

Wood Adhesives- Part 1

Please read

http://www.fpl.fs.fed.us/documnts/pdf2013/fpl_2013_frihart001.pdf

Wood composite products

- The majority of wood products in use have bonded assemblies
- Adhesive choice is dependent upon application
- Important aspects of wood adhesive choice depends upon
 - Cost
 - Cost
 - Mechanical Performance- rigidity, strength, viscoelasticity/creep
 - Durability
 - Color
 - Curing mechanism (what inputs are required to make the adhesive a solid?)

Wood-based composites

- Structural
 - Glulam, cross-laminated timbers, parallel strand lumber, laminated veneer lumber, plywood, oriented strand board (OSB)
- Non-structural
 - Particle-board, medium density fiber board, decorative plywood, overlays

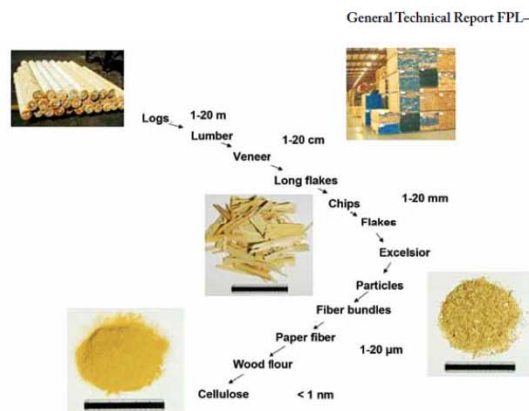


Figure 11-2. Basic wood elements, from largest to smallest (Kretschmann and others 2007).

http://www.fpl.fs.fed.us/documents/fplgtr/fplgtr190/chapter_11.pdf

Wood-Based Composite Materials
Panel Products, Glued-Laminated Timber, Structural Composite Lumber, and Wood-Nonwood Composite Materials

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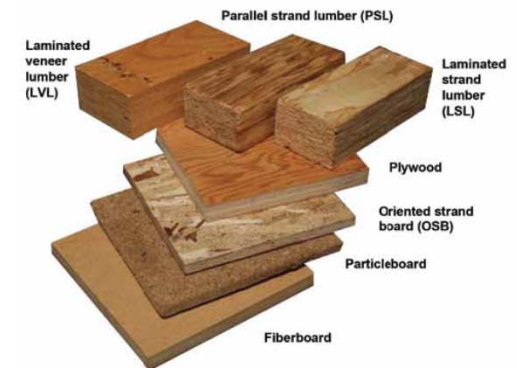


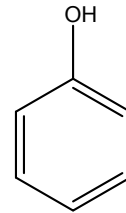
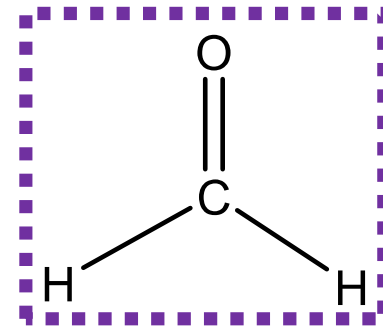
Figure 11-4. Examples of various composite products. From top left, clockwise: LVL, PSL, LSL, plywood, OSB, particleboard, and fiberboard.

Critical chemical and polymer aspects of wood adhesives

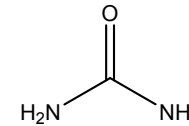
- **Functionality** of the monomer/oligomer leading to various chain architectures (i.e. linear, branched, or network polymers)
- Chemical composition of the polymer impacting **T_g** and interaction with the wood
- **Molecular weight** of the polymer during application and cure
- The chemical composition impacting interaction with the wood

Formaldehyde based adhesives

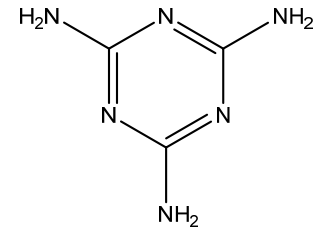
- Formaldehyde adhesives are the oldest synthetic polymers
- Wood adhesives utilize phenol formaldehyde, urea formaldehyde, and melamine formaldehyde (lesser extent)
- Formaldehyde based resins are scrutinized for formaldehyde emissions
 - Consumption will be reduced



Phenol



Urea

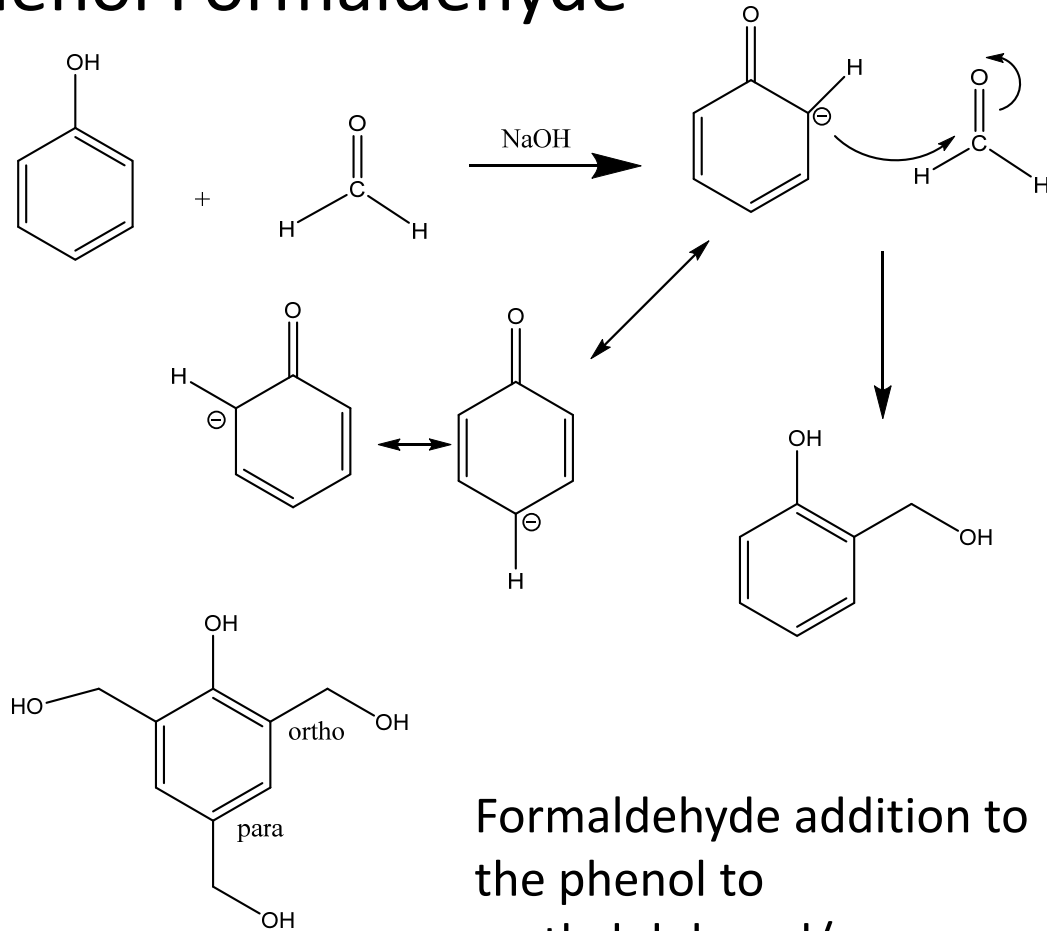


Melamine

Formaldehyde adhesives are used in both structural and non-structural applications

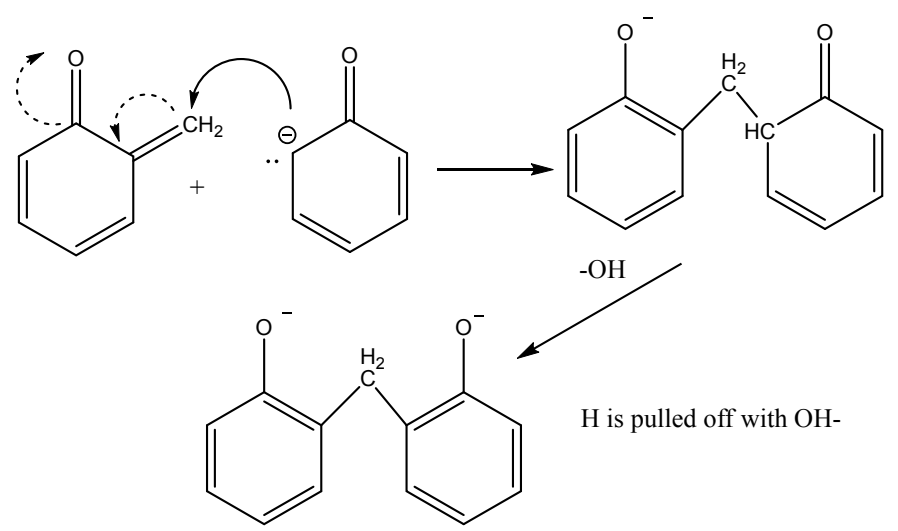
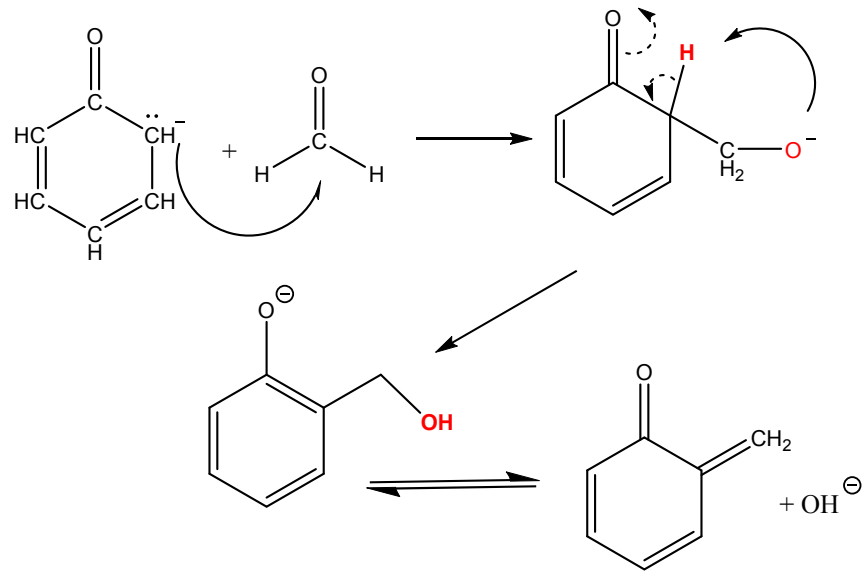
- Typically formulated and applied as solutions in water as low molecular weight polymers
- For exterior grade composites, must use phenol formaldehyde resins although melamine resins provide some water stability.
 - Not rated by composite type (plywood vs. particleboard) but by application exterior vs. interior.
- Resins have a given “shelf life” and formulated by adhesive supplier for particular board producer
- Proper resin cure impacts performance

Phenol Formaldehyde

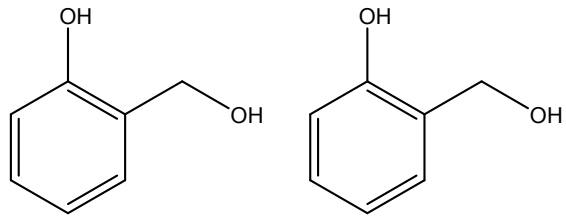


Formaldehyde addition to the phenol to methylolphenol/ hydroxymethyl phenol

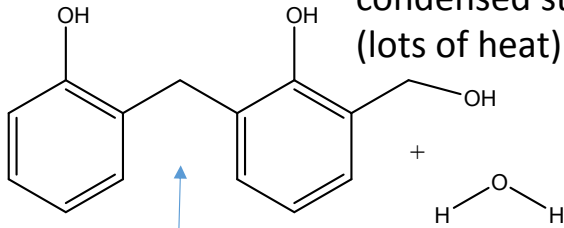
Wood adhesives are alkali catalyzed **“resoles”** PF resins where $P/F < 1$



Phenol Formaldehyde

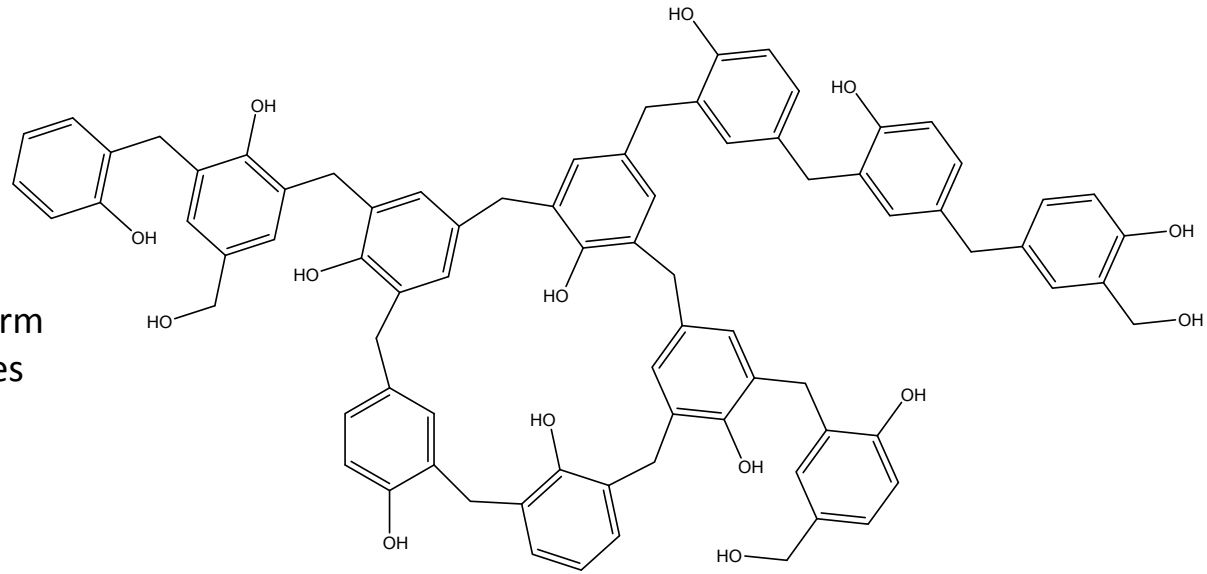


Heat activated to form condensed structures (lots of heat)

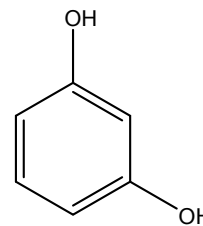


Methylene bridge formation

What happens to the water?



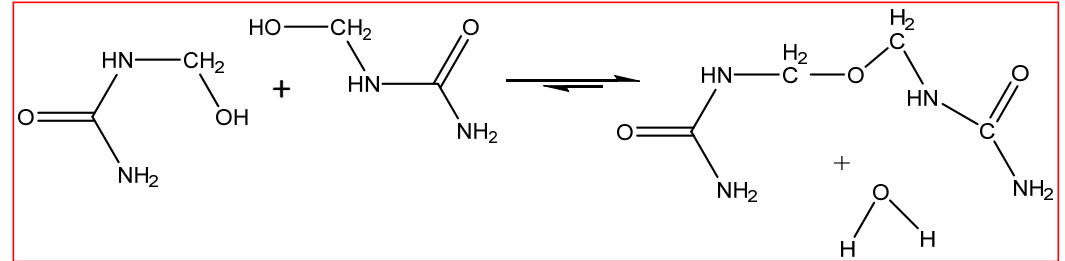
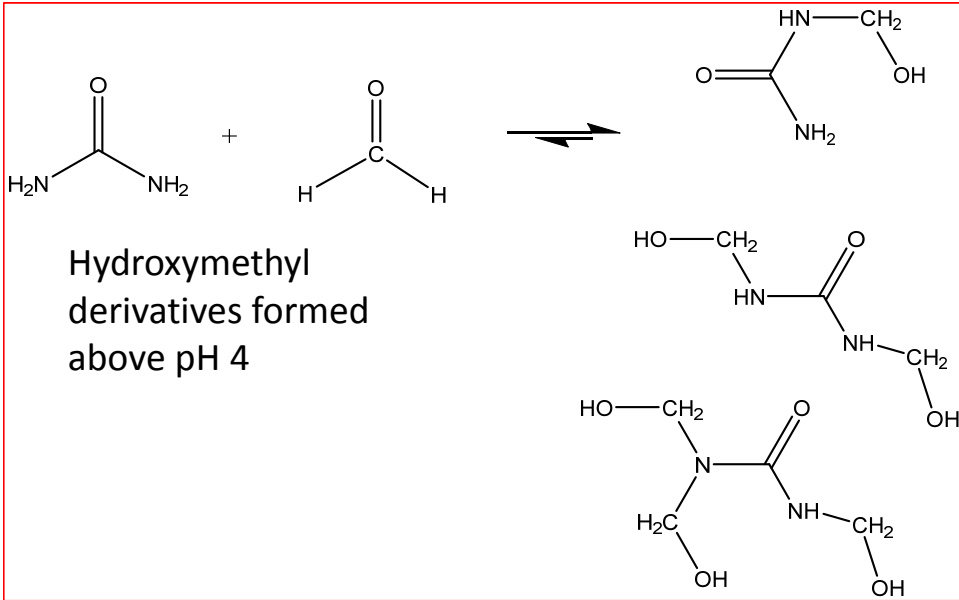
What functional groups are observed?
What else is observed about the backbone of this polymer? The polymer has a dark reddish color.



Note, resorcinol can be added to PF resins to increase the rate of cure and make them cold curing

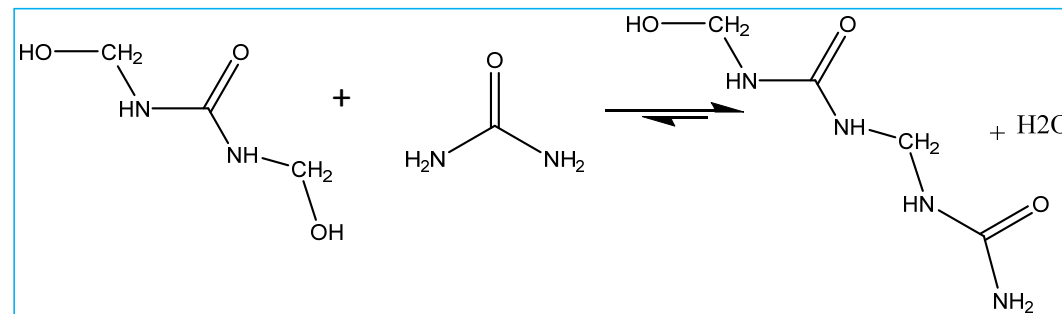
Urea Formaldehyde

>pH 4
conditions



Ether bridges

UF adhesives are milky-white colloidal suspension. Upon cure they form very lightly colored adhesives.

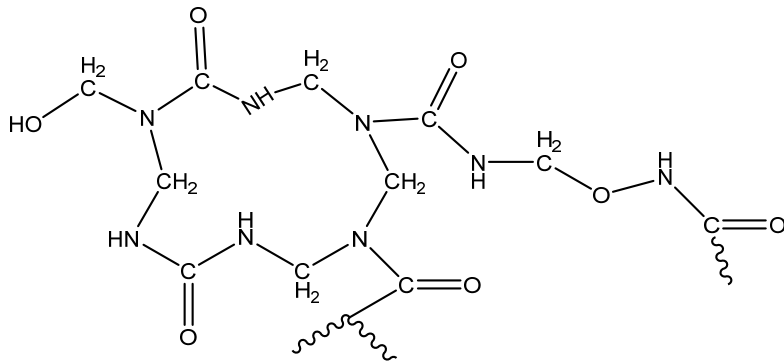


<pH 4
conditions

Urea Formaldehyde

Acidic catalysis are used to cure adhesive

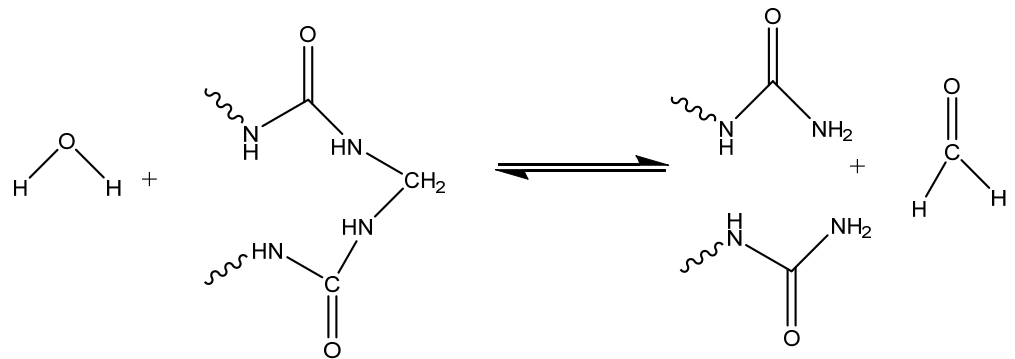
--Salts like ammonium chloride are added into the solutions as the form, ammonia and HCl (ammonia gases off)



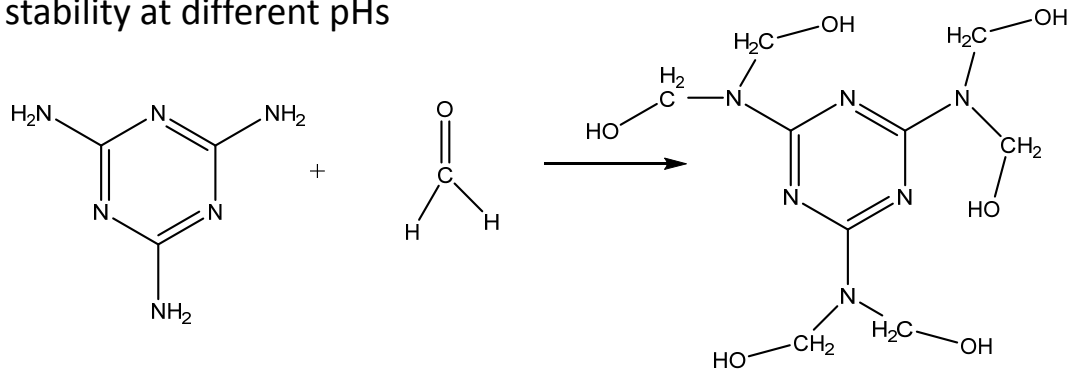
What functional groups are observed?

UF adhesives are not hydrolytically stable and undergo hydrolysis when exposed to water. This causes two issue-cannot be used in exterior exposures and can emit formaldehyde

UF adhesives have been suggested to “cure” as agglomeration of colloidal particles composed of oligomeric UF condensates.



Melamine formaldehyde resins have similar chemistry to UF besides their stability at different pHs

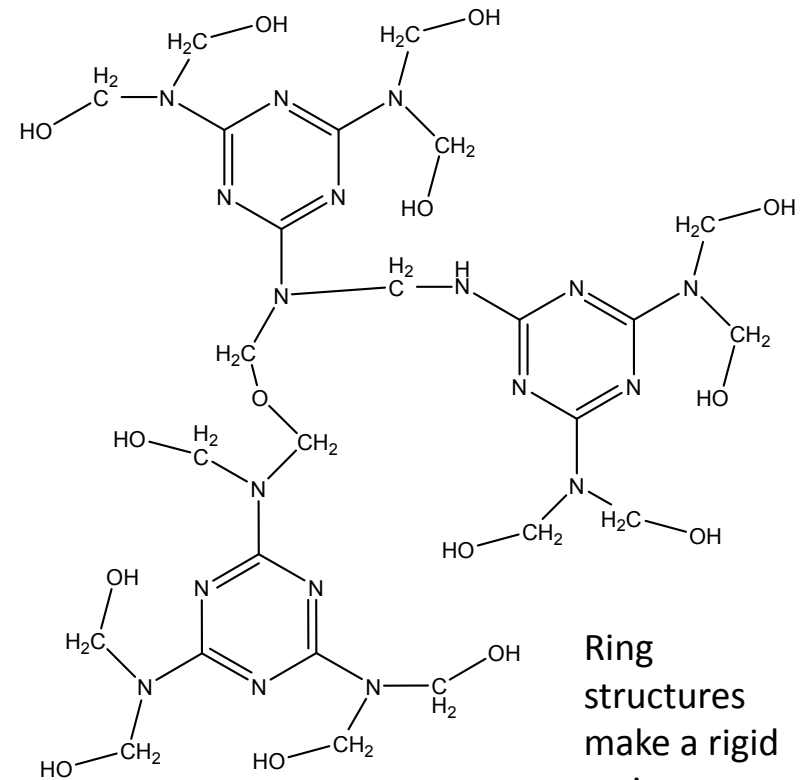


MF resins are commonly impregnated into paper overlays, dried and laminated. They are chemically resistant.

Formica counter tops are based on MF resins (hard surface that is chemically inert)

Melamine Formaldehyde

MF adhesives can still emit formaldehyde but general occurs at lower levels and much more water resistant than UF.



Ring structures make a rigid resin

Be able to

- Indicate differences amongst the formaldehyde based resins for applications
 - Performance, adhesive structure, and physical attributes
- Draw reactants for the resins and understand mechanism of cure
- Discuss formaldehyde emissions from formaldehyde based adhesives