Synthetic Hydrogels for Hide Glue Removal from Parchment

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Background and Project Goals

- Non-destructive book restoration requires softening and removing adhesives without wetting the parchment [1] (Fig.1).
- Hydrogels can deliver water to the parchment but gel residue left behind can alter the artwork as it ages.
- Low acyl gellan gum (LAGG) gel is currently used [1,2] (Figs.2 and 4) but:
  - It is not flexible enough to remove adhesives from uneven surfaces, like book bindings [3].
  - As a physical gel (formed by chelation rather than covalent crosslinking), it will deposit residue from the gel onto the artwork.
- **The goals of this project are to:**
  - Quantify and compare residue and treatment efficiency using high acyl gellan gum (HAGG) gel (Figs.2 and 4) and the chemical gel poly(hydroxyethyl methacrylate)/polyvinylpyrrolidone (pHEMA/PVP) (Fig.3).
  - Use microscopy to determine if the parchment is damaged by the hydrogel treatment.

Fig.1. A book spine with adhesive [3].

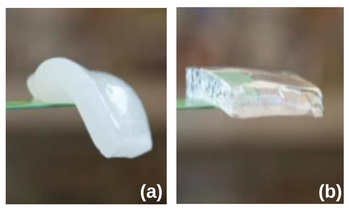


Fig.2. HAGG gel (a) and LAGG gel (b) [3].

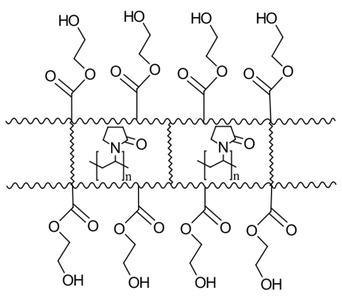


Fig.3. The chemical structure of pHEMA/PVP hydrogel.

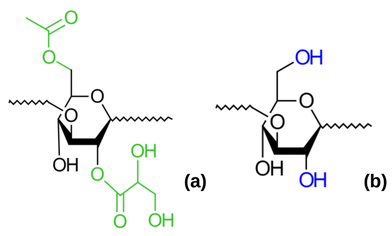


Fig.4. The differences in partial structures of HAGG (a) and LAGG (b).

Experimental Procedures

pHEMA/PVP

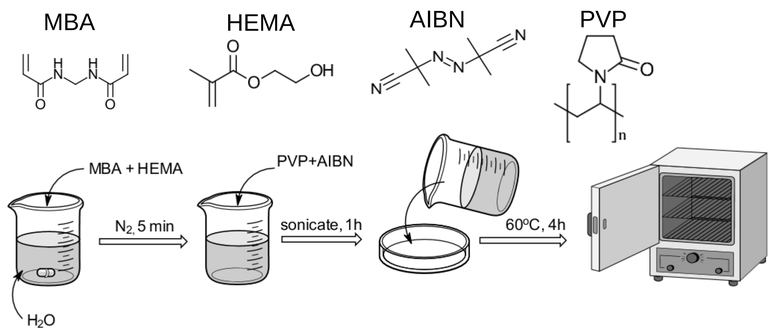


Fig.5. Synthesis of pHEMA/PVP hydrogel. The procedure was adapted from ref.[4]. The hydrogel was synthesized either with 20% w/w HEMA (HEMA 20) or 5% w/w HEMA (HEMA 5).

HAGG

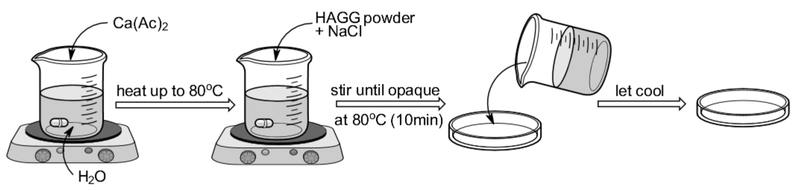


Fig.6. Synthesis of HAGG hydrogel [3].

Parchment treatment

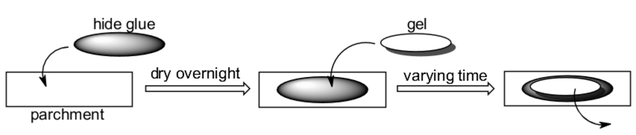
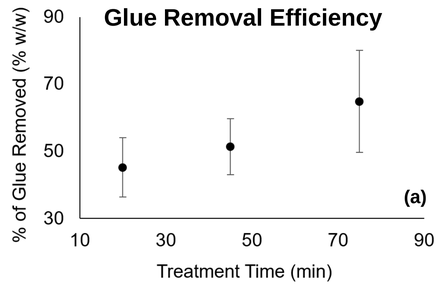
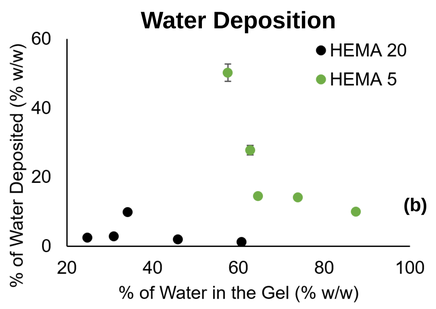


Fig.7. Parchment sample preparation and treatment.

Results

Gravimetric Analysis





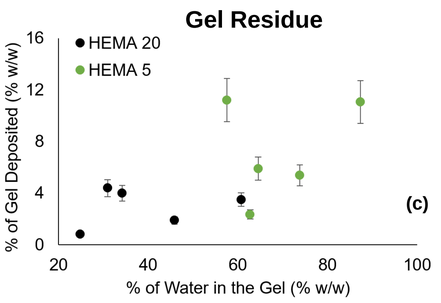


Fig.8. HAGG gel (a), HEMA 20 xerogel (b), and HEMA 5 xerogel (c).

Fig.9. The efficiency of glue removal in HAGG gel treatment (a), water deposition of pHEMA/PVP gels (b), and gel residue of pHEMA/PVP gels (c).

Scanning Electron Microscopy (SEM)

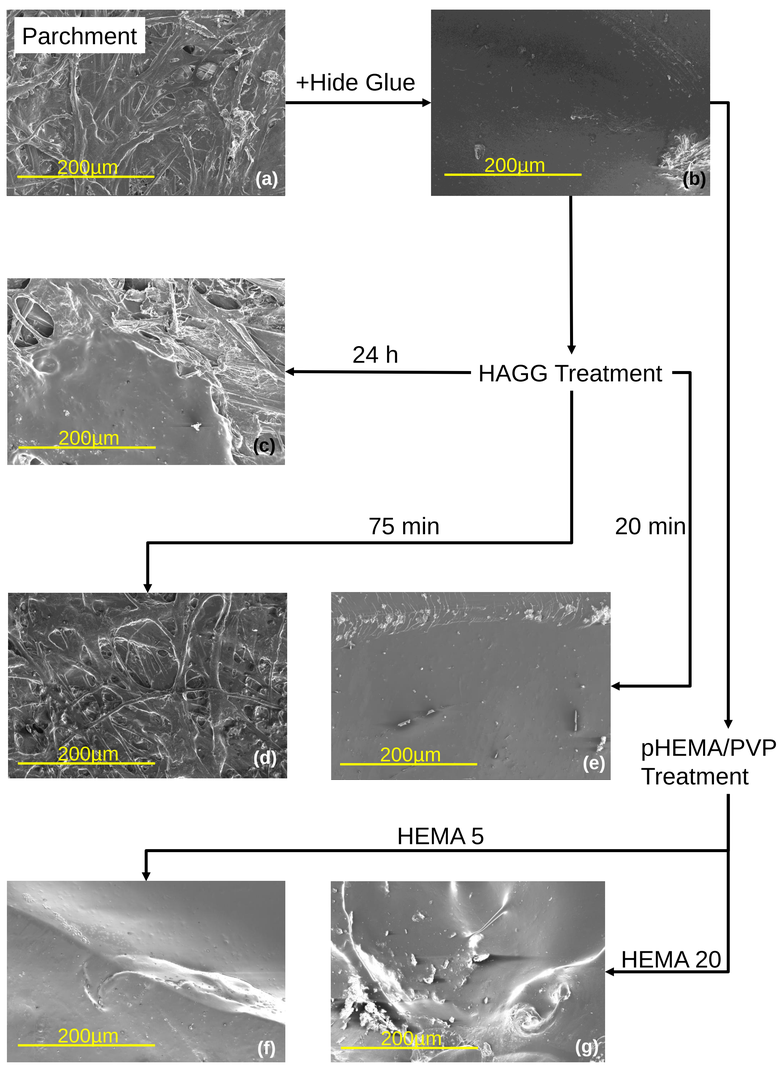


Fig.10. The SEM images of parchment (a), parchment coated with hide glue (b), glue coated parchment after HAGG gel treatment over 24h (c), 75min (d) or 20min (e), glue covered parchment after 30min treatment with HEMA 5 (f) or HEMA 20 (g).

Infrared Spectroscopy (IR)

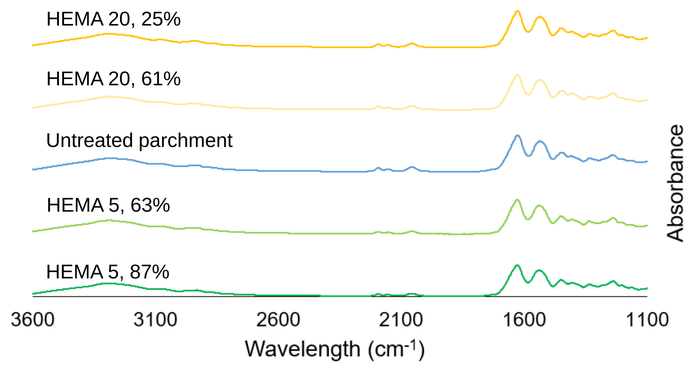


Fig.11. The IR spectra of glue covered parchment samples treated with HEMA 5 and HEMA 20 at different hydration levels.

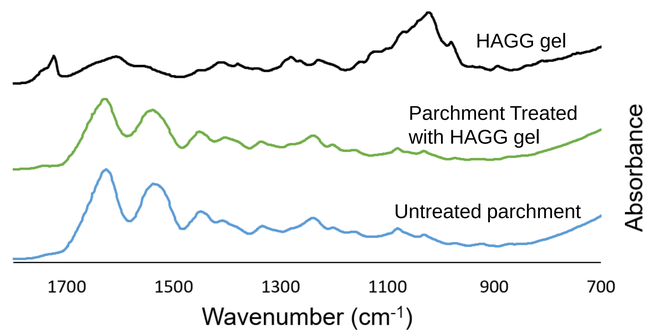


Fig.12. The IR spectrum of parchment covered with hide glue, HAGG gel, and the parchment after being treated with HAGG gel for 75 minutes.

Conclusions

- IR spectroscopy did not detect HAGG gel residue or pHEMA/PVP gel residue on parchment
- Gravimetric analysis indicates that the maximum percentage of residue on parchment of pHEMA/PVP gel was 11.2%
- pHEMA/PVP gel successfully delivered water to liquefy hide glue on parchment
- HAGG gel was able uptake 34.2 to 84.7% of hide glue from parchment over 20- to 75 minutes of contact time
- SEM imaging showed parchment damage from a 24 hour HAGG gel glue removal treatment and possible gel residue after a HEMA 20 gel treatment and 20 minute HAGG gel treatment

Future Work

- Fluorescently label gels to improve detection limit of gel residue left on parchment
- Investigate if water delivered from pHEMA/PVP gel contacts the parchment
- Understand how gel structure controls parchment modification during hide glue removal
- Research the effectiveness of combining pHEMA/PVP and HAGG gels in treatment for hide glue removal from parchment
- Study HAGG and pHEMA/PVP gel hide glue removal effectiveness on uneven parchment surfaces
- Load pHEMA/PVP and HAGG gels with other solvents or enzymes
- Continue research on pHEMA/PVP gel at different concentrations of HEMA

References

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[2] Mazzuca, C.; Micheli, L.; Cervelli, E.; Basoli, F.; Cencetti, C.; Coviello, T.; Iannuccelli, S.; Sotgiu, S.; Palleschi, A., Cleaning of Paper Artworks: Development of an Efficient Gel-Based Material Able to Remove Starch Paste. *ACS Applied Materials & Interfaces* **2014**, *6*, 16519-16528.
[3] Cathie Magee (Kress Fellow at Walters Art Museum), personal communication.
[4] Baglioni, M.; Domingues, J. A. L.; Carretti, E.; Fratini, E.; Chelazzi, D.; Giorgi, R.; Baglioni, P., Complex Fluids Confined into Semi-interpenetrated Chemical Hydrogels for the Cleaning of Classic Art: A Rheological and SAXS Study. *ACS Applied Materials & Interfaces* **2018**, *10*, 19162-19172.

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