Evaluation of Two-Part Barrier Systems to Prevent Siloxane Staining on Porous Surfaces

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INTRODUCTION

Silicone rubber molds are widely used in conservation – to cast replacement components, create impressions, or produce replicas. Over the past 30 years, conservators have become increasingly aware of the tendency for these silicone rubber materials to leave behind siloxane residues, which can lead to changes in appearance where the impression material has contacted the surface. Porous surfaces, such as unglazed ceramic or stone, can be particularly disfigured by siloxane residues.

A barrier layer is recommended to prevent siloxane staining. Two types of barrier layers are commonly used: penetrating or non-penetrating. Non-penetrating barriers (such as Parafilm) introduce bulk between the silicone rubber and original surface, leading to loss of detail. Penetrating barriers (dilute solutions of B72, B48N, or other polymers) are thin and preserve detail capture but are difficult to remove since they are absorbed into porous surfaces. The use of a penetrating barrier layer may therefore lead to a similar type of darkening or discoloration that it aimed to avoid (Fig. 1).

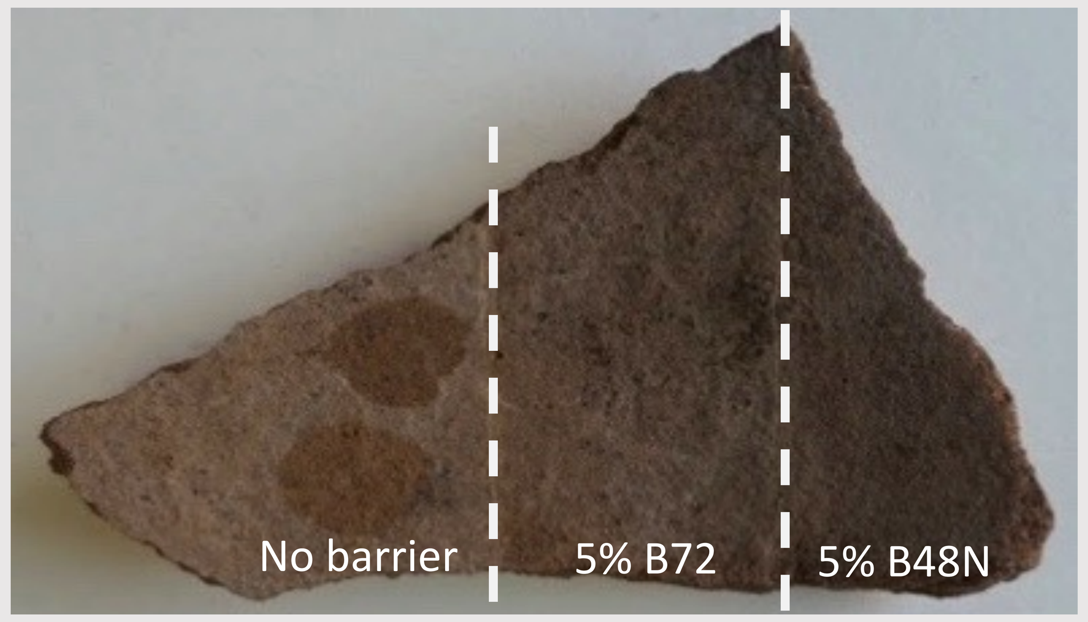


Figure 1. Earthenware sherd with two spots of siloxane staining (left third) and darkening from B72 & B48N barriers, after attempted removal with solvent.

TWO-PART BARRIER SYSTEMS

- First proposed by Brückle et al. (1999). Molten cyclododecane (CDD) is applied to the surface and absorbed into the top layer of the porous material.
- Once absorbed, a thin layer of water-based sealant is applied over top.
- Water-based sealants are recommended as they effectively repel the nonpolar siloxane components found in silicone rubber residues.
- In this research, L-menthol was explored as an alternative to CDD.

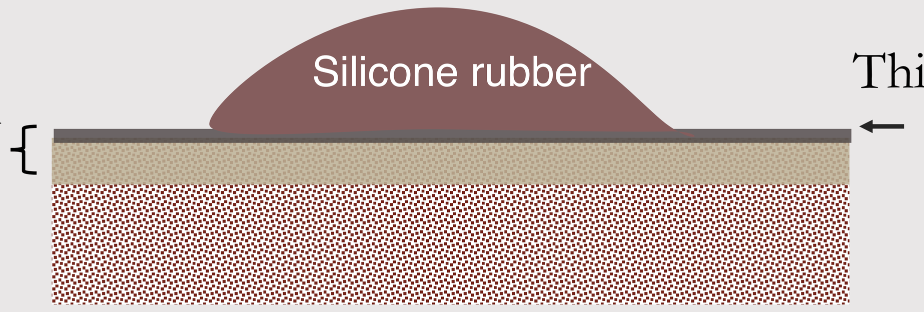
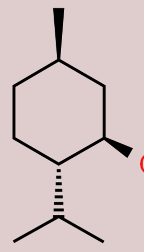
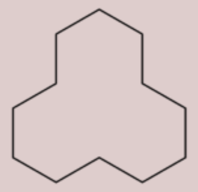


Figure 2. Schematic diagram of the two-part barrier system.

CDD V. MENTHOL

L-menthol has recently been explored as an alternative to cyclododecane for temporary consolidation and archaeological block-lifting (Langdon et al. 2018). The presence of a hydroxyl substituent leads to improved compatibility with polar materials (Han et al. 2014). Sublimation time for L-menthol is faster than CDD and its health and safety risks are better understood (Rowe 2018).

	L-MENTHOL	CDD
		
Melting Point	42 – 45°C	50 – 60°C
Vapor Pressure (@ 25°C)	0.064 mm Hg	0.0295 mm Hg
Sublimation Rate	0.04 mm/24 hours	0.03 mm/24 hours

FIELD LAB TESTING

- Four different two-part systems were tested on archaeological ceramic sherds obtained from Kaman-Kalehöyük using CDD or L-menthol paired with 20% gum arabic or 2.5% methyl cellulose.
- Two fast-setting silicone molds (Xantopren VL Plus and Reprosil®) were applied on top of the barrier layers. Each barrier system was evaluated on the following criteria: 1) ability to prevent deposition of siloxane residues, 2) ease of removal, and 3) thinness of film.
- To explore the use of the two-part L-menthol system in practice, a test sherd was prepared by carving small designs and impression materials were tested in tandem with L-menthol and gum arabic barriers (Fig. 3).

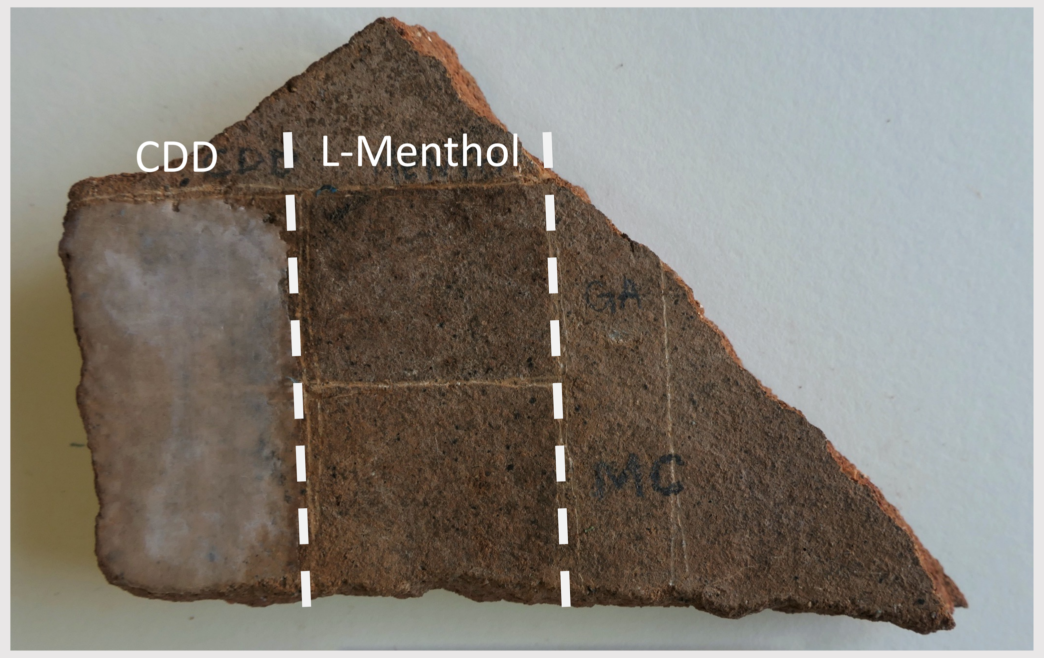


Figure 2. Molten CDD formed thick layers over test sherds, whereas molten L-menthol was readily absorbed into the ceramic surface.

RESULTS

- L-menthol paired with either a 20% gum arabic or 2.5% methyl cellulose barrier produced optimal results, preventing staining from silicone oils and reducing color change to the ceramic.
- CDD rapidly cooled and solidified when applied to the ceramic surface, making it difficult to achieve a thin film (Fig. 2). Water-based sealants pooled on top of CDD layers, failing to form a cohesive barrier layer.
- Molten L-menthol was easily applied to sherd surfaces with a brush and absorbed well into the ceramic matrix. The water-based sealants exhibited better compatibility with L-menthol.
- Water-based sealants were easily reversed with a cotton swab dampened with water. Volatile binding media (CDD and L-menthol) were left to sublimate in the fume hood. Menthol sublimated within 1-3 days, while CDD sublimated within 1-2 weeks.
- Reprosil® performed very well, achieving the highest degree of detail capture, clarity of impression, and caused no perceived alteration to the barrier materials.
- Xantopren appeared to have pulled up some of the barrier upon its removal, although this did not result in any staining.

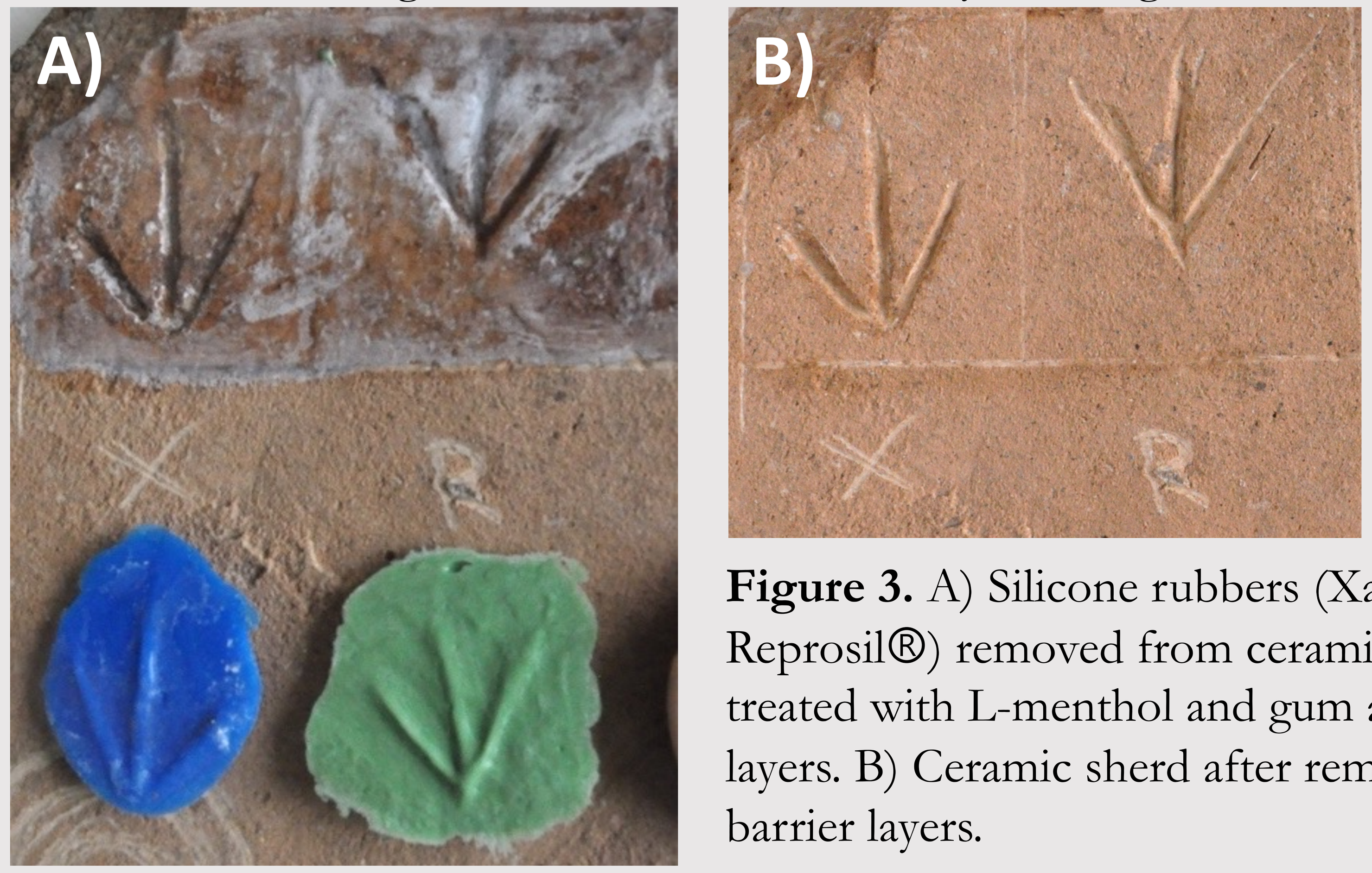


Figure 3. A) Silicone rubbers (Xantopren and Reprosil®) removed from ceramic surface treated with L-menthol and gum arabic barrier layers. B) Ceramic sherd after removal of all barrier layers.

CONCLUSIONS

- L-menthol was found to be a superior alternative to cyclododecane in two-part barrier systems to reduce siloxane staining on porous materials.
- The lower melting point permits increased working time, allowing for the material to be easily applied via brush to produce a thin film.
- L-menthol is more compatible with the hydrophilic barrier layers necessary to prevent deposition of silicone oils. Other benefits include its low cost, availability, and well-documented, minimal health risks.
- The two-part systems were easy to apply and reverse on porous ceramics, providing a viable alternative to polymer barrier layers.

REFERENCES

- Maish, J. P. (2006). Silicone Rubber Staining of Terracotta Surfaces. Studies in Conservation, 39(4), 250.
- Brückle, I., Thornton, J., Nichols, K., Strickler, G., Bruckle, I., Thornton, J., & Nichols, K. (1999). Cyclododecane: Technical Note on Some Uses in Paper and Objects Conservation. *Journal of the American Institute for Conservation*, *38*(2), 162–175.
- Han, X., Rong, B., Huang, X., Zhou, T., Luo, H., & Wang, C. (2014). The use of menthol as temporary consolidant in the excavation of Qin Shihuang's terracotta army. Archaeometry, 56(6), 1041–1053.
- Langdon, K., Skinner, L., & Shugar, A. (2018). Archaeological block-lifting with volatile binding media : exploring alternatives to cyclododecane. *Subliming Surfaces: Volatile Binding Media in Heritage Conservation*, 97–99. Cambridge.
- Rowe, S. (2018). Second fiddle : a review of lesser-known volatile binding media in conservation. *Subliming Surfaces: Volatile Binding Media in Heritage Conservation*, 13–20. Cambridge.

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