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A NEW WOOD PRESERVATIVE: POLYMERIC BETAINE

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Summary

Polymeric betaine belongs to the quarternary ammonium compound family of biocides. Due to its unique structure, polymeric betaine exists as an equilibrium mixture of monomer and dimmers depending on the concentration, pH, and other factors. This property gives polymeric betaine unique attributes as a wood preservative. Due to the betaine nature of the dimeric form, polymeric betaine has relatively flat distribution gradient in pressure treated wood and provides improved penetration in dip-treatment applications. Suitability of polymeric betaine based preservatives for anti-sapstain and wood composite protection is discussed.

1. Introduction

Polymeric betaine, didecyl bis(2-hydroxyethyl) ammonium borate (DPAB), was developed in the 1980's in Europe as a biocide and co-biocide for wood protection. Although it is new to North America, polymeric betaine based products have been used in Europe for almost 20 years.

Impralit™ KDS is a heavy duty preservative for pressure-vacuum applications. It contains copper, polymeric betaine, and boric acid as active biocides. Impralit™ KDS-B is identical to KDS except it does not contain boric acid. Impralit™ TSK is metal-free formulation intended for dip-treatment of framing lumber and other applications. TSK has polymeric betaine and Fenoxycarb as actives.

2. Results and Discussion

The equilibrium shift between the monomer and dimer form of polymeric betaine (DPAB) as a function of concentration has been reported previously (Härtner etc, 2009). The equilibrium shift can be monitored by direct infusion mass spectrometry. Solution pH also has a direct impact on the equilibrium shift. Higher pH stabilizes the dimer while lower pH favors the monomer form (Figure 1).

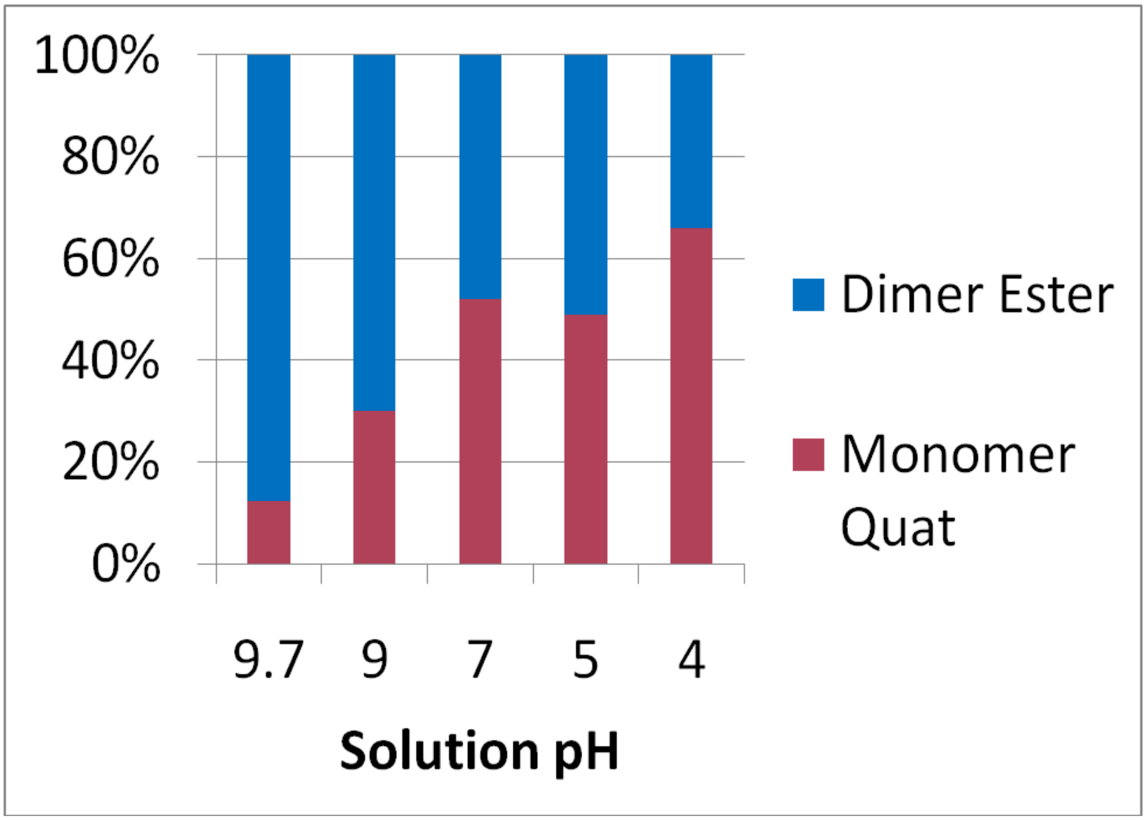

Figure 1. Polymeric betaine (0.6% a.i.) equilibrium shift as a function of pH

It is well known that cationic species such as DDAC interacts strongly and rapidly with wood components (Jin and Preston 1991). As a result, preservative actives such as DDAC has a steep distribution gradient in the treated wood. In contrast, polymeric betaine has a relatively flat distribution gradient in the treated wood (Härtner *et al*. 2009). This can be explained by the fact that in the work solution strength range, the majority of polymeric betaine exists in the dimeric betaine form, which itself does not have a strong interaction with wood. As pH and concentration decrease during the complicated physical and chemical reactions of the fixation process, the dimeric form of polymeric betaine shifts to the monomer form. The monomer form of polymeric betaine, a cationic species, is expected to interact with wood similarly to other conventional quaternary ammonium compounds in addition to hydrogen bonding due the presence of hydroxyethyl groups in polymeric betaine (Härtner *et al*. 2009).

Preservative penetration for dipping applications is very important. European standard EN351 requires a minimum penetration of 3 mm for dip treated lumber and timber intended for roof trusts (UC1). Figure 2 compares the preservative penetration in dip treated Scots pine for two similar formulations. One formulation was based on a conventional quat while the other formulation was based on polymeric betaine (DPAB). The significant difference in preservative penetration can be explained by the betaine nature of DPAB.

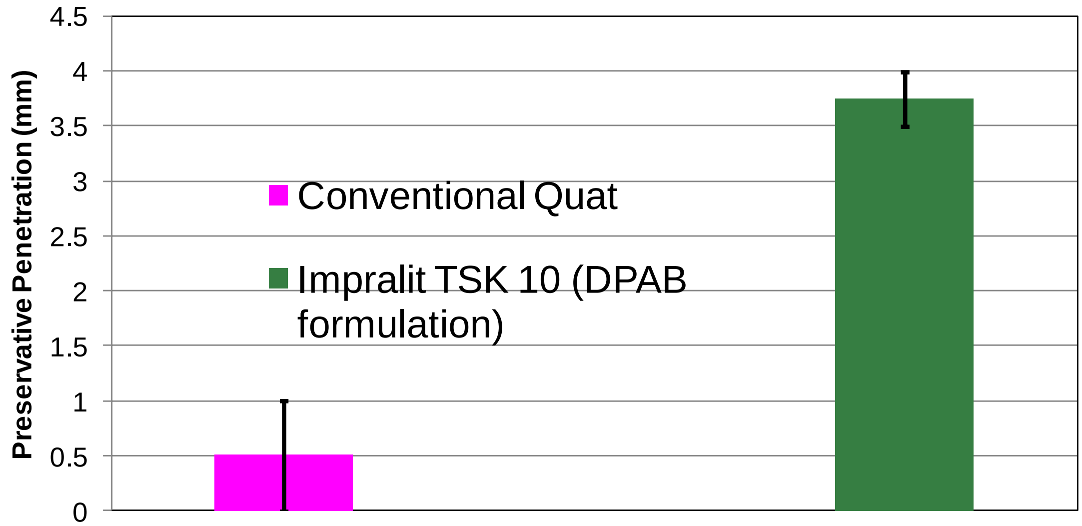

Figure 2. Preservative penetration in dip-treated Scots pine.

The effect of polymeric betaine based formulations on OSB has been reported (Barnes and Kirkpatrick 2005, Kirkpatrick and Barnes 2006). Flakes were treated with various preservatives before board fabrication. It was discovered that OSB boards made from polymeric betaine treated flakes had higher mechanical strength than untreated control.

Glulams are typically made with lumber pre-treated with a preservative for practical reasons. Unfortunately, most water borne and oil borne preservatives have a negative impact on the glue system so that the strength properties and durability of the glulam is compromised.

The effect of KDS treatment on delamination, shear strength, and wood failure during shear testing was studied. Figure 3 compares the % delamination of untreated and KDS treated Scots pine according to test method EN391. It was discovered that KDS actually reduced % delamination comparing to untreated control. The exact mechanism of the enhanced bonding by KDS is poorly understood. But the observations in the glulam study are consistent with the OSB results (Barnes and Kirkpatrick 2005, Kirkpatrick and Barnes 2006).

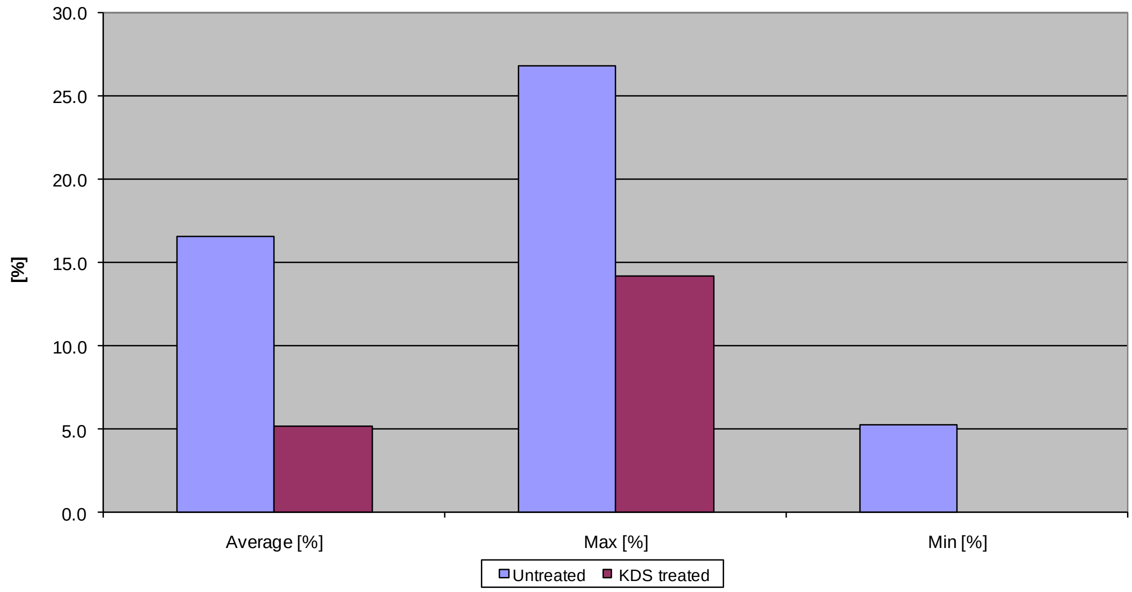

Figure 3. %Delamination of Scots pine glulam according to EN391.

Shear strength and wood failure during dry shear (Figure 4) was similar for KDS treated and untreated Scots pine laminates.

In a number of laboratory and simulated field tests, polymeric betaine (DPAB) showed excellent efficacy as an anti-sapstain active. In a 12-month simulated field test carried out by Forintek Canada Corp. (now FPInnovations), the performance of DPAB at different application rates was compared with the standard commercial product NP-1. As clearly shown in Figure 5, DPAB alone had excellent performance comparing with NP-1 in green Hem-fir. The results were similar in Douglas fir.

In a laboratory test, a formulated product using DPAB as the main active outperformed a leading anti-sapstain product in North America. In an independent European anti-sapstian field test (Aschacher *et al*. 1998), DPAB showed the lowest leaching comparig with commercial and other developmental formulations.

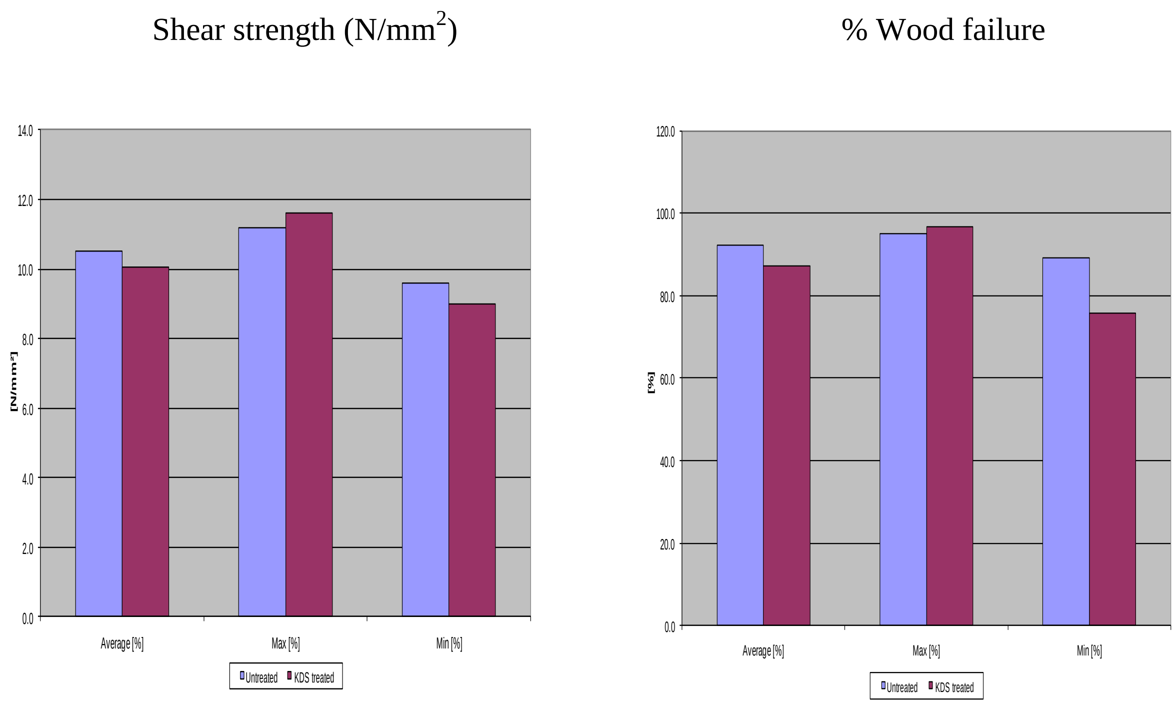

Figure 4. Shear strength and wood failure during dry shear

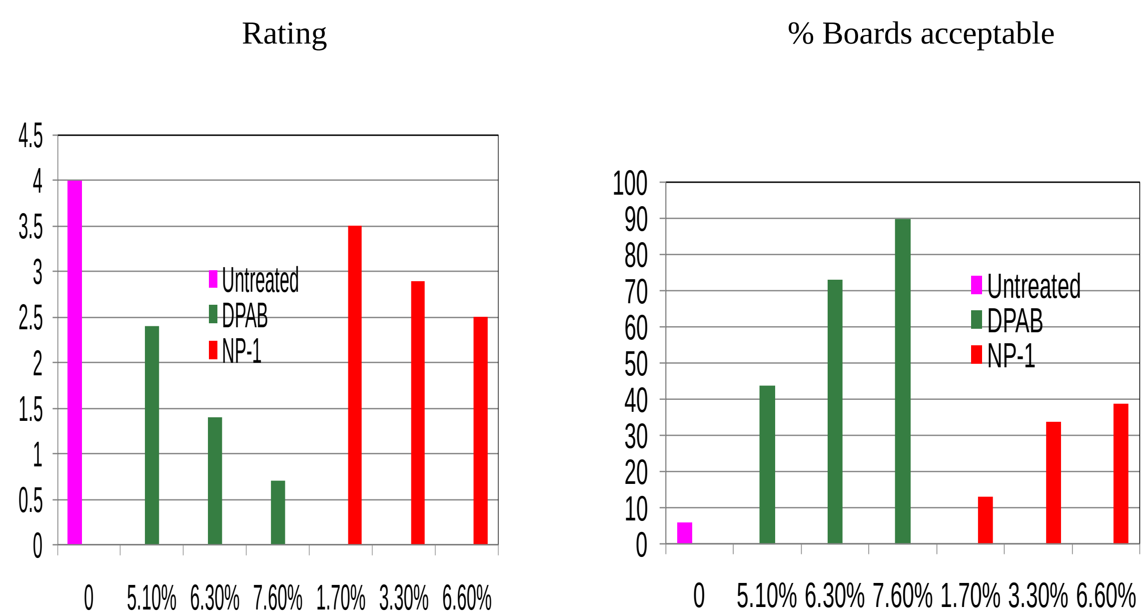

Figure 5. Visual rating and % boards acceptable after a 12-month simulated field testing using green Hem-fir as testing substrate.

4. Conclusions

Polymeric betaine (DPAB) has some very unique properties as a wood preservative. Due to its betaine structure, it has flat distribution gradient in pressure treated wood and improved penetration for dip-treatment products. The presence of hydroxyethyl groups in the molecule makes it possible to form hydrogen bonds with wood components, in addition to other physical and physico-chemical interactions for conventional quaternary ammonium compounds.

DPAB has excellent efficacy as an active for anti-sapstain applications.

One of the most important attributes of DPAB as a wood preservative is probably its suitability for the protection of wood composites. OSB made from DPAB treated flakes has higher mechanical strength than untreated flakes. KDS treated glulam had lower delamination than untreated wood.

5. Literature

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