DOI: TBC
Published: 24 July 2018

POSTER ABSTRACT

Archaeological block-lifting with volatile binding media: exploring alternatives to cyclododecane

Katherine Langdon, Lucy Skinner and Aaron Shugar

Cyclododecane (CDD) is the only volatile solid currently in common use in archaeology, usually as a consolidant in the practice of block-lifting (Figure 1), in which a fragile artefact is safely excavated by undercutting the surrounding soil and keeping the entire unit intact until it can be further excavated in appropriate facilities (Cronyn 1990: 44).[1] CDD is considered by many to be an advantageous consolidant in block-lifting due to the fact that it can be removed from the block through sublimation, whereas traditional adhesive consolidants must be removed (and then only partially) through the use of solvents and mechanical action, which can be hard on the artefacts (Watters 2007). Its ability to be applied as a melt rather than a solution further enables it to be used on objects whose sensitivity to common solvents would prohibit traditional adhesive use (Balachandran 2010: 83).[2] CDD's main drawback is its sublimation rate,[3] which is slow enough that subsequent treatment of heavily coated objects cannot always be done within a suitable time frame.[4] Other volatile binding media (VBMs) with faster sublimation rates exist but are relatively untested for such work. In an effort to overcome the shortcomings of CDD's sublimation rate, this research compares a range of VBMs and mixtures to determine their relative usefulness for archaeological block-lifting.

Figure 1 L. Skinner consolidating wood with CDD and facing tissue for block lifting at Abydos. Photo: L. Skinner.

Criteria were built on those defined by Hangleiter *et al.* (1995), namely that conservation-appropriate VBMs must have a melting point 'under 65 °C, be immiscible with water, be soluble in commonly used organic solvents, have low toxicity, and a low impact on the environment'. Additionally, a successful chemical needed to be commercially available to conservators, have a faster sublimation rate than CDD, and have physical characteristics suitable for consolidation.

Compounds were selected for testing based on

1 Block-lifting with CDD has been performed at many sites, including by L. Skinner (author) at Amarna and Abydos, Egypt, where it has been used for over a decade (Balachandran 2010), at Kaman-Kalehöyük, Turkey (Watters 2007), and at the Burial Complex of Qin Shihuang, Lintong, China (Bucher and Xia 2010). It has been used experimentally for lifting archaeological lacquer fragments (Liang 2009). Previously excavated but fragile fossils were transported with the aid of a CDD coating like that used in block-lifting (Brown and Davidson 2010).

2 CDD is also available as an aerosol. This application technique produces thin coats that are inappropriate for block-lifting.

3 0.03 mm/24 hours, according to data published by Hangleiter *et al.* (1995), though this has been shown to vary significantly with the application technique and ambient conditions (Balachandran 2010: 79).

4 L. Skinner (author) has found in her work at Abydos and Amarna that limited access to field labs and excavated objects (e.g. access exclusively during the excavation season) complicates the treatment of CDD-coated objects. In these situations, artefacts must either receive rushed treatment or wait until a future field season. If in the latter case the packaging fails to prevent sublimation or the CDD is allowed to sublime during the off-season, when there is no supervisor to monitor the process and reinforce the block, the unsupported artefacts risk collapse and destruction.

Figure 2 Jarred samples in fume hood evaporation conditions. Photo: K. Langdon.

published research and chemical availability. CDD, L-menthol, camphene, and three mixtures of CDD and menthol (at the ratios 65 : 35, 90 : 10, and 95 : 5) were tested in mock-ups of consolidation.[5] In the first experiment, the VBMs were melted and applied to microscope slides at certain thicknesses and with and without a gauze facing. For the second test, the VBMs were poured into small jars to encourage a constant surface area during sublimation. All samples were left to sublime in a fume hood with an elevated ambient temperature (26–30 °C), simulating the conditions of an excavation field lab (Figure 2). The samples were weighed periodically to track the rate of sublimation (Figure 3). Residues left after the mass stabilised were analysed with transmission Fourier transform infrared spectroscopy (FTIR).

Camphene was determined to be unsuitable for archaeological block-lifting due to its lack of rigidity, excessively fast sublimation rate and typical impurity. Menthol was found to have the desired properties but was susceptible to melting in a warm climate, as observed in a field test. Its melting temperature may be ideal in colder conditions. Mixtures of CDD and menthol with a low menthol content (≤ 10%) were found to have the desired properties but require further testing. Embedding gauze in the VBM slowed the sublimation of all tested compounds. Crystal size was found to play a potentially significant role in the sublimation rate. It can be

Figure 3 K. Langdon tracking mass changes of slide samples. Image: L. Skinner.

optimised in practice by application with a brush and by keeping the working temperatures of the VBM and object as low as possible.

Biographies

Katherine Langdon is an objects conservator in private practice at Langdon Art Conservation, LLC, based in Urbana, Illinois, as well as the Project Objects Conservator for a collections survey at the Saint Louis Art Museum. She earned her MA in art conservation from SUNY Buffalo State College in 2014, after completing a capstone internship with the Objects Conservation Laboratory at the Museum of Fine Arts, Boston. She also holds a BA summa cum laude from Washington University in St Louis, in Archaeology and Classics. Her research interests include the development of practical conservation techniques, the technical investigation of ancient and traditional technologies, and preservation and storage best practices.

Email: klangdon@wustl.edu

Lucy Skinner is an archaeological conservator specialising in organic materials, particularly from ancient Egyptian and Nubian origins. She is currently enrolled in a PhD programme at the Institute of Creative Leather Technology at University of Northampton and the Departments of Scientific Research and Ancient Egypt and Sudan at the British Museum. The PhD is focused on ancient Egyptian and Nubian leather technology. She is a graduate of the Conservation Department at the Institute of Archaeology, University College London, where she earned an MA and MSc in Conservation for Museums and Archaeology in 2004.

5 Menthol and camphene were among the VBMs considered by Hangleiter *et al.* (1995) in their early research for conservation and were the chemicals available from suppliers at the time of this research project. L-menthol was selected over racemic DL-menthol because it has a more narrowly-defined melting/freezing point rather than a range.

Aaron Shugar is the Conservation Scientist at the Patricia H. and Richard E. Garman Art Conservation Department at SUNY Buffalo State College. Dr Shugar has a focus on inorganic chemistry and has done work at the Smithsonian Museum Conservation Institute, where he was a Research Associate. He also served as Co-Director of the Archaeometallurgical Laboratory at Lehigh University in Bethlehem, PA. With a PhD in archaeometallurgy from University College London, Dr Shugar has completed extensive research of archaeological metals and glass. Dr Shugar is a Guest Scientist at the National Institute for Standards and Technology (NIST) and a member of the Graduate Faculty at the University of Toronto, and has served as the President of the Society for Archaeological Sciences.

References

Balachandran, S. (2010), 'The use of cyclododecane in field stabilization and storage of archaeological finds', in E. Williams and C. Peachey, eds, *The Conservation of Archaeological Materials: Current Trends and Future Directions*, British Archaeological Reports, Oxford, vol. 2116 of *BAR International Series*, pp. 77–87.

Brown, M. and Davidson, A. (2010), 'The use of cyclododecane to protect delicate fossils during transportation', *Journal of Vertebrate Paleontology* **30**(1), pp. 300–303, URL http://www.tandfonline.com/doi/full/10.1080/02724630903413123.

Bucher, S. and Xia, Y. (2010), 'The stone armor from the burial complex of Qin Shihuang in Lintong, China: Methodology for excavation, restoration, and conservation, including the use of cyclododecane, a volatile temporary consolidant.', in N. Agnew, ed., *Conservation of Ancient Sites on the Silk Road: Proceedings of the Second International Conference on the Conservation of Grotto Sites*, The Getty Conservation Institute, Los Angeles, pp. 218–224.

Cronyn, J.M. (1990), *The Elements of Archaeological Conservation*, Taylor & Francis Group, London.

Hangleiter, H.M., Jägers, E. and Jägers, E. (1995), 'Flüchtige Bindemittel – Teil 1: Anwendungen, Teil 2: Materialien und Materialeigenschaften', *Zeitschrift für Kunsttechnologie und Konservierung* **9**(2), pp. 385–392.

Liang, J. (2009), 'The application of cyclododecane (cdd) for lifting fragile lacquer fragments from burial environments.', in *Poster presented at the Annual Conference of the Association of North American Graduate Programs in Conservation (ANAGPIC), Buffalo State College, Buffalo, NY*, URL http://cool.conservation-us.org/anagpic/2009pdf/2009ANAGPIC_Liang.pdf. (Accessed 25 July 2015).

Watters, C. (2007), 'Cyclododecane: a closer look at practical issues', *Anatolian Archaeological Studies* **XVI (2007)**, pp. 195–204, URL http://www.jiaa-kaman.org/pdfs/aas_16/AAS_16_Watters_C_pp_195_204.pdf. Accessed 1 May 2015.