Overcoming Problems With Polyester Resin Blocks
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Abstract
The problems associated with 'plastic embedding' are many, not least air bubble formation during hardening of polyester resin embedments and the clearing and loss of iridescence of lepidopteran wings. These and other associated problems are discussed, with effective solutions for removing some of these disfiguring problems.

Introduction

My heart always sinks slightly when asked to make a series of polyester resin blocks, normally for education purposes so that smaller children can handle delicate biological objects without fear of damage. I think that the idea is good since it enables younger persons to look closely at tissues that would normally be much too delicate for handling. My own reasons are purely personal for disliking the process, especially as I loathe the smell of styrene and all the other methyl-benzene solvents since they tend to linger in the olfactory part of the brain for 12 hours even though I haven't actually inhaled any of the vapour thanks to my efficient fume-extraction bench.

Advantages of embedding

1. Easy handling of delicate objects, ideal for children (and who don't mind giving them back afterwards!)
2. Accidental/incidental scratches can be ground and polished out.
3. The resin does not darken or discolour and I still have perfect mounts from 1968.
4. Items with fugitive colours (UV or air-sensitive, once dried) can be preserved more successfully. This is particularly useful for pale-coloured fungi that quickly turn brown following air or freeze-drying: cf. *Marasmiellus ramealis, Hydnum repandum* and other members of the 'tooth fungi' family. Also for the UV-sensitive colour of the Fly Agaric *Amanita muscaria* whose scarlet colour quickly fades to a dull orange due to natural breakdown of the muscarubrin/purpurin pigments by about 100nm in wavelength.

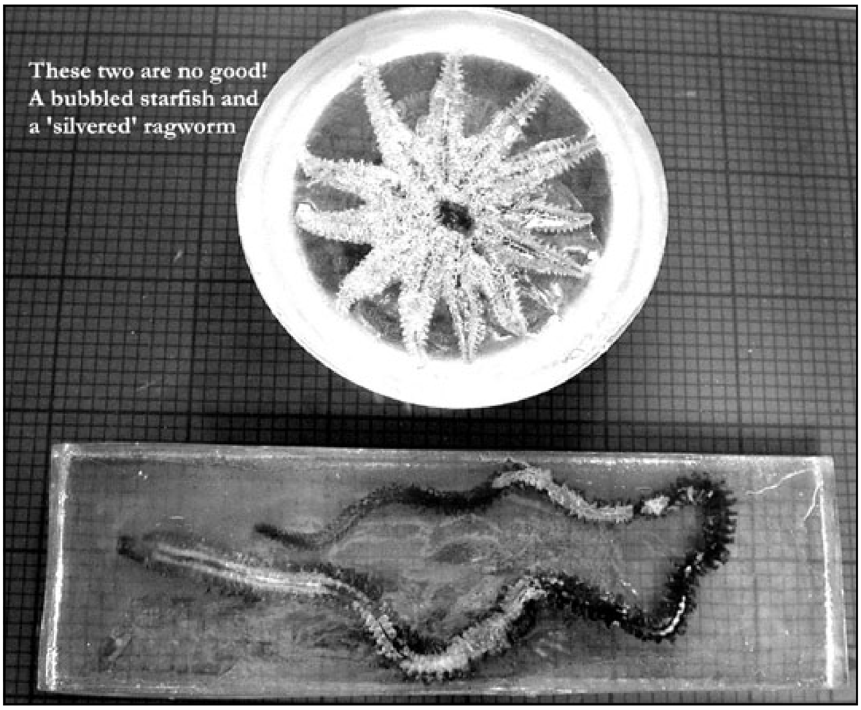

Figure 1: bubbled starfish and 'silvered' ragworm

Problems arising

I always warn anyone who wishes to have specimens embedded in resin that the process may fail for various reasons.

1. The resin may overheat during the curing process causing stress cracks in the resin.
2. The exothermic reaction may also cause air bubbles to be forced out of body cavities, disfiguring the final result (Fig. 1.upper).
3. A similar problem can be the gradual shrinkage of a dry specimen once the resin has hardened resulting in a silvering effect that masks the specimen (Fig. 1.lower).
4. If not totally dry, the specimen may form an emulsive mist around it as the trapped water in the specimen is drawn out into the resin.
5. Surface air bubbles can form on the resin but these can be subsequently ground away.
5. The specimen can become distorted by the process.
6. Although the process is reversible, dissolving out a fragile specimen will often result in its total disintegration due to internal or torsion stresses inside the block.
7. The resin and solvent have a clearing effect so that membranous tissues (e.g. lepidopteran wings) become transparent and blue (lycaenid) butterflies' wings lose their blue iridescence. The latter effect is due to the refractive index of the resin (1.5 – 1.75) being similar to that of the wing scales (see Table).
8. The blocks are fairly fragile: dropping onto a hard surface can easily result in chips and cracks.

Remedies

The main reason for a hyper-exothermic reaction is often due to the use of too much catalyst, especially in warmer weather. I always use the ratio of 1 drop per 10 grams of resin or 2 drops per 30 grams in warm weather. This ratio works well overall but there are still occasions when other (remediable) problems can occur.

1. If all else fails, the process is (slightly) reversible and the resin can be gradually dissolved in xylene. It starts to flake off in sticky lumps after a few days and you will end up with the specimen as before but if the resin has become stress cracked, it may have already broken the specimen. Be aware, however that physical forces are released during this reversing process: fragile specimens may end up completely fragmented! This should only be done for 'silvered' or 'misted' specimens that are sufficiently robust.
2. To avoid aqueous misting, the specimen must be absolutely dry. I usually freeze-dry specimens first to ensure absolute dryness is achieved. Always check that preserved specimens are freeze-dried from deionised water as formalin or IMS vapour are extremely damaging to the machinery of a freeze dryer, especially the vacuum pump! Deionised water must be used else the specimen will dry with a fine calcitic coating!
3. To prevent stress cracks from forming in the block, ensure that each layer of resin is no more than 40mm deep (Voss, c.1980).
4. More fragile specimens have to be dehydrated to acetone and then soaked in raw resin before embedding. This also helps to remove any air bubbles trapped in inner recesses (e.g. snail shells).
5. If the block starts to overheat, then immerse it in cool water, once it has gelled. Surface misting can always be removed by subsequent block grinding.
6. Always monitor the process and if air bubbles start emerging or forming, there will be more to come during the exothermic gelling stage, so beware. Use a mounted needle to tease them out; even if trapped in a lower and gelled layer of resin – push the needle through and move it about (rotate) to force the bubble/s out through the puncture hole which should be coated with fresh resin so that this flows down to fill the bubble's space (see also 10 below).
7. Surface bubbles can be removed by pipetting drops of acetone before the resin hardens.
8. Once the block has been ejected from the mould I always leave it for 24 hours to harden (else it will pick up your fingerprints during its final polymerisation) before grinding or administering any finishing treatment.
9. If the front of the block surface is disfigured by craters these can be filled in by pouring on a thin layer of resin and then grinding 48 hours or more later.
10. Trapped air bubbles inside the block: if the specimen is too fragile to reverse the process, trapped bubbles can be removed by careful drilling. Ensure that the drill bit makes a large enough hole

(5mm)*. The block must not allowed to heat up (1 second maximum for each application of the drill) or it will burn the resin or make it opaque. Also ensure that plastic swarf doesn't get into the block or it will have to be removed using a mounted needle.

10a. Mix up a small amount of resin and wait for the (stirred-in) air bubbles to disappear once it has been mixed with catalyst. Pipette it very slowly down the sides of the drilled holes. Tease out any trapped air bubbles using a mounted fine needle and top-up the levels of resin (Figs 2-4). Tiny craters can also be filled using cyanoacrylate (superglue) under a low-power microscope.

10b. Once hard, the holes may have slightly meniscoid dips which can either be removed by grinding or if the specimen is close to the surface, will require a top-up of fresh resin or adhesive.

*Sometimes the drilled hole will need to be narrower (to 1mm) and the rising air bubbles may be slow in exiting. To precipitate the exit of air bubbles insert a fine pin into the drilled out 'tube' and gently rotate the pin around the exterior of the slowly-rising air bubble. This rotation will help to lift out air bubbles.

11. To reduce or eliminate the transparency effect many sprays were tested but were found to be ineffective as they were dissolved by the styrene solvent: deodorant, photo matting spray (contains dispersed wax), hair lacquer, and even a 5% suspension of PVA in ethanol only gave a slightly improved result (Table 1 & Figs 6-8). Polyurethane resin gave no better result (Table 2).
12. To reduce or eliminate the loss of wing scale iridescence, the wing must first be coated with a substance outside the refractive index parameters of the resin and the wing scales (c. 1.50-1.56) and that will not be dissolved by the styrene. Aqueous, neutral pH PVA was found to work quite well but there were application problems (see below).

Associated Problems

The main problems with 11 & 12 are finding a similar coating that will isolate the wings from the transparency/dulling effect of the resin without forming a visible layer due to dissimilar refractive indices. Also of applying such a layer onto wings using an atomiser: water-based compounds (PVA) tend to coagulate on the wing surface rather than spread evenly, leading to a blotchy result, or require so much application pressure that the wings cannot take such a beating and disintegrate! Solvent-based compounds tend to be affected either by the styrene solvent in the resin or (for urethane-based resins) give rise to many air bubbles just as the resin is in the last stages of curing!

Brushed PVA (aqueously diluted to 50%) gave a fair result except that the careful brushing process, for full strength PVA, removed about c.30% of the wing scales, especially when spreading the PVA to prevent coalescence.

Conclusions

A variety of possible wing coatings for lepidopterans was tested to eliminate or reduce transparency and iridescence. Although some slight success with the former was noted, there was nothing noteworthy with the latter. Several persons connected with the retailing of these resins were contacted in the hope that there might have been a past technique to overcome these obstacles but it appears not. The author hopes that anyone who might know a technique or recipe for success might write it up as a sequel. On a more positive note, the removal of air bubbles and 'silvering' has now been improved.

Table : efficacy for coating agents to reduce lepidopteran wing transparency and loss of iridescence in clear polyester resin.

Coating agent	Transparency	Blue wing iridescence	Colour change?
[Control]	0	0	complete initial loss of iridescence
Hair lacquer	1	0	10% initial loss of iridescence
Photo matting spray	0	0	10% initial loss of iridescence
Spray deodorant	1	0	5% initial loss of iridescence
Spray acrylic lacquer	1	0	20% initial loss of iridescence
Dilute PVA (5% in ethanol)	1	1	slight purpling of blue colour
50% PVA in IMS	2	0.5	80% initial loss of iridescence
50% aqueous PVA (brushed)	3	2	no fall-off, result patchy
50% PVA aqueous (atomised)	2	1	50% initial loss of iridescence, result patchy
PVA aqueous adhesive (brushed)	4	3	30% scales detached, no fall-off, result patchy
10% brown shellac in IPA	1	0	10 % initial loss of iridescence
10% colourless shellac in EtAc	1	0	no fall-off but final result poor
20% colourless shellac in EtAc	1	0	no fall-off but final result poor
50% colourless shellac in EtAc	2	0	80% initial loss of iridescence
100% colourless shellac in EtAc	2	0	90% initial loss of iridescence
50% glycerol in IMS	2	0	90% initial loss of iridescence
50% polypropylene glycol in IMS	1	0	90% initial loss of iridescence
20% Mowital B30H in IPA	2	1	60% initial loss of iridescence
Superglue (α-cyanoacrylate)	1	0	85% initial loss of iridescence
20% Paraloid B72 in acetone	2	0	50% initial loss of iridescence

EtAc = Ethyl Acetate
IMS = Industrial Methylated Spirit
IPA = Iso-propyl alcohol
PVA = Polyvinyl acetate

Colour change and initial loss of iridescence refers to blue wings after spraying or dipping in coating agent and subsequent drying, prior to embedding.

Table 2: efficacy for coating agents to reduce lepidopteran wing transparency and loss of iridescence in clear polyurethane resin.

Coating agent	Transparency	Blue wing iridescence	Colour change?
control	1	0	70% initial loss of iridescence
Hair lacquer	4	0	50% initial loss of iridescence
50% PVA aqueous (atomised)	2	0	60% initial loss of iridescence

Both coating reagents reacted with resin at final stages of curing producing obscuring layers of air bubbles.

Two types of butterfly wing were used: pale/orange brown with darker spots and male blue butterfly.
Lined paper was viewed through a low-power microscope using the darker spots on the wing to test for transparency vs. opacity:
Transparency is rated for 0 to 5.
0 for total transparency.
1 slight fall-off in transparency.
2 lines on paper still just visible.
3 (acceptable): lines barely visible.
4 for the lines on the paper being barely visible (only under microscope).
5 for total opacity.

Iridescence was tested by tilting the finished block in incident light and is also rated at 0 to 5:
0 no iridescence – wing totally dull.
1 a slight blue flash (from small patches of wing).
2 shows the slightest sheen (result slightly patchy).
3 (acceptable) a noticeable blue flash and a reasonable sheen (over entire wing).
4 only a very slight dulling.
5 normal iridescence.

Reference

Voss, Klaus-W. *Casting with polyester.* Uetersen, Germany, c.1980.