

PHENOLATION OF WOOD AND ITS APPLICATIONS FOR THE PRODUCTION OF ENGINEERED POLYMERIC MATERIALS

M. HAKKI ALMA, TUFAN SALAN

KAHRAMANMARAS SUTCU IMAM UNIVERSITY, DEPARTMENT OF
MATERIALS SCIENCE AND ENGINEERING, FACULTY OF FORESTRY,
KAHRAMANMARAS, TURKEY

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**“Innovative production technologies and increased
wood products recycling and reuse”**
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Solvolytic Liquefaction

Solvents

- Phenol
- Glycerol
- Ethylene Glycol
- Polyethylene Glycol (PEG)
- Dioxane
- Ethanol
- Acetone

Catalysts

- Sulfuric Acid
- Hydrochloric Acid
- Oxalic Acid
- Phosphoric Acid
- NaOH
- $MgSO_4$

Heat

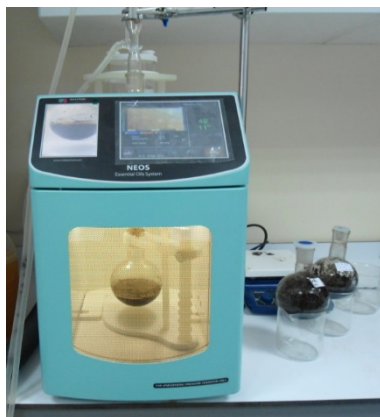
- 80-150 °C (With Catalysts)
- 240-270 °C (Without Catalysts)

Time-Pressure

- 60-150 min.
- Atmospheric pressure or high pressure



Conventional Glass Flask



Microwave Assisted



Pressure-proof Autoclave

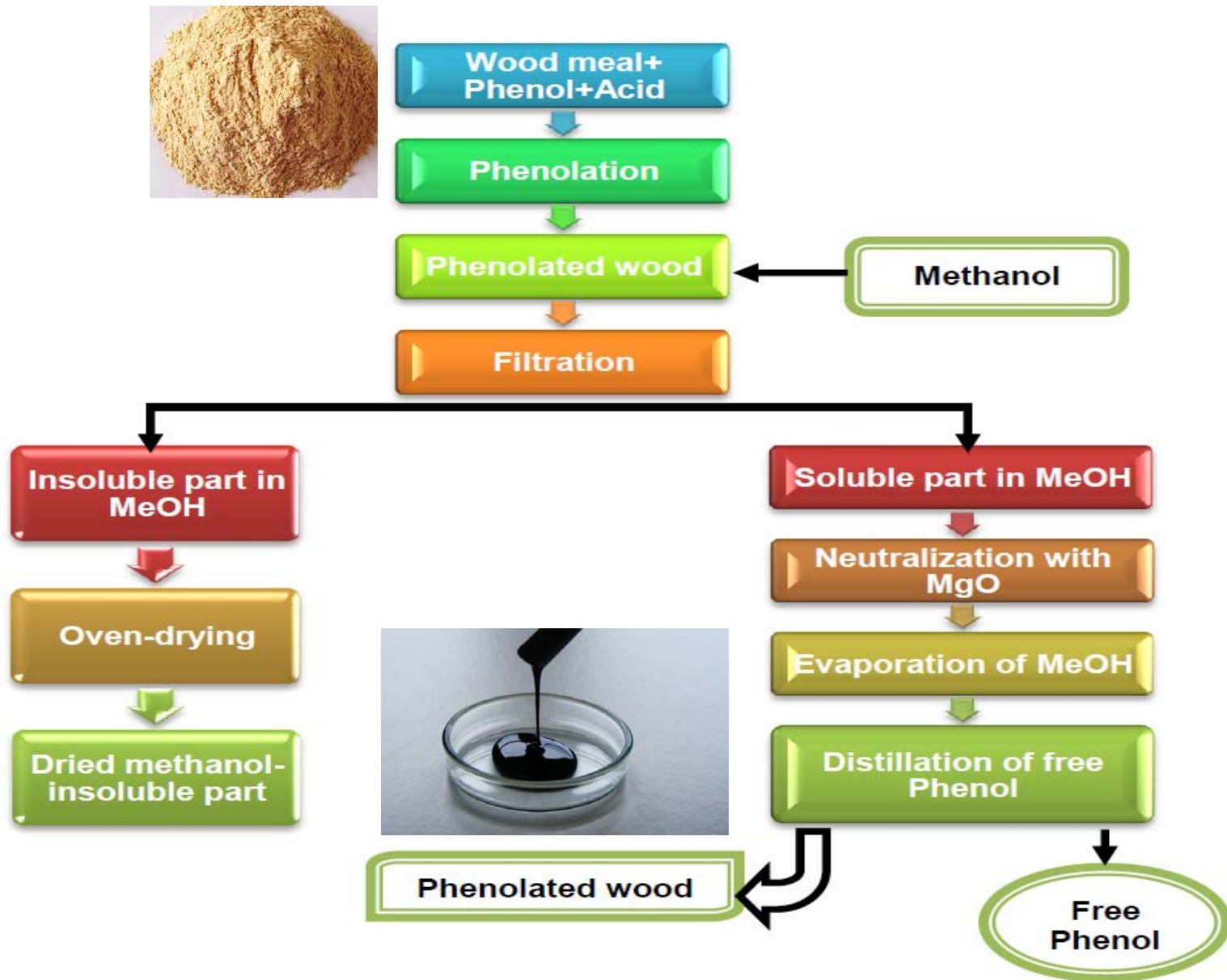


Solvent Evaporation



Filtration

Phenelation of Wood

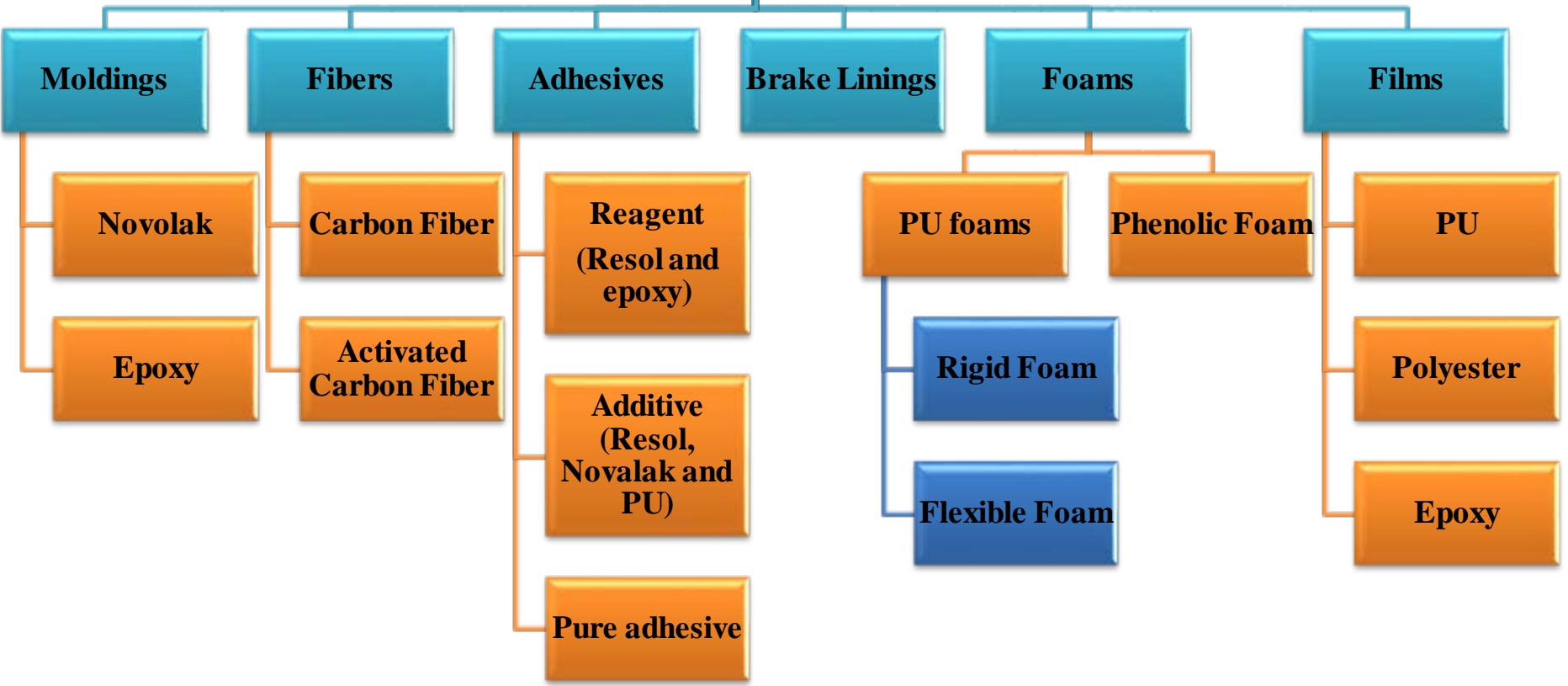




Applications of Phenolated Wood



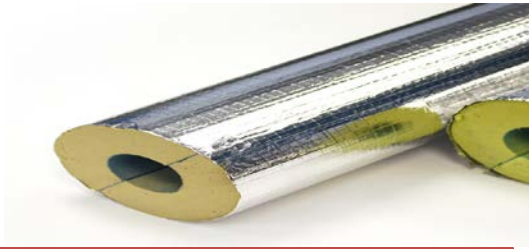
Liquefied/Phenolated wood and Its components



Applications of Phenolated Wood



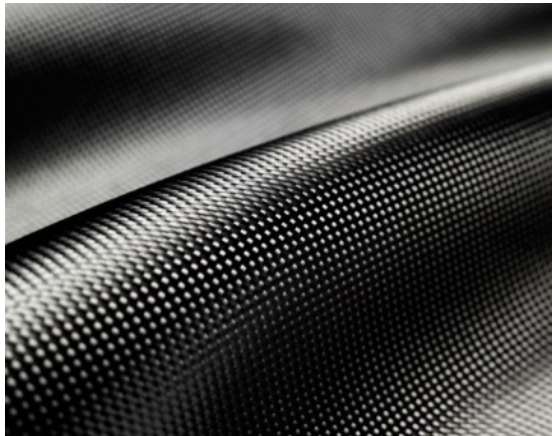
Phenolic Foams



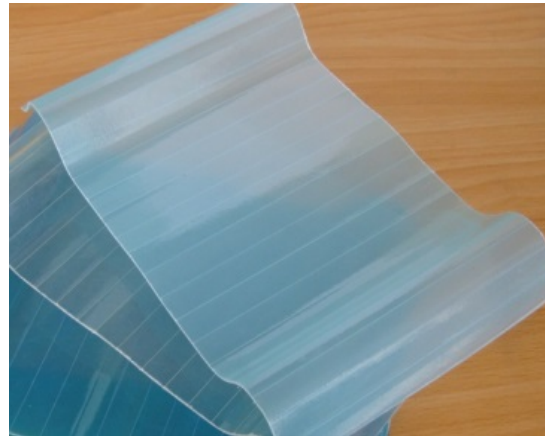
Phenolic Resins



Adhesives



Carbon Fibers

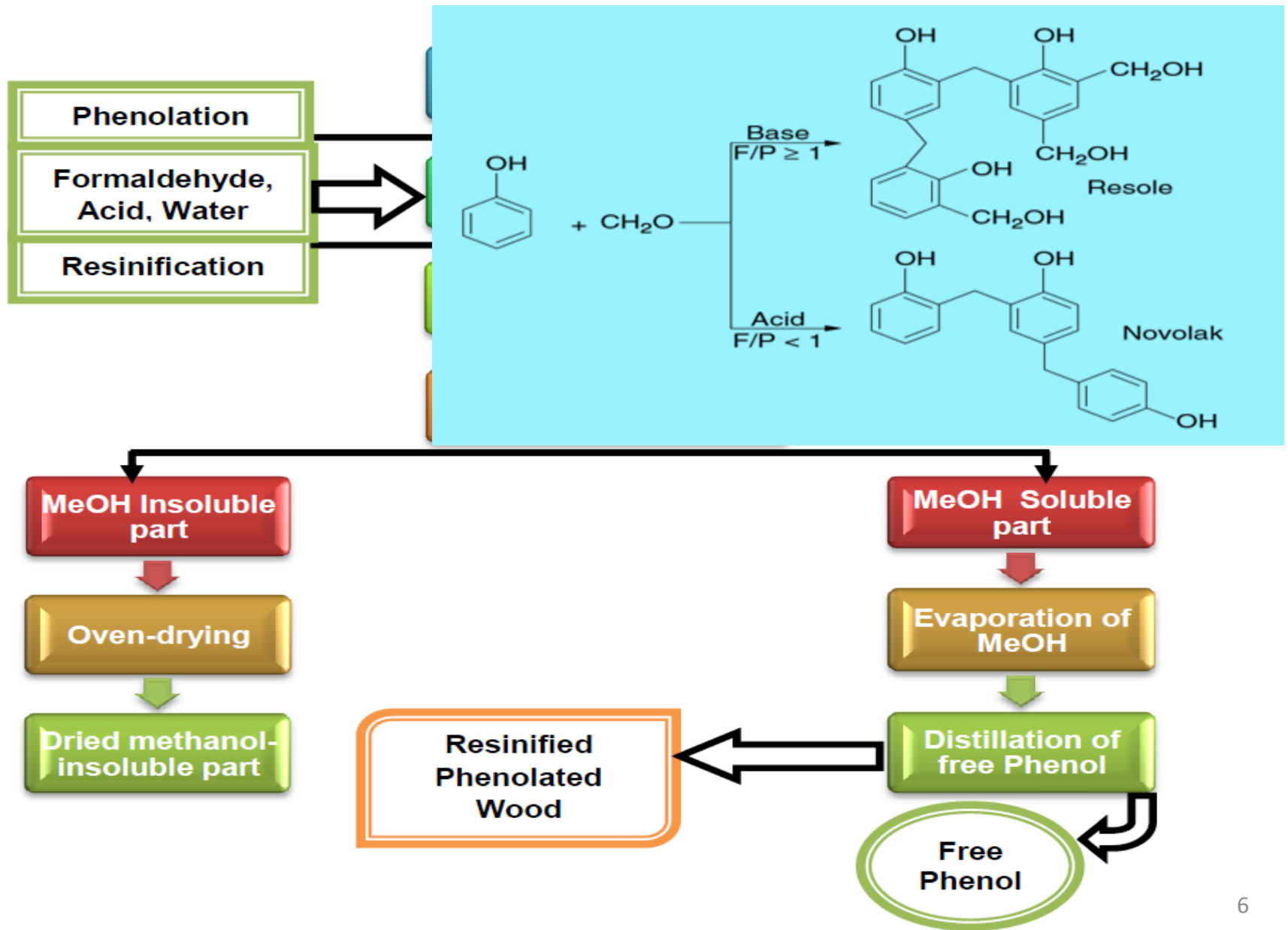


Polyesters



Moldings

Resinification of Wood



Thermosetting Molding Production

Resinified phenolated wood



Hexamethylenetetramine (HMTA) (as curing agent)
Zinc Stearate (as lubricating agent)
Calcium Hydroxide (as accelerating agent).
Wood Powder

Hot Pressing
(190 °C, 40 MPa, 5 min)



Molding Material



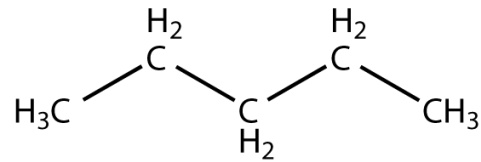
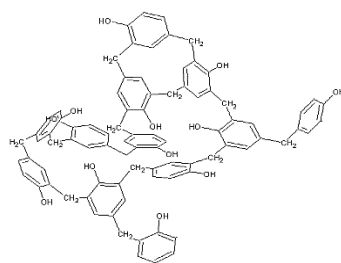
Tests:
Mechanical
and Physical



Phenolic Resin Foam Production

- Phenol
- Acid catalyst
- Formaldehyde
- Resinification: 55-90 °C
- Cooling to 40°C
- Neutralization with sulfuric acid
- Evaporation of volatile components

Liquefaction/Resinification of wood

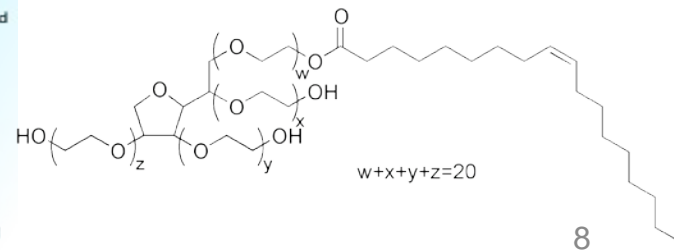
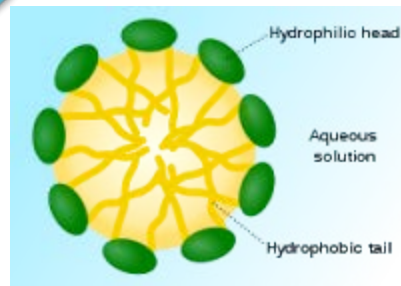
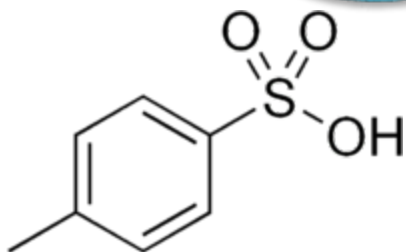


Foam Preparation

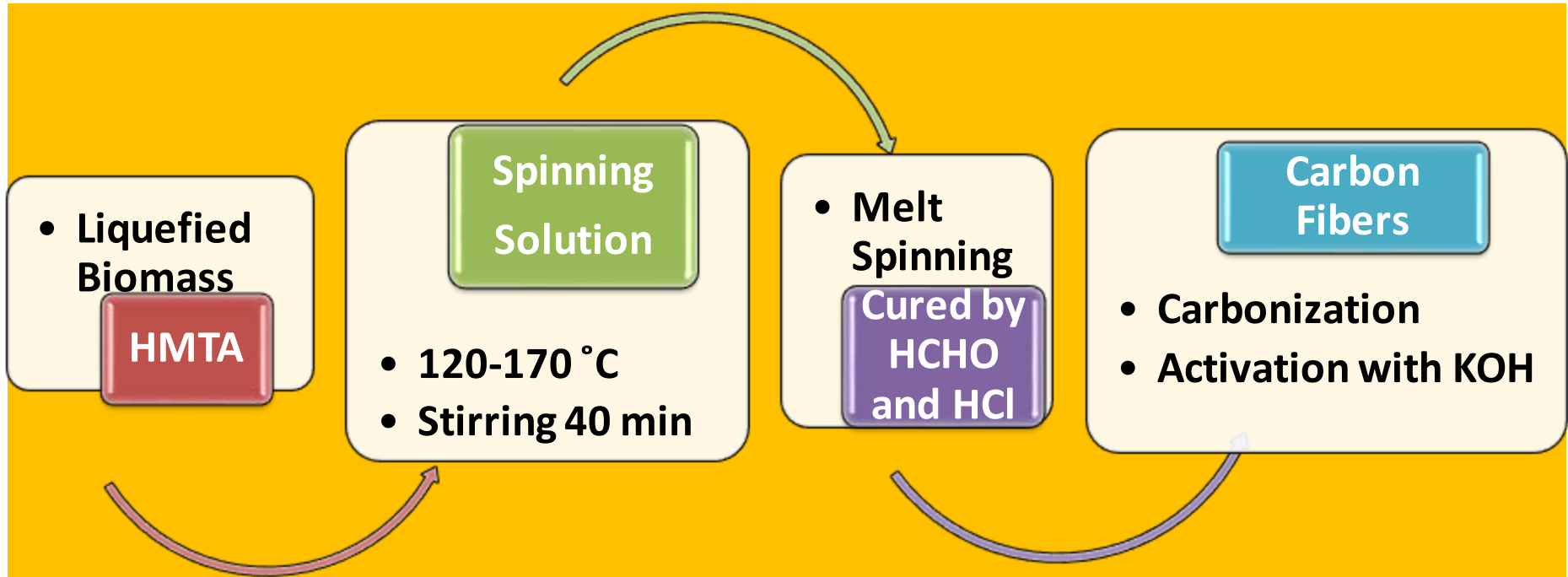
- Rapid Mixing (10-20 sec)
- Resol resin
- Surfactant
- Catalyst
- Blowing agent

- Immediate pouring to a mold
- Curing at room temperature for 1 h

Curing



ACF Production

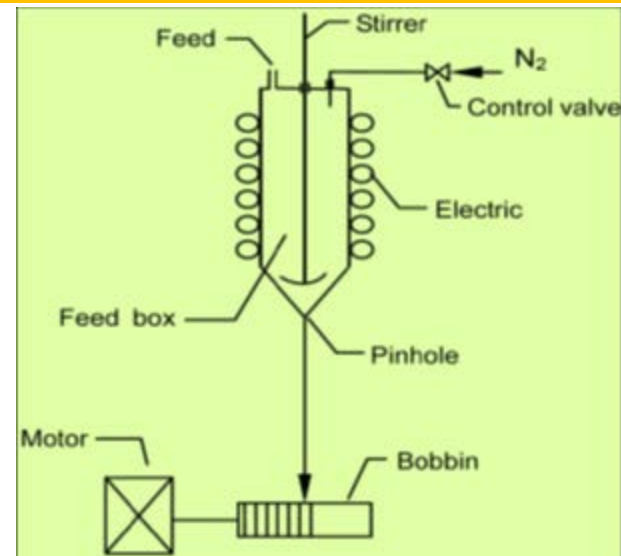


Liquefaction
160 ° C, 2.5 h (Phenol, H₂SO₄ or HCl)

Curing
95 ° C, 4 h

Washing with distilled water
90 ° C, 2 h

Activation
800-1000 ° C
40 min-2 h



Epoxy Resin Synthesis

Liquefaction of biomass

- Phenol or PEG/Glycerol cosolvent
- Resorcinol
- Sulfuric acid

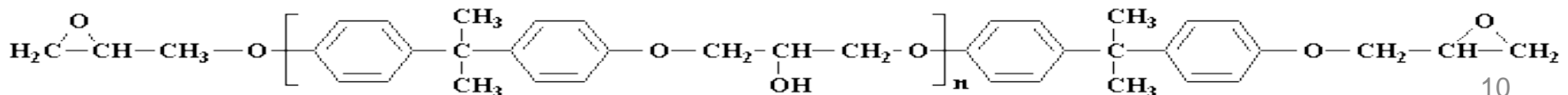
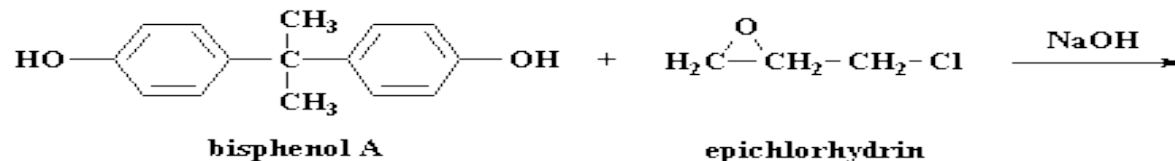
Glycidyl etherification of liquefied wood

Copolymerization

- Stirring 110 °C, 2 h
- Liquefied biomass
- Epichlorohydrin
- Bisphenol A
- NaOH (Dripping 2 h)

Purification

- Dilution with acetone
- Filtration of salts
- Evaporation of acetone and nonreacted excess epichlorohydrine



Polyester Resin Synthesis

- Polyhydroxy alcohol mixtures of
- Ethylene glycol
- Ethylene carbonate
- Glycerol
- Diethylene glycol
- Phenol
- p-toluene sulphonic acid

Liquefaction of biomass

Esterification

- Liquefied biomass polyol
- 110 °C
- Cross linkers: Carboxylic acids or anhydrides
- 200 °C stirring
- Dibutyl tin oxide (esterification/trans esterification catalyst)
- Water vapor removal via nitrogen
- Time: 160-180 min

- When the acid value was reduced to less than 30 mg KOH/g
- Homogeneous mixture molded in a polished plate
- Curing: 1–5 h, 140–180°C

Curing/Molding

Thank You

