

Technology Profile

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Using Adhesives on Wood – Best Practices

Adhesives are universally used to manufacture a wide variety of value-added wood products and proper gluing practices are essential to ensure optimum performance. This article provides a summary of wood adhesive types and applications, surface bonding mechanisms, and processing factors and safety. In addition, frequent gluing defects and solutions for preventing them are discussed.



Wood Adhesives – Types and Applications

There are two main types of adhesives used in wood products manufacturing: thermo-set and thermo-plastic. Thermo-set adhesives need an elevated temperature to start curing and once set will not return to their original state. Thermo-plastic adhesives could return to their original state if heated, mixed with the original solvent or moisturized. Each adhesive has its own suggested gluing parameters. For example, epoxy adhesives work well close to 0°C while polyvinyl acetate (PVA) is adversely affected by low temperature. For most of the water-based adhesives, the ideal gluing temperature is close to room temperature (15 to 20°C).

Preparing the Surface for Bonding

Adhesives bond to wood surfaces in different ways with mechanical interlocking being the primary and most frequent bonding mechanism. In this process, the adhesive penetrates into the porous surface of the wood fibre and interlocks with the surface wood fibres as it cures. The second method of bonding is through the physical attraction between molecules (e.g., like 2 magnets). The third method of bonding is through a chemical bond where a new product is formed by the chemical combination of wood and adhesive.

To ensure a good bond, a thin glue line on a surface devoid of planer skips, torn, crushed, chipped or loose fibres is recommended. The surface to be glued has to be free of foreign material such as oil, grease, loose fibres, etc. In addition, all wood surfaces to be bonded should be glued within a maximum time of 24 hours after dressing to reduce the risk of surface oxidation and to minimize the effect of any moisture changes that may have occurred after dressing.

Sawn Surfaces

Sawn surfaces give a good bonding medium for most adhesives, however, dull saws tend to crush and close the surface wood fibres so it is important to keep saws sharp. Sawn surfaces give a rougher surface than knife cut surfaces but are satisfactory for gluing structural and non-structural joints.

Sanded Surfaces

Sanded surfaces only give an acceptable bonding surface because the sanding operation tends to crush and close the surface wood fibres thus preventing the adhesive from mechanically interlocking with the top fibre surface.

Knife Cut Surfaces

The knife cut surface given by planers and jointers are the best surfaces for bonding wood. A knife cut surface leaves a smooth, open grain surface thus enhancing the adhesive penetration into the surface fibres of the wood to be bonded. However, if the knives are dull or the feed speed is incorrect, the resulting crushed or burnished surface can impact the quality of the glue joint.

Table 1: Overview of wood adhesives and their applications.

Adhesive	Application	Adhesive Setting Process and Cure Time	Advantages/ Disadvantages
Thermo-Plastic			
Protein- and Starch-based	Specialty interior grade products – laminated or decorative	<ul style="list-style-type: none"> Water evaporation 2 to 4 hours 	<ul style="list-style-type: none"> Good gap filling properties Not moisture resistant
Tannin- and Lignin-based	Specialty interior grade products	<ul style="list-style-type: none"> Sets with heat 	<ul style="list-style-type: none"> Needs to be mixed with another adhesive
Casein (Milk Protein)	Specialty interior grade wood products	<ul style="list-style-type: none"> Water transfer and evaporation 2 to 4 hours 	<ul style="list-style-type: none"> Low cost
Polyvinyl Acetate (PVA)	Interior grade wood products	<ul style="list-style-type: none"> Water transfer and evaporation 40 minutes at room temperature 	<ul style="list-style-type: none"> Easy to work with
Catalyzed Polyvinyl Acetate (PVA)	Interior and exterior grade wood products	<ul style="list-style-type: none"> Water transfer and evaporation 40 minutes at room temperature 	<ul style="list-style-type: none"> Easy to work with
Rubber-based (Contact cement)	Wood to metal, plastic, fibreglass, etc.	<ul style="list-style-type: none"> Sets by solvent evaporation 	<ul style="list-style-type: none"> Instant grip on contact Low strength
Hot Melts	High speed production lines (<i>edge banding, carpentry, plastic, etc.</i>)	<ul style="list-style-type: none"> Sets by cooling 	<ul style="list-style-type: none"> Grips on contact when hot
Thermo and Room Temperature Set			
Phenol and Resorcinol Formaldehyde	4x8 Panel product (<i>OSB, Plywood, etc.</i>)	<ul style="list-style-type: none"> Sets in 2 minutes with heat and 6 hours at room temperature 	<ul style="list-style-type: none"> Waterproof Low cost
Thermo-Set			
Urea and Melamine Formaldehyde	4x8 Panel product (Particleboard, Plywood, Fibreboard)	<ul style="list-style-type: none"> Sets with heat in 2 minutes and 30 minutes to 12 hours at room temperature 	<ul style="list-style-type: none"> Moisture resistant Low cost
Isocyanates and Polyurethanes	4x8 Panel product (<i>mainly in OSB</i>)	<ul style="list-style-type: none"> One component sets with heat in 2 minutes From 2 to 60 minutes at room temperature for two-part resins 	<ul style="list-style-type: none"> Excellent adhesion to wood, metal, fibreglass and other products 100% solid Good gap filling properties No formaldehyde Low glue spread rate Expensive
Catalyst			
Epoxy Resins (2 components)	Specialty products (<i>Wood to Glass, Ceramic, Metal, Plastic, etc.</i>)	<ul style="list-style-type: none"> Sets in 5 minutes at room temperature 	<ul style="list-style-type: none"> 100% solid Good gap filling properties Expensive

Processing Factors

Pressure Application

The purpose of applying pressure when gluing is to bring the glued surfaces into close contact with one another. This helps the adhesive penetrate into the surfaces, wets the surfaces to be glued, and improves the spread uniformity of the adhesive over the entire glued surface.

A pressure of 175 to 250 PSI is generally recommended for hardwood species and 125 to 150 PSI for softwood species. The higher the density of the wood to be bonded, the higher the pressure should be. Too much pressure will create a starved joint as the adhesive will be pushed into the wood and away from the glue joint. Too low a pressure will not ensure the close contact needed between the two pieces to be bonded.

Press Time

Press time is governed by the cure method of the adhesive. All water soluble adhesives need time for the water to diffuse into the adjacent wood material and for the adhesive to catalyze and create a sound bond between the two pieces.

Moisture Content

Most adhesives will not form a satisfactory bond if the moisture content of the wood is over 20% because adhesives cannot penetrate saturated wood and the high moisture content prevents the adhesive from interlocking with the surface fibres. In general, bond quality is reduced when the moisture content of wood is over 15% or under 5%.

Glue Spread

The glue spread rate should be just enough to completely cover both surfaces. Usually 6 to 8 mils in thickness is a sufficient glue spread rate to cover both surfaces when using waterborne adhesives, although the manufacturers recommended spread rate should be consulted.

Evaluating Gluing Defects

Gluing problems are often expensive to repair. One method to evaluate the integrity of a glued joint is to look for wood particles on the glued surfaces of a broken joint. Wood particles or fibres on the open joint mean that the broken joint is as strong as, or stronger than the adjacent wood. Some common gluing defects, their causes, and solutions are shown in *Table 2* on the next page.



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Practical Bonding Tests

A simple test to evaluate the bonding properties of a surface to be bonded is to wipe a wet rag over a portion of the surface to be bonded, wait one minute, and then remove the excess water. Now compare this wetted surface to an adjacent dry surface. If the wetted surface is much rougher than the dry portion, this means the surface has been altered by the machining operation and the bond could be weaker compared to a sound surface.

Another test for surface gluability or surface inactivation is the water drop test. Put a drop of water on the surface to be glued and another drop on a freshly sanded portion of the same surface. The water drop should start to be absorbed in the wood within a minute and be totally absorbed in less than 60 minutes. If not, the surface is likely to be resistant to adhesive wetting and the integrity of the joint may be compromised.

Safety

In general, wood product adhesives are considered safe in their cured state except for Urea Formaldehyde-based adhesives which may release small concentrations of formaldehyde in the presence of water or moisture. Other adhesives will cause burns or irritation to the skin and to the lungs in their uncured state. The solvent-based adhesives will release organic solvents and should be used in ventilated areas. Adhesives within the Isocyanate and urethane families should be used in well ventilated areas and gloves, mask and personal body protection should be worn at all times.



Table 2: Common gluing defects.

Defect	Cause	Solution
Open glue joint	<ul style="list-style-type: none"> • Too high or too low wood moisture content • Surface of joint too rough • Too high or too low glue spread rate • Pre-cured or pre-dried glue line • Too short pressing time • Too high or too low pressure on the joint 	<ul style="list-style-type: none"> • Follow the recommended parameters for each type of joint to be glued
Sunken joint	<ul style="list-style-type: none"> • Machining the panel too soon after pressing 	<ul style="list-style-type: none"> • Wait 16 to 24 hours after pressing before machining
Telegraphing	<ul style="list-style-type: none"> • Non uniform support from the core 	<ul style="list-style-type: none"> • Actually accentuated through a thin face material or high gloss finish
Visible glue lines	<ul style="list-style-type: none"> • Non uniform edge machining 	<ul style="list-style-type: none"> • Use a lower glue spread on the joints
Blistering (No adhesion between layers)	<ul style="list-style-type: none"> • Skips in glue spreading • Pre-cure of the glue line, or • Pre-drying of the glue line • Non uniform thickness of the core • Surface inactivation or oily wood specie 	<ul style="list-style-type: none"> • Assemble the glue joints immediately after glue spreading • Check for uniformity of the thickness of the core • Reduce the glue spread rate • Follow the recommended parameters for each type of joint to be glued • Sand the surface with a fine grit paper or wash the surface with an organic solvent like alcohol
Panel warping	<ul style="list-style-type: none"> • Un-balanced construction 	<ul style="list-style-type: none"> • Check thickness, density, moisture content and species of the components
Non uniform component thickness	<ul style="list-style-type: none"> • Non uniform moisture content of the components 	<ul style="list-style-type: none"> • Equalize the moisture content of the components before assembly

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