TKH Technical Briefing Note 5

EPI adhesives

Version: October 2015

Published by Technische Kommission Holzklebstoffe (TKH Technical Committee on Wood Adhesives) of Industrieverband Klebstoffe e.V., Düsseldorf

Industrieverband Klebstoffe e.V.
www.klebstoffe.com

This technical briefing note is available from:
Industrieverband Klebstoffe e.V., P.O. Box 26 01 25, D-40094 Düsseldorf,
Phone +49/211/6 79 31-14, Fax +49/211/6 79 31-33,
Internet: www.klebstoffe.com, E-Mail: info@klebstoffe.com

Contents

Introduction

EPI adhesives were already addressed in the TKH Technical Information Leaflet 3 on "Dispersion Wood Glues," under item 1.3 EPI systems (emulsion polymer isocyanate). This supplementary leaflet provides further technical details about the special features of this type of adhesive.

1. Characterisation of EPI adhesives

EPI adhesives are dispersion adhesives that can be based on different polymers. In general, they are free of solvents but may contain additives that were added to adjust the processing and bonding properties of the adhesive. A usually high content in mineral fillers can cause increased tear on the machines due to the abrasive properties of mineral fillers.

The key feature is that EPI adhesives are crosslinked using a relatively high amount of an MDI-based isocyanate (usually by adding 15 % by weight). This crosslinking reaction leads to a high resistance to water and heat.

What if D4 is insufficient as the sole requirement?

The classification of wood adhesives according to DIN EN 204, defines applications for the highest durability class D4 as follows:

Indoor with frequent long-term exposure to running or condensed water. Exterior exposed to weather but with protection by an adequate surface coating.

However, experience has shown that some applications have higher demands.

2. Applications

Thermoplastic wood adhesives are classified according to their water resistance as regulated in DIN EN 204. This classification does not apply to thermosetting (e.g. condensation adhesives) or elastomeric adhesives (e.g. polyurethane adhesives). Due to their processing properties, EPI adhesives can be classified as thermoplastic wood adhesives. These adhesives can be tested according to DIN EN 205. In some cases, the achievable results of this test can be considerably higher than the values of a D4 adhesive. The same applies to the heat resistance test according to DIN EN 14257 (WATT '91), where EPI adhesives show significantly better results than standard D3 or D4 adhesives based on PVAc.

These properties make EPI adhesives particularly suitable for applications in which D4 is insufficient as the sole requirement. Good examples of this are dark coloured oak door panels, modified wood or exotic wood. While D4 would still be sufficient for these applications, joint opening could not be excluded with standard PVAc D4 glues. The combination of exposure to moisture and a high thermal stress causes tensions in the wood due to swelling and shrinkage, reduced water absorption or wood components.

This type of applications, with exposure to extreme conditions, requires an adhesive that can provide a superior bond strength even under the abovementioned climatic conditions.

This can be achieved either with adhesives for load-bearing glulam (see box) or with EPI adhesives. It must be observed that only certified adhesives may be used to manufacture load-bearing parts according to DIN 1052. In addition, such parts may only be manufactured by certified and monitored companies.

Adhesives used for load-bearing glulam are subject to extensive tests regarding their resistance to extreme indoor and outdoor climatic conditions. After successful testing according to DIN EN 301/302, these adhesives can be certified for load-bearing parts according to DIN 1052. This includes thermosetting adhesives based on condensation resins, polyurethane adhesives, but also EPI adhesives.

Table 1: Examples of applications for thermoplastic wood adhesives for solid wood

Application	Wood types	Durability class	Typical adhesives	Notes
Furniture, interior fittings	Domestic wood species	D1, D2, D3	PVAc casein glue	
Furniture, interior fittings	Exotic wood	D1, D2, D3	PVAc casein glue, EPI adhesives	For furniture, EPI adhesives are used mainly in Asia.
Manufacture of parquet	Wood-based materials, different hardwood species	D3	PVAc casein glue, EPI adhesives	The use of EPI adhesives is increasing due to the many different wood species and the high heat resistance.
Window corner assembly	Domestic wood species, special wood for windows	D3, D4	PVAc casein glue	Increased heat resistance (> 7 N/mm²) according to DIN EN 14257 required.
Window scantlings	Domestic wood species, special wood for windows, modified wood*	D4	PVAc casein glue, EPI adhesives	Increased heat resistance (> 7 N/mm²) according to DIN EN 14257 required.
Conservatory construction, non-load-bearing applications	Domestic wood species, special wood for windows	D4 not applicable	EPI adhesives	Weather-resistant exterior joints; in general, prior testing is essential
Wood for outdoor applications	Impregnated wood, larch	D4 not applicable	EPI adhesives	

** Currently, wood can be modified by a variety of methods. This includes e.g. acetylation, acrylation, furfurylation, treatment with water-repellent agents, impregnation with thermosetting resins, heat treatment.*

The objective of all wood modifications is to improve certain physical properties of the wood throughout its entire cross-section. For instance, wood treated with the abovementioned methods has an increased decay resistance. Therefore, even domestic wood species can be used for outdoor applications or in wet environments, without any short-term damages due to fungal decay. The natural tendency of wood to swelling and shrinkage, deforming and cracking is reduced due to a lower water absorption capacity.

The different methods and varying complexity of wood modification require preliminary trials to test the adhesion.

Bonding compounds where an isocyanate was used as crosslinking agent have a very high weather resistance compared to other bondings. However, as it is the case with all polyurethane-based systems, direct exposure of the bondline to UV radiation combined with oxygen causes an oxidation reaction reducing the bonding strength. This means that the open adhesive film is not resistant against exposure to sun light. The resistance is only provided in bondings where the bondline is located inside the construction. Therefore, it is recommended to protect the bondline by a constructional or chemical surface protection, as it is also required in DIN EN 204 for D4 durability class bondings.

3. Processing systems and methods

In general, the basic adhesive (dispersion component) and the crosslinking agent (isocyanate component) have to be mixed according to the prescribed mixing ratio until homogeneous before application. After mixing, the adhesive must be processed within the specified pot life.

Manual application method	Automatic application method
Weighing the dispersion and the crosslinking according to the manufacturer's specifications. Manually mixing in the crosslinking agent e.g. with blade agitators.	Automatic dosing and mixing units with dynamic or static mixing elements.
Manually applying the adhesive with brushes, spatulas or roller applicators. Special attention has to be paid to the pot life when pressurised containers or glue pumps are used.	The mixed adhesive can be applied with roller or blade applicator units. When depositing heads are used, the circulating adhesive volume should be kept at a minimum due to the short pot life. For start-stop systems with no circulating adhesive, the stored amount of adhesive should be kept at a minimum.

4. Fault analysis

In addition to the fault analysis in the TKH technical information leaflet 3 "Dispersion Wood Glues," this edition focuses on the special characteristics of 2-component dispersion adhesives.
EPI adhesives are mixed with the crosslinking agent directly before processing, according to the manufacturer's specifications. In general, EPI adhesives have a very short pot life due to the high reactivity of the adhesive system. It is essential to use up the mixed adhesive within the indicated pot life to avoid bonding failures.

Mixed EPI adhesives tend to foam towards the end of their pot life. Therefore, mixed adhesives should not be stored in closed containers (danger of bursting).

However, pot life and the processing properties also depend on the processor and the ambient conditions:

- High temperatures will lead to a shorter pot life.
- Stirring for too long will lead to a shorter pot life.
- Insufficient stirring will lead to an inhomogeneous distribution of the crosslinking agent.

5. Environmental and safety aspects

5.1. Main component based on dispersion

Like almost all polymers, polymer dispersions have a poor biodegradability. Once hardened, they will remain in the environment and degrade abiotically and biologically very slowly. However, they are not classified as toxic to the environment, nor do they result in bioaccumulation. Therefore, polymer dispersions are of less significance from an environmental point of view.
Modern component systems of polymer dispersions have very low emissions on account of their composition.

5.2. Hardener component based on isocyanate

Health issues are assessed taking into account the hardener system used. In general, hardeners based on diphenylmethane diisocyanate (MDI) are used.

Isocyanates are reactive compounds. In terms of their health characteristics, among other toxicological aspects, it is necessary to take into consideration their irritating effect especially on skin, eyes and the respiratory system as well as their sensitising potential based on the type of isocyanate used and the method of application. As a result, allergic skin reactions may occur, especially after repeated contact. Overexposure to diisocyanates by means of inhalation may lead to sensitisation of the respiratory system with asthma-like symptoms. While sensitisation is a consequence of a single or repeated overexposure, secondary allergic reactions may occur, however, in persons already sensitised even at considerably lower concentrations. People suffering from allergies, asthma and other diseases affecting the respiratory system are not permitted to perform any tasks that involve products containing isocyanates.
Except from aerosol-based application methods (e.g. spray application) and heat-curing, the workplace limits for diisocyanates are usually not exceeded, provided adequate ventilation is ensured. Low-volatile polyisocyanates do not contribute to respiratory system exposure under normal conditions. Skin exposure is prevented by wearing appropriate protective gloves.

Application methods with aerosol formation require the installation of effective extraction units. In case of short-term and temporary exposure, the use of personal protection equipment consisting of respiratory protection (fresh air respirator and filter A2 – P2), protective clothing, safety glasses and safety gloves (based on butyl or fluorine rubber) may be sufficient. According information is provided in the manufacturers' material safety data sheets. When it comes to industrial safety and monitoring, the regulations of TRGS 430 Isocyanates – Exposure and Monitoring – apply.

Properly hardened EPI adhesive systems are inert (fully polymerised synthetic resins) and are safe physiologically.

The manufacturers' latest material safety data sheets are to be observed.

Literature:

1) Technical Information Leaflet TKH-3 "Dispersion Wood Glues"
2) DIN EN 204 "Classification of thermoplastic wood adhesives for non-structural applications"
3) DIN EN 205 "Adhesives - Wood adhesives for non-structural applications - Determination of tensile shear strength of lap joints"
4) DIN EN 301 "Adhesives, phenolic and aminoplastic, for load-bearing timber structures - Classification and performance requirements"
5) DIN EN 302 "Adhesives for load-bearing timber structures - Test methods"
6) DIN EN 923 "Adhesives – Terms and definitions"
7) DIN EN 14257 "Adhesives - Wood adhesives – Determination of tensile strength of lap joints at elevated temperature" (WATT' 91)
8) DIN 1052 "Entwurf, Berechnung und Bemessung von Holzbauwerken - Allgemeine Bemessungsregeln und Bemessungsregeln für den Hochbau"