Ancient Egyptian Coffins past, present, future

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Experimenting with adhesives and consolidants for the conservation of Egyptian polychrome wooden objects

Giovanna Prestipino, *Vatican Coffin Project*
Vatican Museums
giovannaprestipino@gmail.com

A pilot study on adhesives and consolidants used in the conservation of Egyptian polychrome wooden coffins was begun in the context of the Vatican Coffin Project. The research was conducted in collaboration with the Laboratory of Diagnostic for Conservation and Restoration of the Vatican Museums, directed by Ulderico Santamaria.
Initial research and studies on the most suitable materials to use in conservation, those showing the required levels of stability, compatibility and reversibility, were carried out. The aim was that of evaluating the effectiveness, changes and degradation of materials used in conservation, in relation to the constituent materials of Egyptian polychrome wooden coffins.
Adhesives tested were Klucel G, Aquazol 200, Acrylic E411, animal gelatines - both fish and bovine - and Funori.
Consolidants tested were Klucel GF, Acrysol WS24, Aquazol 50, Acrilmat, Regalrez 1094 and Funori.

Preparation of samples

To evaluate the behaviour of these products, several samples were prepared using the same materials with which Egyptian polychrome wooden objects are made:
- the first ground layer, made of clay and gum Arabic, was applied to a small tablet of acacia wood.
- the second ground layer, a mix of calcium carbonate, calcium sulphate dihydrate and arabic gum.
- Egyptian pigments - yellow ochre, red ochre, ivory black, malachite, Egyptian blue - with gum arabic were then applied (Figs. 1, 2, 3, 4).

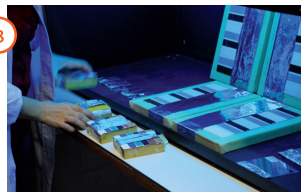
The painted surface of the samples on which the consolidating materials were to be tested, was, on the other hand, prepared by applying the pigments with just water, without the addition of gum arabic, in order to render the surface to be treated less cohesive.
Sample 7 was prepared exclusively in order to verify the adhesive properties of the materials: two thick ground layers were applied, in order to create evident lifting. In this way the sort of deterioration often seen on original materials was induced by technical means (Fig. 5).
The adhesives and consolidating materials were applied to the samples.
Among the adhesives tested was:
Aquazol 200, a synthetic polymer produced in four distinct types - 5, 50, 200, 500 - which correspond to different molecular weights. In the pilot study, Aquazol 200 as an adhesive and Aquazol 50 as a consolidant were tested.
Klucel G, hydroxypropylcellulose, already in use as adhesive for conservation of Egyptian polychrome wooden objects
Two gelatines, fish (Lapigelatina Type GAL/F20) and bovine (Lapigelatina Type GAL20), produced for the alimentary and pharmaceutical industries.
A polysaccharide extracted from Funori algae, prepared by the Laboratory of Diagnostic of the Vatican Museums.
The tests effected with animal gelatines produced negative results: the water in the solutions softened the binder of the samples, gum arabic, and made them soluble (Fig 6).
Evaluating the parameters of the materials tested and the characteristics of the substrate to which the adhesives were applied, Klucel G, Acrylic E 411 and Funori showed the requisite improvement.
Sample 7 adhesion trials by injection were effected with the adhesives which had shown the best results after application with a brush. The two animal gelatines - fish and bovine - Funori algae and two synthetic adhesives - Aquazol 200 and Acrylic E411 - were tried.

The natural adhesives - Funori and the animal gelatines - possessed a greater capacity of penetration with respect to the synthetic adhesives, and a better adhesive power. The gelatins, particularly in the case of the bovine glue, but also the fish one, made the surfaces too wet and dissolved the painted medium. (Fig. 7) Aquazol 200 showed a light yellowing.
Among the consolidants chosen were: Klucel GF, hydroxypropylcellulose of low molecular weight
Acrysol WS24, an acrylic polymer in dispersion
Aquazol 50
Acrilmat, an acrylic emulsion used as it is.
Regalrez 1094, an aliphatic resin of low molecular weight
Klucel GF and Acrysol WS 24 showed the best results.
More generally, this first phase of tests showed that the water-based products – the animal glues, Acrilmat and Aquazol– dissolved the painted layer, gum arabic, which is very sensitive to water.

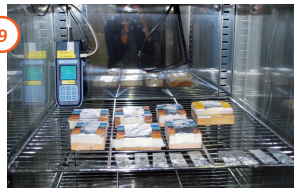
1. Preparation of samples
2. Application of preparatory layer 1: 1p quartz, 2p clay + 1p gum arabic (3:1)
3. Application of preparatory layer 2: 1,5p calcium carbonate, 0,5p calcium sulphate dihydrate + gum arabic (2:1)
4. Application of painted film: pigment + gum arabic for tests on adhesives; pigment + water for tests on consolidates
5. Adhesive tests

6. Tests with animal gelatins

7. Test for re-adhesion with natural adhesives: bovine gelatin



8. Artificial aging: UV radiation. Constant temperature and relative humidity (T 26°C RH 50%)



9. Artificial aging: thermo-hygrometric variation (T 16°C RH 60% for 15 minutes; T 35°C RH 70% for 99 minutes; T 35°C RH 75% for 99 minutes; T 15°C UR 60% for 10 minutes)

To evaluate the stability of the materials tested, the samples were subjected to a first cycle of artificial aging, with ultraviolet radiation, maintaining the thermo-hygrometric parameters constant, for sixteen consecutive days (Fig. 8).
After the first cycle in the artificial aging chamber, on each sample tested was made colorimetric measurements, with three different tests on each colour: the first on the colour before the application of the product; the second on the colour on which the material was applied, but protected with aluminium foil; the third on the portion of artificially aged colour.
Among the adhesives, those which best supported photochemical aging are the same as those which showed the best characteristics after being applied to the samples: Klucel G, Acrylic E 411 and Funori.
Among the consolidants, Klucel GF, Funori and Acrysol showed the best results.
The samples were subjected to a second phase of artificial aging, with sudden thermo-hygrometric variations, over seven days. (Fig. 9). Between adhesives, protein adhesives – fish and bovine gelatine – reacted best when subjected to thermo-hygrometric stress, while, of the consolidants, the best results were seen in Aquazol 50 and Acrilmat.

Conclusions

Concerning the adhesives, Klucel G, Acrylic E 411 and Funori showed the best results, demonstrating good adhesive strength, good diffusion, absence of a shiny skin and chromatic alteration - even after ultraviolet radiation - excellent compatibility with the constituent material and ease of application, both with a brush and by injection. Animal gelatines, particularly the bovine gelatine, whilst having the best adhesive properties and the best mechanical resistance, interfered with the constituent materials. Aquazol 200 showed chromatic alteration soon after application, which became more marked after being under ultraviolet radiation.
Klucel GF, Acrysol WS 24 and Regalrez 1126 provided the best results in the consolidates class, showing cohesive strength, excellent penetration, absence of chromatic variation and a shiny skin, as well as compatibility with the constituent materials. Aquazol 50 and Acrilmat showed the best resistance under thermo-hygrometric stress when compared to the other materials. Aquazol 50, however, showed a discrete yellowing, while Acrilmat was excluded at the beginning, because it solubilised the painted medium.
The results from the research were applied during the conservation of the outer coffin of Butehamon from the Museo Egizio in Turin with excellent results. (Figs. 10, 11, 12, 13)

10. The outer coffin of Butehamon Inv. 2236/1-2
11. 12. 13. The coffin of Butehamon during conservation