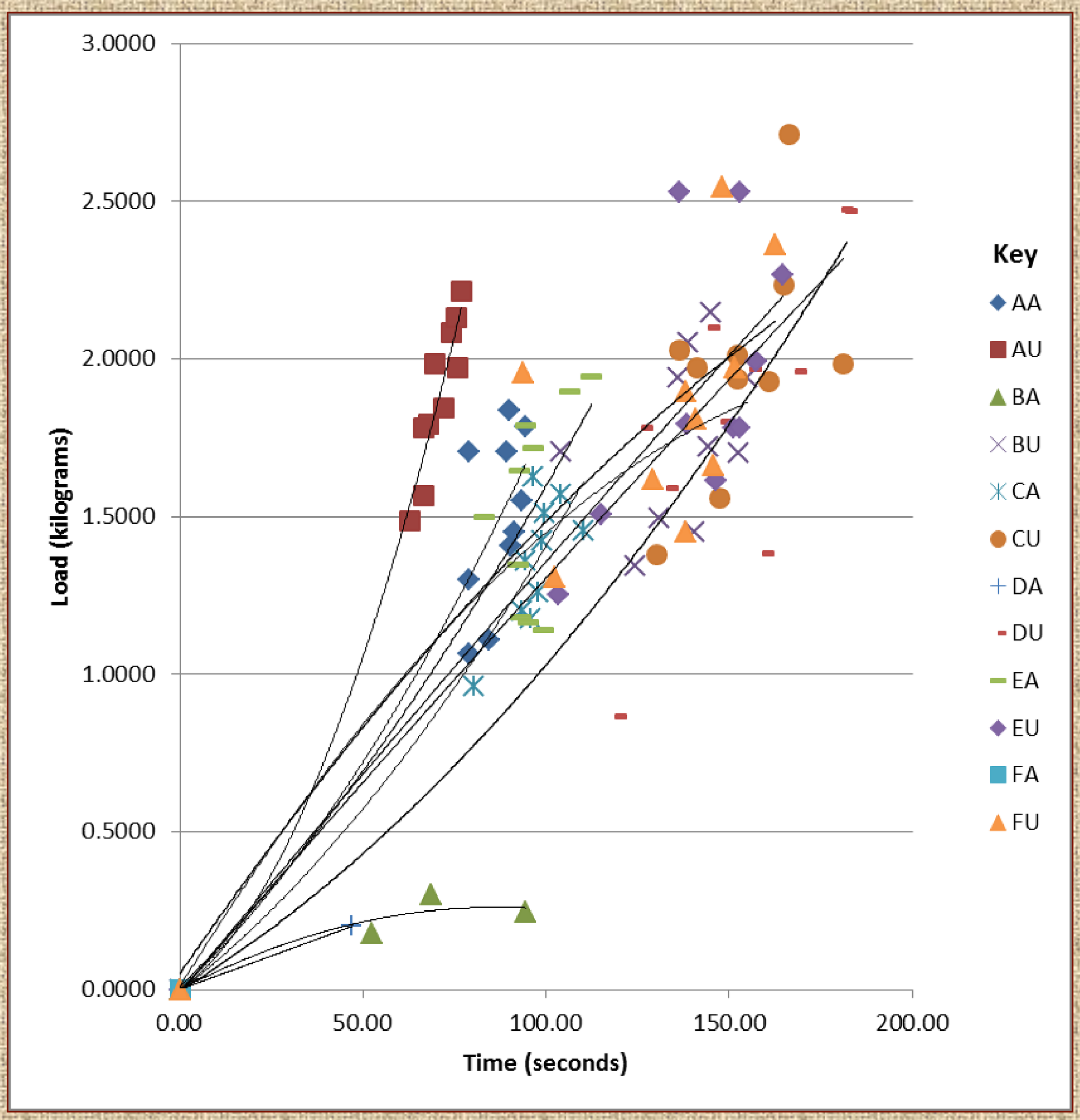

Figure 3. Stress-Strain Curve.

Table II. The pH Values.

	Group C Not Aged	Group C Aged	Group D Not Aged	Group D Aged
Average pH	5.99	5.90	5.88	5.51
Standard Deviation	0.07	0.05	0.07	0.06

Figure 4. Mandrel Test.

3. Tensile Strength

- Across the not aged and rusted groups a slight increase in tensile strength after application of the calcium phytate and calcium bicarbonate solutions was noted. On average, the weight required to break these threads increased from 1.750 +/- 0.2679 kg to 1.858 +/- 0.3823 kg (see Figure 3).
- Unfortunately, the aged and rusted samples from group D and F were not able to be tested as the samples were too brittle to obtain accurate measurements.

4. Mandrel Test

- All of the not aged and not rusted groups did not break during the test, which was to be expected.
- Groups B and D broke after being wrapped around the 2.9 cm and 7.6 cm ring respectively.
- Interestingly, the aged and rusted threads in group F had an increased flexibility, which was not expected given their inability to be tested in the tensometer.

Conclusion

Calcium phytate and calcium bicarbonate solutions were able to reduce the Fe^{2+} ion concentration on the rusted linen thread samples. These solutions also improved the flexibility of the threads as seen in the Mandrel Test. Unfortunately, the threads were too brittle, even after being treated, to allow their tensile strength to be evaluated. This was due to the fact that the threads were left in the environmental chamber for too long, which resulted in the overexposure and extreme brittleness of the aged and rusted threads in group D and F. In general, this research has demonstrated that calcium phytate and calcium bicarbonate, a treatment previously used only in paper conservation, has the possibility to be used as an interdisciplinary treatment; however, future research is needed to investigate the affect of the treatment on the tensile strength of the tacking margins.

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