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Effect of Polyborate Pre-treatment on the Shear Strength Development of Phenolic Resin to Sitka Spruce Bonds

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Summary

Pre-treating the constituents of wood-based composite panels with fungitoxic chemicals prior to lay-up and pressing offers some advantage over post-pressing treatment. Boron is a strong candidate pre-treatment chemical for this application but it influences the bonding mechanisms that must occur during hot pressing. In the present study, the effects of boron loading level (0 to 15% boric acid equivalent, BAE) on the strength development rates of small phenol formaldehyde-to-wood (sitka spruce) test bonds was investigated. Each bond (15 mm × 15 mm overlap) was formed under pre-selected time (20 to 240 s) and temperature (70, 80 or 95 °C) conditions and immediately thereafter tested in shear mode. This enabled three approximately isothermal bond strength development curves to be constructed for each boron loading level investigated. All levels of boron pretreatment hastened initial strength development rates, although levels above 7.5% BAE had diminishing effects on isothermal rates – with possible decreases at very high (15% BAE) levels. Though not exactly reproducing conditions that occur around bonding sites in panels during pressing, the techniques described may aid in our basic understanding of the mechanisms affected by chemical pre-treatment.

Introduction

As markets for wood-based composite products expand, these materials will be increasingly used under conditions conducive to fungal and insect attack. Assembled panels can be treated with conventional wood preservatives using pressure processes but the associated fluid uptake can lead to excessive swelling or delamination. Furthermore, treatment difficulties inherent with certain wood species can result in poor penetration of panels derived from them (Mitchoff 1990); this may lead to decay problems in service.

As an alternative, veneers, flakes or particles may be preservative treated prior to being layed up, thus enabling quite uniformly treated panels to be produced. Either dipping or soaking methods may be used thereby avoiding the need for elaborate pressure treatment equipment. Boron, one potential chemical for this application, has excellent activity against fungi and insects in conditions where material is protected against continuous wetting (Carr 1959; Cockroft and Levy 1973). Boron compounds have several other advantages over conventional waterborne preservatives such as chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (ACZA), and ammoniacal copper arsenate (ACA); for example, they readily diffuse through the wet heartwood of species such as Douglas-Fir which often resists chemical treatment. Factors such as a low mammalian toxicity, minimal impacts on the environment or the wood's appearance also favor the use of boron (Burton *et al.* 1990).

While boron pre-treatments can produce decay-resistant panels, the process changes the surface chemistry of the wood and this may alter its bonding characteristics. Earlier studies have noted substantial decreases in internal bond strength, modulus of elasticity, modulus of rupture, and thickness swell in panels made from boron treated flakes and glued with phenolic (PF) resins (Laks *et al.* 1988). Declines of wet shear strength were also observed in plywood panels made from veneers treated with ammoniacal copper borate and glued with PF resin using varying closed assembly times (Vick *et al.* 1990). These effects have been attributed to a tendency of boron to locally hasten polymerization of PF resin during the pressing process – a phenomenon which may inhibit subsequent resin spreading and penetration (Pizzi 1983).

Although the results of earlier studies suggest that borate pre-treatment is not appropriate for use in the manufacture of panel products, little is known fundamentally about the effects of boron on resin curing and wood-resin bonding. With better understanding, it may possibly be feasible to tailor adhesives to the chemical charasteristics and structure of the pre-treated wood; this may enable well bonded and durable panels to be produced.