The Strength Inside your Model – Adhesives Part 2

John Bristow of Deluxe Materials (www.deluxematerials.com) focuses on some particularly common types of adhesives: Emulsion and Epoxy polymers

In part 1 we learnt what an adhesive has to do and how a combination of adsorption and chemisorption play an important role in delivering adhesive and cohesive forces that ultimately hold materials together and fill gaps. Now, having considered how glues work, let us have a closer look at how they are built to serve our modelling needs, including tips on how best to use them.

First up are the water-based, air-drying adhesives commonly used for modelling. The best known of these is polyvinyl acetate, more commonly known as PVA.

Polymer Adhesives and the arrival of PVA

It was at the beginning of the twentieth century when scientists discovered that certain potentially reactive chemicals, usually with a small molecular size, could be made to undergo chemical reactions which caused them to link together. This produced very large molecules called polymers, which had quite different properties from those of the individual starting chemicals.

Polymer adhesives can be produced in several forms as well as chemical types.

The earliest types, and still one of the most common known to aeromodellers , are solvent carrier adhesives e.g.

• Balsa cement, which uses a relatively hard polymer. Here the polymer is dispersed in a solvent and hardens after application by evaporation of the solvent.

(There are also solvent free adhesives, both one and two part, which harden by chemical reaction. Examples of this type are cyanoacrylates and epoxy resin adhesives.)

Vinyl acetate was produced in Germany in 1912 and was found to polymerise easily to give a solid plastic material. By the late 1920's emulsion polymerisation was developed allowing vinyl acetate to be emulsified as droplets in water. This produced the familiar 'white' product PVA (PolyVinyl Acetate) which has become commonly known as 'wood adhesive'.

The process by which an emulsion glue like PVA adhesive dries is through water loss. Eventually the PVA resin particles in solution join and, with help from a coalescent solvent, dry further to form a hard adhesive film. In the case of Speedbond PVA, the glue utilises special solvents that accelerate the drying process.

This hardness which gives good sanding makes PVAs unsuitable to join flexible materials such as plastics without some form of modification. Many significant advances have taken place since the early PVA glues;

• Plasticisers initially used to soften and flexibilise the PVA have now been replaced by naturally softer polymers such as vinyl acetate ethylene (VAE) that are added at between 5-40% into the mix.

• New polymers (Aliphatic Resin) have been developed that can be cross-linked giving the benefits of greater strength and better joint stability. It is now possible to produce wood adhesives that are suitable for exposure to water once they have set.

There are lots of different adhesives available from various manufacturers, but do you know which to use where?

Design of Hard and Soft polymers

There are many other types of polymer emulsion widely used as adhesives to give specialist performance. In our R/C Modellers Canopy glue (can also be jolly useful for FF & CL builders!) we use a very soft polymer that dries clear but with a trace of added solvent that assists adhesion to clear plastic. You might notice a distinctive odour….well that's what it is! This adhesive will also gap fill and bond painted surfaces and plastic covering film.

Hints and tips with PVA type emulsion glues

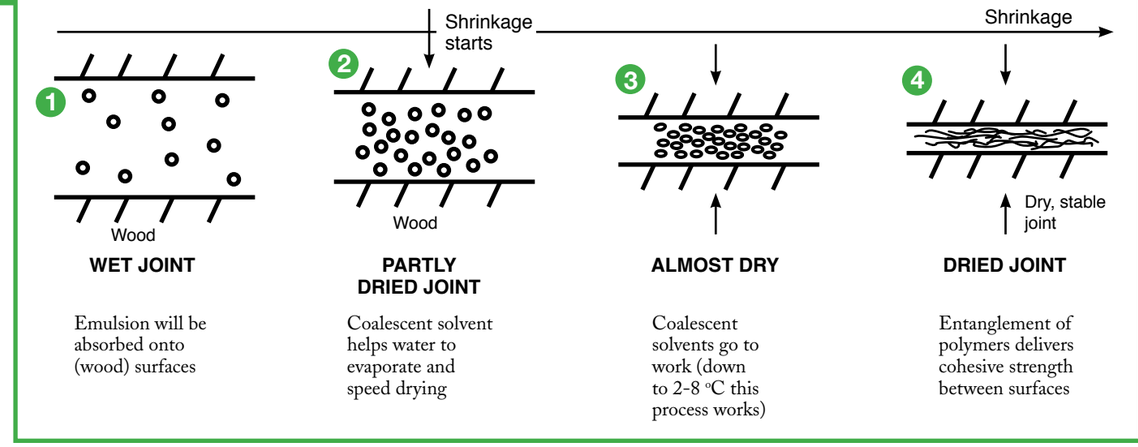
• As the temperature drops, PVA type adhesives take longer to dry until they will not dry at all below 7 or 8 oC. So keep joints above 7-8C

• Store out of the sun, sealed, in a cool, dark environment

• Do not allow to freeze.

• Keep dispenser tops sealed when not in use and squeeze the bottle where possible to remove as much air as possible from a part used container.

In summary then, emulsion glue technology is making great strides and we, as modellers, can have a wide choice of products with the properties we want. For easy sanding, quick grab and high strength, use a hard cross-linking polymer aliphatic resin. For a fast drying PVA, choose something like Deluxe Materials Speedbond which uses a pure PVA system with coalescing solvents to speed up drying. Beware cheap PVAs which use fillers to bulk as these glues can, over time, weaken joints.



Epoxy Adhesives

The well-known adhesive strength of epoxies is due to the strong polar bonds it forms with the surfaces it comes in contact with. Inorganic materials such as glass, metals etc. form particularly strong bonds and hence it can be used with glass composites. One sq cm of an epoxy is capable of holding 300kg weight!

The advantages of epoxy adhesives are several:

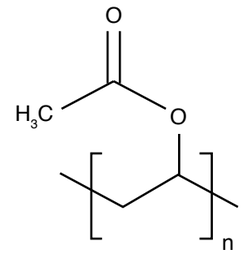
• Epoxy glues don't require anything other than the chemicals themselves to cause the cure. Other adhesives require the presence of moisture or absence of air. Thus the bond strength is highly reliable, consistent and not subject to environmental factors.

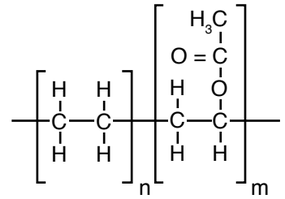
• Epoxies also exhibit high cohesive strength due to their highly cross-linked structure thus giving great strength across gaps.

• A large choice of hardeners is available to the formulator giving setting times from minutes to hours. Thus they can give modellers plenty of adjustment time without losing strength.

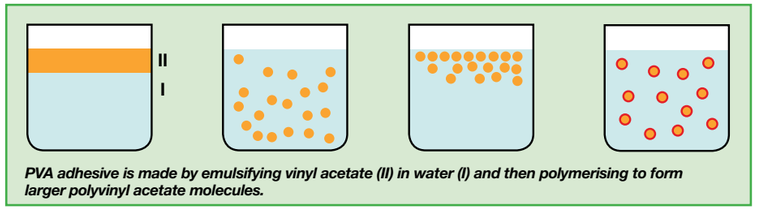
• Similarly, different hardener chemistry can be employed to change ultimate bond strength as shown in the example of the 3 types of Speed Epoxy II

So what sort of decisions does the development chemist make when designing a new epoxy? Explained below is the work conducted for two of our latest epoxy products formulated for the modeller.

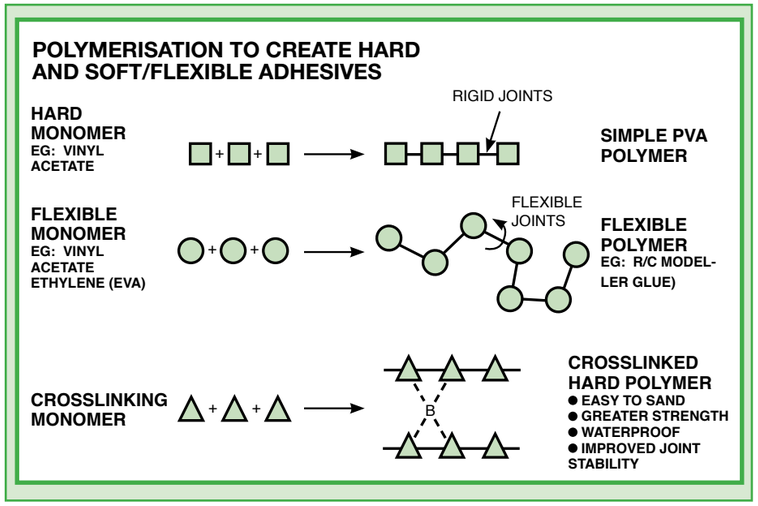


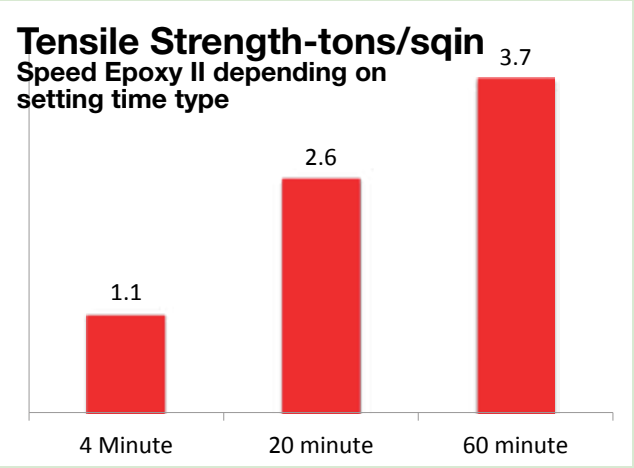


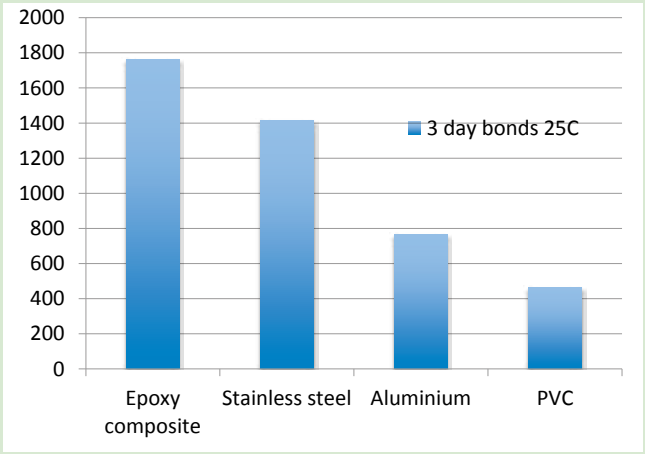
Structure of: (Top) Poly vinyl acetate (hard film), and below Vinyl acetate ethylene EVA (soft film).

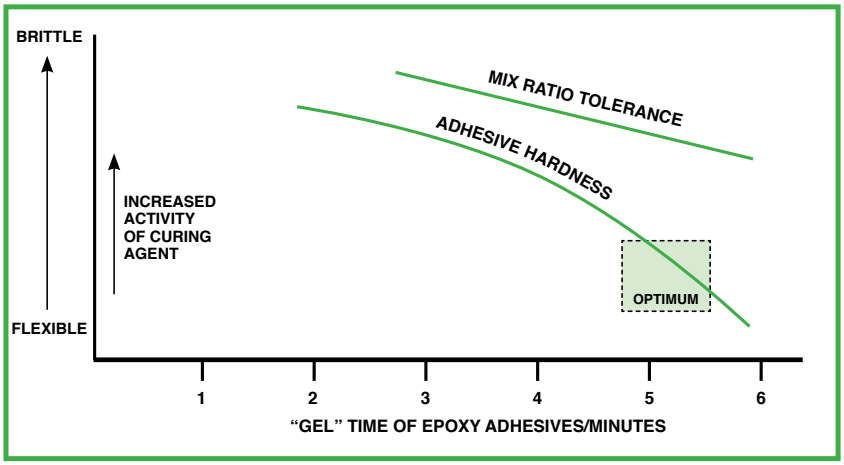


PVA adhesive is made by emulsifying vinyl acetate (II) in water (I) and then polymerising to form larger polyvinyl acetate molecules.









Lef: Finding the optimum attributes for new 4 Minute Speed Epoxy II
Above: Using hard wood to test pieces with different ratio epoxy mixes.

Fast Curing Epoxy

Developing our new fast setting 4 minute Speed Epoxy II has been a particularly interesting piece of work. Having identified the key performance benefits we then set about designing the hardener and then fine tuning the epoxy resin to match it (flow properties). These were the properties we thought modellers were looking for from an epoxy adhesive:

• High strength

Aero Tech epoxy was developed for areas such as formers in glass composites fuselages.

• The right balance of setting time and flexibility i.e. non brittle

•Sandabilty

• Mix ratio tolerance up to 10%. To cope with errors occurring with small 2-3g mixes.

Working through over 40 variations of hardeners and epoxy resins, we found the right balance of cure time and flexibility. Shortening the cure time would result in a film that was too quickly cured and brittle but delivered mix ratio tolerance, whereas extending cure time a little introduced flexibility and toughness into the bond.

The adhesive's properties were then all assessed for cure time, flexibility, sandability, and mix ratio tolerance (90/100, 100/90) using hardwood test pieces and the final formula fell into the dotted area shown.

In a second example, we wanted to develop a special epoxy product for bonding plywood to glass composites e.g. for gluing formers into glass composite moulded fuselages.

By talking to modellers, we identified the following features required of this advanced epoxy product:

• High adhesion to composite surfaces making it ideal for highly stressed parts e.g. engine mounts, control horns.

• Thixotropic, non-runny in use so it did not flow away from joints whilst setting.

• Gels in 3-4 hours with full cure in 24-28 hours.

• A visible bond (so you can see where the glue is)

From these requirement we developed Aero Tech epoxy which has been successfully "tuned" to give highest strength to composites.

Hints and tips for using Epoxy

Whatever brand of epoxy you use, the following will help you get the most from it:

• Measure accurately resin and hardener.

• Mix thoroughly - you can't over mix!

• Don't mix too much at a time 20-30ml max.

• Ensure surfaces to be bonded are clean and abrade if possible. Acetone is a good surface cleaner.

• Always keep hardeners and epoxy glues off your hands. Wipe adhesive away and wash hands with soap and water if contaminated.

• Keep away from excess heat and light especially hardeners which are the most sensitive.

• You can re-use crystallized solid epoxy resin by melting gently with warm water.