The Evaluation of Modified Laponite Solvent-Gel as a Poultice in Paper Conservation

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Introduction

Laponite RD is a type of synthetic silicate ($Na^{+0.7}[(Si_8Mg_{5.5}Li_{0.3})O_{20}(OH)_4]^{-0.7}$) that forms a clear, colloidal gel when hydrated in water. The working properties of Laponite are dependent on the formulation of the gel, which can be modified with the addition of solvents and additives. The focus of this study was to determine how the introduction of additives into a Laponite-acetone gel would affect its efficacy as a poulticing material. Different thickening agents including, xanthan gum and sodium carboxymethyl cellulose (CMC), were added into the Laponite solvent-gel to minimize the lateral movement of the poultice in an effort to limit the development of tide lines. The Laponite-acetone gel was applied to artificially aged samples of masking tape to illustrate the effectiveness of the poultice on modern adhesive tapes.

Materials

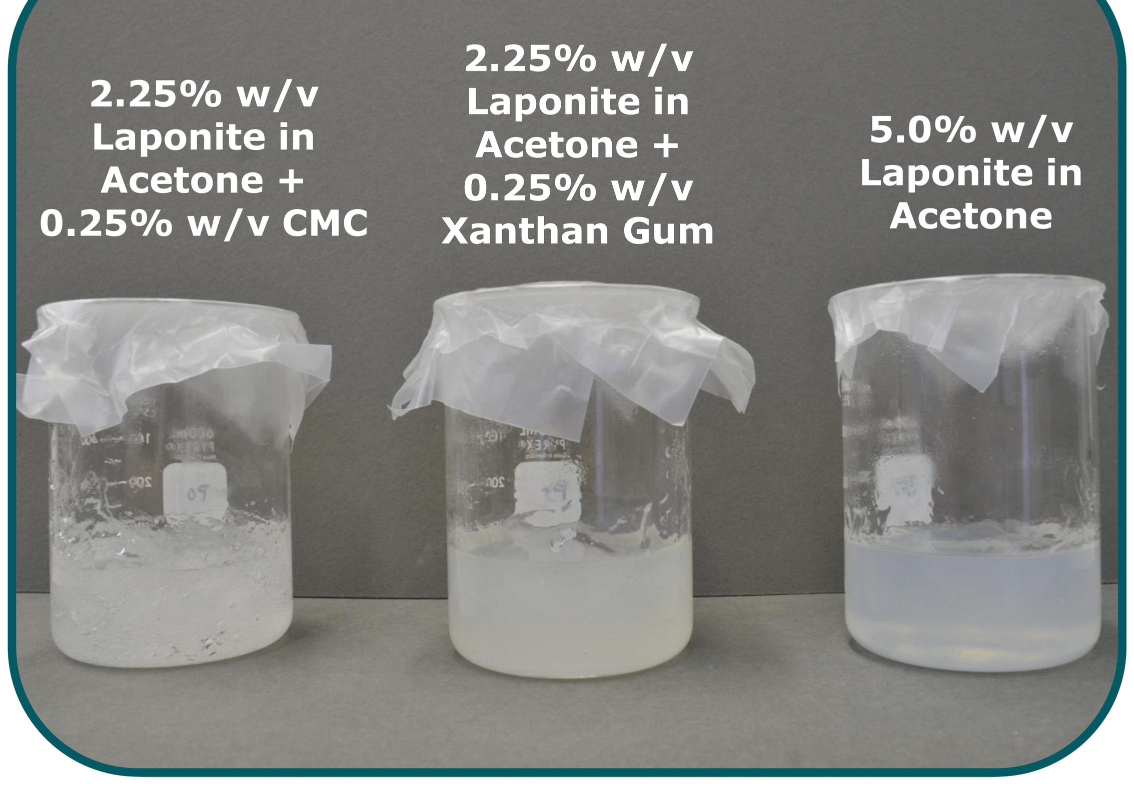
- Poultice: Laponite RD
- Papers: Fabriano Artistico Watercolour Paper (coarse surface texture) and Stonehenge Artist paper (smooth surface texture)
- Barrier tissues: lens tissue, gampi silk tissue, 100% rayon sheet
- Additives: xanthan gum or carboxymethyl cellulose (CMC)
- Adhesive: Scotch #2020 General Purpose Masking Tape that were artificially aged at 80°C, 65% RH for 18 days

Sample Preparation

The poultices were applied to an uniform thickness of 0.5cm over a barrier tissue onto un-aged paper samples. The treatment was carried out for 30 minutes. After which the poultice along with the tissues were discarded and the samples were left to air-dry overnight. Taped samples were artificially aged and used in the latter part of the experiment.

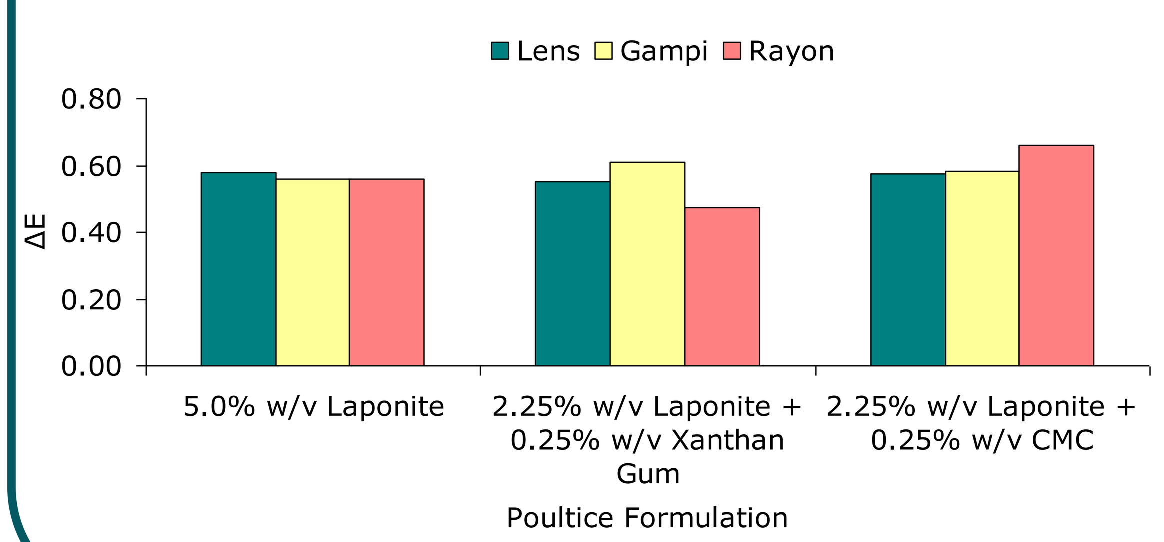
Fig. 1. Paper samples being treated with Laponite poultice through barrier tissue.

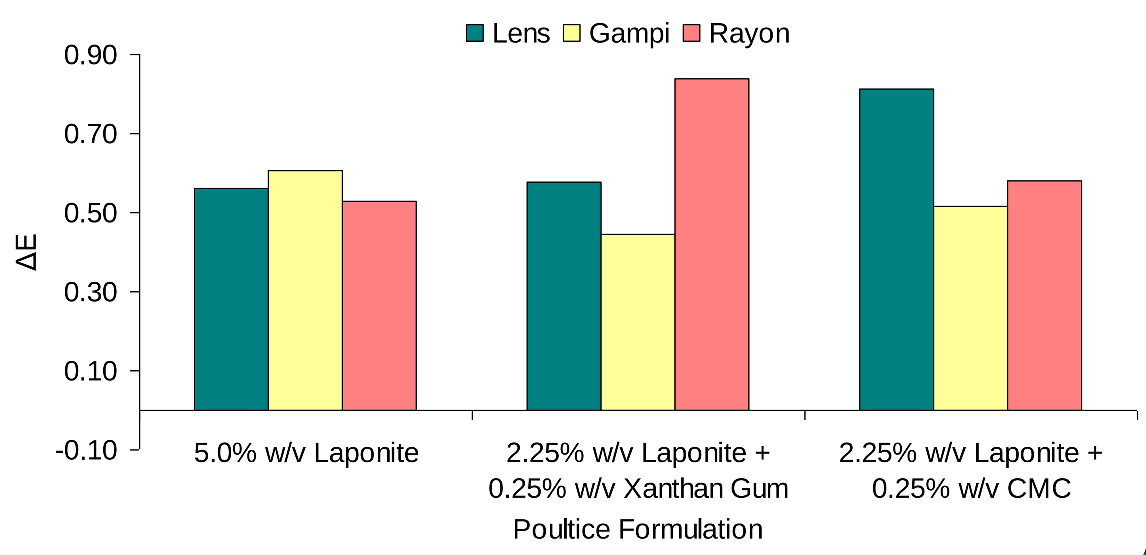
Laponite Formulations



Colorimetry

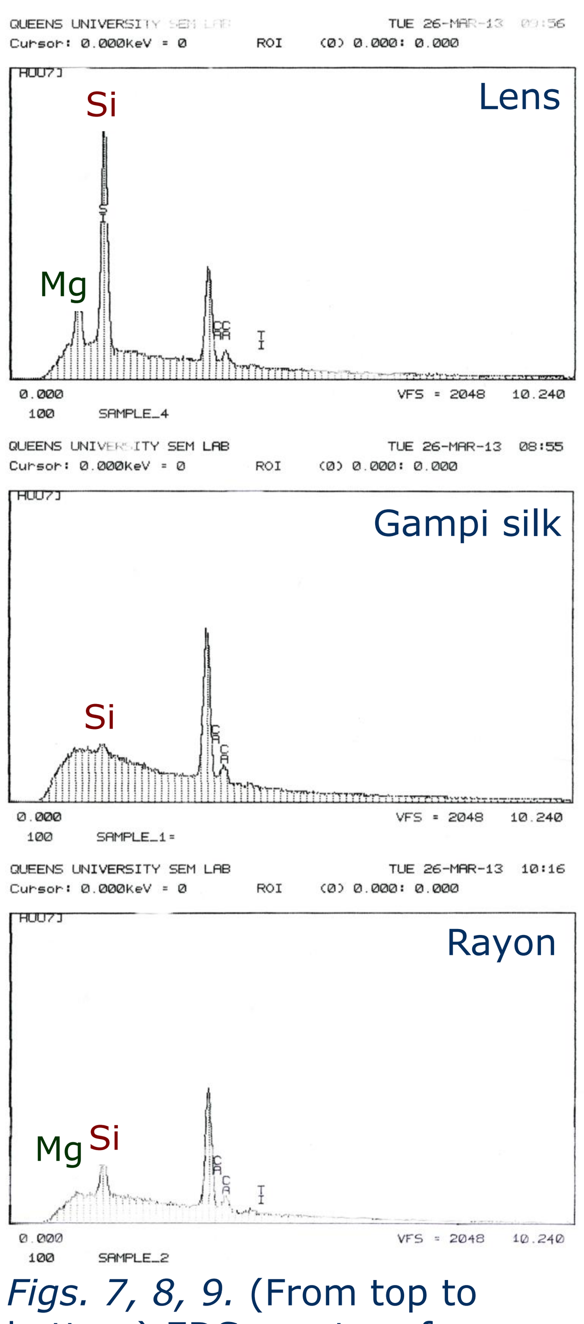
The Fabriano Artistico paper in general exhibited smaller colour changes after treatment in comparison to the Stonehenge. ΔE calculated with the CIE L*a*b* system (Minolta CR-300 Chroma Meter) from the following equation: $\Delta E = \sqrt{(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2}$.





Figs. 2, 3. ΔE of Fabriano Artistico (left) and Stonehenge (right) paper samples after poultice treatment.

Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS)



Figs. 7, 8, 9. (From top to bottom) EDS spectra of Stonehenge paper samples treated with 2.25% w/v Laponite with 0.25% w/v CMC.

SEM-EDS analysis was carried out on some of the poultice-treated samples. Visual images of the poultice residues could not be obtained from SEM examination. The small size of the 'Laponite platelets' (25nm in diameter) and the resolution (2μm) of the SEM available (JEOL JSM-840) limited the amount of information that could be extracted from the SEM images.

EDS (Tracor-Northern TN-5500) identified magnesium (Mg) and silicon (Si) on all the samples that were treated with any one of the Laponite formulations. Both Mg and Si are key components in the composition of Laponite; therefore, the detection of these elements provided strong indicator for the presence of Laponite residue.

The degree of residue deposition could be deduced based on the relative peak heights of Mg and Si observed in the EDS spectra, as shown in Figs. 7, 8 and 9. On the same set of papers that were treated with the same poultice formulation, the sample that had the lens tissue as barrier generally showed the highest peak intensities for Mg and Si in relations to the other barrier tissues (e.g. Fig. 7). This trend concurred with the findings obtained from UVA-induced visible fluorescence.

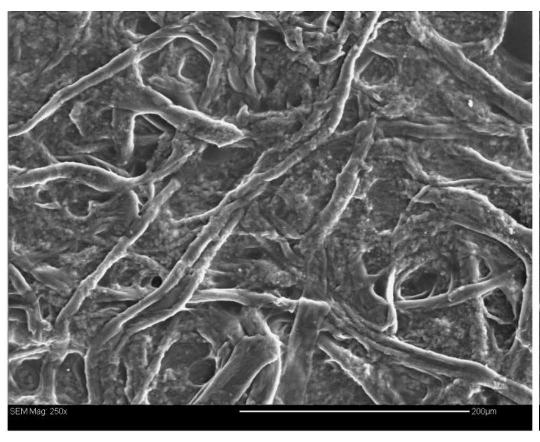


Fig. 10. SEM (Mag. 250x) of Stonehenge paper treated with 2.25% w/v Laponite with 0.25% w/v CMC with lens tissue barrier (same sample as Fig. 7).

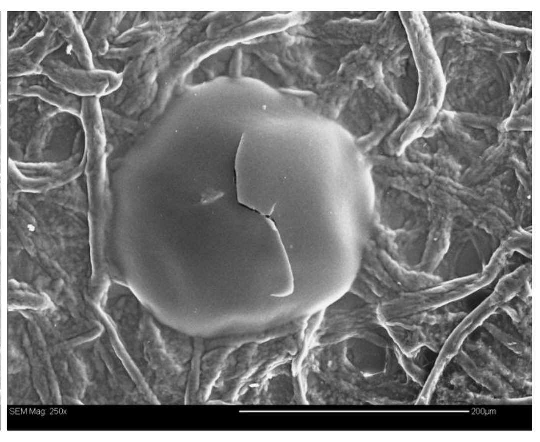
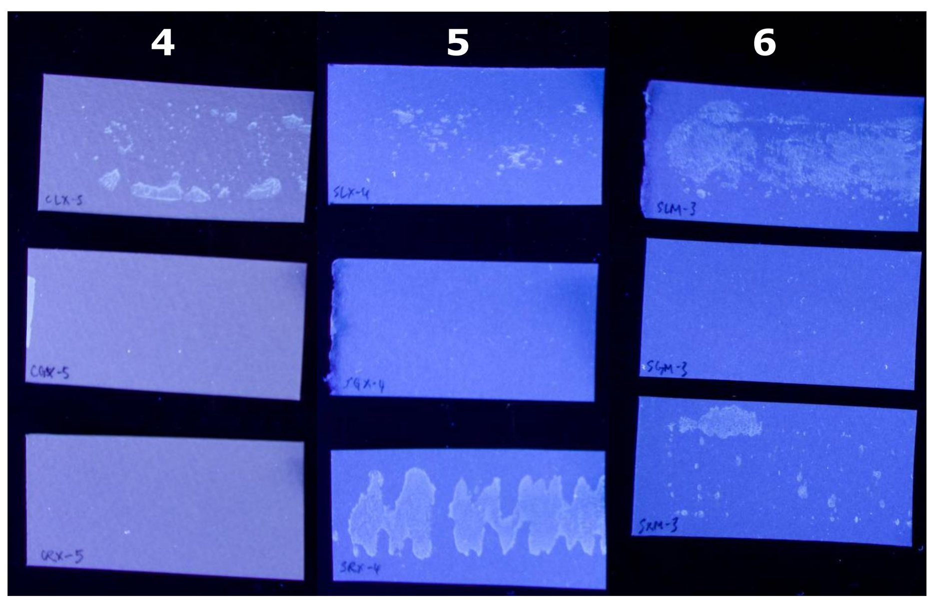


Fig. 11. SEM (Mag. 250x) of Mg aggregate on Stonehenge paper treated with 2.25% w/v Laponite with 0.25% w/v xanthan gum with rayon barrier tissue.

Long Ultraviolet Light (UVA)-Induced Visible Fluorescence

Residues from the Laponite poultices were not visible to the naked eye when viewed under normal reflected light; however, the same residues fluoresced under long ultraviolet light (UVA). Lens tissue generally performed poorly as a barrier against the deposition of poultice residues. An overview of the effectiveness of the barrier tissues could be inferred from the relative size of the fluorescing residues.



Figs. 4, 5, 6. UVA-induced visible fluorescence photographs. *Fig. 4.* Fabriano Artistico paper treated with 2.25% w/v Laponite with 0.25% w/v xanthan gum. *Fig. 5.* Stonehenge paper treated with 2.25% w/v Laponite with 0.25% w/v xanthan gum. *Fig. 6.* Stonehenge paper treated with 2.25% w/v Laponite with 0.25% w/v CMC.

Fourier-Transform Infrared Spectroscopy (FT-IR)

Traces of poultice residues were difficult to identify with FT-IR (Nicolet FT-IR Spectrometer with Golden Gate Attenuated Total Reflection). The strong and broad bands of cellulose in paper obscured most of the characteristic peaks associated with Laponite and both additives. Laponite displayed characteristic peaks at around 950cm^{-1} (strong intensity) and 646cm^{-1} (medium intensity). The peak at 950cm^{-1} is likely attributed to the Si-O bonds in Laponite.

The slight shift of the characteristic cellulose peak to a lower wavenumber (from the 1000cm^{-1} region to the 960-970cm^{-1} range) or the presence of a weak intensity peak at around 646cm^{-1} could be used to determine the presence of Laponite residues in a sample. This shift was particularly noticeable with samples that underwent poultice treatment with a lens barrier tissue.

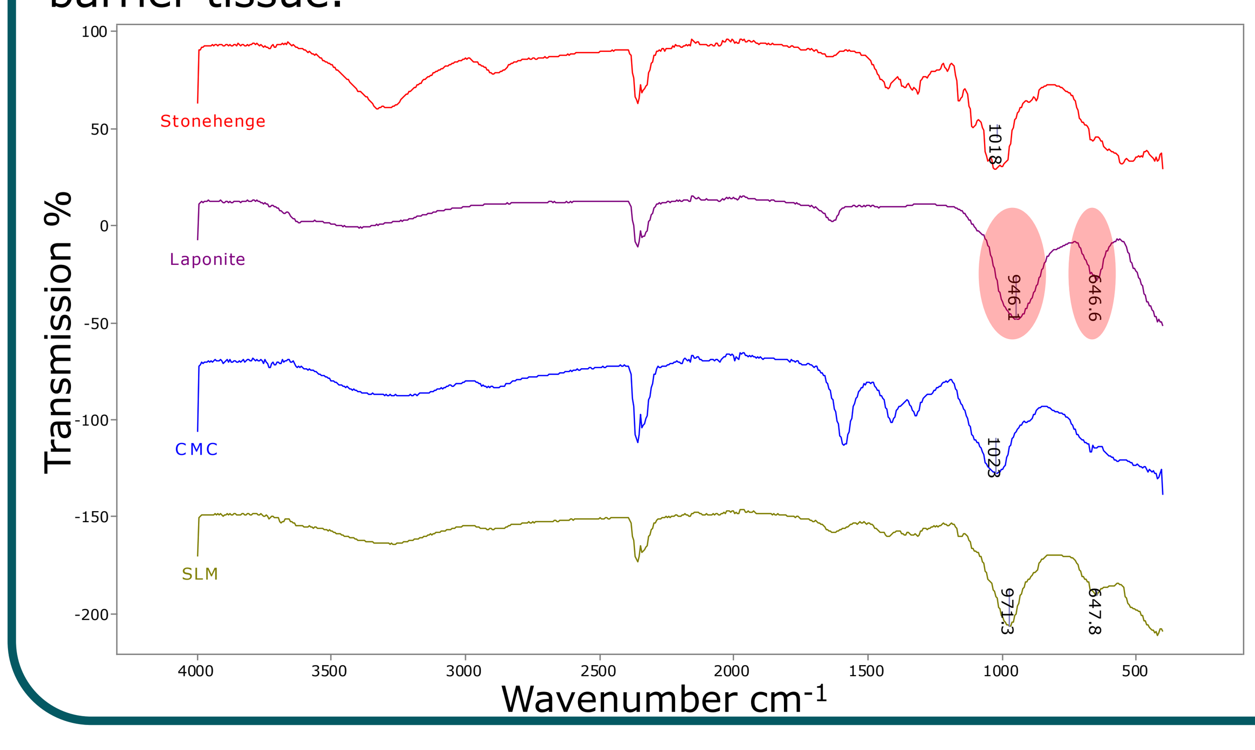


Fig. 12. (From top to bottom) FT-IR spectra: Stonehenge paper; Laponite with characteristic peaks highlighted; CMC; Stonehenge paper treated with 2.25% w/v Laponite with 0.25% CMC through lens tissue barrier.

Conclusions

The gampi silk tissue and lens tissue were respectively the best and worst barrier tissues in limiting residue deposition. The addition of xanthan gum and CMC into the Laponite formulation did not appeared to have significant effect in reducing residues. The smooth-surface paper (Stonehenge) trapped residues more easily than the coarser paper (Fabriano Artistico). The quantification of residues will be carried out in the latter part of the study with inductively coupled plasma atomic emission spectroscopy (ICP-AES).

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