SEMI-ANNUAL PROGRESS REPORT

MDI ADHESIVES FOR VENEER APPLICATIONS

By

Brian K. Brashaw
Research Fellow

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Subaccount No. 543250

Prepared For:

Minnesota Technology, Incorporated
111 Third Ave. South, Suite 400
Minneapolis, MN 55401

Natural Resources Research Institute
University of Minnesota, Duluth
5013 Miller Trunk Highway
Duluth, Minnesota 55811

MDI Adhesives For Veneer Applications

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Coordinator: Brian Brashaw

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Objective: To assist in development of MDI as an adhesive for use in laminated veneer lumber (LVL), plywood, and I-joist manufacturing.

Background: LVL is an engineered wood product designed to meet specific strength and size requirements. LVL applications in residential and commercial construction include flange material of wood I-joists, headers, beams, planks, and other structural and industrial applications. Many of these applications require thick (greater than traditional 1½-inch) material which is currently manufactured in a two-step process or in a very long press cycle. Development of an MDI adhesive for use in the production of LVL would enhance the ability of a manufacturing facility to produce thick cold pressed LVL in a shorter one-step process. MDI is a structural exterior adhesive used in the composite panel industry which results in reduced volatile organic compound (VOC) emissions during the drying and pressing cycle. It can bond wood that has a slightly higher moisture content than phenol-formaldehyde (PF) adhesives.

The NRRI has manufactured thick billets of LVL for use as utility pole crossarms and blades for wind-powered electric generators in previous projects for Minnesota companies. Cold-curing catalyzed polyvinyl acetate (PVA) adhesives were used to produce the thick billets (2-4 inches) of material from aspen and red maple veneer. Since MDI has better durability, the evaluation of a structural MDI is a logical extension of the previous LVL research conducted at NRRI.

An alternative adhesive for use in LVL manufacturing would have certain ideal performance characteristics. It would have minimal environmental effects, be readily available, and have a wide range of pressing parameters. MDI has acceptable bonding performance at slightly higher veneer moisture contents than PF, which reduces the VOC emissions during the drying of veneer. MDI has lower VOC emissions than PF during the pressing portion of the LVL manufacturing process. By varying the amount of catalyst used in the MDI, it will cure under a wide variety of pressing conditions. MDI will cure at ambient temperatures (60°-80°F), under heat (300°-400°F) and by using combinations of hot pressing and radio frequency heating.

Summary of Progress: During the first six months of this project resin chemists from Miles Inc. worked on formulating acceptable two component resin systems. Input was provided by Natural Resources Research Institute (NRRI) scientists on the adhesive parameters that would be suitable for manufacturing LVL and plywood. Since this was a new product there was initial difficulty in obtaining a useable adhesive and the first formulation samples were sent in January. Two additional samples were formulated to improve on the performance characteristics. These were also two component systems. The "A" component used throughout the project was the standard Miles Inc. diphenylmethane diisocyanate (MDI) resin that is used for oriented strandboard production. The "B" component resulted in bonding at low or room temperatures when mixed with the "A" component at appropriate mix ratios. During the second six months of the project these three separate formulations of the "B" component were evaluated by NRRI personnel for suitability in manufacturing LVL, plywood, and I-joists.

MDI application equipment options were identified and suppliers of extruder and curtain coater equipment identified and contacted. This information will be beneficial at the completion of the project. MDI will probably not be applied to veneer by traditional glue spreaders since the cleanup is difficult and a large amount of adhesive is wasted. Extruders and curtain coating equipment is easier to cleanup following use. NRRI equipment was modified for use as an extruder and used during the course of the project to manufacture laboratory scale panels.

The three formulations were evaluated to assess their potential use as laminating adhesives for LVL and prefabricated wood I-joists. The adhesive systems were evaluated to determine:

1. Optimal application and pressing parameters.
2. Ability of the adhesive to be used in existing equipment.
3. Environmental impact and cleanup.

The optimal parameters were determined by conducting mechanical and durability tests of the bonded joints. The tests of the adhesive for LVL included plywood shear testing of control and vacuum-pressure-soaked specimens. To determine acceptability for prefabricated wood I-joists, the adhesive joints were tested using ASTM D2559.

The initial formulation provided acceptable bonding performance but the "B" component had a very high viscosity of approximately 38,000 centipoise (cps). It would be difficult to pump this component through adhesive lines prior to mixing. Preliminary evaluations of the optimum application and pressing parameters showed that a minimum press time of 30 minutes and a minimum spread rate of 45 pounds of adhesive per 1000 square feet of glue line were needed for adequate bonding of aspen veneer. Wood failure percentages exceeding 75 percent were recorded from samples that underwent vacuum-pressure-soak accelerated aging according to the American Plywood Association (APA) U.S. Product Standard PS 1-83.

Our tests showed the optimum moisture content of the wood substrate needs to be greater than 10 percent. This information means that the veneer would not need to be dried to the 2-3 percent moisture content that phenol-based adhesives require for bonding. By not drying the wood to these low levels, VOC emissions from the drying process are reduced. The fast cure of this system holds a lot of potential for I-joist manufacturing as it could result in increased production rates.

Based on this information, the second formulation of the "B" component was prepared. The primary goal was to reduce the viscosity. The fillers were removed to bring the viscosity of this material to approximately 2,180 cps. However, by reducing the fillers in the system, the reaction time decreased. The open pot life was reduced to approximately three minutes. This would make it impossible to apply the adhesive to the material. Problems would occur in the application equipment and the time required to lay up panels will exceed the open assembly time of the adhesive. Therefore this formulation was not used for testing.

The third formulation of the "B" component was then prepared by Miles Inc. This was formulated to have a longer pot life than the previous formulation. This sample had an acceptable viscosity of 2,080 cps. Appropriate amounts of the "A" and "B" components were mixed together and used to prepare laminated beams. These samples were tested using ASTM D2559. The target wood product for this third formulation is prefabricated I beams because the assembly time and cure time may be too short for LVL products.

This project is being extended by matching funds from Miles Inc. Complete evaluations of the acceptable third formulation will be conducted during the next six months. These evaluations will include the determination of optimum adhesive spread rates, maximum open and closed assembly times, wood moisture content, and press cycles for bonding solid sawn lumber and oriented strandboard. This report will be amended at the completion of these evaluations to reflect additional results. The project will focus on bonding performance of prefabricated wood I-joists. This adhesive system will be used to bond the oriented strandboard webs to the solid sawn lumber or LVL flanges. Prototype joists will be manufactured for test purposes.

At this time we cannot make LVL with cold-curing MDI adhesive. This is due to the short assembly time of the adhesive. Additional chemical formulations and evaluations will be required to produce acceptable LVL and plywood adhesive.