Technical Note

# Increasing Cold Tack of Polymeric Methylene Diphenyl Diisocyanate Resin with Partial Soy Flour Substitution

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## Abstract

Partial substitution of polymeric methylene diphenyl diisocyanate resin with soy flour increases the cold tack of the resin to the level achieved by urea formaldehyde resin. The tack can be fine-tuned by adjusting the amount of soy flour added. The increase in tack is caused by the reaction of the isocyanate resin with the water contained in soy flour, as well as with hydroxyl and other groups present in soy flour components. The higher cold tack should increase the stability of pre-press mats, especially in particleboard manufacturing.

Urea formaldehyde (UF) resins are typically used in the manufacture of particleboard. Concerns with formaldehyde emissions from these resins have prompted a switch to binders such as polymeric methylene diphenyl diisocyanate (pMDI). However, the low cold tack of pMDI reduces the structural integrity of the pre-press mat (Solt et al. 2018, 2019), and it is described as considerably lower than UF (Mantanis et al. 2018). Cold tack is also important for veneer, where low cold tack can distort layer orientation prior to entering the press. Attempts have been made to increase the cold tack of pMDI, e.g., by adding a combination of polyols and monols to pMDI; an increase in tack has been reported by Moriarty (2017a,b). In previous work we have shown that partial (~15%) substitution of soy flour in pMDI resin for the manufacture of oriented strand board and particleboard leads to significant cost benefits without compromising wet or dry board properties (Cheng et al. 2019). We now demonstrate an additional benefit of soy flour substitution—an increase in the cold tack of pMDI resin, which improves the pre-press integrity of a mat.

## Materials and Methods

Defatted soy flour (7B) was provided by Archer Daniels Midland (Chicago, Illinois); its moisture content was 5.9 percent. The pMDI resin was MONDUR 541 from Covestro. Different batches of pMDI were used for the various measurements, so the results should only be compared within each set. UF resin was obtained from Arauco Wood Products. The soy/resin adhesives were prepared by adding the soy into the resin in small batches and stirring until the mixture was uniform. Ensuring that the mixture is uniform is very important for maintaining wet strength, as will be discussed in a future article.

The tack of the various resin formulations was measured with a modified ASTM technique (ASTM International 2017). Metal coupons were coated with resins at a density of 0.65 g over 26 $cm^2$ at 40°C. This temperature is an optimum for mixing pMDI with soy flour (Via et al. 2019). The plates were angled at 30°, and a steel bolt (2.2 cm wide, 1.34 cm in diameter, 13.14 g) was rolled down each plate, and its travel distance averaged from four measurements.

## Results and Discussion

Figure 1 shows the effect of resin tack on the distance travelled by the various bolts. The distance is longest for the MDI-treated plate (reflecting its low tack) and is about equal to UF for 10 percent soy substituted plates. The travel distance falls linearly with soy flour substitution as illustrated in Figure 2, reflecting a corresponding increase in tack. The tack most likely develops from the reaction of

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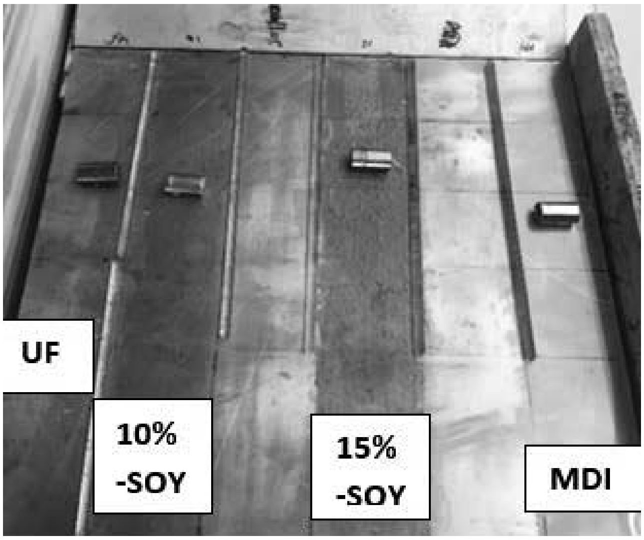


*Figure 1.—Images of bolts after rolling down inclined resinated plates. UF = urea formaldehyde; MDI = methylene diphenyl diisocyanate.*

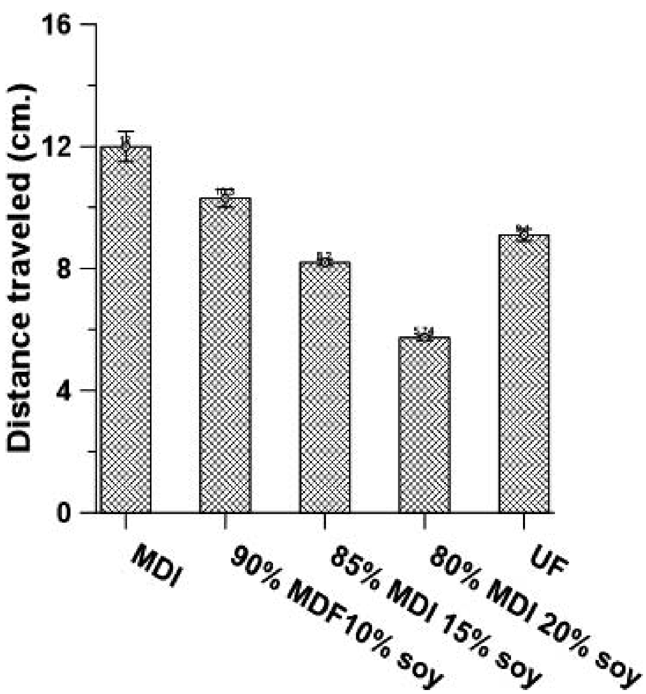


*Figure 2.—Effect of soy flour substitution on distance down an inclined surface. UF = urea formaldehyde; MDI = methylene diphenyl diisocyanate.*

water contained in the soy flour (5.9%) and of functional groups in soy flour with MDI. Weaver and Owen (1995) have shown that pMDI reacts with water more rapidly than it does with cellulose or wood polymers. It follows that adding water to pMDI should also increase the tack of pMDI in our ''inclined plate'' measurements. Water (1% by weight of pMDI) was added to pMDI, and the resin was filmed on a metal coupon as above to test this hypothesis. The travel distances of a bolt on the control and water-modified resins were 18.5 ± 0.3 and 13.7 ± 0.8 cm, respectively, i.e., a drop of 26 percent. If water is mainly responsible for the tack increase induced by soy flour, then a similar drop should be obtained from Figure 2. Substituting 20 percent soy flour in pMDI adds the equivalent of 1.2 percent water to the resin. The corresponding decrease in travel distance is 52 percent, which is twice the value obtained from adding water alone. The difference is probably due to the hydroxyl and other groups present in soy flour components that can also react with pMDI. The likely reason for the increase in cold tack is that water increases the polarity of the pMDI resin by adding amine and derived functionalities to the pMDI structure. The increased polarity would allow the resin to better wet the surface of the wood.

## Conclusions

The cold tack of pMDI resin increases by an increase in partial substitution with soy flour to the same level obtained with UF resins. The tack can be fine-tuned by adjusting the amount of soy flour added. The increase in tack is caused by the reaction of the isocyanate resin with the water contained in soy flour and with soy flour components. Soy flour is much cheaper than pMDI resin and provides the same wet and dry strength properties when substituted in pMDI at or about 15 percent. The added benefit of cold tack provides a compelling economic and technical justification for its use in engineered wood.

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