A Preliminary Review of Some Alternatives to PhillySeal R Epoxy for Conservation and Mountmaking

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Introduction

Loss compensation in some object conservation treatments may require the addition of structural components. Additionally, the handling and display of art objects may entail the addition of temporary supports for movement or more permanent mounts for display. Epoxy putties have played an important role in these applications, and since the 1980s conservators and mountmakers have extensively used one product in particular, PhillySeal R produced by Philadelphia Resins. In 2007 Philadelphia Resins announced that the market for the product had diminished, and it would no longer produce the material.

The Material

PhillySeal was developed as a marine filling compound for the repair of metal walls but was also known as a "rat-seal;" applied over openings it prevented the migration of rodents through small gaps present within ships. The two-part material, known initially as Pliacre, was available in the 1980s as a tan-colored putty and transitioned to a new name with its now familiar grey color (from the black hardener and white resin) in the late 1980s. In general the epoxy was mixed by eyeballing the volumes of the two components and hand mixing. Its ease of use and relative low cost made it a popular choice for many applications in the conservation field

General Properties

PhillySeal epoxy had many properties which made it useful to conservation. Beneficial working properties included hand mixing, water smoothing, good working time, low heat on setting, high compressive strength (15,000 PSI), and very hard once cured (Barcol 25 ASTM D-2583). It was also relatively inexpensive and available in bulk. It passed Oddy testing repeatedly (silver, copper, and lead coupons) and was considered inert. However, to produce the putty consistency, PhillySeal was heavily loaded with fillers such as free silica. These materials could be released on grinding and could also dull cutting and lathe tools. PhillySeal had a pot life of 45 minutes, set time of 6 hours, and a 16 hour cure time.

Applications

PhillySeal resin has been used to create fills in the restoration of ceramics, stone, and metal but has also been used in treatments of skeletal materials in natural history collections (1, 2). For the repair of ceramic losses, the catalyzed epoxy putty was rolled out into thin sheets and laid over a protected plastic-covered area of the vase. The sheet would slump over the vase assuming its contours. Once set, or when rubber hard, the sheet could be aligned with the area of loss and trimmed to shape. Once the correct shape was achieved, the replacement sherd would be adhered in place usually with an acrylic resin. For structural purposes this was sufficient although the epoxy "sherd" could be finished further with acrylic fillers and paint (fig. 1).

figure 1

Similarly the putty could be used for filling losses in marble ranging from small losses to larger more modeled sections (fig 2).

figure 2

Perhaps one of the largest applications of PhillySeal was for mountmaking, where it was integrated into mounts or used as an interface layer. The putty was pressed and contoured to uneven sections of objects (covered in a suitable barrier), providing intimate contact between the object and mount.

This keying into the overall surface provided for excellent capture and support of an object (fig. 3a, 3b).

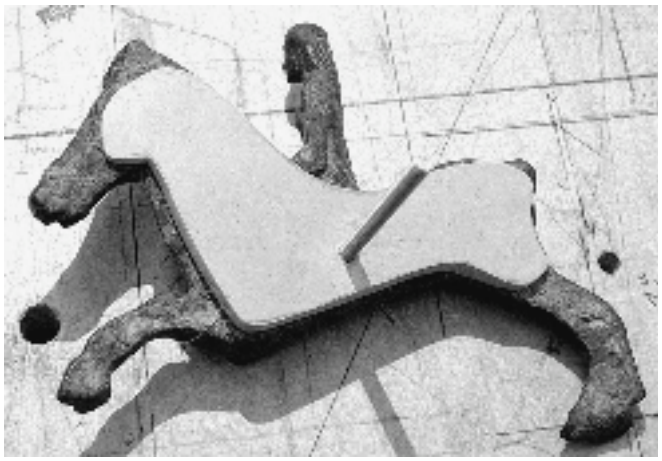

figure 3a

figure 3b

figure 4

Cast interfaces under an object eliminate any rocking or point-loading caused by an uneven surface and often provide an opportunity to achieve a specific display orientation (fig. 4).

Finally, because of its high compressive strength, PhillySeal was also used in crating and for lifting rigs. Targeted areas on a sculpture could be sandwiched between wood supports, cut with the approximate contours of the object, and interfaced with PhillySeal epoxy. Once cured, the interfaced supports would prevent the sculpture from moving during transport. With difficultly shaped objects, the interfaced supports become lifting rigs when placed opposing each other and put into compression around the sculpture, for example, with a thread-rod. This would allow the object to be lifted from the rigs, versus complicated rigging with straps on the object (fig. 5a, 5b).

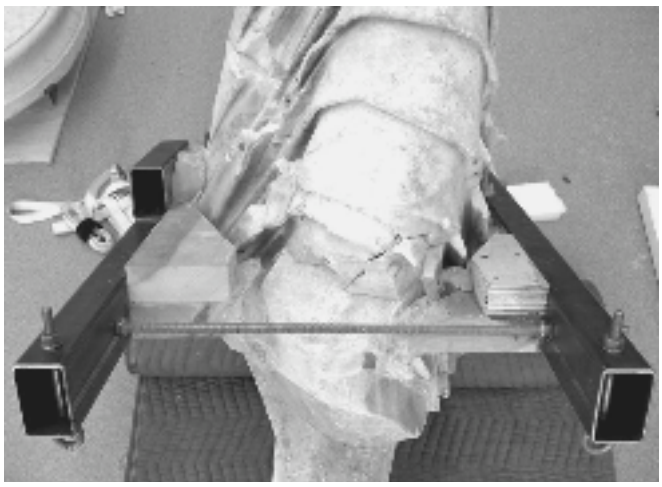

figure 5a

figure 5b

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Replacement Parameters

Several factors were considered in selecting a suitable replacement product. Again, these included ease of mixing, consistency, working and set time, and availability in larger, more economical quantities. As with PhillySeal, all potential replacements had to pass a non-contact Oddy testing using silver, copper, and lead coupons.

Philadelphia Resins was initially consulted regarding replacements but only limited recommendations and no direct replacement products were offered. Several epoxy suppliers and distributors were also contacted with similar outcomes. Because of the specific requirements and "niche" market of the material type, the search eventually turned to on-line suppliers and word-of-mouth recommendations from conservators and mountmakers.

Products Tested

An initial search showed a range of products available with similar but somewhat different working properties. Testing was expanded to include less viscous pastes epoxies as well as the thicker putties (3). All the resins were tested for workability as well as for stability in a museum environment. Over thirty samples were prepared for Oddy testing by casting strips, mixed by weight, into small rectangular molds. Once set, the strips were cut into cubes, approximately 1 cm on edge. In general samples were 4-6 weeks old at the initiation of the Oddy testing (4). Non-contact Oddy testing was conducted with copper, silver, and lead coupons (5) with results outlined below:

Manufacturer	Product	Silver fail	Copper fail	Lead fail
PC	Crete			
PC	Plumbing			
PC	Metal			
PC	Marine			
PC	Lumber			
Aves Studio	Apoxie Sculpt			
Aves Studio	Fixit Putty			
Aves Studio	Fixit Paste			
The Compleat Sculptor	Magic Smooth			
Wood and Stone Co.	Akabond 621 KG			
Procreate	Terrain		t	
The Complete Sculptor	Magic Sculpt		t	
PC	Farenheit		t	
Fiber Resin, Inc.	Gapoxio		t	
PC	Fast-N-EZ	X		
PC	Concrete EZ		X	
Kraftmark	Fab Epoxy		X	
Procreate	Professional Sculptors		X	
POR 15, Inc.	POR 15		X	
Milliput	Yellow Gray		X	
Milliput	Terracotta		X	
Devcon	Magic Bond		X	
Paleo-Bond	Paleo Sculpt PB121		X	
PC	7		X	
Epoxy Technology	Epotek 731		X	
PC	Superepoxy			X
PC	11		X	X
Cir-Cut Corp.	All Game/All Fix		X	X

X - Fail t - Temporary use

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Discussion

The Oddy results were variable with a high percentage copper coupon fails. This prompted an initial review of the epoxy constituents to determine if there was a common epoxy component in the copper coupon fails. The MSDS sheets were of some assistance in identifying components although listings were not complete. As often encountered, manufacturer contacts were of limited help. The reluctance to reveal proprietary information was especially the case with many epoxy putty manufacturers since the epoxy products were often formulated for very specific application and formed a major product line within small companies.

To help better understand the copper coupon failures, a copper coupon Oddy test was conducted on one particular epoxy, using the resin and catalyst separately and then the catalyzed resin (fig.6).

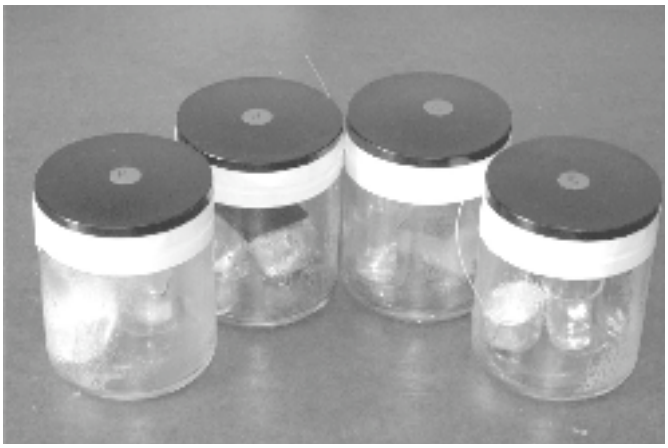

figure 6

The results show the resin itself had no effect on the copper coupon, the catalyzed resin had slight corrosion, but the catalyst alone was found to be highly corrosive. A noticeable effect on the copper coupon was noted after only a few days. This suggested that the presence of some components could lead to greater corrosion during Oddy testing. A brief survey hints at the chemical variability possible in epoxy manufacture:

Epoxy resin types
- Glycidyl
  - GEBRA (diglycidylether of bisphenol A)
  - TGMDA (tetraglycidylmethylene dianiline)
- Non-Glycidyl
  - Phenol cresol novolac
  - Cycloaliphatic epoxies (CA)

Curing agents
- Polyamine/amine (most common and durable)
  - Tetramine (tetraamine)
    - Hexamethlylene
    - EDA, DTA, TETA
- Polyamide/amide
- Phenolic
- Acid Anhydrides
  - Phthalic Anhydride
  - Pyromelliltic dianhydride.
- Isocyanates (aromatic/aliphatic)
- Polymercaptans

Comparison to available product descriptions show no clear correlation between chemical listings (curing agents) and Oddy fails even though the functional groups may appear to be chemically similar:

PaleoBond (Phenol 4,4' 1-methylethylidine)	Fail
Magic Smooth (1-methylethylidene)	Pass
PC Marine (polymeric phenolic amine)	Pass
PhillySeal (triethylene tetramine)	Pass
Gapoxio (triethylene pentamine)	Fail

In order to establish some correlations conservation professionals should continue to gather information on epoxy components. For example, if polymeric phenolic amines continue to pass, this may be a good indicator of a future Oddy pass. Conversely, the failure of a pentamine vs. tetramine may indicate some other as yet unidentified component influencing the Oddy test. At this point we would suggest mixing epoxy putty components well, since they are typically harder to mix. Mixing by weight is encouraged to ensure that no component is present in excess, particularly catalyst (fig. 7), and MSDS's and manufacturers should be consulted for listed components such as catalyst type.

figure 7

Mixing Characteristics

Pastes and putties have slightly different working properties and applications. Pastes are generally fluid enough to mix in a cup and cannot be hand-mixed. They are more easily compressed and may be more suited to the capture of fine detail with minimal load applied to the object. However, their lower viscosity leads to slumping in thicker applications, especially if applied on vertical surfaces. Pastes mixed in large volumes may also generate more heat on setting, and therefore accelerate set time.

Putties can be hand mixed but differ somewhat in consistency and workability. Some putties are easily mixed while some are slightly tacky during handling. Putties are ideally suited for compression as they tend to extrude into larger voids such as the underside of marble sculpture bases. Putties can also retain a defined or modeled shape with minimal slumping. Putties and pastes may also be used in conjunction with one another. The general orientation of a sculpture, for example, may be obtained with ribbons of epoxy putty under its base. Epoxy paste can then be used to fill and capture fine detail between these strips.

Results

Evaluation of cost, working properties, and Oddy test passes suggested several promising products, each with their own unique characteristics. Although no direct replacement for PhillySeal was found, a few have similar working properties and favorable results could be achievable (6). These are the products that passed our non-contact Oddy tests with positive results, grouped by similar working properties:

The focus of the investigation was for material used on mounts and objects in collections; further testing would be required to make recommendations for outdoor use. The authors will continue to investigate possibilities and welcome any suggestions for similar products.

Notes

1. Landry, Helene. Remontage d'un Squelette de Beluga, *Proceedings of the 14th annual IIC-CG conference*. Wellheiser, Johanna ed. IIC Canadian Group, 1989, pp.168-171.

2. Levinson, Judith, Niewenhuizen, Linda. Chiefly Feasts: A Collaborative Effort, *Objects Specialty Group Postprints,* 1994, pp. 9-21.

3. The authors would like to thank Erik Risser, Jerry Podany, and McKenzie Lowry (JPGM) for their product recommendations.

4. Samples were prepared for Oddy testing by Juliette Jacqmin, Antiquities Conservation Intern 2007-2008.

5. Oddy testing conducted by Mara Schiro and David Carson according to: Bamberger, J.A., Howe, E.G., Wheeler, G. A variant Oddy test procedure for evaluating materials used in storage and display cases, *Studies in Conservation*, 1999, 44 (2), pp. 86-90.

6. Because of the variability of material types and treatment options for art objects, the authors recommend that any of these epoxies be evaluated further prior to use for a specific application.

Product	Manufacturer	Contact
Fast curing paste 5-30 min. set time, 6-8 hr. cure		
Akabond 621 KG	Wood and Stone Co.	axson-na.com/axna-ws-epoxy
Slow curing pastes 2-4 hr. set time, 24 hr. cure		
Fixit Paste	Aves Studio	avesstudio.com
Magic Smooth	The Compleat Sculptor	sculpt.com
Fast curing stick putties 5-30 min. set time, 30-60 min. cure		
Crete	PC Products	pcepoxy.com
Plumbing	PC Products	pcepoxy.com
Metal	PC Products	pcepoxy.com
Marine	PC Products	pcepoxy.com
Slow curing putties 2-4 hr. set time, 24 hr. cure		
Apoxie Sculpt	Aves Studio	avesstudio.com
Fixit Putty (White)	Aves Studio	avesstudio.com