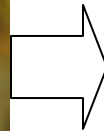




Durable Soy-Based Adhesive Dispersions

James M. Wescott, Amy E. Traska- Heartland Resource Technologies,
Waunakee, WI

Charles R. Frihart, Linda Lorenz- Forest Products Laboratory, Madison, WI





Outline

- HRT?????
- History of Soy Adhesives
- New Soy-Based Dispersions
- Strand-board Results
- Potential Cost Savings
- Conclusions
- Acknowledgements





HRT History

- Frank S. Trocino vision
 - Start-up in 2000
 - Privately funded
 - Bio-based technology
- FPL Relationship
 - Cooperartive Research and Development Agreement (CRADA)
 - 2002- Present





HRT Thrust Areas

- Liquid
 - Alkaline
 - Slightly acidic dispersion
 - Formaldehyde Free
 - PVA extenders
- Powder
 - Molded products
 - OSB (core?)





Soy History (Quickly!)





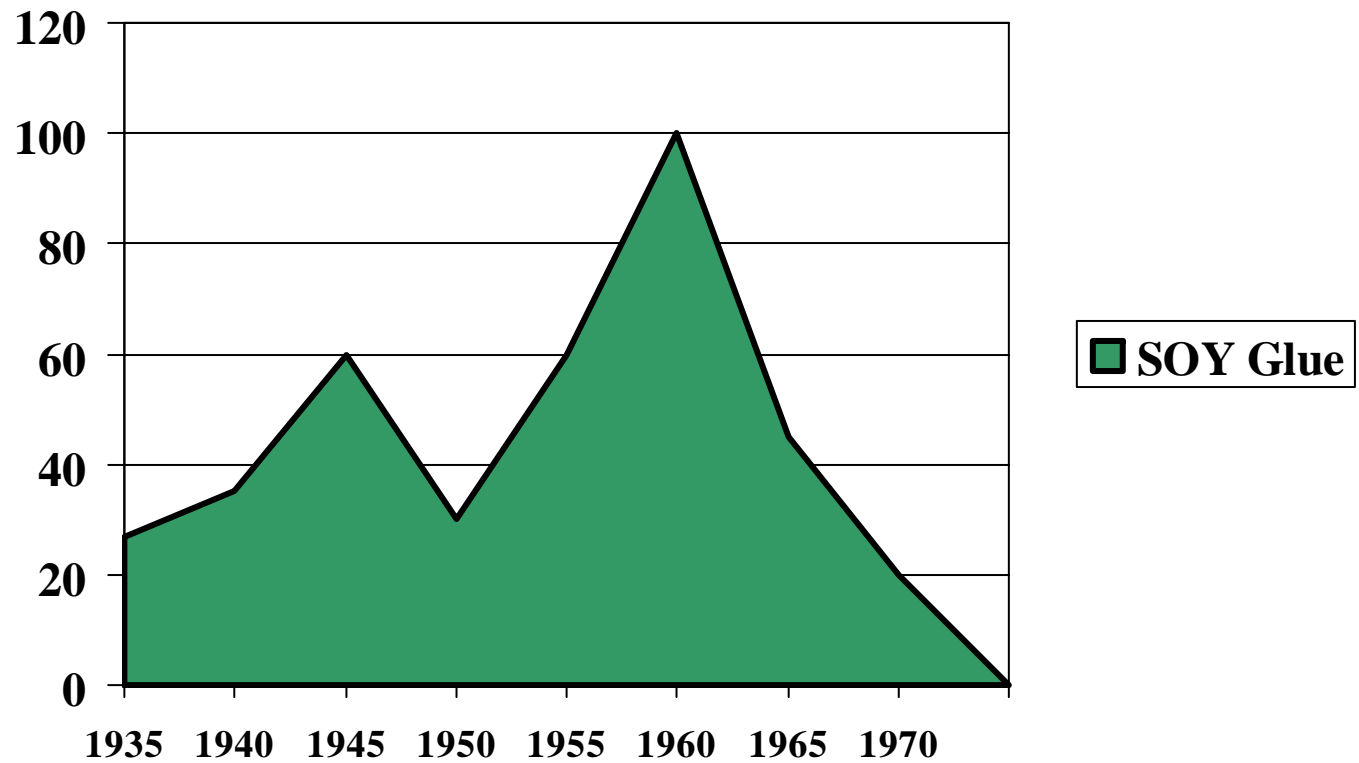
Soy Protein Adhesive History

- 1930-1960 protein glue technology at its peak
- Used for interior grade of softwood plywood
- PF and UF were developed in the 20's
- WWII forced rapid development of petroleum adhesives
- Within a decade of WWII, these glues became an affordable commodity
- Protein glues, however, held on to their interior use markets until the 60's when the petroleum glue prices became so low they displaced protein adhesives from their traditional interior market
- Recent activity is much increased in this arena





Soy Glue Usage (million lbs)





New Soy Based Dispersion Resins





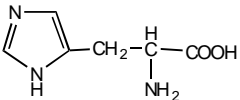
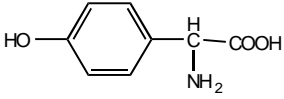
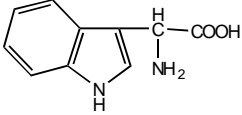
Soy Technology Advances

Past Soy Problem	Solution
1) Biologically unstable	By proper denaturing and copolymerizing with small amounts of reactant, the product is believed to be rendered biologically stable. We are continuing to work in this area.
2) Low Solids	By developing a new method for denaturing and copolymerizing with viable crosslinking agents, the soy resins are offered at solids ranging from 35-40%
3) Slow Press Times	By copolymerizing with reactive crosslinking agents, slow press times are not an issue as the cure rate can easily be tailored to meet a variety of applications
4) Poor Water Resistance (durability)	By copolymerizing with reactive crosslinking agents, the soy resin actually becomes a water resistant thermoset resin
5) Very short pot life	By innovative processing, the soy resin's shelf lives are an excess of 120 says





Functional Soy Protein Side Groups

Anino Acid	Structure	% in Soy Protein
Lysine	$\text{H}_2\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{C}-\underset{\text{NH}_2}{\overset{\text{H}}{\text{C}}}-\text{COOH}$	6.8
Histidine		3.4
Arginine	$\text{H}_2\text{N}-\overset{\text{NH}}{\parallel}{\text{C}}-\text{NHCH}_2\text{CH}_2\text{CH}_2-\underset{\text{NH}_2}{\overset{\text{H}}{\text{C}}}-\text{COOH}$	7.7
Tyrosine		4.2
Tryptophan		1.3
Serine	$\text{HOH}_2\text{C}-\underset{\text{NH}_2}{\overset{\text{H}}{\text{C}}}-\text{COOH}$	5.4
Cysteine	$\text{HSH}_2\text{C}-\underset{\text{NH}_2}{\overset{\text{H}}{\text{C}}}-\text{COOH}$	2.5
Total		31.3





Soy Resin Preparation

- Denaturation of soy flour
 - Expose groups for reaction and adhesion
 - Introduce viscosity/performance stability
- Modification and stabilization with CH_2O
- Copolymerization with PF
- Inversion with acid addition
 - Soy flour is used
 - No pressure or vacuum steps required
 - 4-5 hour cycle times





Advantages of Dispersion Technology

- Excellent stability
- Ease of manufacture
- Lower viscosity
- Multiple copolymerization options
 - PF
 - UF
 - p-MDI
- Very high soy loads (>3/1 soy/phenol)
- Durable panels





Soy Resin Properties

Resin	Soy (wt %)	PF (wt %)	pMDI (wt %)	pH	Solids (wt %) ¹	Viscosity (Cp) ²	Insoluble (%) ³
Control PF	0	100	0	11.0	53.8	184	71
Soy-50	50	50	0	4.3	38.1	300/364	77
Soy-66	66	34	0	4.3	36.0	606/764	69
Soy-66A	66	34	0	10.4	35.2	1030/1284	72
Soy-66-Iso	59	31	10	4.2	38.0	982/1236	73
Soy-100	100	0	0	12.5	32.4	1396/2000	10

¹ Solids are from 150 C /1hr oven pan method

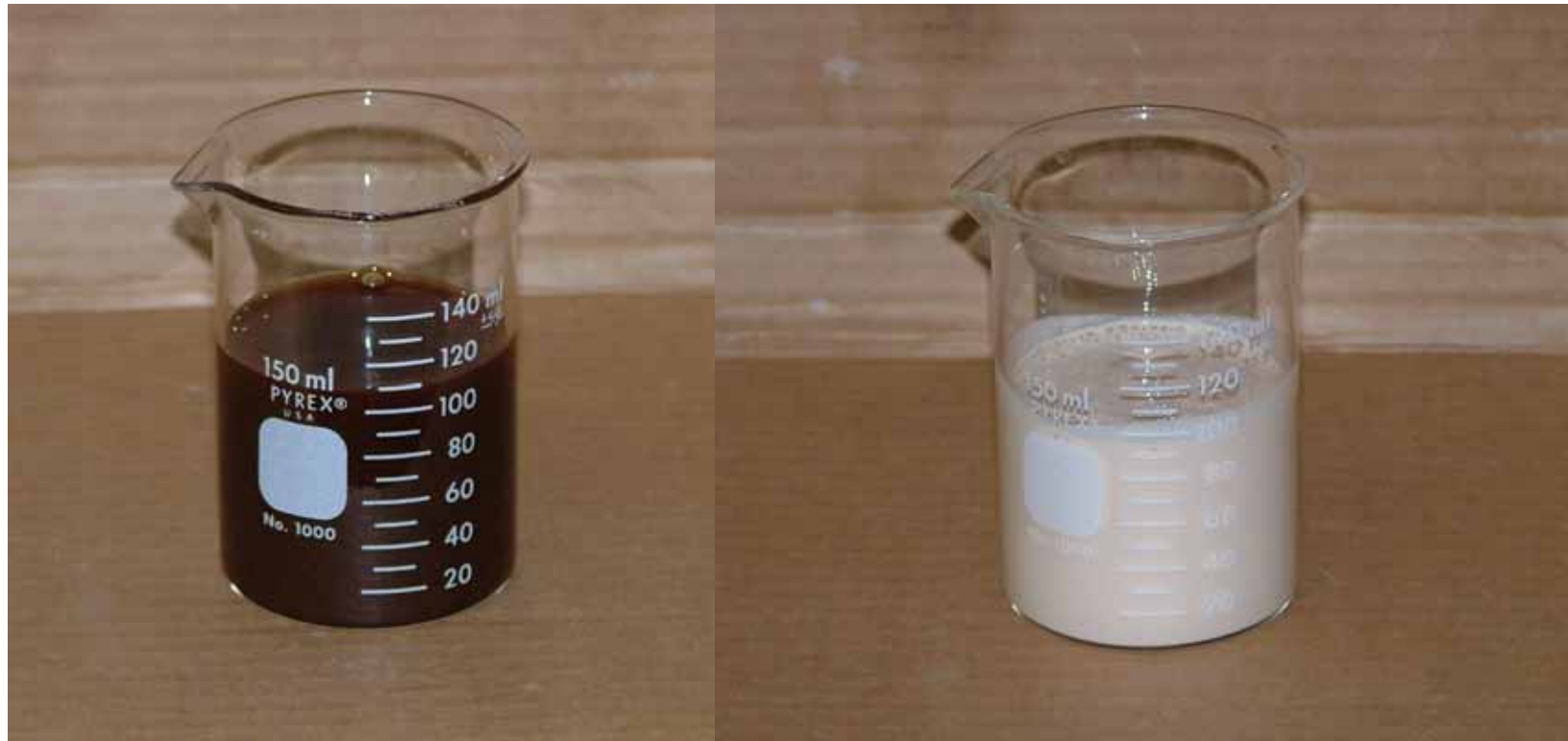
² Viscosity was measured using a Brookfield LVT viscometer at 60/30 RPM

³ Water insoluble material after 24 hour water Soxhlet extraction of oven solids prepared samples





Soy Alkaline vs Soy Acid Dispersion



Soy 66A (Alkaline)

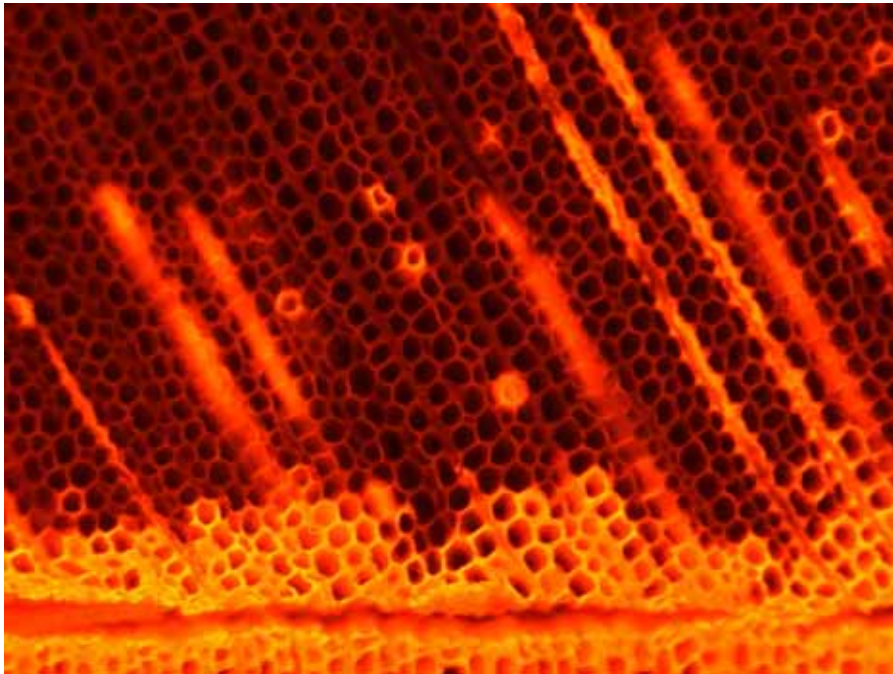
Soy 66 (Acidic dispersion)



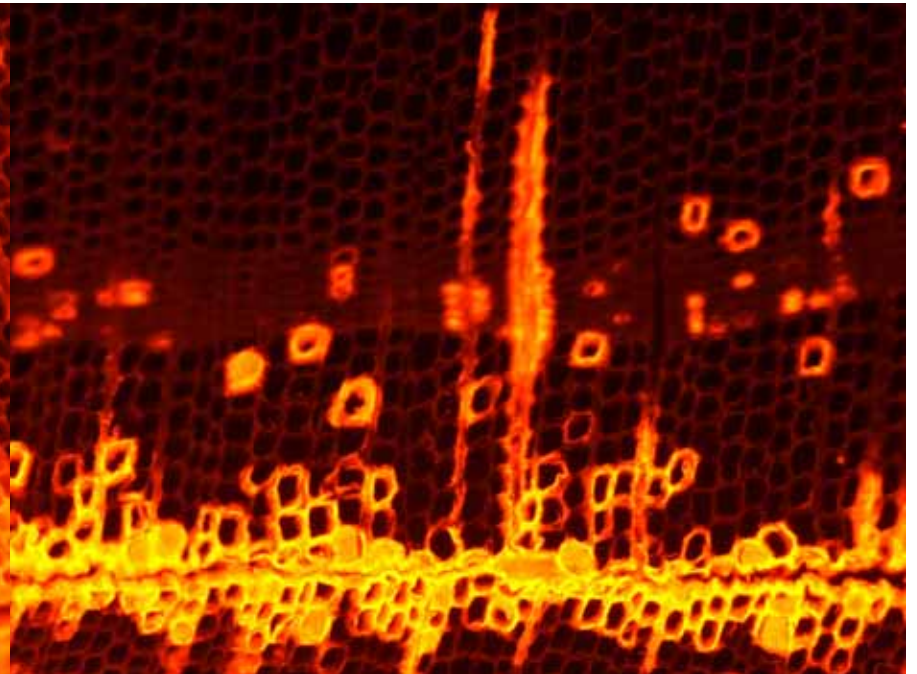


Soy Alkaline vs Soy Acid Dispersion

(SYP, Rhodamine B added to adhesive)



Soy 66A (Alkaline)



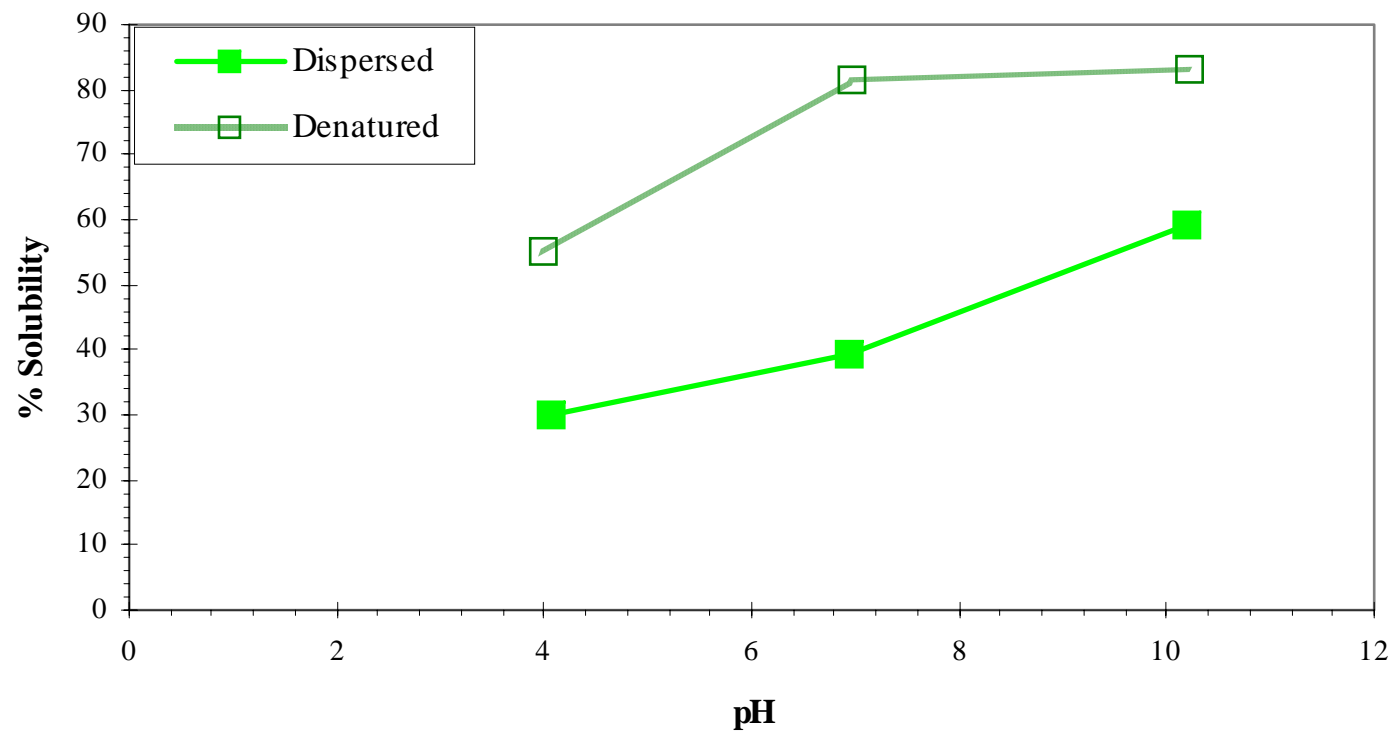
Soy 66 (Acidic dispersion)





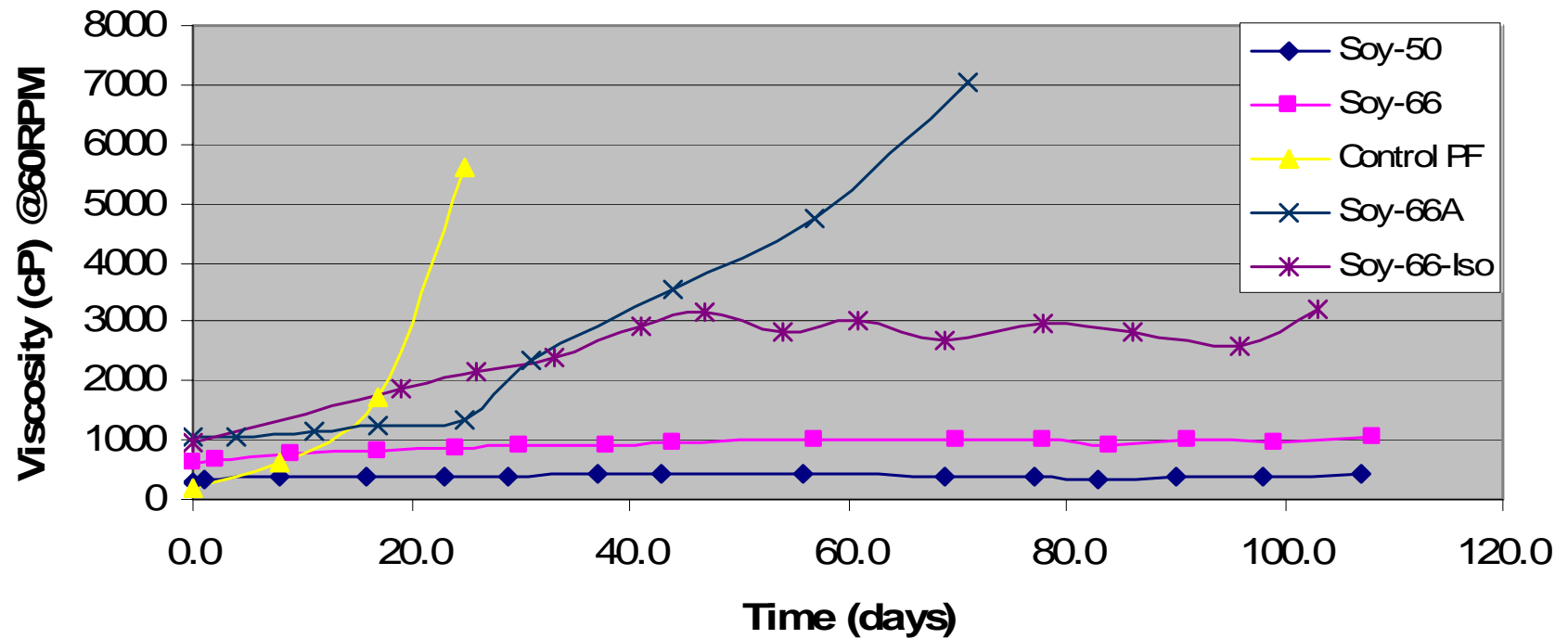
Soy Dispersion?

Percent Solubility of Dispersed and Denatured Soy Flour





Stability of Soyad Resins





Random Strand- board Results





Application in Strandboards

Formed Mat Size (In X In)	22 X 22
Trimmed Board Size (In X In)	20 X 20
Resin Application	Air Atomization
Furnish Moisture (%)	4.5
Furnish Type	Mixed hard/soft
Face/Core Ratio (Wt/Wt)	55/45
Final Thickness (Inches)	7/16
Final Target Density (PCF)	42.0
Face Resin (%)	3.26
Core Resin (%)	3.89 (always PF Control)
Face Wax Emulsion (%)	1.31
Core Wax Emulsion (%)	1.39
Press Size (In X In)	36 X 36
Press Temp (C)	200
Press Soak Times (Sec)	210 and 310
Press Close Time (Sec)	40-50





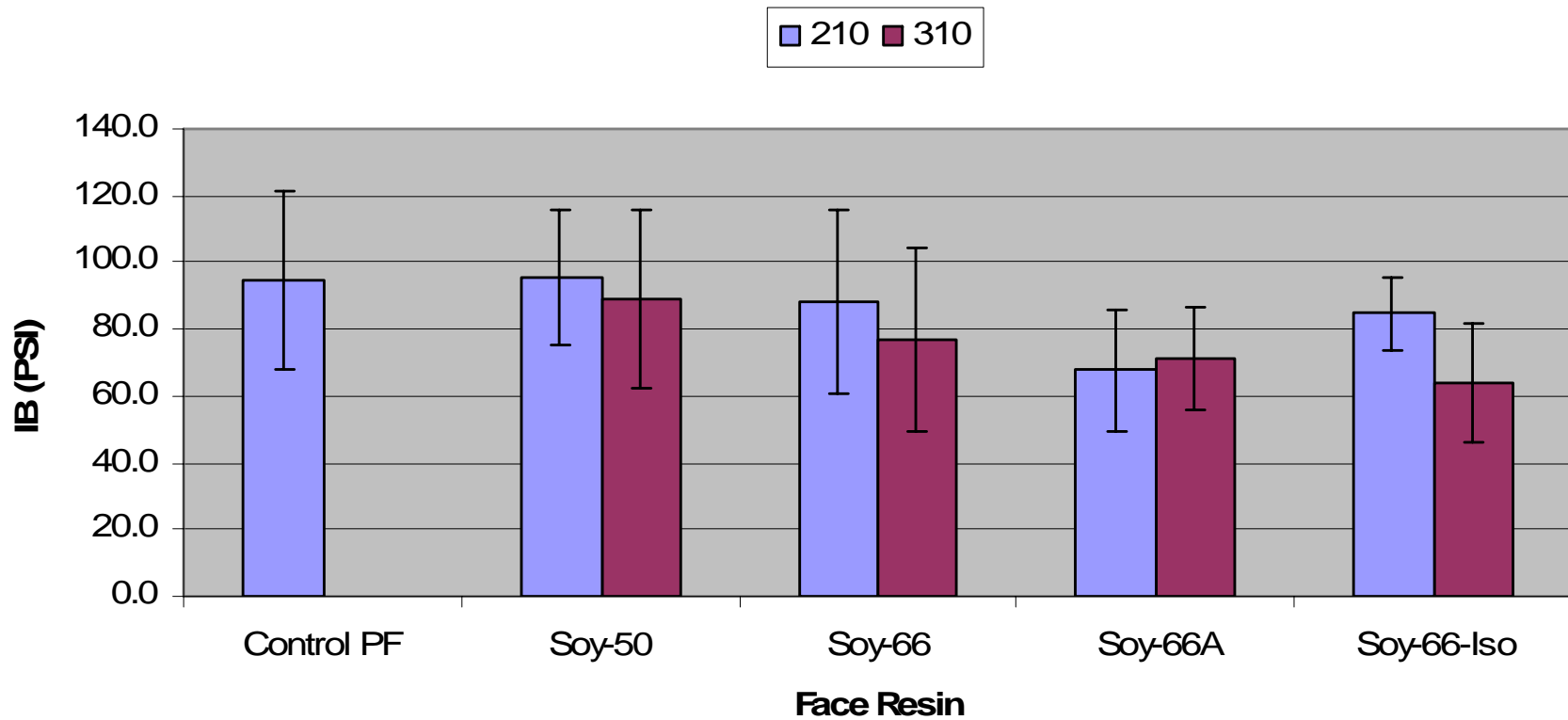
FPL 3' X 3' Press





Dry Internal Bond (PSI)

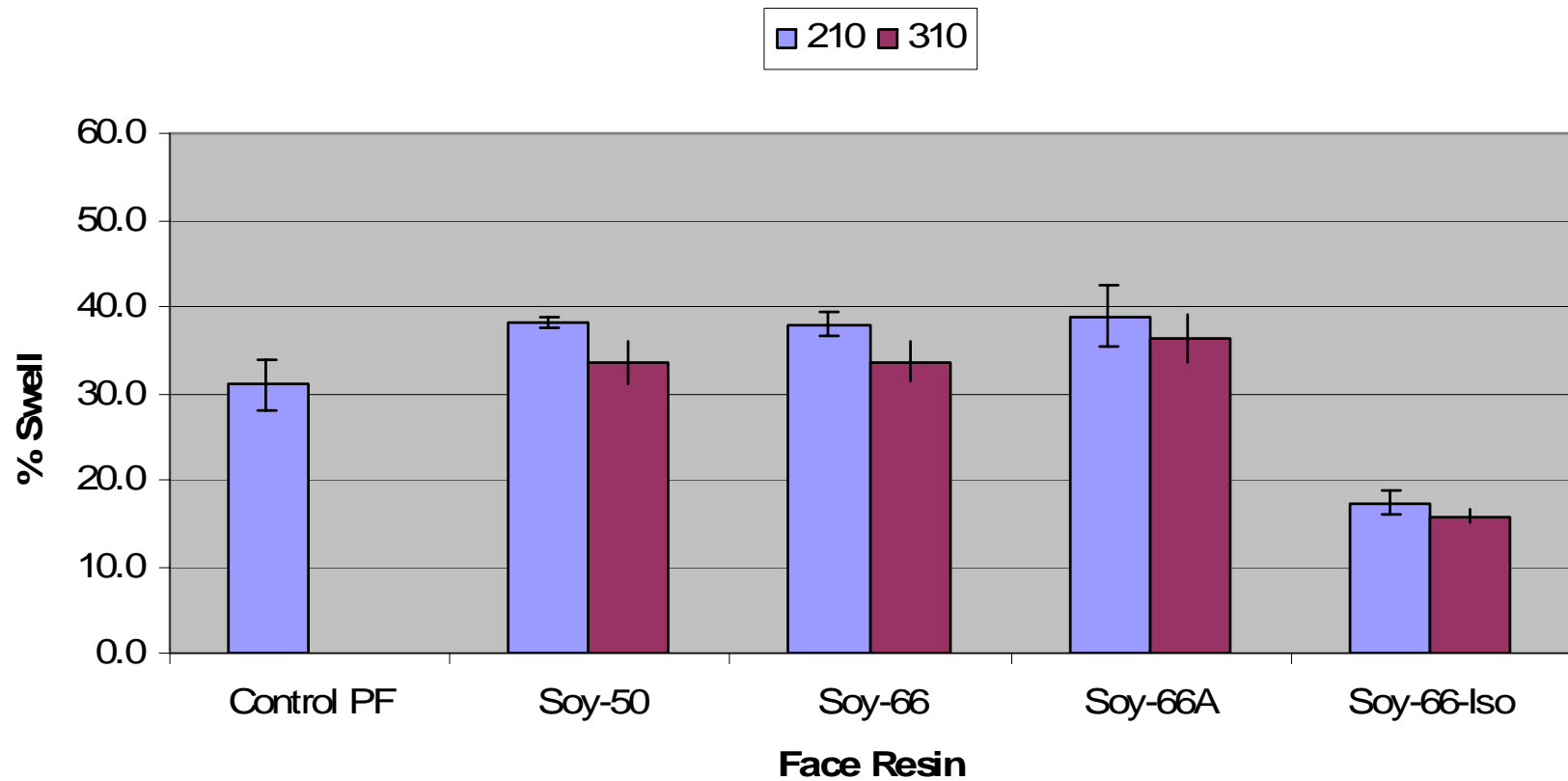
(Ref: ASTM D-1037-99)





24 Hour RT Soak

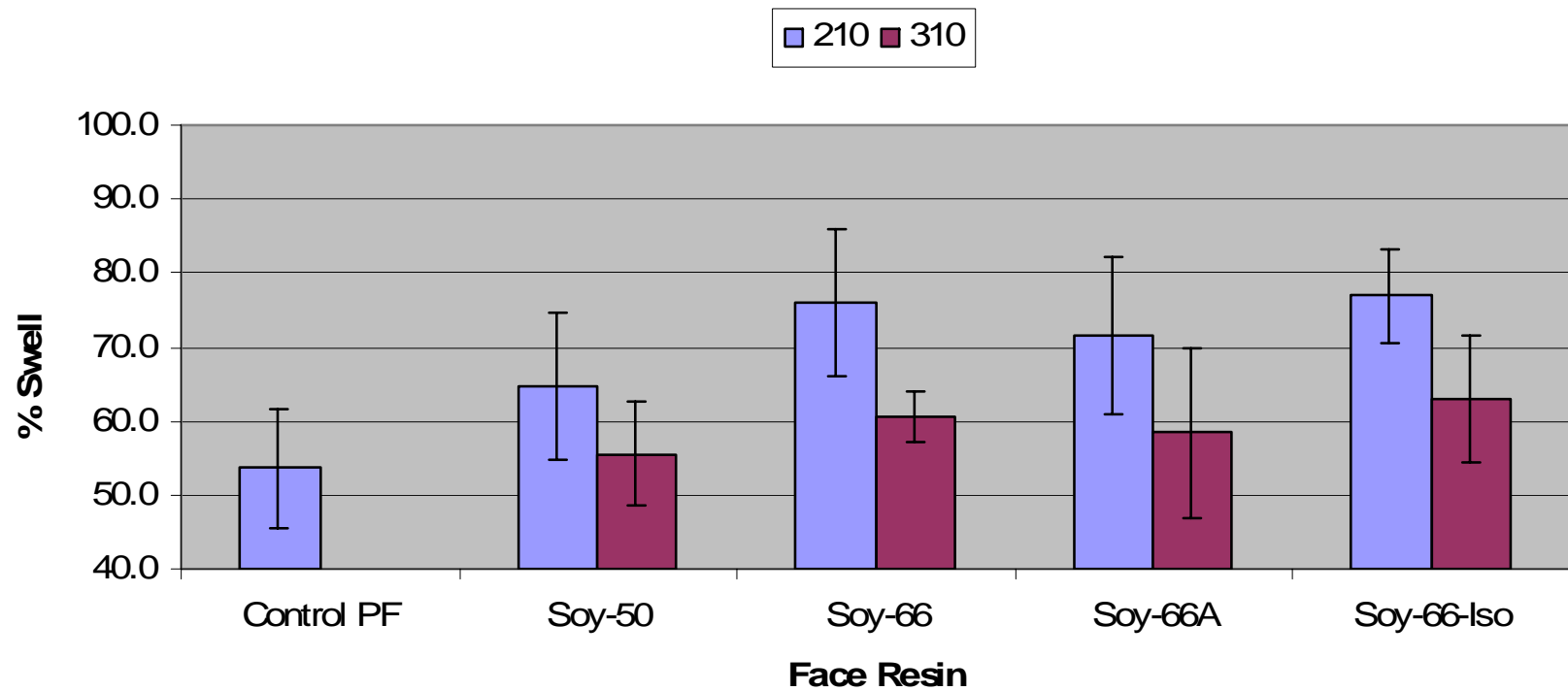
(Ref: ASTM D-1037-99)





2 Hr Boil Swells

(Ref: ASTM D-1037-99 for preparation and measurements)





Potential Cost Savings





Potential RMC Savings

	Resin RMC Cost (Solids Basis)			% Cost Reduction (vs 2)		
	Phenol Cost/lb			Phenol Cost/lb		
	0.50	0.60	0.70	0.50	0.60	0.70
Commercial PF (w/0% urea)	0.429	0.494	0.559			
Commercial PF (w/20% urea)	0.373	0.425	0.477			
Soy 50	0.282	0.309	0.336	24.3	27.3	29.6
Soy 66	0.245	0.262	0.280	34.4	38.3	41.3
Soy 66iso	0.300	0.316	0.332	19.6	25.7	30.4





Conclusions





Conclusions

- Soy based resin dispersions with up to a 3.4/1 ratio of soy/phenol have been prepared using a manufacturing friendly process.
- Soy-PF dispersion resins are lower in viscosity with better stability than alkaline Soy-PF resins
- These resins, when used for the face section of strand boards, offer comparable performance to a commercial face PF resin. (with lighter color)
- A potential raw material cost saving of up to 20-40% exists.





Acknowledgements

- David Marr- FPL
- Mike Birkeland- HRT

