

ADHESIVES IN CONSERVATION

There are many adhesives available to the working furniture Conservator/restorer today, some cure to an extremely hard and brittle material and some remain relatively flexible, some are reversible and some are not.

The actual practicalities and necessary solvents mean that even some of the adhesives that are theoretically reversible are not actually practically reversible in the wider context of the overall wellbeing of the piece.

The plethora of practical and ethical demands of the Conservation/restoration profession often means that the full range of adhesives available to us must be considered as possible practical solutions and as such their properties need to be examined.

Using the information gathered in practical sessions of the "Applied Science" module, in which 6 of the most common adhesives were compared for their respective properties and applications.

Their practical usefulness to the Conservator will be assessed and the ethical and practical consequences of their use will also be scrutinised against the ethical overview that governs the decision making process.

ADHESIVES TESTED

REVERSING AGENTS

SCOTCH GLUE

CELLULOSE THINNERS

P.V.A.

METHYLATED SPIRITS

CASCAMITE

METHYL ACETATE

ARALDITE

**NITRO-MORS(Di-chloromethane based
stripper)**

EVO-STICK

WHITE SPIRIT

PARALOID B72

PARAFFIN

ACETONE

TURPENTINE

CARBON TETRACHLORIDE

HOT WATER

THE PRINCIPLES OF THE ADHESIVE BOND

1/Properties of woods that affect adhesive bonding;

Wood has a very complex structure, therefore gluing it can often pose some problems.

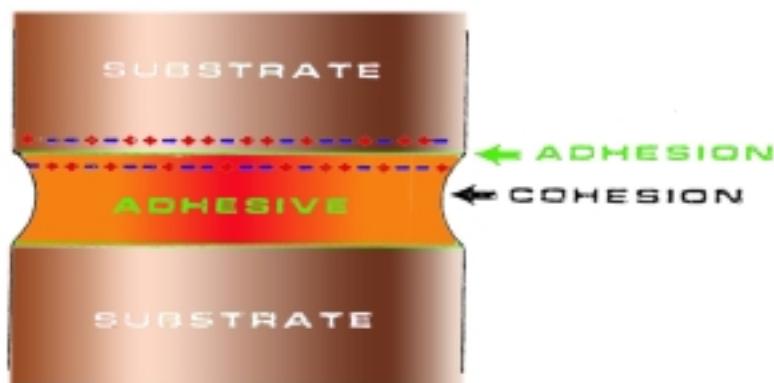
Wood density is a major factor here, this varies from softwood to hardwood from heartwood to sapwood, and from species to species.

A woods density will effect the amount of adhesive penetration. This mechanical interlocking of the adhesive and the surface structure of wood was once accepted to be the main mechanism of adhesion, it is now thought to be only a secondary factor.

2/The adhesive bond;

Any discussion of adhesive properties must first address the basic question of “why does glue stick?” To answer this question we must consider the hypothetical bond discussed above and examine it at a molecular level.

A Hypothetical bond;



From this diagram it seems obvious that adhesion depends on the attractive nature of neighboring electrical forces.

As the example on the previous page shows there are positive (+) and negative (-) charges on the surface of the **substrate** and also on the very outer surface of the **adhesive**.

These positive and negative charges are created by the naturally occurring polarity of the

molecules in the materials. Very much as is the case with magnets, opposite polarities attract each other, this attractive force is called adhesion.

3/Cohesion;

For an adhesive bond to be strong this adhesion needs to be strong but also the actual adhesive must be strong as well. In other word it must also have similar internal bonds.

Adhesives are nearly always polymers because polymer molecules are intrinsically large enough to have many positive and negative polarity sites for this self-attraction to be strong.

PROPERTIES OF SOLVENTS USED IN REVERSIBILITY TESTS;

1/ CELLULOSE THINNERS

HANDLING;

Cellulose thinners are extremely volatile and have an extremely low surface tension causing the thinners to run very readily and much care is needed as such a solvent will attack a shellac or wax finish and dissolve it almost instantly. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Extremely low

HEALTH & SAFETY PRECAUTIONS;

Cellulose thinners are an extremely volatile organic solvent and subject to stringent C.O.S.H.H. regulations governing handling and respiratory protection for users. It must also be noted that this substance is highly flammable. Eye protection is recommended.

TIME TO WORK;

Due to the volatile nature of the solvent some gelling may be necessary to determine this fully

ETHICAL IMPLICATIONS;

As this solvent evaporates completely the ethical reversibility is not in question.

2/ METHYLATED SPIRITS

HANDLING;

Methylated spirits are also extremely volatile and have an extremely low surface tension causing the meths to run very readily and much care is needed as such a solvent will attack a shellac finish and dissolve it almost instantly. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

Methylated spirits or I.M.S. is a volatile organic solvent and subject to stringent C.O.S.H.H. regulations governing handling and respiratory protection for users. Again it must be noted that this substance is highly flammable. Eye protection is recommended.

ETHICAL IMPLICATIONS;

As this solvent evaporates completely the ethical reversibility is not in question.

TIME TO WORK;

Due to the volatile nature of the solvent some gelling may be necessary to determine this fully

3/ METHYL ACETATE

HANDLING;

Methyl acetate is a volatile substance that needs to be handled with gloves, and much care is needed, as such a solvent will attack a shellac or wax finish readily. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

Methyl acetate is a volatile solvent and subject to very stringent C.O.S.H.H. regulations governing handling and respiratory protection for users. Again it must be noted that this substance is highly flammable. Eye protection is recommended.

ETHICAL IMPLICATIONS;

As above

TIME TO WORK;

Due to the volatile nature of the solvent some gelling may be necessary to determine this fully.

4/ NITRO-MORS

HANDLING;

This sort of Di-chloromethane based stripper addresses the handling problems associated with the other previously mentioned solvents by using a gelling agent to decrease volatility and increase viscosity. There is always a necessity for the wearing of gloves and eye protection is recommended.

VOLATILITY;

Relatively Low

VISCOSITY;

High

HEALTH & SAFETY PRECAUTIONS;

These Di-chloromethane based strippers carry stern health and safety instructions on the tin and are also subject to very stringent C.O.S.H.H. regulations governing handling and respiratory protection for users. Again it must be noted that these substances are highly flammable. Eye protection is recommended.

ETHICAL IMPLICATIONS;

As previously mentioned these strippers can sometimes stain woods darker or bleach them lighter and this will need to be considered in the context of the overall restoration.

TIME TO WORK;

If poulticed the working time can be extended into hours with no re-application being necessary.

5/ WHITE SPIRIT

HANDLING;

White spirits need to be handled with gloves. Eye protection is recommended

VOLATILITY;

Medium

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

White spirits are highly flammable and skin contact and inhalation should be avoided, eye protection is recommended.

ETHICAL IMPLICATIONS;

Residue may cause ethical implications.

TIME TO WORK;

Due to the low viscosity of White spirit some gelling may be necessary to determine this fully.

6/ PARAFFIN

HANDLING;

Paraffin needs to be handled with gloves. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

As paraffin is a petro-chemical derivative it gives off dangerous evaporation products and as such is subject to the C.O.S.H.H. regulations. Eye protection is recommended.

ETHICAL IMPLICATIONS;

The use of such a chemical may pollute timbers adjacent to their target and this will need to be considered on an individual basis.

TIME TO WORK;

Due to the low viscosity of Paraffin some gelling may be necessary to determine this fully.

7/ ACETONE

HANDLING;

Acetone is a volatile substance that needs to be handled with gloves, and much care is needed, as such a solvent will attack a shellac or wax finish readily. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

As above, gloves and masks are mandatory and C.O.S.H.H. should be consulted before use. Eye protection is recommended.

ETHICAL IMPLICATIONS;

None as this solvent evaporates completely without leaving a residue.

TIME TO WORK;

Due to the volatile nature of the solvent some gelling may be necessary to determine this fully.

8/ TURPENTINE

HANDLING;

Turpentine needs to be handled with gloves, as skin contact is not recommended. Eye protection however is recommended.

VOLATILITY;

Medium

VISCOSITY;

Quite low

HEALTH & SAFETY PRECAUTIONS;

As above the use of gloves is mandatory and eye protection is recommended.

ETHICAL IMPLICATIONS;

One must bear in mind that turpentine is in fact an extremely fine lubricant and as such any residual traces need to be considered in the context of the work being carried out.

TIME TO WORK;

Due to the low viscosity of Turpentine some gelling may be necessary to determine this fully.

9/ CARBON TETRACHLORIDE

HANDLING;

Carbon Tetrachloride is a volatile substance that needs to be handled with gloves, and much care is needed, as such a solvent will attack a shellac or wax finish readily. Eye protection is recommended.

VOLATILITY;

High

VISCOSITY;

Low

HEALTH & SAFETY PRECAUTIONS;

These solvents are subject to very stringent C.O.S.H.H. regulations governing handling and respiratory protection for users. Again it must be noted that this substance is highly flammable. Eye protection is recommended.

PROPERTIES OF THE ADHESIVES TESTED

The Comparison opposite shows some of the most relevant practical properties of 4 of the 6 adhesives from this test. SCOTCH GLUE is referred to as Hide glue, Casein is the correct name for the genre containing Cascamite, Urea Formaldehyde resin is not part of our test but is a very strong exothermic epoxy equivalent made from industrial Urea. P.V.A. or Polyvinyl Acetate is described, as is Epoxy, the group of resins of which Araldite is a part. Finally Impact adhesives, we have chosen Evo-stick to represent this group of glues.

PROPERTIES OF THE 6 ADHESIVES TESTED

1/ SCOTCH GLUE

HANDLING;

Quite possibly the most difficult glue on the list as far as handling is concerned.

The correct consistency has to be achieved when making up this glue and the correct temperature (around 70*c) has to be maintained in the pot.

The joints to be glued need to be warmed to prevent premature gelling and as a result of these parameters open assembly time is relatively low.

VOLATILITY;

As this is a "Hot-pot" glue kept at 70*c the water that forms the solvent is very prone to evaporation and water needs to be periodically added to maintain a working consistency.

VISCOSITY;

Quite high

HEALTH & SAFETY PRECAUTIONS;

A relatively safe product with very few regulations regarding its use, obviously harmful by ingestion.

TIME TO WORK;

As previously mentioned open assembly time is relatively low and the actual time to harden depends very much on the thickness of glue film and other factors such as wood porosity and temperature.

ETHICAL IMPLICATIONS;

As this is a fully reversible adhesive that can be dissolved decades after its original application there are no adverse ethical compromises.

2/ P.V.A.

HANDLING;

Quite easy to handle because no temperature maintenance is necessary to ensure a stable bond. As P.V.A. is a Thermo-plastic suspended in water as a solvent washing off excess glue is easy before curing (oxidization activated) begins.

VOLATILITY;

Relatively low depending on humidity and temperature

VISCOSITY;

Quite high, but can be diluted with the addition of water.

HEALTH & SAFETY PRECAUTIONS;

Gloves are recommended, as are goggles.

TIME TO WORK;

Fairly short to medium, depending on film thickness and temperature etc.

ETHICAL IMPLICATIONS;

As P.V.A. is non-reversible the implications of this render it an ethical compromise and must be considered as such when its use is contemplated.

3/ CASCAMITE

HANDLING;

A relatively easy adhesive to handle and some control over consistency is possible at the mixing stage, all over-spill must be wiped back with a damp rag otherwise staining of the timber will occur.

VOLATILITY;

Relatively low depending on humidity and temperature

VISCOSITY;

Medium to high depending on mix.

HEALTH & SAFETY PRECAUTIONS;

Gloves should be worn whilst working with the mixed product and the powder should not be inhaled during initial mixing. Eye protection is recommended.

TIME TO WORK;

Mix and temperature can affect this but usually sets in 3-8 hours.

ETHICAL IMPLICATIONS;

Again a Thermo-plastic that is non reversible, the implications of this render it an ethical compromise and must be considered as such when its use is contemplated.

4/ ARALDITE

HANDLING;

A messy product with the two parts of the adhesive needing to be mixed in equal quantities prior to use. Not water soluble even when unmixed.

VOLATILITY;

Low

VISCOSITY;

High

HEALTH & SAFETY PRECAUTIONS;

Gloves are recommended, as are goggles.

TIME TO WORK;

Mix and temperature can affect this but usually sets in 1-4 hours.

ETHICAL IMPLICATIONS;

Another Thermo-plastic that is non reversible, the implications of this render it an ethical compromise and must be considered as such when its use is contemplated.

5/ EVO-STICK

HANDLING;

A difficult adhesive to handle being highly viscous and incredibly tacky.

VOLATILITY;

High

VISCOSITY;

High

HEALTH & SAFETY PRECAUTIONS;

As contact adhesives are extremely volatile, solvent release dictates that they be used in a well ventilated area, preferably using a vapour protection mask, the use of gloves is mandatory and eye protection is recommended.

TIME TO WORK;

Rapid, due to the fast solvent evaporation and the "Contact" nature of its recommended application.

After the two elements of the joint are united there is an inevitable decrease in the rate of solvent evaporation and thus the final curing phase may take several hours.

ETHICAL IMPLICATIONS;

Evo-stick is theoretically reversible by the application of Carbon tetrachloride but in practice it is a very hard glue to reverse, as such the implications of this render it an ethical compromise and must be considered as such when its use is contemplated.

6/ PARALOID B72

HANDLING;

Reasonably difficult as paraloid has a similar consistency to water and all spillage needs to be cleaned up with acetone.

VOLATILITY;

High

VISCOSITY;

Very low

HEALTH & SAFETY PRECAUTIONS;

As with Acetone, gloves, eye protection and vapour precautions.

TIME TO WORK;

Entirely dependant on the available evaporation and release of the acetone solvent and the volume in which it is applied (Paraloid is often used as a consolidant and as such is often allowed to soak into timber to increase strength. In this mode a considerable amount of time needs to be allowed to allow all of the solvent to be released).

ETHICAL IMPLICATIONS;

As Paraloid is reversible by the application of acetone its reversibility and therefore ethical compliance is rarely in question.

TEST RESULTS

All 6 of the Adhesives in this test; scotch glue, P.V.A., Cascamite, Araldite, Evo-stick and paraloid B72 were tested for reversibility in the following way;

Small blocks of beech were cut, 12 in all, all the same size to standardize gluing surface area. Each of the 6 pairs of blocks was glued together with a different adhesives, and all 6 pairs were cramped together to standardize cramping pressure.

These blocks were left for a week to allow the adhesives time to cure fully.

Each glued pair of blocks was then treated with the 10 solvents; Cellulose thinners, Methylated spirits, Methyl acetate, Nitro-mors, White spirit, Paraffin, Acetone, Turpentine, Carbon tetrachloride and hot water.

The reaction was monitored and any breakdown of the adhesive bond was noted.

The results are shown below;

SCOTCH GLUE;

REVERSED WITH;

Hot water only, none of the other solvents had any effect.

EFFECT ON ADHEREND;

Some swelling of fibres around the area wetted.

P.V.A.;

REVERSED WITH;

Hot water slightly softened the P.V.A. as did acetone, but the Nitro-mors dissolved the P.V.A. quite effectively.

EFFECT ON ADHEREND;

Hot water causes some swelling of fibres around the area wetted, Nitro-mors can affect colouration in some timbers.

CASCAMITE;

REVERSED WITH;

The Nitro-mors had a slight softening effect on the Cascamite but no solvent was found to reverse this thermoplastic adhesive.

EFFECT ON ADHEREND;

Nitro-mors can affect colouration in some timbers.

ARALDITE;

REVERSED WITH;

The Nitro-mors dissolved the Araldite, but no other solvent was found to reverse this thermoplastic adhesive.

EFFECT ON ADHEREND;

Nitro-mors can affect colouration in some timbers.

EVO-STICK;

REVERSED WITH;

The Nitro-mors dissolved the Evo-stick, the carbon tetrachloride had a softening effect on the bond.

EFFECT ON ADHEREND;

Nitro-mors can affect colouration in some timbers.

PARALOID B72;

REVERSED WITH;

Acetone, the original solvent, and also with Nitro-mors.

EFFECT ON ADHEREND;

Acetone evaporates leaving no residue so no effect here, Nitro-mors can affect colouration in some timbers.

RESULTS DISCUSSED:

What is really required by the Conservation/restoration profession when it comes to their choice of adhesives?

1/ An adhesive that fulfills the absolute reversibility requirement demanded by the Code of ethics of the U.K.I.C. and B.A.F.R.A.

2/ An adhesive that fulfills practical criteria dictated by the particular task to be undertaken.

3/ An adhesive with no adverse side effects.

REVERSIBILITY;

It is clear from the results of the reversibility test that of all 6 glues tested only 2 fully meet the requirements of heading 1, these being Scotch Glue and Paraloid B72.

Moving on to heading 2, it is highly likely that Scotch glue will fulfill the necessary practical demands, where wood has to be joined to wood, as it has an extremely similar polymeric structure to that of Cellulose, the polymer from which wood is composed.

It is reasonable to assume therefore that in these instances Scotch glue is the preferred option.

There are instances however where the practical dictate of heading 2 may require a weaker bond, for example if the wood to be glued in is not required to carry much load and the need for reversibility is more evident.

It may also be possible that other materials might need gluing to themselves or to wood, Paraloid may form better Adhesive bonds with some other materials and in these instances its use could be preferential.

Paraloid B72 is not affected by moisture and is non-organic. This may well lead to its adoption where moisture problems would be detrimental to Scotch glue, such as the restoration of feet that are to stand on a damp stone floor.

Here the use of a hygroscopic protein based glue that is not chemically dissimilar to Agar jelly would be asking for trouble. Mould and fungus growth may be encouraged and over time the moisture would break down the bond.

PHANTOM REVERSIBILITY;

The fact that Di-chloromethane based strippers will dissolve P.V.A., Araldite, Evo-stick, is useful information for the conservator. It must be said however that these adhesives fall within the realms of non-practical or phantom reversibility, as their reversal in the real context of the common access and fragility problems usually associated with the restoration of antique furniture is often impossible.

COHESIVE STRENGTH;

Of the 4 adhesives that were found to be non reversible, 3 are thermoplastics, these being P.V.A., Cascamite and Evo-stick. Thermoplastics cross-link at a molecular level to form very powerful bonds, thus their cohesive strength is always very high. Indeed some manufacturers of adhesive proudly pronounce on their packaging "Stronger than the wood itself".

These properties are not always an advantage to the conservator.

The possibility of future kinetic damage has to be understood; Using the example of a Windsor chair, where a certain amount of frame movement is inevitable, and necessary for the piece to function and bear its load.

A leg and its associated stretcher joint have become loosened and they need gluing back into the seat.

Should a Thermoplastic adhesive be used here, and it were stronger than the wood itself, breakage of the timber would occur, probably around the joints, causing much more damage to the object than if breakage had occurred on the glue-line itself, as it does and did with Scotch glue.

The author would argue that here, in the re-gluing of an original joint, a conservators glue always needs to be weaker than the timber it is gluing.

ETHICAL COMPROMISE;

There are always going to be practical problems that face the conservator where the ethical concerns of heading 1 need to be subservient to the demands of practical necessity. Sometimes an adhesive with powerful cohesive qualities may well be required;

An example of such a scenario would be the repair of a table leg that has suffered a nasty break across the grain.

It is in situations such as these that these strong thermoplastic adhesives come into their own.

For the example we will accept that no timber can practically be removed or spliced in and a glued repair is necessary and viable.

If it is a recent break and the fibres are relatively undisturbed then it is possible with some care to re-mesh the two broken members for a dry trial. If a good fit is possible an extremely strong bond will be needed to bear whatever adverse forces caused the original break.

Furthermore reversibility of such a break is much less likely to be an important factor than the future reversibility of a mortise and tenon joint on the same piece.

The one remaining non reversible glue genre, contact adhesives can come into their own due to the fact that their extremely high viscosity and tack causes them not to be absorbed into materials anywhere near as readily as the other glues in the test.

These properties can be useful in applications such as the fixing of gimp to an upholstered sofa or in fact any temporary fabric fixing where glue show-through would be unsightly.

SUMMARY;

The conscientious conservator should always endeavor to use an adhesive that fulfills the ethical requirements of reversibility and non-pollution of the original object.

A large percentage of the time this is possible but sometimes the requirements for the overall well being of the piece dictate an un-ethical solution to solve the problem.

To put it another way; "You may have to lose a battle to win the war"

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