

Investigation of green wood adhesives from soy protein

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OVERVIEW

- Wood adhesives
- Modification of soy protein
- Results and discussion
- Acknowledgement

Issues Associated with Currently Used Wood Adhesives

- **Petroleum-based**
- **Formaldehyde emission**
 - ❖ **Formaldehyde is a human carcinogen**

Wood adhesives

- **The goal of my research program:
Development and characterization
of environmentally friendly wood
adhesives from renewable
materials**

Two-ply wood composites bonded with soy-based adhesives

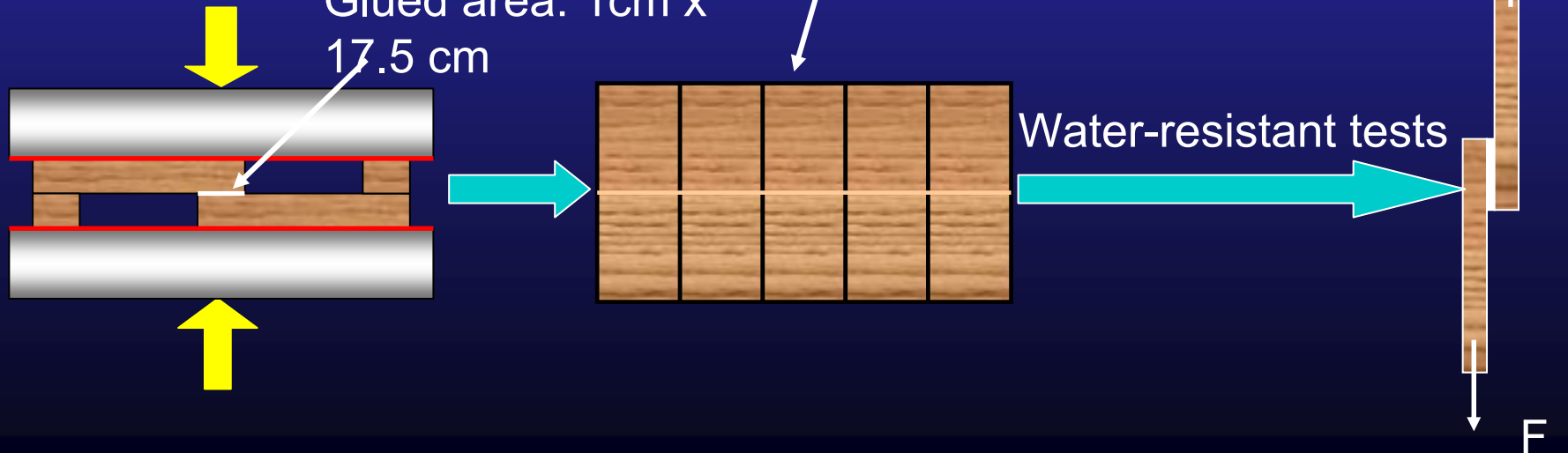
5 samples

Bonded area for each sample: 1 cm x 2.54 cm

• Hot press conditions:

120 psi, 120 °C, 5 min

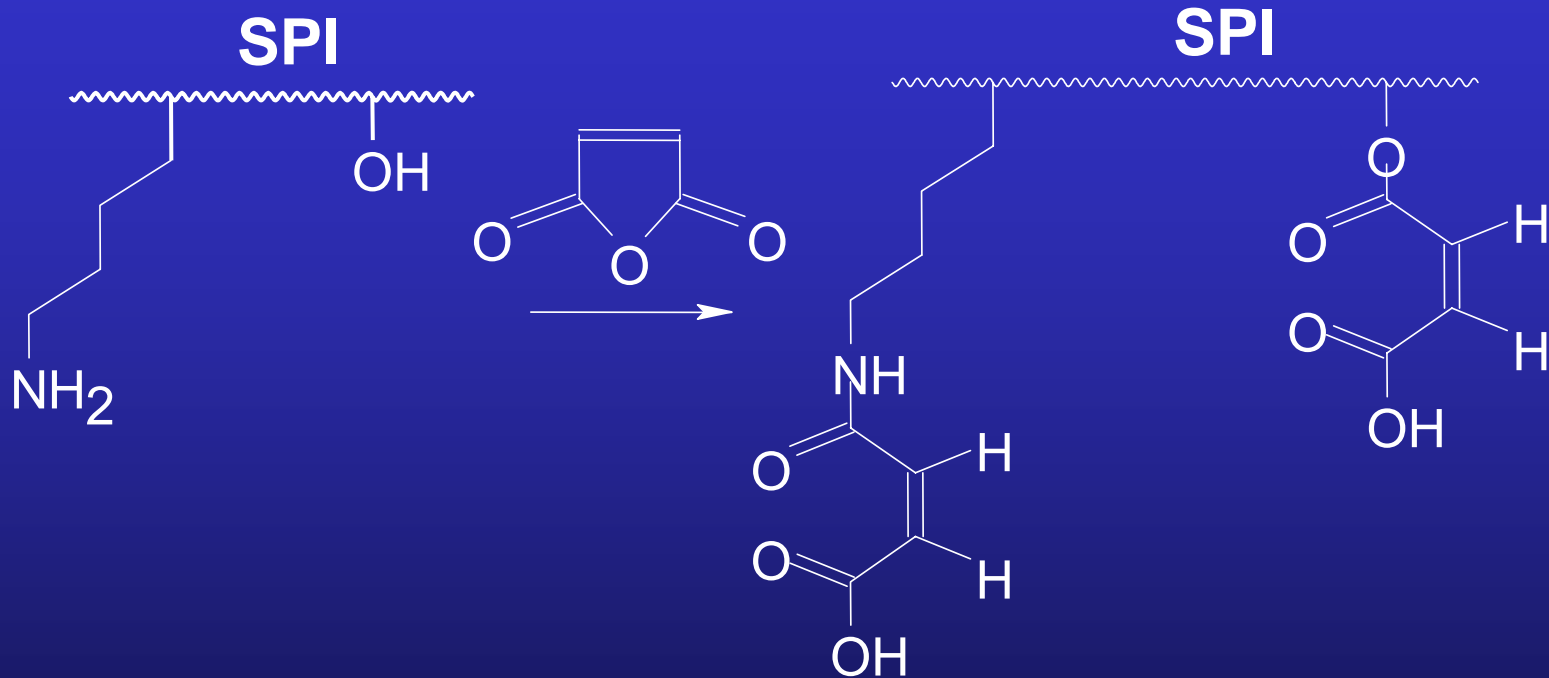
Glued area: 1 cm x 17.5 cm



Water Resistance Test

- Boiling-water test (**BWT**): boiled in water for 4 h, dried for 20 h at $63\pm 3^{\circ}\text{C}$, boiled in water for 4 h, cooled down with tap water and evaluated for the shear strength while the specimens were wet (**BWT/wet**). The specimens were dried in a fume hood for 24 h and then evaluated for the shear strength (**BWT/dry**)

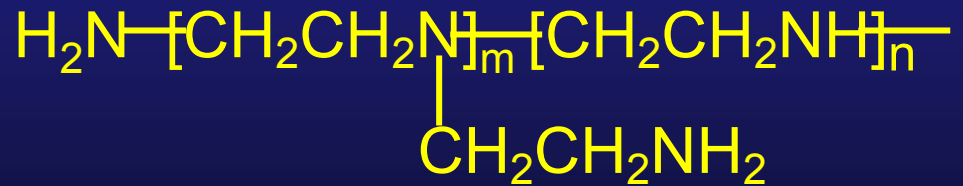
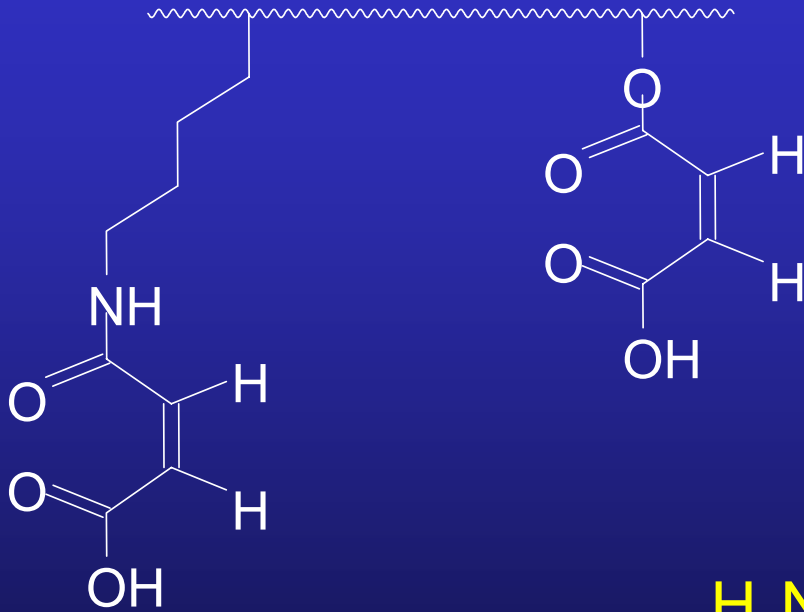
Maleic anhydride-modified SPI (MSPI)



Maleic anhydride was added in the SPI solution with stirring. The pH of the mixture was maintained at 8 ~ 9 by adding 1.0 NaOH solution

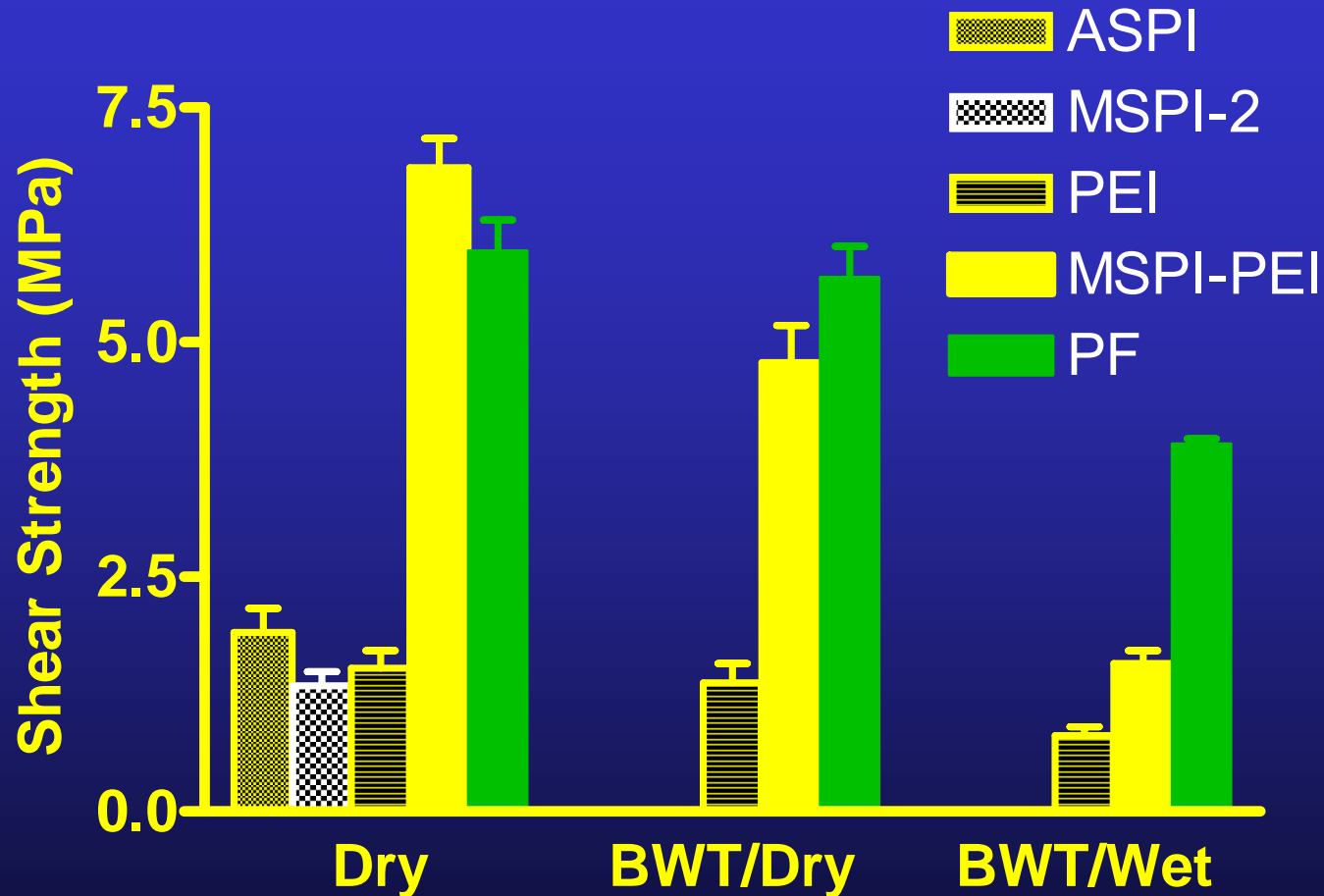
MSPI-PEI adhesives

SPI



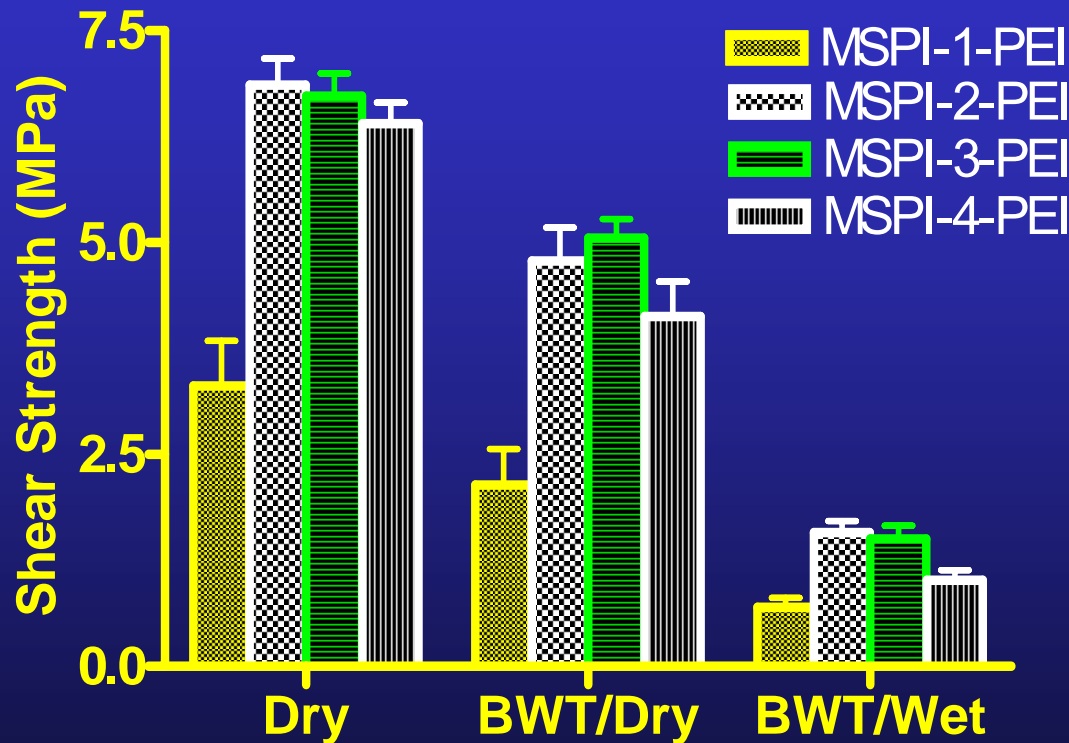
Polyethylenimine (PEI)

MSPI-PEI adhesives



Adhesive: 20 wt% PEI ($M_w=750$ kDa) + 80 wt% MSPI-2 Hot press temperature=160 °C, hot press time=5 min

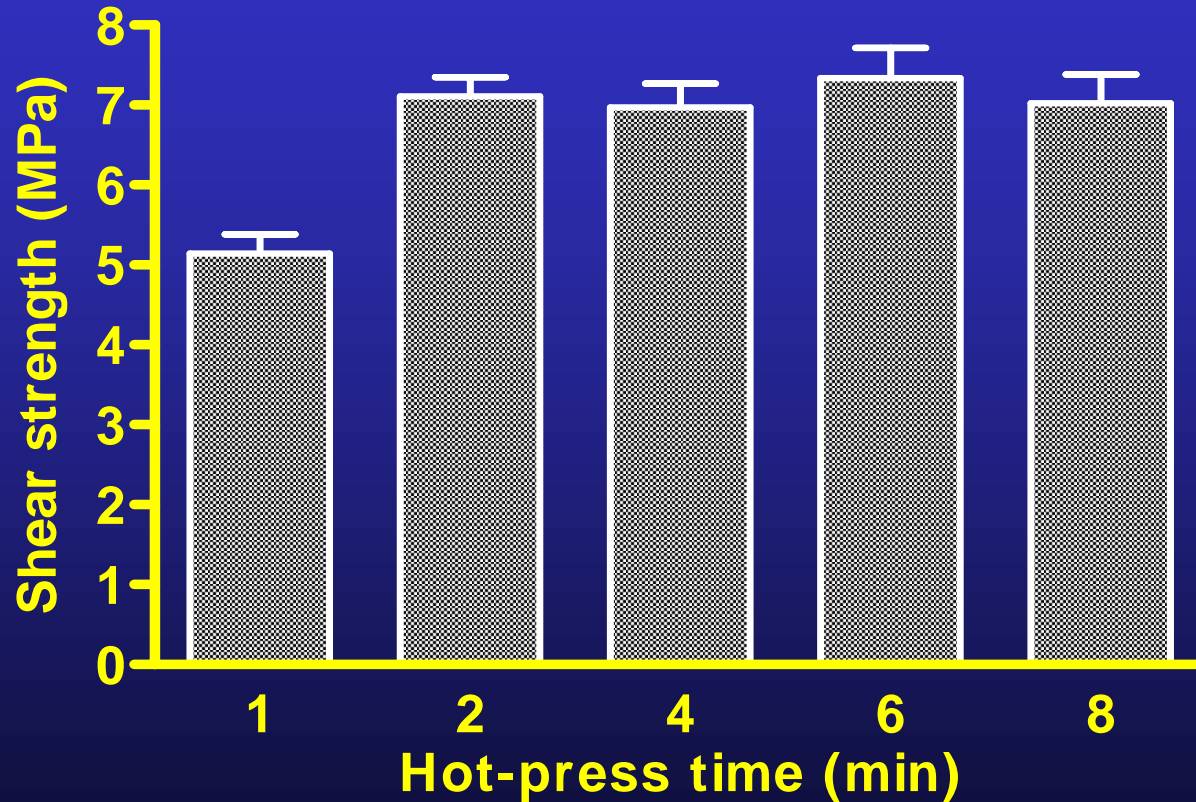
Effects of the MA dosage in maleylation on shear strengths



	MA dosage in maleylation MA:SPI (wt:wt)
MSPI-1	0.5:10
MSPI-2	1:10
MSPI-3	2:10
MSPI-4	5:10

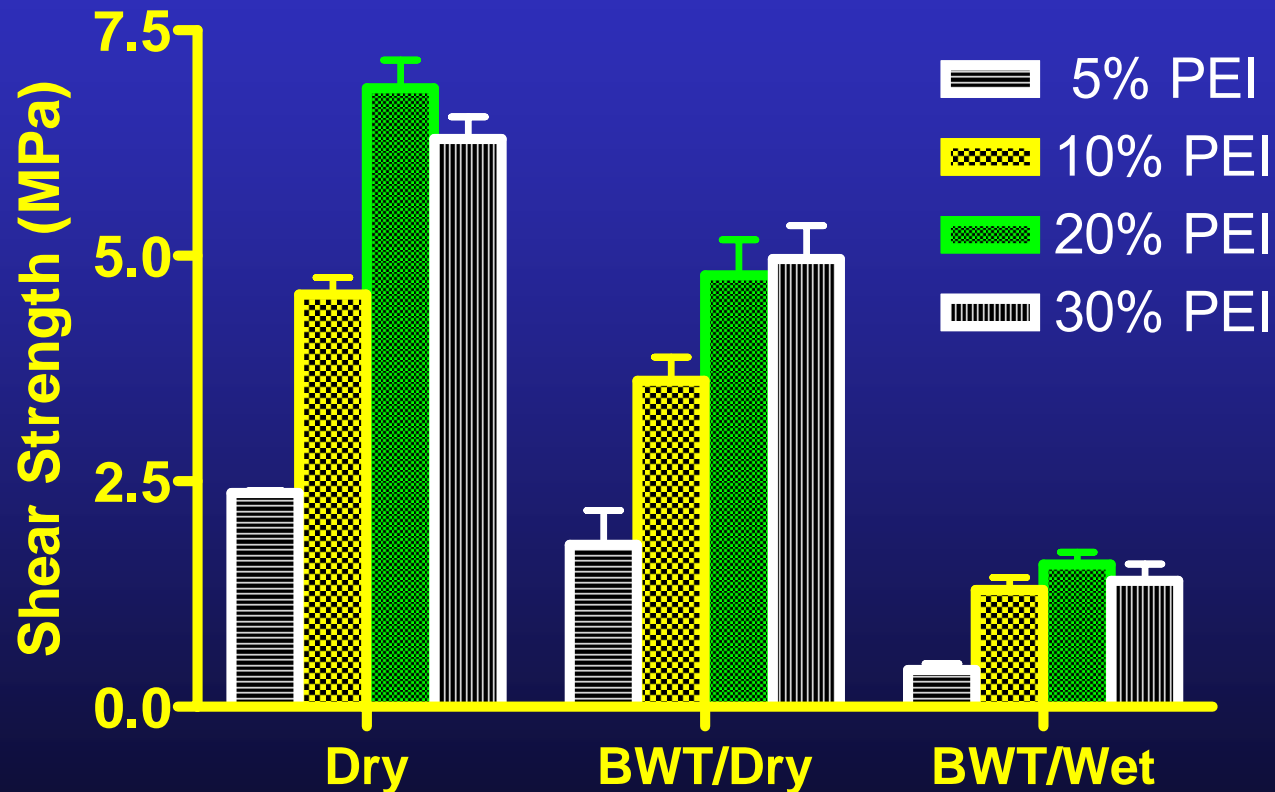
Adhesive: 20 wt% PEI ($M_w=750$ kDa) + 80 wt% MSPI-2
Hot press temperature=160 °C, hot press time=5 min

Effects of hot-press time on the dry shear strength



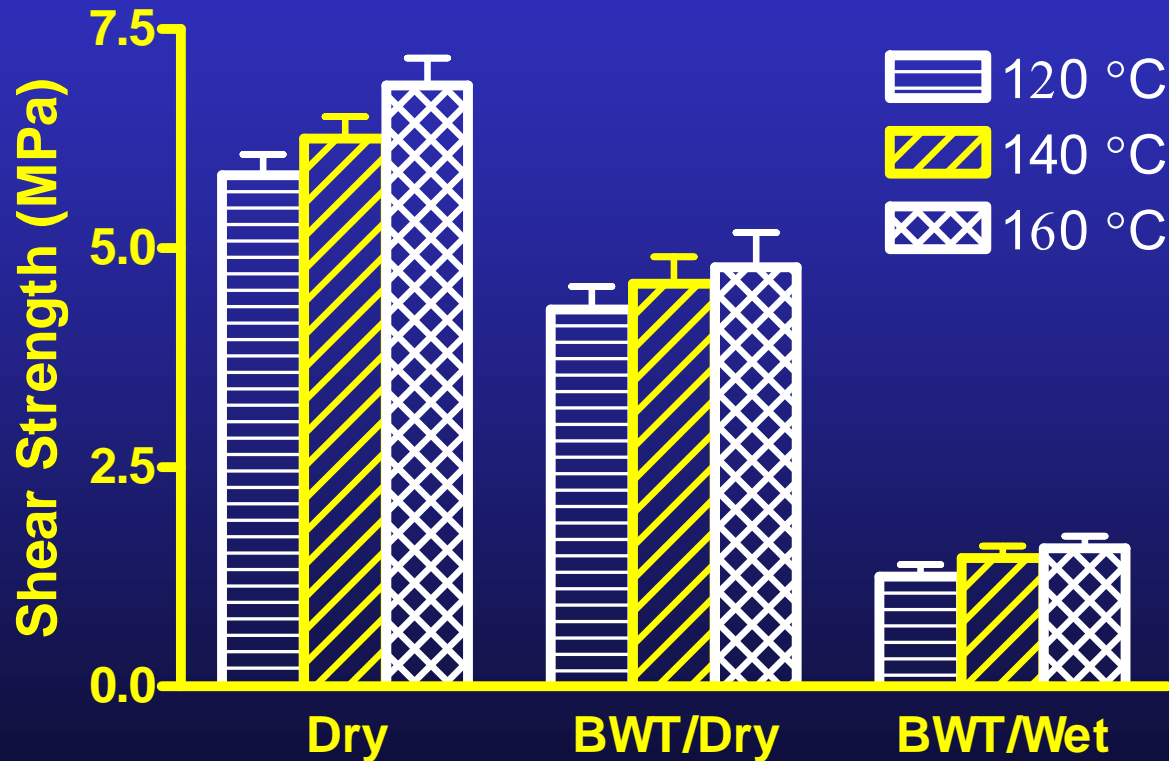
Adhesive: 20 wt% PEI ($M_w=750$ kDa) + 80 wt% MSPI-2
Hot press temperature=160 °C

Effects of the PEI content in Adhesives on shear strengths



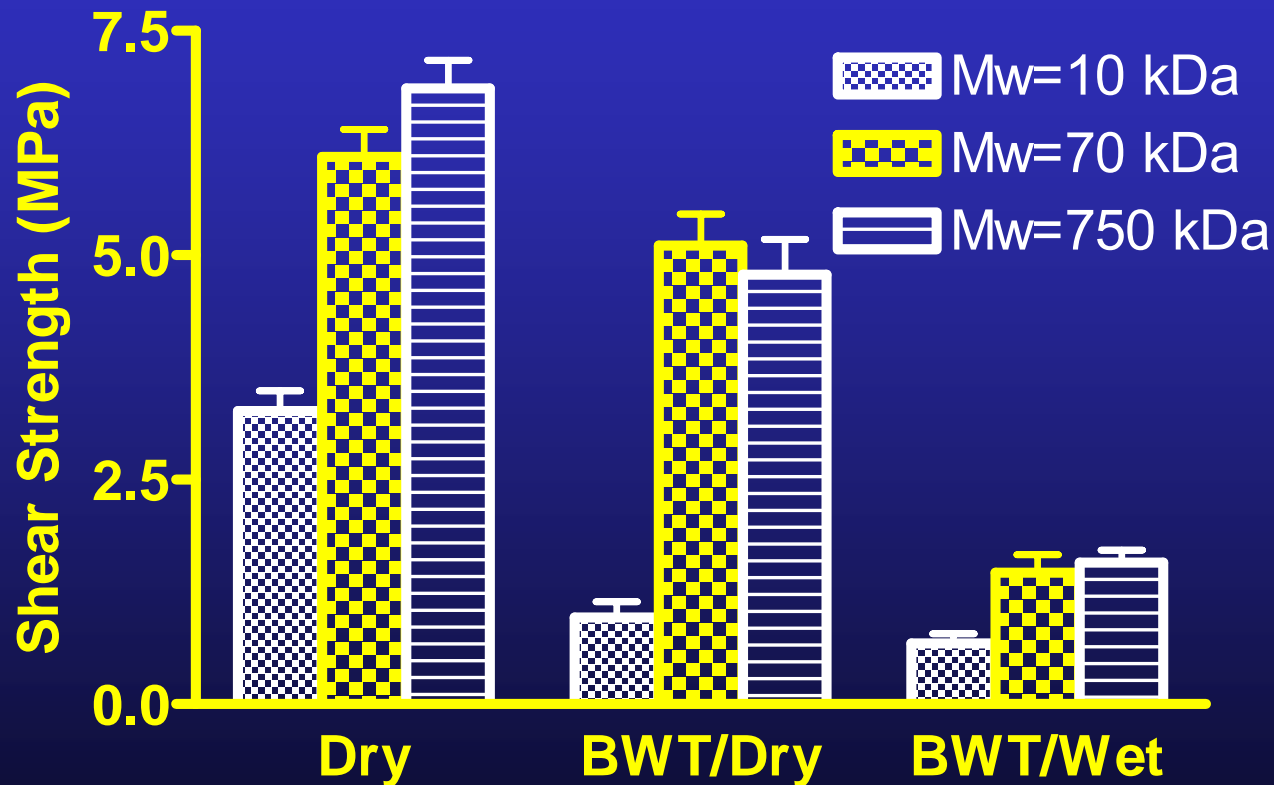
Adhesives: PEI (Mw=750 kDa) + MSPI-2; hot-press temperature=160 °C; hot press time=5 min

Effects of hot-press temperature on shear strengths



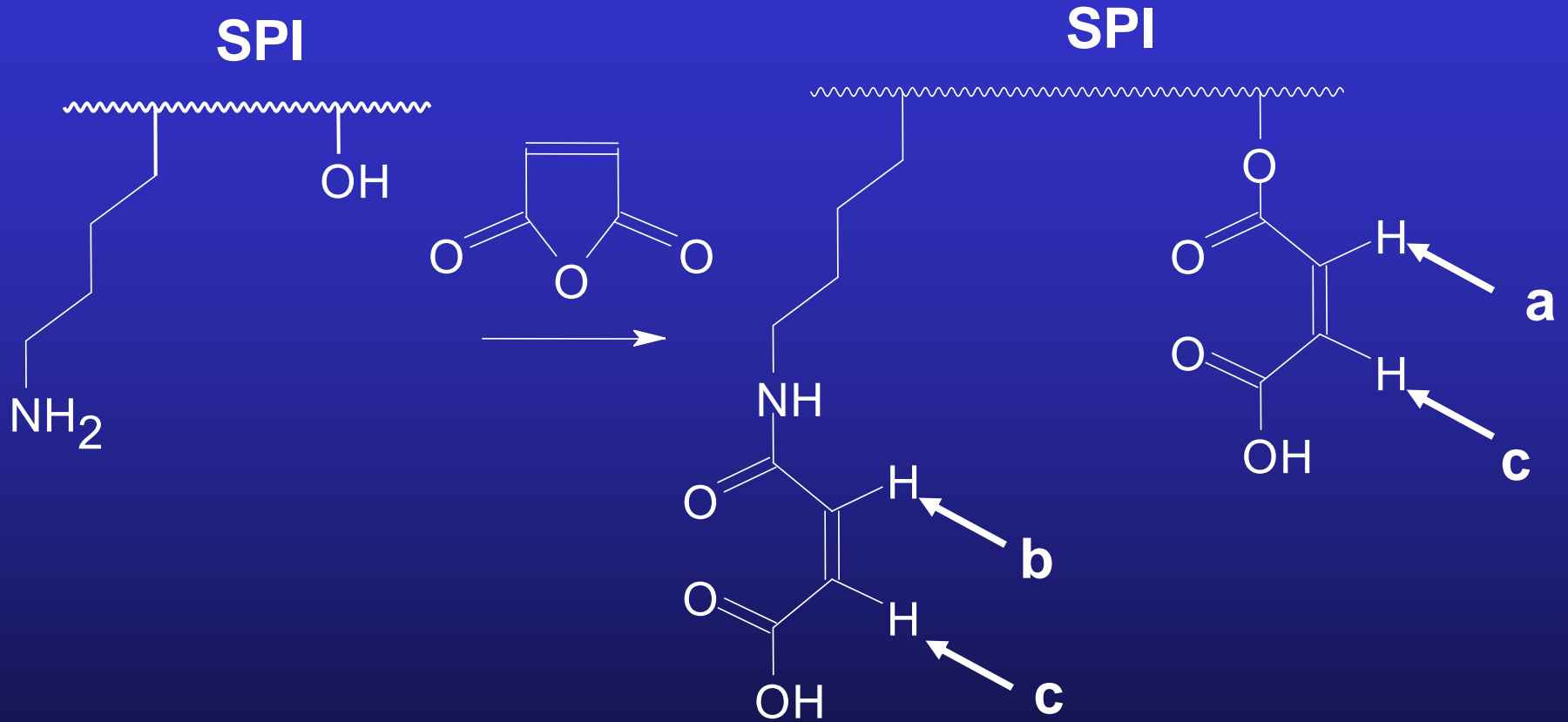
Adhesive: 20 wt%PEI ($M_w=750$ kDa) + 80 wt% MSPI-2
Hot press time=5 min

Effects of the Mw of PEIs on shear strengths

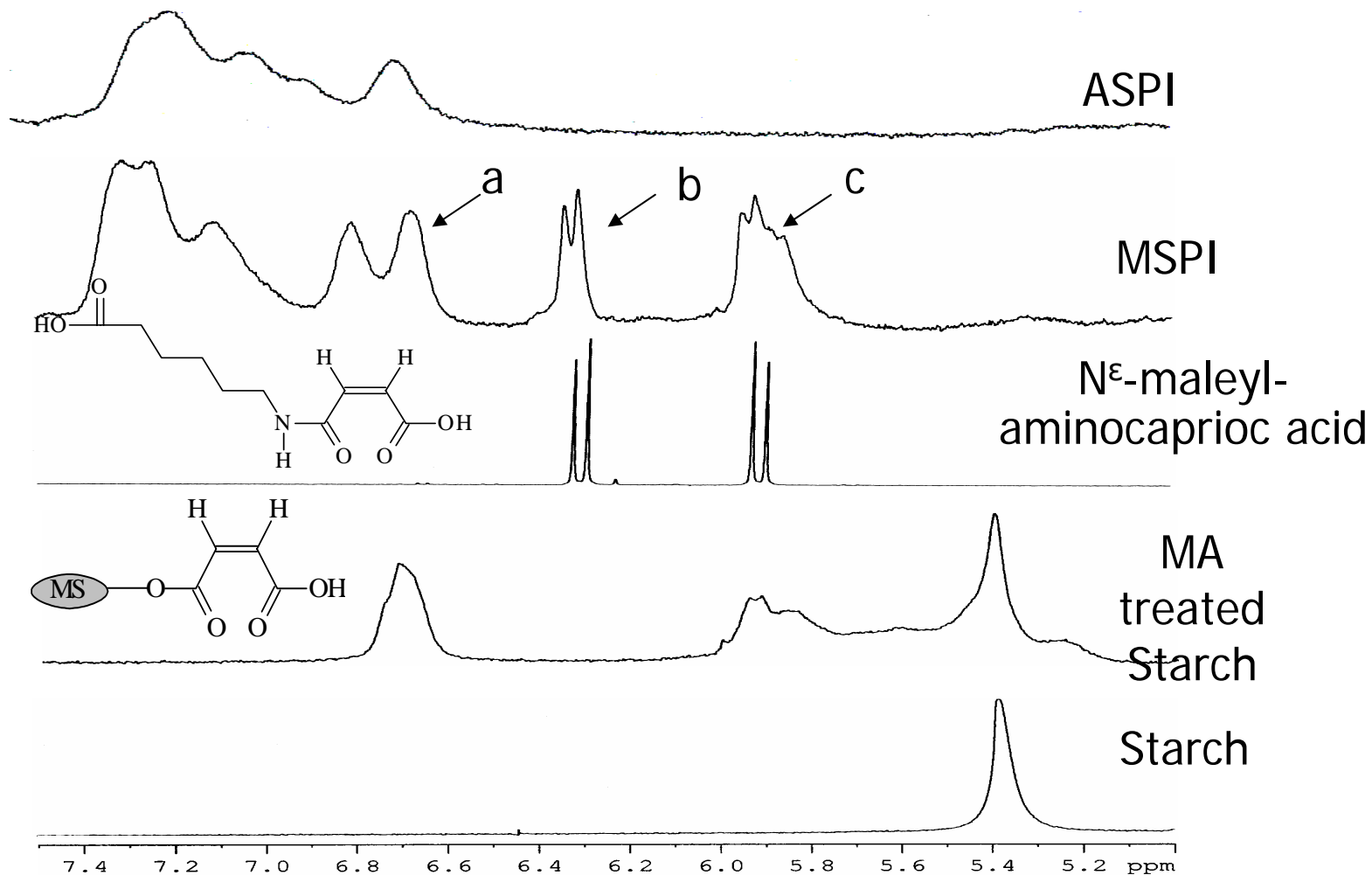


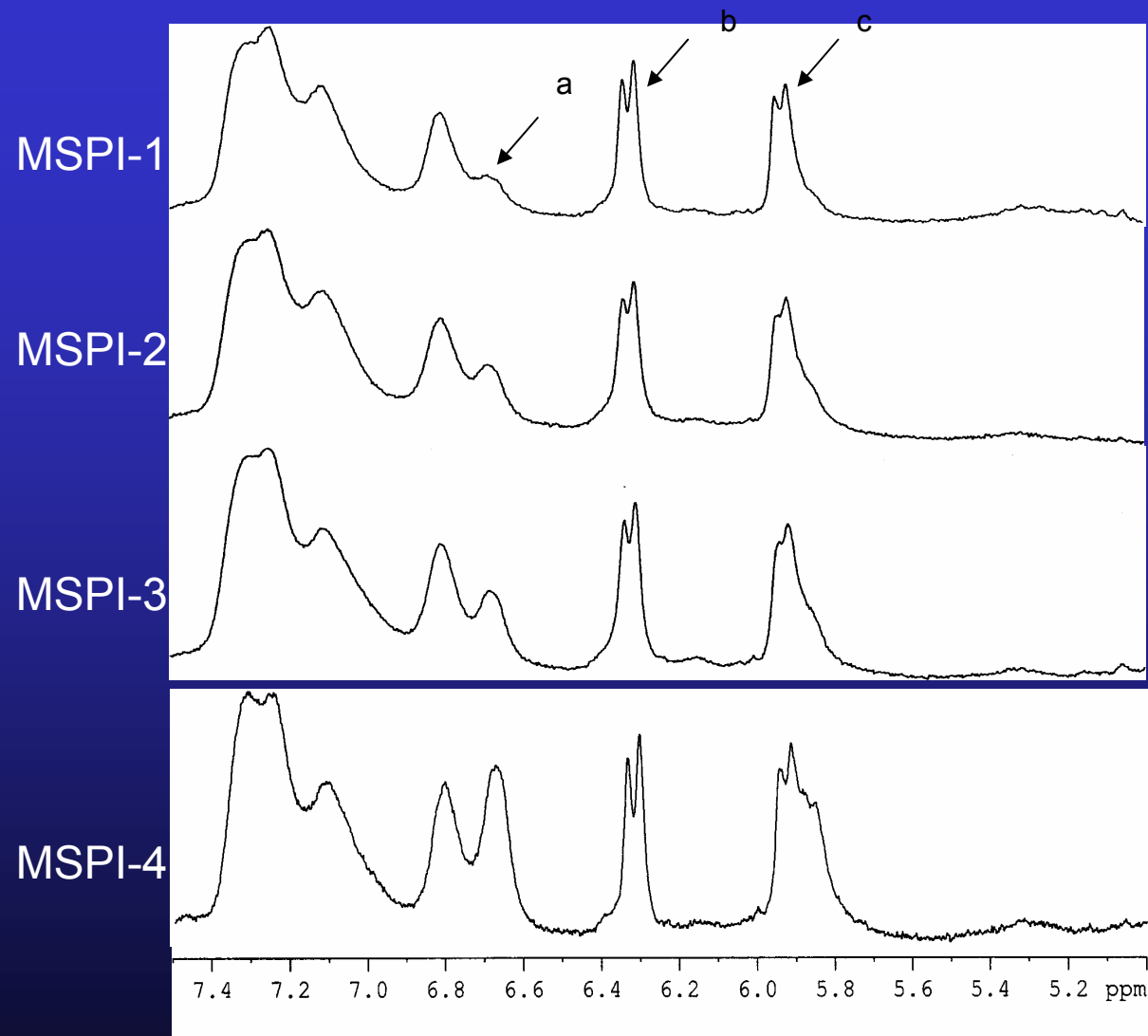
Adhesives: 20 wt% PEI and 80 wt% MSPI-2;
Hot press temperature=160 °C; Hot press time=5 min

Characterization of MSPI



NMR spectra of MSPI

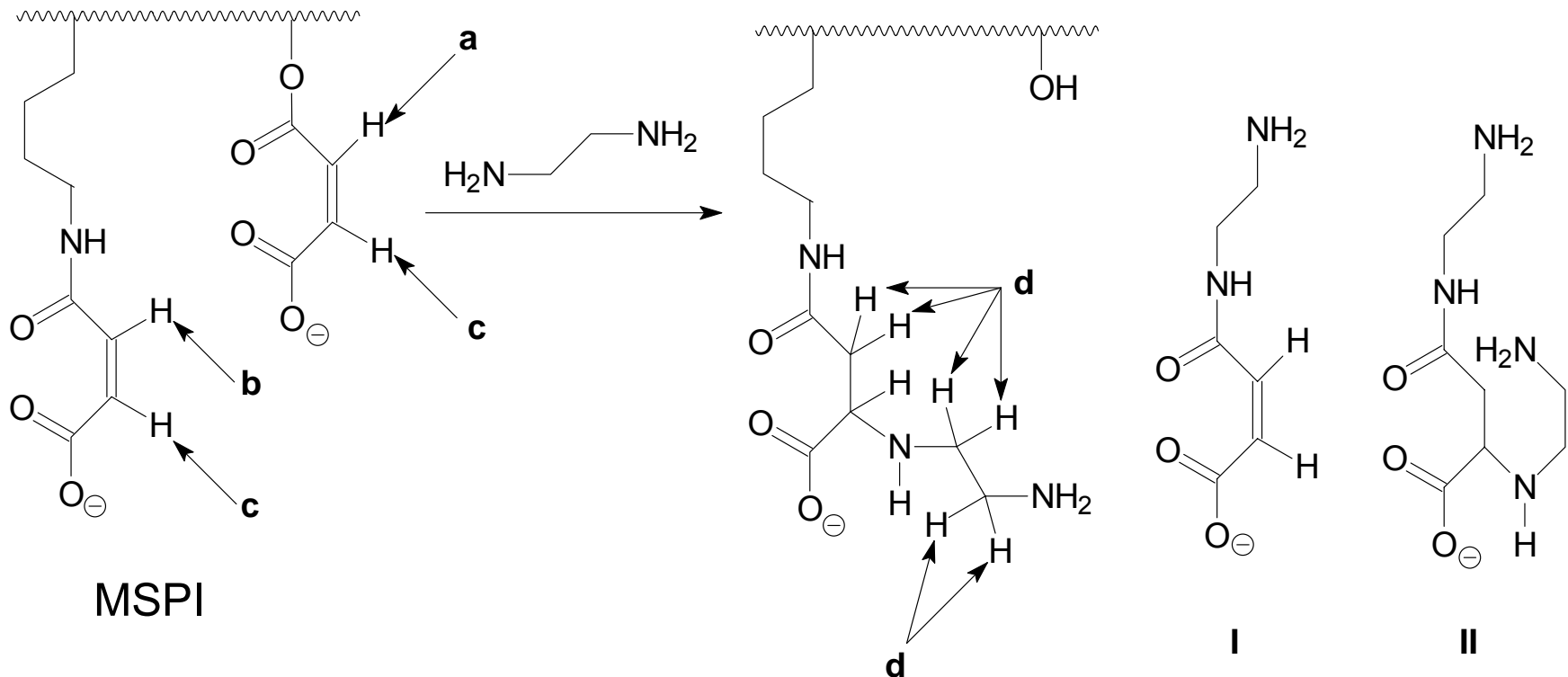




	MA dosage in maleylation MA:SPI (wt:wt)
MSPI-1	0.5:10
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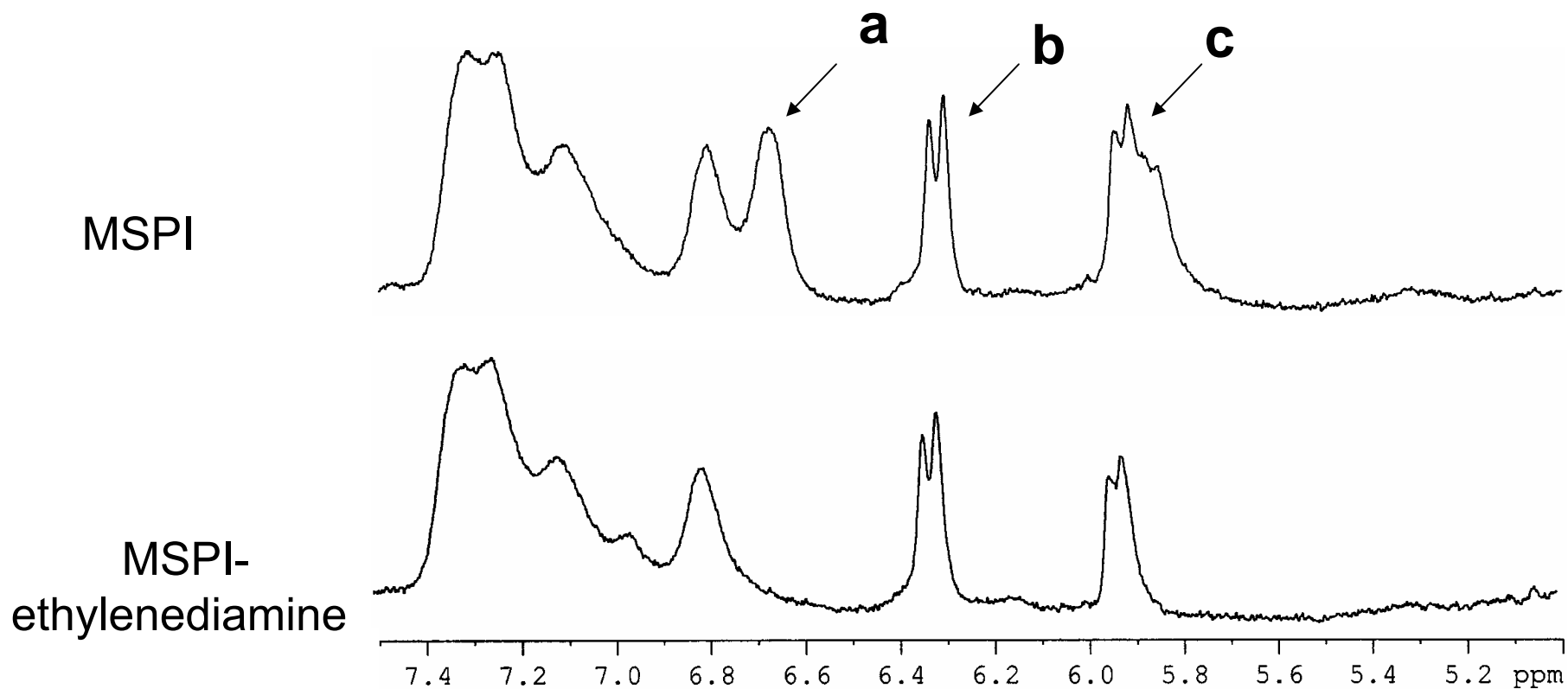
- The ester content increased with increasing the MA/SPI ratio.

Proposed reactions in the curing of MSPI-PEI adhesives



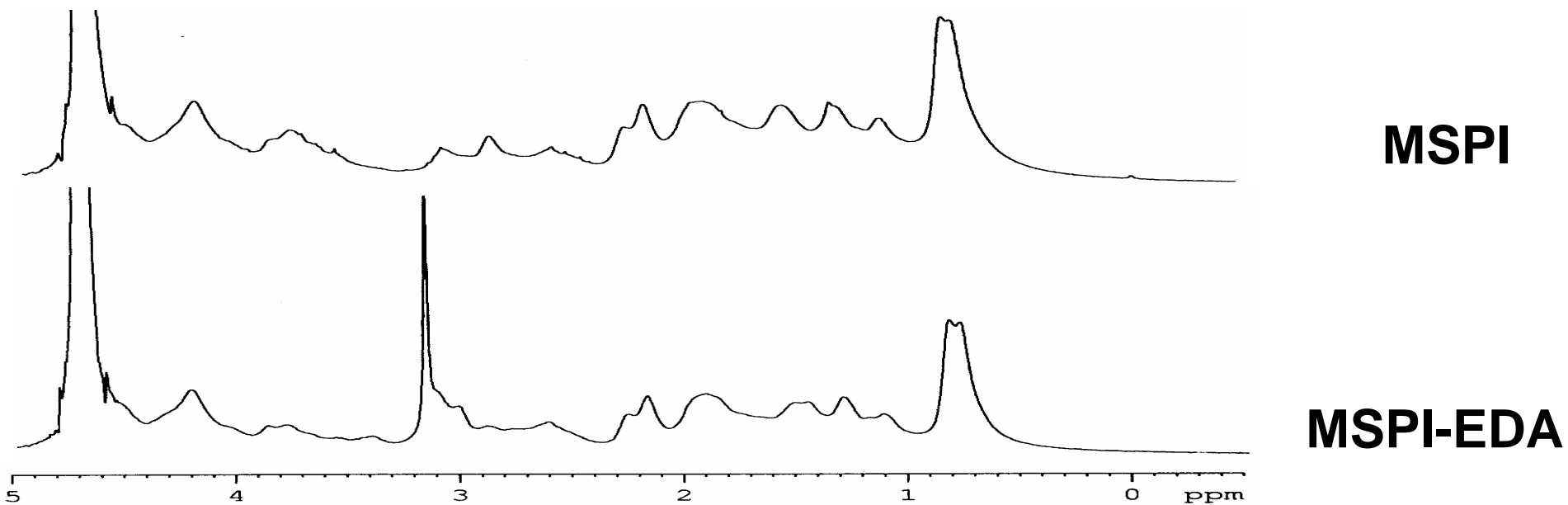
- The Michael addition reaction

- The reaction between an amino group and the maleyl ester



The peak **a** disappeared, indicating that the maleyl ester linkage disappeared

A new peak appeared, indicating the Michael addition reaction occurred



Conclusions

- **A new formaldehyde-free wood adhesive was successfully developed through the modification of SPI with maleic anhydride followed by mixing with PEI.**
- **Wood composites bonded with MSPI-PEI adhesives were very strong and very water-resistant.**

Conclusions

- **Maleic anhydride was grafted onto SPI via either an amide or an ester bond.**
- **The reactions between amino groups of PEI and maleyl groups are responsible for the curing of MSPI-PEI adhesives**

ACKNOWLEDGEMENTS

- We appreciate the financial support from **NRICGP** of the **USDA**
- **Dr. Yuan Liu**