Progress in the investigation of silicone rubbers and their residues

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Silicone rubber molds are often used to cast and reproduce objects and artifacts. These molds are frequently used in conservation because of their ability to capture high levels of detail, making them very useful for examining surface topography of objects. Paired with scanning electron microscopy or other imaging techniques, impressions taken with silicone rubbers can often reveal technological details, such as tool marks, which can help to reveal the processes of an object's manufacture [1; 2]. In the past two decades conservators have begun to notice that silicone rubbers leave behind a residue, locally discoloring the surface of the object where the impression was made. Residues can sometimes be seen in the form of pieces of cured silicon rubber, trapped within interstices or recesses, but more problematic are components of the silicone rubbers which may be either absorbed by the surface or left on it as a film. These can cause permanent staining of the surface, as well as changes in the surface properties. Some research exists on the characterization of silicone rubbers, the identification of their residues and their mitigation on surface of objects [3]. However, new silicone rubbers have since been commercialized and used in conservation without having been systematically tested for their safe use on historical objects. The current study focuses on an in-depth chemical analysis of eight of these silicone rubbers, and identifies potential residues left behind by them. The silicone rubbers investigated include President Jet Light Body (Coltène), Extrude XP (Kerr Corporation), Elite Double 8 (Zhermack), Elite HD+ Maxi Putty Soft Fast (Zhermack), Elite HD Plus Putty Normal (Zhermack), Silastic J RTV (Dow Corning), HS II (Dow Corning) and P-4 (Silicones, Inc.). Bulk samples of each of these molds were prepared by casting the silicone rubber on different substrates: glass slides, slides coated for analysis in the mid-infrared region, and limestone. The bulk samples were analyzed by mass spectrometry using evolved gas analysis (EGA) to obtain information on the volatility of components within the mold. Then, gas chromatography mass spectrometry (GC-MS) techniques including pyrolysis gas chromatography mass spectrometry (Py-GCMS) were used to clarify the composition of the individual silicone rubbers and verify the solubility of components in the cured molds. The composition of the bulk and surfaces of the silicone rubbers were also compared by attenuated total reflection Fourier transform infrared (ATR-FTIR) microscopy. The residues left behind on the different substrates were studied by FTIR and GC-MS techniques. The study shows that all silicone rubbers investigated leave siloxanes residues to varying extents. Among the tested silicone rubbers President Jet Light Body leaves the least amount of residue. Although non-polar solvents would be suitable to solubilize the residues, the use of a suitable barrier prior to their application on art objects would be recommended, as the masses of polysiloxanes left on the surface may be too high to allow for their complete removal with a solvent or poultices.

[1] Larsen, B. "SEM-Identification and Documentation of Tool Marks and Surface Textures on the Gundestrup Cauldron". *Recent Advances in the Conservation and Analysis of Artifacts*, London, pp. 393-409 (1987)

[2] Sax, M., Meeks, N.D. "Methods of engraving Mesopotamian quartz cylinder Seals". *Archaeometry 37*, 1995, pp. 25-36

[3] Jeffrey P. Maish, "Silicone Rubber Staining of Terracotta Surfaces" *Studies in Conservation 39, no. 4* (Nov. 1994) pp. 250-256.