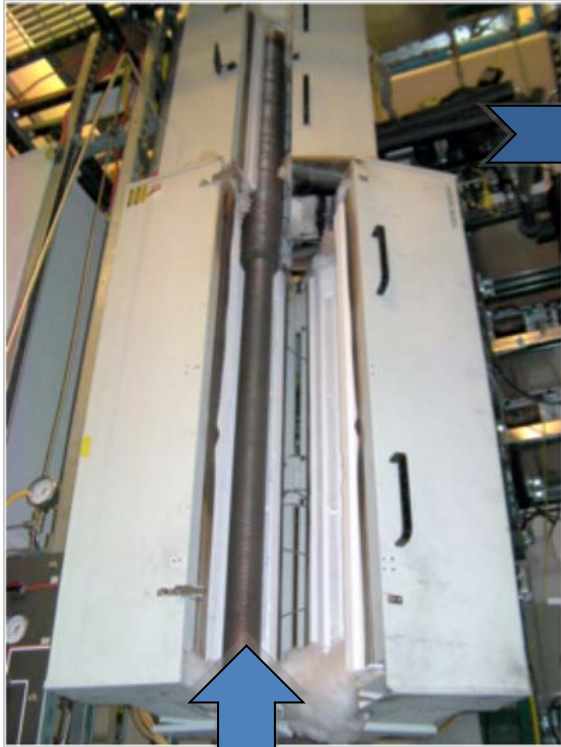


Catalytic Cascade to Refine Pyrolysis Oil



Biomass

- Cellulose
- Hemicellulose
- Lignin

- **Small oxygenates**
(aldehydes, alcohols, ketones, acids)
- **Sugar-derived compounds**
(levoglucosan, furfurals)
- **Lignin-derived phenolics**
(guaiacol, vanillin, anisole, etc.)

Two Problems:

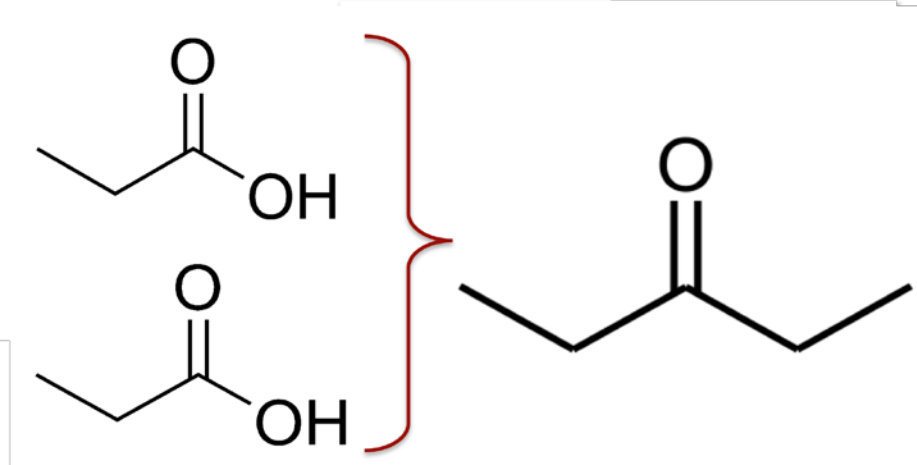
- to eliminate excess oxygen
- to bring products to gasoline/
diesel ranges



- Small oxygenates**

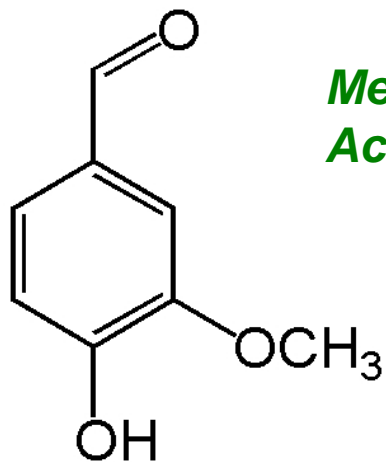
(aldehydes, alcohols, ketones, acids)

Aldol
Condensation
Ketonization
Esterification



Basic and Acidic Zeolites – Mixed Oxides

- Lignin-derived phenolics**



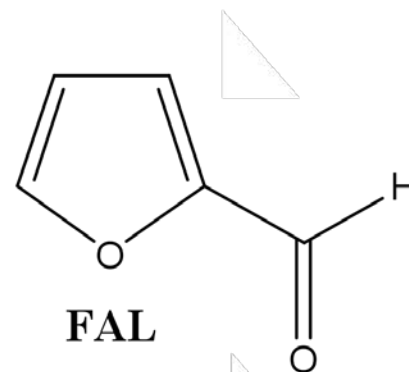
**Metals and
Acidic Zeolites**



BTX

Deoxygenation
Alkylation

Sugar-derived compounds



Bases



Aldol Condensation
And Canizarro Reaction

C8	C11	C13
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**Pd, Ni
Ru**



Deoxy
genation

Diesel

