Technical Research Bulletin

Volume 7
2013

The British Museum

A Bulgarian *kukeri* mask: a diplomatic gift and the conservation of its polyurethane foam decorations

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SUMMARY In 1971 the British Museum (BM) acquired a recently made Bulgarian *kukeri* mask as part of a significant ethnographic collection that had been specially assembled for the BM by the Bulgarian government. Such masks were worn at annual ritual celebrations and were not generally intended to last for any length of time. The materials used were often cheap and ephemeral, with the result that preserving them in a museum context presents particular problems.

By 1991 the set of polyurethane ether (PUR) foam roses and leaves crowning the mask had deteriorated severely and any movement of the object resulted in significant shedding of the foam. In 2004 a desire to redisplay the mask led to its reassessment. A technique devised at the Netherlands Cultural Heritage Agency (RCE), which uses a combination of an antioxidant (Tinuvin B75) and a consolidant (Impranil DLV/1) dispersed in isopropanol (propan-2-ol) and applied as a fine mist through a nebulizer, was tested on foam samples. The results for this consolidation method, which provides both physical and chemical stabilization of the PUR foam, were assessed using pin, compression and flexibility tests, attenuated total reflectance Fourier transform infrared spectroscopy and visual assessment using an indicator dye. Treatment times of five minutes or more achieved a penetration depth of 2–5 mm and resulted in a strengthened foam that was less prone to shedding. The consolidation of the roses and leaves was most successful on the least deteriorated foam, suggesting that early intervention is desirable, possibly at the time of acquisition.

Figure 1. The Bulgarian mask donated to the British Museum in 1971 (Eu1971,01.316) on display in 1977

Figure 2. The mask as received for conservation in 2004

Introduction

Materials from the twentieth and twenty-first centuries are increasingly being incorporated into museum collections and the British Museum (BM) is no exception. Among these new materials are plastics and, while many plastics are relatively stable, a number are known to be particularly prone to degradation, including cellulose nitrate and acetate, heavily plasticized polyvinyl chloride and polyurethane foams.

In 1971 the BM acquired a recently made Bulgarian mask crowned with a set of flexible polyurethane foam roses and leaves. In 1977 the mask was included in the exhibition *Bulgarian Village Arts* at the Museum of Mankind and photographs taken of the display appear to show the roses in good condition, Figure 1. By 1991, the roses and leaves had deteriorated badly and any movement of the mask resulted in shedding of the foam. At that time no conservation treatments had been developed and tested for polyurethane foam and museums were only just beginning to address the issues presented by degrading plastics in their collections [1, 2]. As a result, while other areas of the mask were conserved, the foam roses and leaves were left untreated.

The object was again considered for display in 2004 but the condition of the roses had deteriorated further, Figure 2. By this time, however, finding an appropriate treatment looked more promising as the degradation mechanisms of polyurethane foam were better understood and a number of experimental consolidation treatments had been carried out [3–11].

This contribution describes the background to the acquisition of the mask as a gift to the BM, how the mask would have been used in its original context and discusses the experimental conservation treatment of the roses and leaves.

History and significance of the mask

A dramatic concoction of multi-coloured beads, fabrics, mirrors and coins, with gaping red eyes and mouth, this metre-high mask is part of a large ethnographic collection specially assembled for the BM by the Bulgarian government in 1971, Figure 1. The gift was conceived by the ‘Bulgarian Committee for Friendship and Cultural Relations with Foreign Countries’ to mark the planned visit to London in 1970 by the Committee’s president, who had been invited by the Great Britain-East Europe Centre, an organization that fostered links with a number of Iron Curtain countries. The collection contains some 350 objects, carefully gathered between 1969 and 1971 from all over Bulgaria by the curators of the Ethnographic Museum in Sofia; they are superbly documented, with the region of each piece, its purpose and its component materials all faithfully recorded. Despite some distinguished acquisitions of European ethnographic material in the late nineteenth and early twentieth century, there had been no coherent history of collecting such objects in Europe by the BM and this gift became the springboard for subsequent acquisitions.

Masked rituals in Bulgaria are a rural activity occurring twice in the year: *survakari* takes place at New Year in western and south west Bulgaria (*sur* = green, a word used in the traditional New Year blessing) while *kukeri* takes place at the beginning of Lent in central, southern and eastern Bulgaria. The etymology of *kuker* is unclear and although it is generally translated as ‘mummer’, the term *kukeri* has become generic and is currently used for all masked rituals whenever they take place.

Both rituals involve elaborate costumes incorporating not only large and often terrifying animal masks but also a series of heavy cowbells worn at the waist, which make a tremendous noise as the wearer dances – traditionally to drive away evil spirits. During both the New Year and Lent festivals the mummers visit the houses in the village to wish the occupants good health and prosperity. In addition to the masked men, there are a number of stock characters, also played by men, who enact various ritual scenes. However, the Lenten custom to which this mask belongs is distinguished by a specific performance in the village square of a ploughing and seeding ceremony to bring fertility and welcome the spring, as well as an enactment of the killing and revival of the tsar, symbolizing the resurrection. The men who wore these masks – although there are now female mummers this is a relatively new development – were traditionally young and unmarried, and for them this was one of the rites of passage to manhood [12; pp. 171–174, 196–201].

Under communism, folk culture and activities were initially discouraged as part of the homogenization of the country. But the early 1960s saw the introduction of state support for Bulgarian folk customs and the establishment of the biannual festivals of *kukeri* and *survakari* from 1965. The festivals became in themselves a new art form, with masks specially created to dazzle and impress a large audience, while the award of monetary prizes provided a huge incentive for the revival of local customs [13–15]. The prizes were awarded by a jury of specialist scholars for “the best recreation of tradition” [14; pp. 37, 72]. The festivals are still popular today, as are village traditions that are inherently carnivalesque and poke fun at the authorities. These traditions still retain intense meaning for Bulgarians, as demonstrated by the use of *kukeri* during the economic collapse in Bulgaria in 1997, when students dressed up as mummers and performed in front of the parliament building to drive out evil forces [13; p. 127]. It is a form that is in constant development.

Composition and structure of the mask

With the Bulgarian gift of 1971 there was no mention of the makers of the mask, although such masks were generally made by the men who wore them. However, this mask, with its complex arrangement of embroidery, has much in common with costume decoration carried out by women and may have been made by a number of hands. The serried rows of braiding, rickrack (flat narrow braid woven in zigzag form) and beading could almost come straight from a Bulgarian *sukman*, the tight-fitting coat worn as part of a woman’s costume, Figure 3 [16; pp. 36–37].

The core of the hood is a tall cone of black felted wool, the upper part stiffened inside with a padded fabric cushion, the front rigid with embroidered flowers and fruit, among which there are pomegranates, a symbol of fertility, as well as glass and plastic beads and buttons. In the lower half of the mask, the face has openings for the eyes and mouth bordered with red woollen cloth, and a long padded nose, itself covered with rickrack and sequins, ending in a string of pearls hanging from the tip. The bands of beading above the eyes form grotesque

Figure 3. Detail of the face of the mask showing applied beading, mirrors and embroidery

eyebrows that meet in the middle, where an old Ottoman token is sewn. Three more Ottoman tokens are sewn at the top of the hood. They are of thin stamped metal imitating coins, made purely for ornamental purposes; all four bear the date 1808, corresponding to the reign of Sultan Mahmud II (1808–1839). Three standard handbag mirrors are placed on each cheek and on the forehead to deflect evil spirits. Any remaining space is filled by snaking threads of silvered glass beads to catch the sunlight.

At the base of the hood is pinned a piece of professionally made antique folk jewellery from the late nineteenth or early twentieth century: a copper alloy bridal head ornament known as a *prochelnik*, usually worn pinned to a headscarf with the large element placed centrally, the dangling pendants hanging down over the forehead and the long multiple chains carried round the side of the head and secured at the back, Figure 4.[1] The form of this *prochelnik*, with four chains on either side, is characteristic of the Sliven area, from which the mask comes. By 1970 traditional jewellery and costume was worn for festive occasions only; no longer needed, the ornament was instead placed on the mask. The chains are dotted with leaf-shaped pendants each stamped out to create a central raised hemisphere, Figure 4. The leaves would also swing in the wind, catching the light and adding a gentle rustle to the vibrant clang of the mummer's bells.

The mask is decorated at the sides with red waxed-paper roses and at the very top, the curled foam roses that form the subject of this paper. To the west of the Sliven region, where this mask was made, is the rose-growing area of Bulgaria, which produces about 70% of the world's rose oil. Roses are the flower most commonly found on Bulgarian headdresses.[2] At the back of the mask, a printed cotton fabric covers the hood but is almost obscured by the coloured paper streamers that hang from the top, which are attached with white metal coils and chains.

The mask is, in short, a palimpsest of Bulgarian traditional culture, mixing old and new in an object that had the dual function of ritual and display, for an audience to whom the associations of the Ottoman imitation coins, the bridal jewellery no longer used for its original purpose, the shining beads and mirrors, and the Bulgarian roses would have been redolent with meaning.

Condition of the foam roses and leaves

In 2004, when the mask was assessed for display, all its component materials, with the exception of the foam roses and leaves, were in good condition and did not require treatment. The focus of the conservation was, therefore, on the set of flexible foam roses and leaves.

Commercially produced in Bulgaria, two small and two large roses are each constructed from between one and five 'petals' cut to shape from sheets of coloured polyurethane flexible foam approximately 2–3 mm thick, Figure 5 [17]. The top edges of some of the petals have been delicately curled outwards, a subtle detail that enhanced their rose-like appearance. The petals are wrapped around a paper-covered metal wire that extends as a stem, with green paper leaves incorporated around the base of the roses. The three foam leaves are similarly cut from 2–3 mm thick polyurethane foam sheet and were presumably once tied or stitched against the stems of the roses and/or the textile base of the mask.

By 2004 all the roses and leaves were fading and disintegrating, with the two larger roses seemingly in worse condition than the smaller roses and leaves. Most of the degradation was on the outer surface of the outermost petals. Any movement of the object resulted in significant shedding of the foam and fine red and green powder could be seen on the surface and base of the mask. All the roses exhibited tears and losses, particularly along edges and tension points, such as where the petals curled outwards. Some sections of the larger outer petals had lost so much structure that they had come loose from their wrapped positions and hung unsupported from the mask, Figure 6. Two of the green leaves had come away from their stems while a third, although still attached, had a large tear and loss. Fine particulate soiling greyed the colours of the foam, primarily on the outer surfaces of the roses and leaves that had been most exposed in storage.

Identifying the foam

Analytical identification by Fourier transform infrared (FTIR) spectroscopy confirmed that the foam roses and leaves were constructed from polyurethane ether foam. The many different types of polyurethanes all contain urethane linkages (–NH–(C=O)–O–), which are produced by polyaddition reactions of a polyisocyanate (containing at least two –N=C=O

Figure 4. Detail of the base of the hood showing the bridal head ornament

groups) with a polyalcohol (polyol; containing at least two –OH groups). The polyisocyanate may contain a variety of aromatic or aliphatic groups. Equally, the polyols may contain a variety of groups and generally fall into two classes: polyethers and polyesters. Those polyurethanes containing polyester groups (PUR ester) are considered less stable to hydrolysis than polyurethanes made from polyether polyols (PUR ether), while PUR ethers are considered less stable to thermo-oxidation [18]. Polyurethanes containing aromatic groups are more prone to photo-oxidative yellowing than polyurethanes made from aliphatic polyisocyanates [18]. The FTIR spectra of the foam roses and leaves showed the characteristic pattern for PUR ethers, with many broad peaks in the fingerprint region (1800–600 cm^{-1}) dominated by a strong C–O–C absorption peak around 1100 cm^{-1}. No absorption occurred in the 3300–3000 cm^{-1} region, indicating that aromatic compounds were not present.

Both PUR ester and PUR ether can be manufactured into foam products, particularly those with open cell structures. The roses and leaves examined here are of the open cell type and are vulnerable to degradation as they have a large surface area that is easily accessible to damaging environmental factors such as oxygen, light and moisture. The PUR ether foam in the roses and leaves shows a typical degradation pattern for the material; within 20 years of acquisition, the outer layers of foam had become embrittled, while the interior of the foam, protected from light, was still in reasonably good condition and had retained some flexibility. In contrast, PUR ester foam would degrade very differently as water vapour could move freely within the open cell structure causing hydrolysis throughout the cellular structure. As a result, deteriorated PUR ester foam does not regain its shape after compression but instead collapses into a loose and often sticky mass.

Proposed treatment

An ideal conservation treatment would strengthen the roses and leaves, prevent further shedding, inhibit further oxidation, avoid altering the foam's visual appearance or structure and would be reversible and/or re-treatable.

Several treatment approaches were considered including long-term, low temperature storage (freezing) of the roses, housing them in an anoxic (oxygen-free) environment and consolidation. Chemical reactions slow down as temperature is reduced, so low temperature storage should reduce the rate of deterioration of the polyurethane foam. Since oxidation causes the deterioration of the foam, storage in an anoxic environment should inhibit further degradation. Freezing and anoxia were discounted as neither would prevent shedding

Figure 5. The delicately curled petals of the roses, which show a loss of mechanical strength due to deterioration

Figure 6. Evidence of the deterioration of the roses: fading, fragmentation and extensive shedding of the foam

of the foam that had already degraded, nor would they have allowed the roses to be reattached to the mask or enable handling for study.

Given the advanced stage of degradation, consolidation was considered the most appropriate treatment approach. Consolidation met all but one of the required outcomes of the treatment as it was accepted that in this case the severe deterioration of the foam precluded the option of reversibility or re-treatability.

Several methods of consolidating polyurethane flexible foam have been discussed in the conservation literature and summarized by van Oosten [19; pp. 47–56]. The most promising appeared to be a combination of a consolidant and antioxidant treatment that addressed not only the physical but also chemical stabilization of PUR foam. This method, which was devised and tested at the Netherlands Cultural Heritage Agency (RCE)[3] uses Tinuvin B75 (a mixture of a phenolic antioxidant, UV-absorber and sterically-hindered amine light stabilizer) and Impranil DLV/1 (an anionic aliphatic polycarbonatester-polyether polyurethane dispersion) suspended in isopropanol (propan-2-ol) and applied as a fine mist through a nebulizer. The treatment was found to be successful and have long-term stability when tested in accelerated ageing experiments [19; pp. 87–90].

This consolidation method was tested on naturally and artificially aged foam models in preparation for the conservation treatment of the roses and leaves.

Testing

A sheet of new PUR ether flexible foam, chosen because of its similarities with the foam used in the roses in terms of thickness, cell size and chemical composition (as confirmed by microscopy and FTIR spectroscopy respectively), was artificially aged to generate some degraded material for testing. Light ageing was selected rather than thermal ageing in order to produce a foam with deteriorated outer layers but a relatively intact inner structure that closely modelled the degradation pattern observed on the roses. The model foam was light-aged for five weeks in a Microscal light fading tester with a mercury-tungsten self ballasted 500 W lamp, giving a light level of *c.*49000 lux and an ultraviolet output of 860 μW.lumen^{-1}. Test pieces of this foam, together with some naturally aged material (again selected for its similar thickness, cell size and chemical composition to the roses), were treated with the Tinuvin B75 and Impranil DLV/1 mixture. A batch of 200 mL of the consolidant and antioxidant dispersion was made from 10 mL Tinuvin B75, 50 mL Impranil DLV/1, 25 mL isopropanol and 115 mL deionized water. The treatments were carried out using a PARI LC PLUS nebulizer powered by a PARI BOY N compressor.

For health and safety reasons fume extraction was necessary. Initial tests showed that direct extraction in the studio fume cupboard or using a mobile extractor unit was too strong as it caused the fine consolidative mist to be extracted before it reached the foam. A small tent-like box was therefore

Figure 7. Treating a sample of aged foam with the nebulizer inside a custom-made enclosure

constructed, with clear polyethylene sides and an adjustable front flap large enough to allow access for the nebulizer cup and for it to be manipulated comfortably inside the box, Figure 7. The box was situated within a fume room and an additional mobile fume extractor removed any mist escaping from the box. Nitrile gloves and a vapour mask appropriate to the particle size generated by the nebulizer were worn.[4]

Due to the nature of the nebulizer system it was necessary to hold the nebulizer cup upright with the mist ejected horizontally. As a result, the object under treatment had to be supported in a way that allowed rotation and access to all surfaces, which was achieved by supporting the roses and leaves with blocks of polyethylene foam (Plastazote).

In three rounds of consolidation tests, over 30 test pieces of foam were treated for varying lengths of time ranging from 10 seconds to 20 minutes. The approximate test piece dimensions were 3 × 15 × 50 mm. Thicker foam blocks and stacks up to four layers thick were also tested.

The success of treatments was assessed using pin, compression and flexibility tests. In the pin test, the cell walls in the treated foam were manipulated under hand pressure with a metal pin and their resilience assessed under an optical microscope. Compression and flexibility tests were carried out manually using a glass rod to crush and fold consolidated test foam pieces, and the resulting quantity of shed foam assessed empirically, Figure 8.

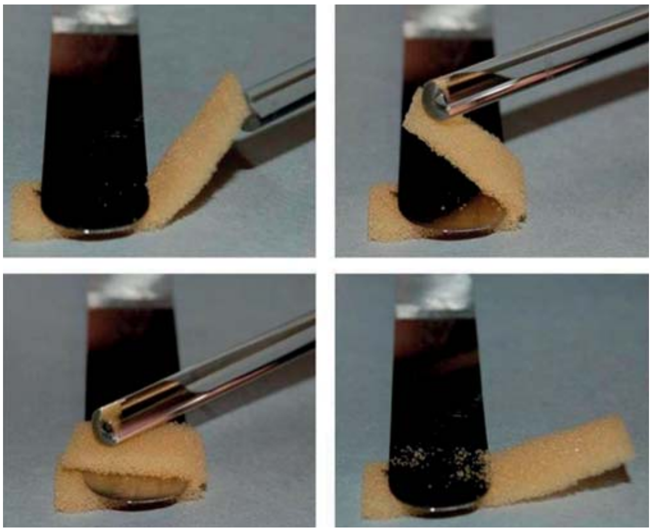

Figure 8. Testing the flexibility of the foam samples to assess the effects of varying the treatment time

Short treatment times (10–30 seconds) did not result in any improvement in flexibility or resistance to breakage in the foam. Treatment times of one to two minutes showed some success with less shedding and breakage of the foam cell structure, but in all cases the degraded foam was still fragile after treatment. Increasing the treatment time to five minutes or more resulted in a stronger foam that exhibited fewer breakages and shed less material compared with untreated foam.

Due to the crumbling nature of the foam it was important to attempt to consolidate as deeply as possible, preferably throughout the entire thickness of the foam (5 mm). To determine the depth of penetration, two experimental approaches

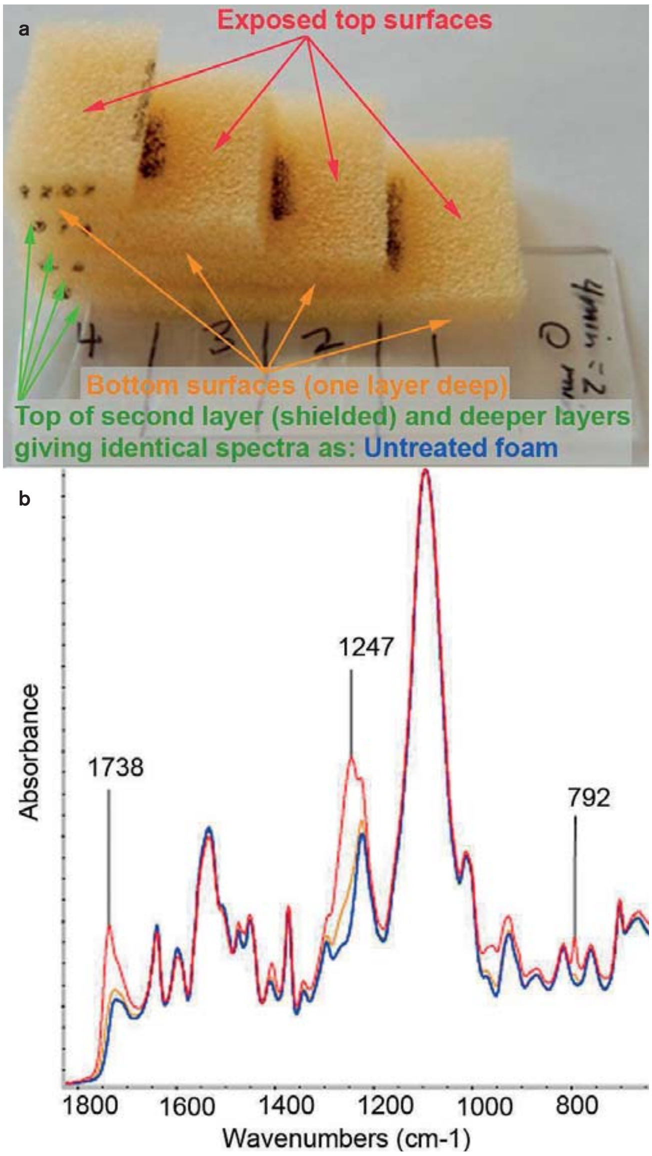

Figure 9. Analysis of the stepped foam layers using ATR-FTIR to test the depth of penetration: (a) the locations at which measurements were made; and (b) the spectra recorded at these locations. The red spectra were recorded on the top surfaces exposed to the consolidating mist, the yellow spectra on the bottom surface of the layer exposed to the mist, the green spectra on the bottom surfaces deeper in the layer structure and the blue spectra on untreated foam

Figure 10. Foam rose model treated with a consolidant mixture containing methylene blue as an indicator

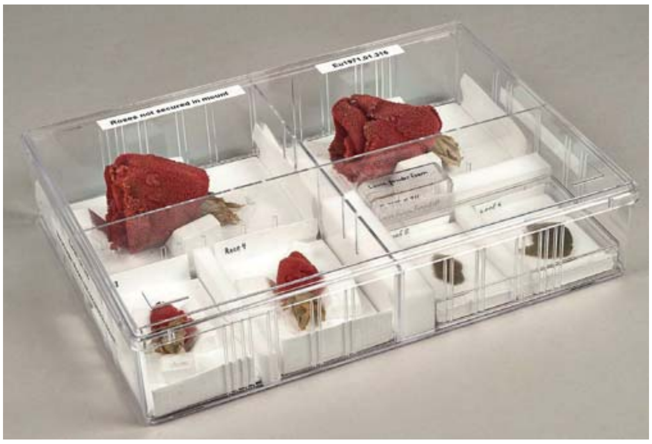

Figure 11. The roses and leaves after conservation, housed in a new storage box

were followed. Spectroscopic detection of the consolidant was carried out at different depths and an indicator dye was added to the consolidant mixture during some of the test applications so that the depth of penetration could be assessed visually.

The stacked layers of 5 mm thick foam were treated for a total of four minutes, which equates to two minutes on any particular area, due to the small area covered by the output from the nebulizer cup. The results were assessed using attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy.[5] Spectral peaks indicative of the consolidant (at 1738, 1247 and 792 cm^{-1}) were clearly present on the exposed upper surface of the top layer of foam exposed to the nebulizer and were just discernible on the bottom surface of this foam layer. Lower layers of foam showed no traces of the consolidant, which suggests a penetration depth of 5 mm with a two- minute treatment time, Figure 9.

The indicator dye methylene blue was added to the consolidant mixture and applied, by nebulizer treatment, to a foam block and an artificially aged model foam rose. Here, results showed that the consolidant penetrated to depths of between 3 and 4 mm over five minutes with a strong saturation gradient; the surface was heavily stained while considerably less consolidant had reached beyond the first 1–2 mm, Figure 10. The observed difference in penetration depths compared to the ATR-FTIR tests could be due to an increase in viscosity of the consolidant mixture after addition of the indicator dye. This is consistent with a noticeably faster clogging of the nebulizer equipment once the indicator dye was added.

Overall, the test results suggest a penetration depth of 3–5 mm over a two to five minute treatment time. This is considerably less than the 20 mm depth achieved at RCE during a treatment lasting five minutes [19; p. 72]. The difference in penetration depth could be due to a variety of factors: the viscosity of the treatment solution; the nebulizer equipment used; the particle size output; the dose delivered; and the nebulizer pressure. Furthermore, the nature and level of deterioration of the foam will also have an effect, with larger pore sizes allowing deeper penetration than would be possible in denser foams or severely degraded surfaces with a collapsed cell structure.

As only the outer layers of the roses had deteriorated, it was decided that it was unnecessary for the consolidant to penetrate fully into the multi-layer structure of the roses and it was considered sufficient to treat the exposed area of each rose and leaf for five minutes, to give an expected penetration depth of 2–5 mm.

Treatment

To facilitate conservation treatment, the roses and leaves were removed from the mask. One leaf was left *in situ* as its removal would have necessitated cutting through the foam, which was felt to be inappropriate. This untreated leaf will also act as a point of reference to determine the effectiveness of the consolidation over time.

Due to the extreme fragility of the foam, it was not possible to remove the soiling from the roses and leaves before consolidation, particularly where it had penetrated deep into the foam's structure. Any physical manipulation would have caused further disintegration and it was accepted that the dirt would most likely be consolidated during treatment.

Each rose and leaf was consolidated individually using the same equipment, procedure and precautions as during the tests. The roses and leaves were supported in position using blocks of polyethylene foam and rotated by hand as each section needed to be accessed. Due to the small output area of the nebulizer cup, each rose took between one and five hours to consolidate and was left in an extracted fume room to dry overnight. After approximately 20 minutes, the nebulizer cup would clog and need cleaning with isopropanol before further consolidant could be applied.

Results and discussion

The consolidation treatment was successful on the two leaves and two smaller roses; since treatment their colour and structure has not changed visibly and they have not exhibited further shedding of foam, although they remain very fragile and are not strong enough to be reattached to the mask.

The consolidation treatment was only partially successful on the two larger, more severely degraded roses and they still shed foam when handled, although noticeably less than before treatment. Small, torn areas remain vulnerable to loss and the consolidant can be seen on some surfaces of the degraded foam as fine white droplets. It is not clear why the treatment was not as successful on these roses, but may in part be attributed to their advanced stage of degradation; perhaps there was not enough original structure to which the consolidant could adhere. Alternatively, longer treatment times or consolidation further into the structure might have been needed, although the droplets of dried consolidant suggest that the surfaces had become saturated.

The different treatment outcomes observed between the severely degraded larger roses and slightly less degraded smaller roses and leaves indicate the treatment might be most effective if applied to foam that has not yet reached an advanced stage of degradation. Taking this further, it has been proposed that treatment be considered as a preventive measure and applied to relatively new polyurethane ether foams as they enter museum collections [19; pp. 87, 90]. Research at RCE has suggested that the application of this consolidant and antioxidant mixture will significantly extend the lifetime of PUR foam and it is the only effective treatment found to date for the long-term stabilization of PUR foam.

Another approach for new PUR ether foam entering collections may be to enclose it in a sealed environment that is starved of oxygen, thereby preventing, or at least reducing, the rate of oxidation. Such anoxic environments can be provided by creating a sealed enclosure from oxygen-impermeable film and displacing the internal air by flushing with nitrogen or another inert gas. The insertion of oxygen scavengers in the enclosure can help maintain and prolong the anoxic conditions. The benefit of sealed storage for natural rubber materials has been proven in long-term studies at the BM [20–22]. Some of the Museum's rubber objects are now housed in anoxic enclosures and the intention is to extend anoxic storage to include other materials that are vulnerable to oxidation, such as PUR ether. This practice is, however, labour intensive as regular monitoring and maintenance procedures need to be in place and the increased storage volume provides further challenges for large collections that are short of storage space. This storage method does not preclude the object being taken out for display or study but such activities will further increase the work load in terms of removal from and replacing in appropriate anoxic enclosures.

It should also be borne in mind that objects such as this mask were never meant to last. Scheffler recorded cases where the masks lasted for five to 10 years if they were kept well [15; p. 48], but they were generally refurbished or completely remade. Anyone participating in a festival needed to have a mask that had not been seen before, while new and ever more 'modern' elements could be added to masks used locally to make them look fresh every year. When this mask was made the foam roses were commercially available in Bulgaria, while those used currently are imported from China [17]. It would be possible, therefore, to obtain new roses to attach to the mask if it were to go on display and to continue to purchase further sets as the older roses deteriorate. This assumes that the supply will continue, but also raises questions about representation and authenticity that are beyond the scope of this paper.

As the roses and leaves were not strong enough to reposition on the mask they were packed for storage. Each rose was placed on a Tyvek (bonded polyester fabric) covered polyethylene foam support, with Tyvek-covered polyethylene foam blocks stitched into specific positions to prevent the roses from moving during transport, Figure 11. Tyvek handles allow them to be lifted from the box without touching the foam directly. The mounts sit in a clear polystyrene Carmo box housed in a padded drawer built on top of the mask's existing wooden box, ensuring that the roses are kept with the mask and protected from light. To prevent volatile emissions from the wood adversely affecting the mask, the interior of the wooden box was covered with Moistop PP0038. This is a laminated barrier foil (consisting of polyester, aluminium foil and polythene), which is used routinely as a barrier against off-gassing from wood or fibreboard.

Conclusions

The consolidation treatment for these polyurethane ether foam components of the mask was most successful on the least deteriorated material, suggesting that to preserve polyurethane foam early intervention is desirable, possibly at the time of acquisition. As it seems likely that objects containing polyurethane will become increasingly ubiquitous as the Museum's twenty-first century collections expand, the rapid degradation of the roses also highlights the importance of identifying vulnerable plastics within the collection and the need to consider intervention before the onset of deterioration.

Acknowledgements

The authors would like to thank: Thea van Oosten, retired senior conservation scientist at RCE, who generously shared her research and hosted two of the authors (CW and MH) on her PUR foam consolidation workshop; Imogen Laing and Marianne Eve for assisting with the improvements to the mask's storage; and Ian Fahy for carrying out storage box modifications. They also thank: Sarah Posey who, when a curator in the former Department of Ethnography, supported the efforts to find a suitable treatment and made many helpful comments on the draft text; James Parker, former conservation scientist at the BM, for carrying out initial testing of the PUR foam; Vesta Curtis, curator, Department of Coins and Medals for identifying the Ottoman tokens; and Elena Vodinchar of the Ethnographic Museum, Sofia, for her informative comments on the mask.

Materials and suppliers

- Carmo boxes: Carmo A/S, Hoejvangen 19, DK-3060 Espergaerde, Denmark.
- Impranil DLV/1: WhitChem, 23 Albert Street, Newcastle-under-Lyme, Staffordshire ST5 1JP, UK.
- Moistop, Tyvek and Plastazote: Preservation Equipment Ltd, Vinces Road, Diss, Norfolk IP22 4HQ, UK.
- Tinuvin B75: Elastomerics Ltd, Summit House, 48a Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH, UK.
- PARI LC PLUS nebulizer and PARI BOY N compressor: PARI Medical Ltd, The Old Sorting Office, Rosemount Avenue, West Byfleet, Surrey KT14 6LB, UK.

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Notes

1. The BM collection includes a woman's head ornament of *prochelnik* type (Eu1971,01.275) from Sliven, Bulgaria. Analysis of Bulgarian jewellery in the BM in 2011 showed that it is nearly all made of copper alloy with small amounts of silver and arsenic as a whitener [23].
2. An example is a headdress from Pleven in northern Bulgaria (Eu1971,01.11), which is part of a complete bridal costume with similar waxed paper roses as well as a row of red wool roses.
3. Formerly the Netherlands Institute for Cultural Heritage (ICN).
4. 3M 4277 half mask respirator fitted with an organic vapour, inorganic gases, acid gases or particulates filter.
5. ATR-FTIR was carried out using the Smart iTR diamond accessory on a Nicolet 6700 bench. Spectra were collected from top and bottom surfaces on each layer over the range 4000–650 cm^{-1} using 32 scans at a resolution of 4 cm^{-1} and automatic gain.