

# ASHLAND®

## *Formaldehyde Emissions from Composite Wood Products*

Presented to the U.S. OMB on 7/09/12  
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### *Outline*

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- Formaldehyde
  - Sources of formaldehyde in a composite wood product
  
- Composite Panel Emissions
  - Experimental Plan
    - Hardwood Plywood-Completed 6/2010
    - Particleboard-Completed 4/2012
  
- Review of Commercially Available Adhesives

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### *Sources of Free Formaldehyde In Composite Wood Products*

- 1) Native - free formaldehyde does exist in ALL wood in very small amounts
- Processing (i.e. drying of wood, and pressing of panels) can result in more to be produced
  - Supplied by nature

Formaldehyde Produced: PRE panel making

Large Chamber Contribution: Low

Total Product Life Emission Potential: Low

4

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### *Sources of Free Formaldehyde - continued*

- 2) Process & Adhesive - Many adhesives contain bound formaldehyde, and when these molecules react they often PRODUCE ADDITIONAL free formaldehyde.
- Catalyst and other processing parameters will impact formaldehyde levels
  - Emission levels directly related to the amount of formaldehyde formulated in the adhesive

Formaldehyde Produced: DURING panel making

Large Chamber Contribution: High

Total Product Life Emission Potential: Low-Med

5

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### Sources of Free Formaldehyde - continued

3) *Hydrolysis (in use generated)* - Some formaldehyde-based bonds are prone to reversing back to free formaldehyde when exposed to water

- Largest long term contributor to emissions
- Level is VERY dependent on conditions (relative humidity and temperature)
- Not all formaldehyde bonds hydrolyze
- Urea-formaldehyde (UF) is MOST easily hydrolyzed

Formaldehyde Produced: POST panel making

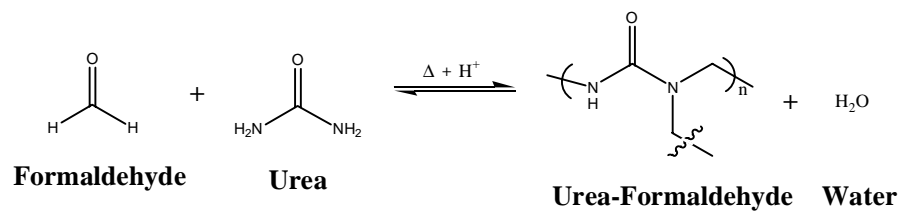
Large Chamber Contribution: Very Low

Total Product Life Emission Potential: High

6

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### "Produced" Formaldehyde



- Urea-formaldehyde (UF) is low-cost and reacts rapidly to form a strong bond
- Reaction is reversible and provides potential for long-term formaldehyde release

7

## *Adhesive Classifications*

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NAF - (Prescription Based): "No added formaldehyde" as part of the resin cross linking structure for making hardwood plywood, particleboard, or medium density fiberboard. "No-added formaldehyde based resins" include, but are not limited to, resins made from soy, polyvinyl acetate, or methylene diisocyanate. (CARB Definition)

NAUF - (Prescription Based): No Added Urea Formaldehyde (USGBC, LEED)- Any adhesive with or without formaldehyde that DOES NOT contain any urea-formaldehyde

ULEF - (Emission Based): "Ultra-low-emitting formaldehyde (ULEF) resins" means resins formulated such that average formaldehyde emissions are consistently below the Phase 2 emission standards in section 93120.2, as provided in section 93120.3(d). (CARB Definition)

8

## *What does this mean??*

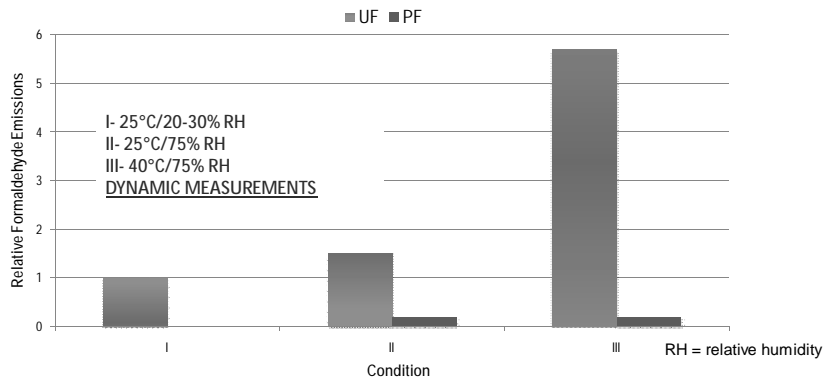
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- Hydrolysis is often the largest contributor to formaldehyde emissions over the life of the product
- Current testing does NOT capture the propensity for a panel to generate this source of formaldehyde
- UF-based (MUF too) adhesives SHOULD be the primary concern for potential long-term formaldehyde emissions
- Other formaldehyde adhesives (NAUF) should still be monitored closely for emissions

9

## Past Work on UF Hydrolysis

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Reference: Myers, G. *Wood Science* 1981, Jan Vol 13, No 3, pp 140-150

Elevated temperature and humidity results in a significant increase in formaldehyde emissions from UF hydrolysis

10

## Experimental Approach

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- Ashland collaborated with Dr. Charles Frihart of the U.S.D.A Forest Products Laboratory (FPL) in Madison, WI

### Objective:

- Expand the previous work by George Myers to assess the new generation of UF-based resins (CARB Phase 2 capable)
- Initially evaluated hardwood plywood, and recently evaluated particleboard

11

## Experimental Plan

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- Particleboard (PB) made with NAF and UF-based Adhesives
  - ¾" PB Specimens
  - CARB Phase 2 commercially produced panels made with UF/MUF adhesives
  - NAF panels laboratory produced (36" X 36")
  - BOTH produced with the same sourced commercial wood!
  - BOTH made with comparable adhesive levels and process parameters to achieve comparable strength
- Desiccator method in sealed bottles
  - Modified EN 717-3
- Varying levels of humidity and temperature
- Aged Evaluation
  - Panels were conditioned for up to 14 weeks at 77 °F/50% relative humidity (RH) and then tested using a one day run at 77 °F/50%RH and 95 °F/100% RH

12

## Testing Method

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- Static (constant air)
  - Desiccator (JIS A1460, ASTM D-5582)
  - Flask (EN-717-3)

	EN-717-3	Our Method
Temperature	40 C	25 C and 35 C
Test Duration	3 hr	1-4 days
% Relative Humidity	100%	30, 75, 100%

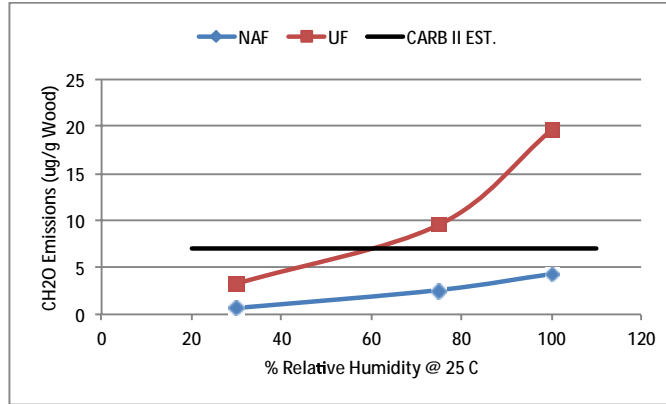
30% - Sat  $MgCl_2$   
 75% - Sat  $NaCl$   
 100% - No salt



13

## Results - Formaldehyde at 25 °C, (4-Day Tests)

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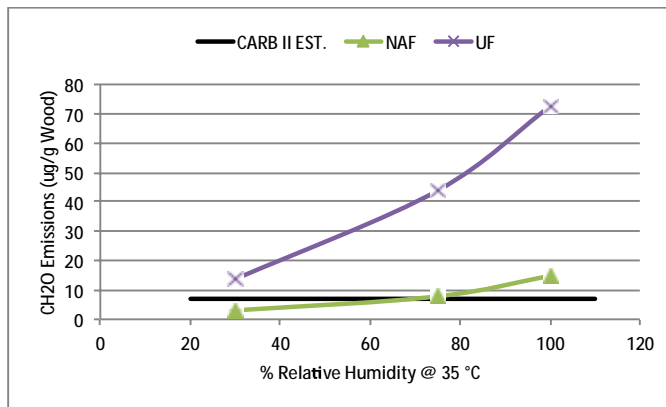
\*CARB Level is an estimation only

UF: Levels over CARB 2 at >60% RH, 3X at 100%  
 NAF: Levels ALWAYS under CARB 2  
 NAF shows presence of "Native formaldehyde"

14

## Results - Formaldehyde at 35 °C (4-Day Tests)

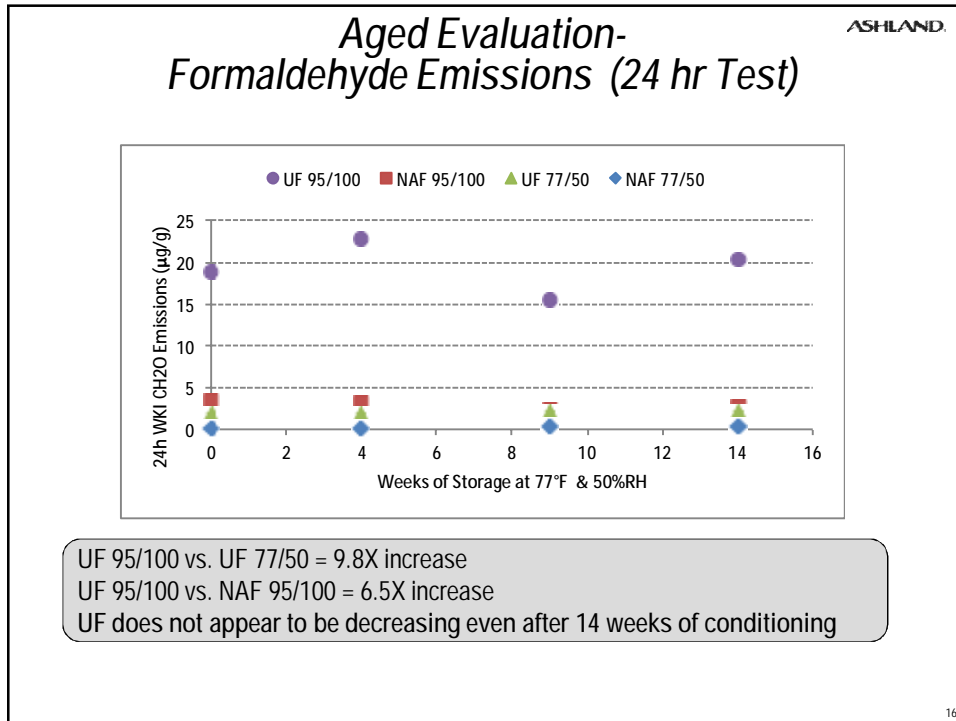
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CARB Level is an estimation only

UF: Levels over CARB 2 at ALL % RH, 10X at 100%  
 NAF: Levels under CARB 2 for <75%, 2X at 100%  
 NAF shows "native formaldehyde" impact

15



### Adhesive-Product Attributes<sup>1</sup>

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Class	Type	Emissions	EH&S	PB/MDF			Plywood (Interior)		
				Cost-in-Use	Ease of Use	Panel Properties	Cost-in-Use	Ease of Use	Panel Properties
None	UF/MUF	●	●	●	○	●	●	●	●
NAUF	PF	○	●	○	●	○	●	●	●
	MF	●	●	●	●	○	n/a	n/a	n/a
NAF	pMDI	●	●	○	●	○	n/a	n/a	n/a
	PVAc*	○	○	n/a	n/a	n/a	●	●	○
	Soy	●	●	○	○	○	○	●	●

No Known Concerns  
  Some Minor Concerns  
  Some Major Concerns  
  Significant Concerns

**Wide range of adhesive types are commercially available**

(1) Information presented is based on a combination of experimental data, literature discussions and consumer/producer interviews. Assessment can vary greatly depending on specific formulation. Chart is intended to serve as a general guideline.

17



## Summary

- The use of UF-based resins in composite panels WILL result in significantly higher formaldehyde emissions when exposed to elevated temperature and/or humidity levels. The higher the temperature and the higher the humidity the higher the emissions will be.
- UF-based resins appear to have been developed to satisfy accepted emission based regulations, which are only achieved under the least challenging indoor environmental conditions (77 °F / 50% relative humidity).
- The current testing protocols are not adequate to predict long term emission potential at all conditions.
- NAUF resins, although generally less likely to hydrolyze, should be closely monitored as formulation and process parameters can greatly impact emission levels.
- There are alternative NAF and NAUF resins available to serve the needs of the market.