Electrolysis in Removing Soluble Salts from Paper

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Introduction

The aim of this research was to test the use of electrolysis in removing soluble salts from paper that had been damaged by seawater. Two types of watercolour paper were tested, smooth-pressed and uncalendered. The absorption and desorption of soluble salts of the two different papers were determined using two different washing techniques: low-voltage electrolysis and standard washing in demineralized water. Reducing washing times and finding the most efficient method of removing salts from paper were the ultimate goal of the experiment, along with maintenance of mechanical stability of the paper, legibility of the media and integrity of the object.

Materials and Samples

Materials

- H_2Ocean Natural Reef Salt
- Arches 40lb Hot Pressed Watercolour Papers
- Arches 40lb Uncalendered Watercolour Papers
- Speedball Super Black India Ink
- Staedtler HB Graphite Pencil
- Two titanium electrodes, 10x5 cm each

Fig. 1. H_2Ocean Natural Reef Salt

Samples

- Three control and two experimental sets were used.
- 600 samples were prepared: 300 for fold endurance testing and 300 for tensile testing.
- Samples of each paper were made using India ink and graphite.

	Paper	Media	Electrolysis	Absorption
	S and R	Gr and I	or FW Wash	Time
Control 1	Smooth	Graphite	NA	NA
Untreated		Ink	NA	NA
C1	Rough	Graphite	NA	NA
		Ink	NA	NA
	Smooth	Graphite	FW	NA
Control 2		Ink	FW	NA
Wash	Rough	Graphite	FW	NA
C2		Ink	FW	NA
Control 3	Smooth	Graphite	ele	NA
Electrolysis		Ink	ele	NA
C3	Rough	Graphite	ele	NA
		Ink	ele	NA
Experimental 1	Smooth	Graphite	FW	12 hours
Salt water, wash		Ink	FW	24 hours
E1	Rough	Graphite	FW	12 hours
		Ink	FW	24 hours
Experimental 2	Smooth	Graphite	ele	12 hours
Salt water, electrolysis		Ink	ele	24 hours
E2	Rough	Graphite	ele	12 hours
		Ink	ele	24 hours

Fig. 2. Sample Chart

Experimental

- Two types of watercolour papers, hot pressed and uncalendered, were placed in a climate chamber at 80°C and 65% relative humidity for eight weeks.
- The papers submerged in the H_2Ocean salt water solution mixed to 35ppt for 24 and 48 hours.
- Trials were carried out using two different treatments; washing in demineralized water, and electrolysis.
- Sodium levels in the paper before and after treatments were determined using Inductively Coupled Argon Plasma Emission Spectra (ICP-AES).
- Fold endurance testing, as well as standard tensile elongation tests were performed to determine strength and ductility of paper.

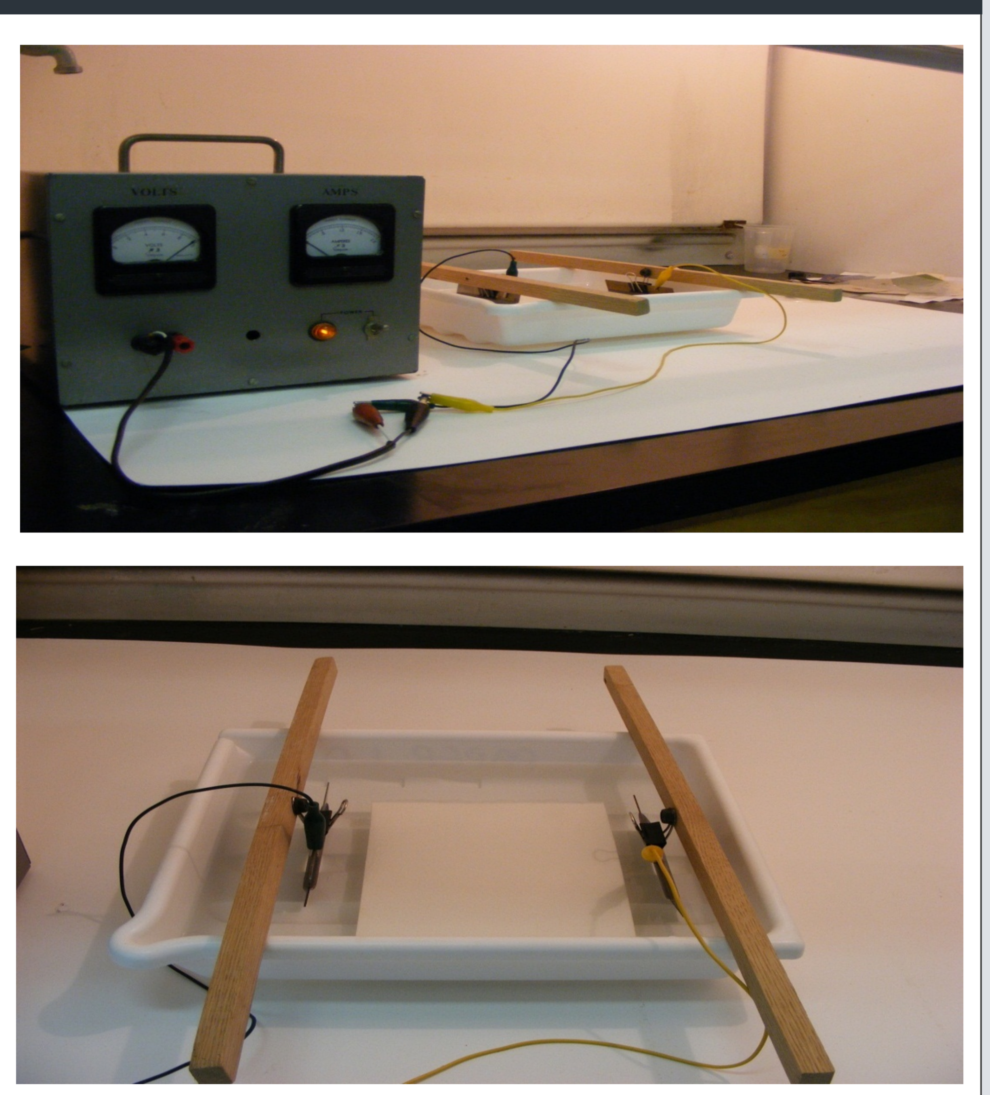

Fig. 3. Electrolysis equipment (top) and paper being treated with electrolysis (bottom).

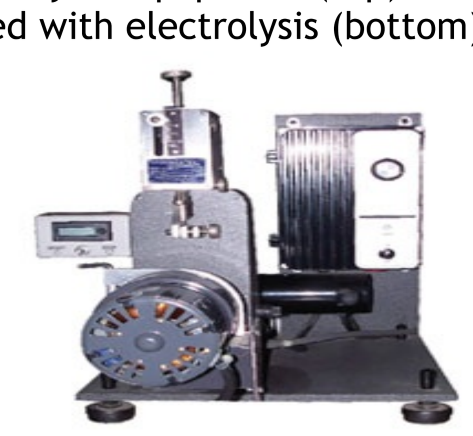

Fig. 4. Fold endurance tester

Results

During the electrolysis treatment of paper soaked in salt water solution, a yellow sediment was observed to settle at the bottom. FTIR testing concluded that the yellow sediment was an animal protein, with the spectrum closely matching that of gelatin. It was determined that the protein was most likely a sizing agent included in the paper. The leaching out of the size only occurred during electrolysis treatment of papers that contained sodium.

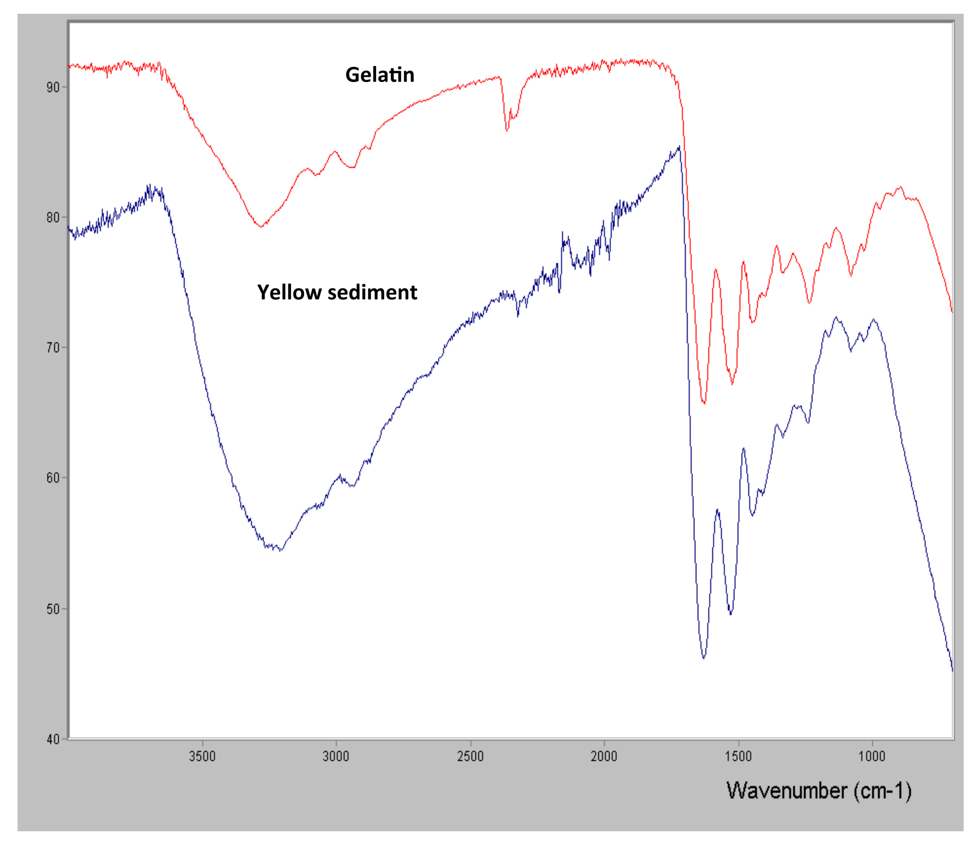

Fig. 5. FTIR spectrum of yellow sediment with a comparison spectra for gelatin.

Fig. 6. Image of electrolysis bath water and demineralized water after washing salinated paper.

Residual sodium levels in the paper were testing using ICP-AES. The level of residual salts in the paper varied greatly between the uncalendered paper, and the smooth-pressed paper.

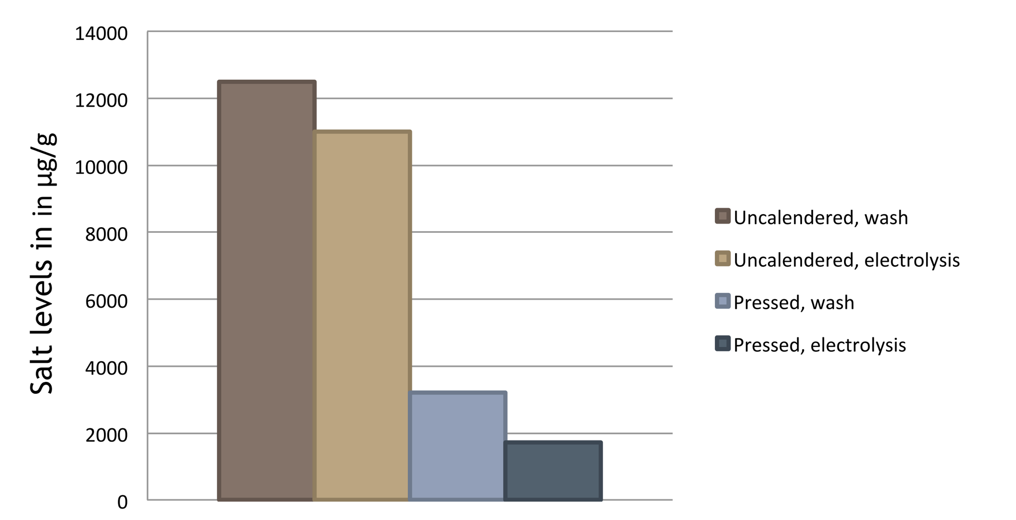

Fig. 7. Salt levels in paper salinated for 48 hours, as determined by ICP. Untreated paper assumed to be 0.

Uncalendered papers were on average twice as strong in fold endurance than the smooth-pressed papers. This was evident in both the untreated papers, and papers that had been treated with regular washing, and electrolysis.

Paper that had been submerged in water proved to be much stronger in both tensile strength and fold endurance than paper that had not undergone any treatment. Paper submerged in salt water, then washed in demineralized water was the strongest, despite having a higher level of residual salts.

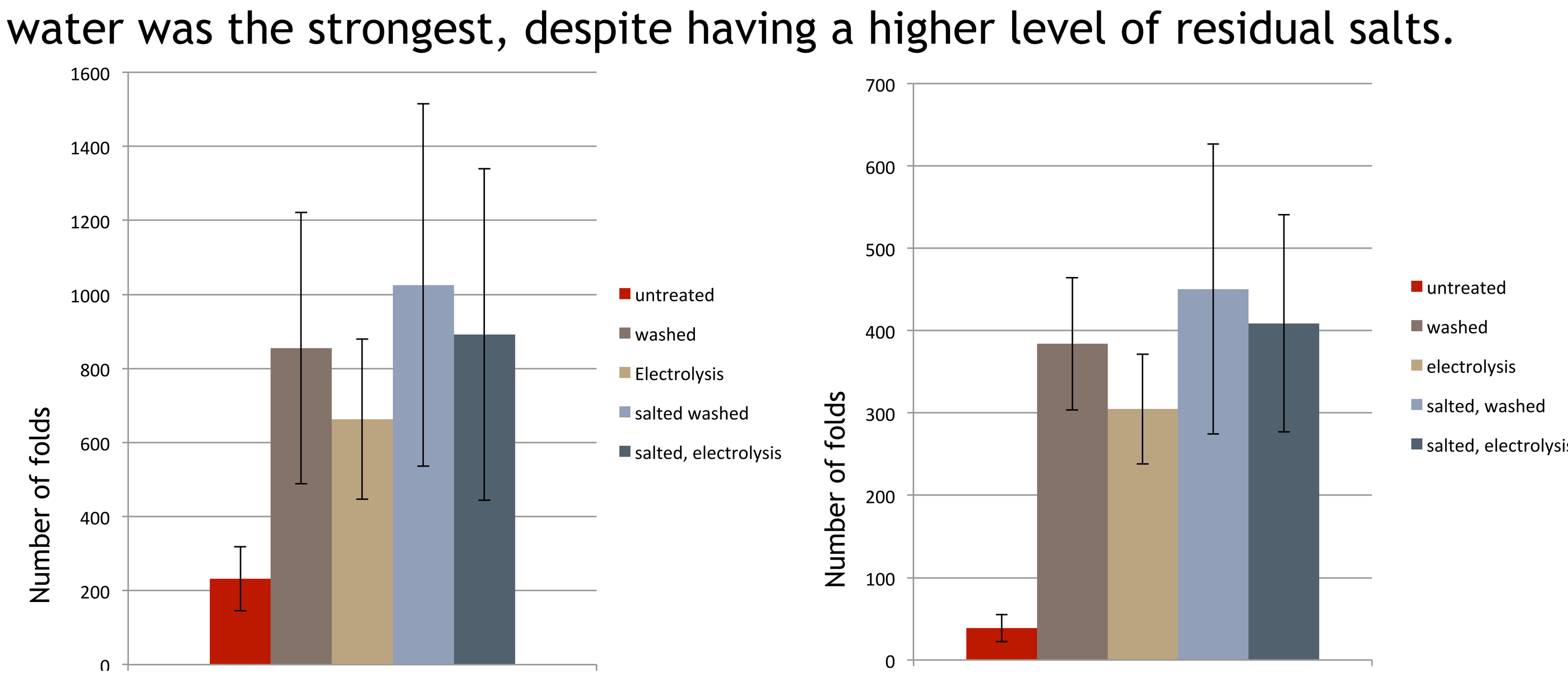

Fig. 8. Fold test results for uncalendered paper (left) and smooth pressed paper (right).

Conclusion

Papers that had been immersed in salt water, then treated with regular washing were stronger than papers treated with electrolysis, most likely caused by the loss of the sizing agent during electrolysis.

Electrolysis proved more effective in removing soluble salts from both smooth-pressed and uncalendered paper. Paper that had been treated with traditional washing maintained was stronger, and more ductile than paper treated with electrolysis, although both types of treatment increased the overall strength of the paper compared with untreated paper.

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