Biojet fuel production from ring opening of biomass-derived aromatic hydrocarbons

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Introduction

- **Petroleum Jet fuels consists primarily of hydrocarbon compounds: paraffins, cycloparaffins(naphthenes), aromatics, and olefins. The predominant classes of compounds are shown in the table below**

Compounds	Composition (%)
N-alkanes	43.81
Monosubstituted alkanes	27.72
Disubstituted alkanes	4.00
Cyclohexanes	**4.30**
Monosubstituted aromatics	3.41
Disubstituted aromatics	6.23
Multisubstituted aromatics	5.65
Total	95.12
*source: Air Force 1988	

Introduction

- Bioderived jet fuels are produced from plant lipids, waste cooking oils or algae lipids
- The main characteristics of these bioresources are that they are long chain alkanes
- Lignocellulosic fuels derived from hydrotreating biomass pyrolysis oils are mostly cycloalkanes (naphthenes) which can only be used as blend stocks.

Introduction

- **Objectives**
- Produce catalytic pyrolysis oils from lignocellulosic biomass feedstocks
- Develop catalyst to open the lignin aromatics rings and form long chain alkanes
- Hydrotreat pyrolysis oils with catalyst to produce alkanes, isoalkanes, cycloalkanes, and aromatics in one-step process that will qualify as jet fuel.

Pyrolysis process

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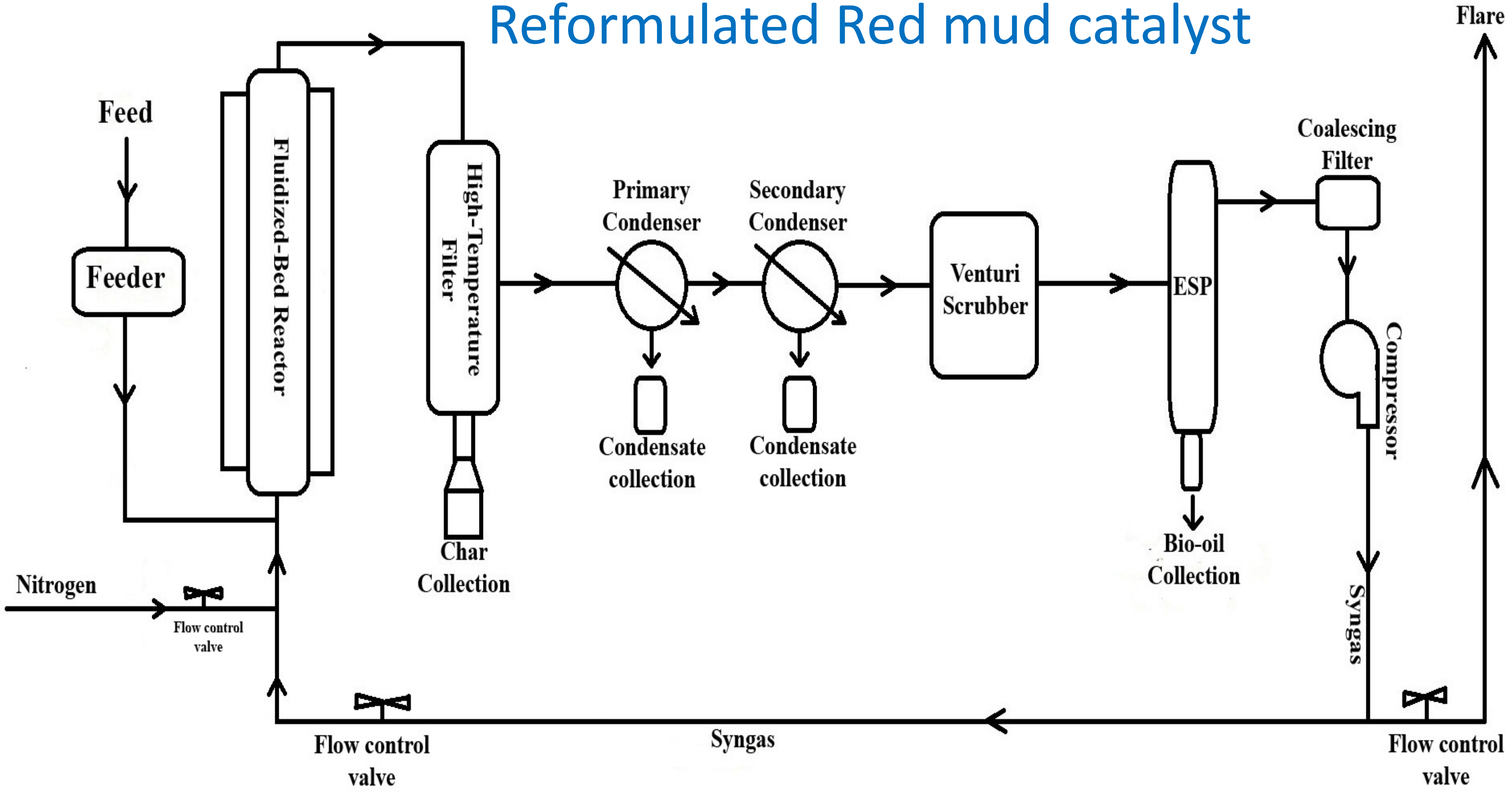
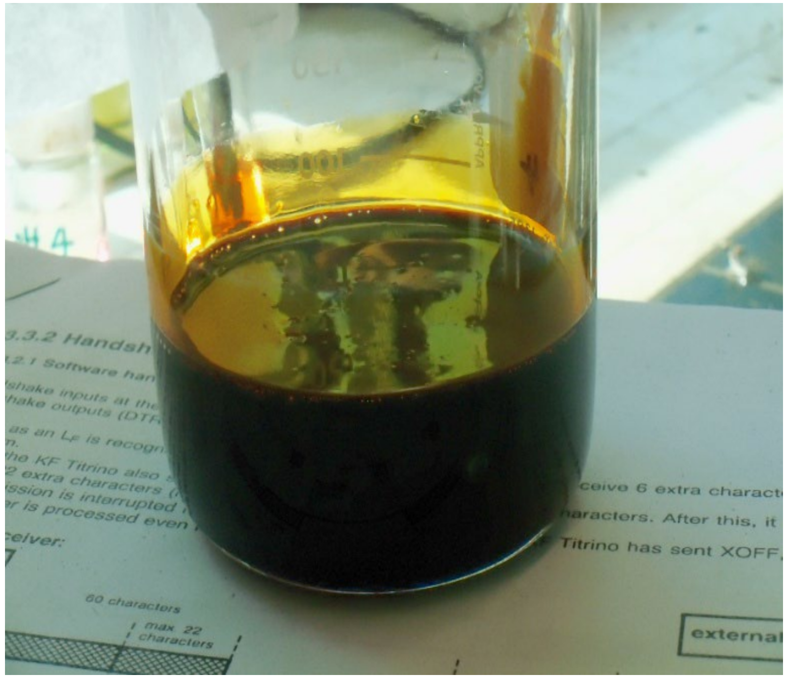
Reformulated Red mud catalyst



Pinyon juniper red mud catalytic pyrolysis oils

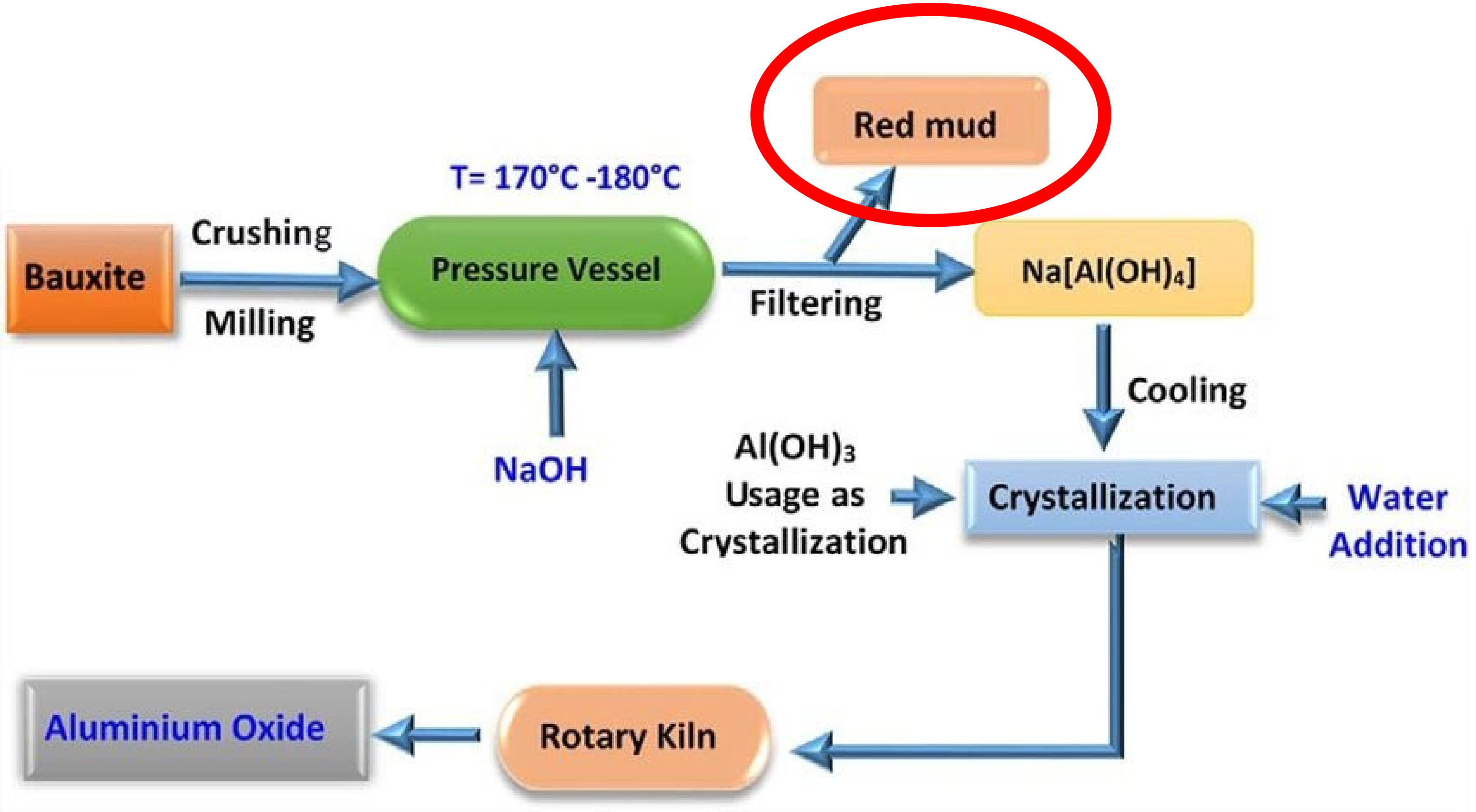


Condenser oil

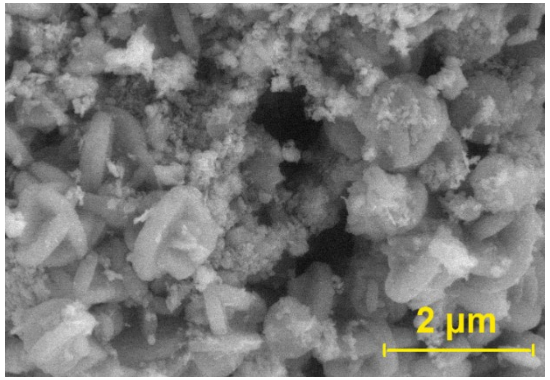
ESP oil

Synthesis of new catalysts from Red Mud

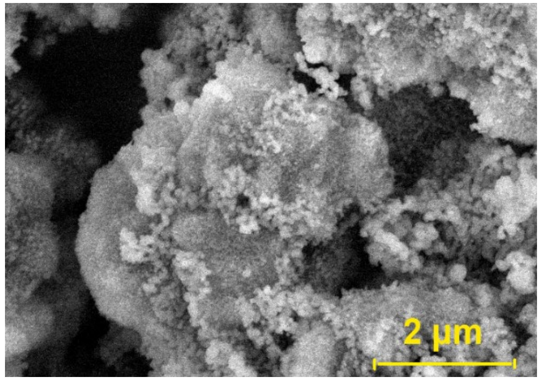
- What is Red Mud?
- Red mud problems



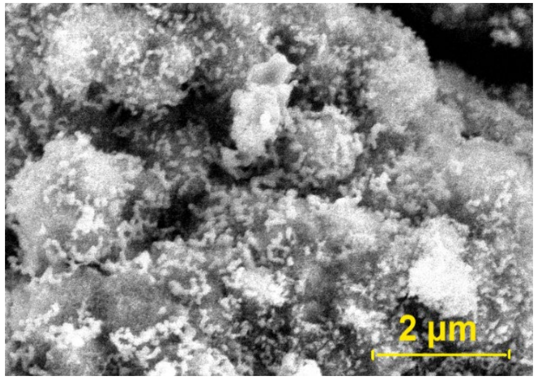
Surface morphology – SEM images



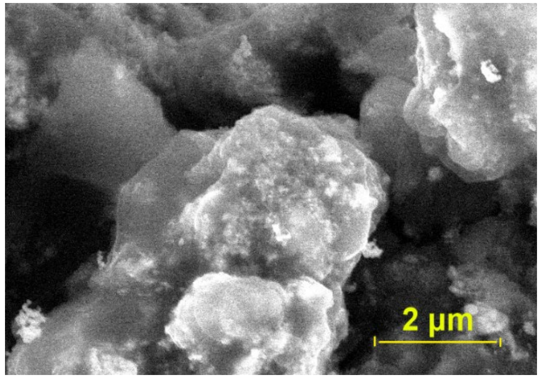
RM support



40%Ni/RM – Calcined



40%Ni/RM – Reduced form



Used (coked) Ni/RM

Pyrolysis oil processing

- Traditional process: 3-step

1- Ketonization

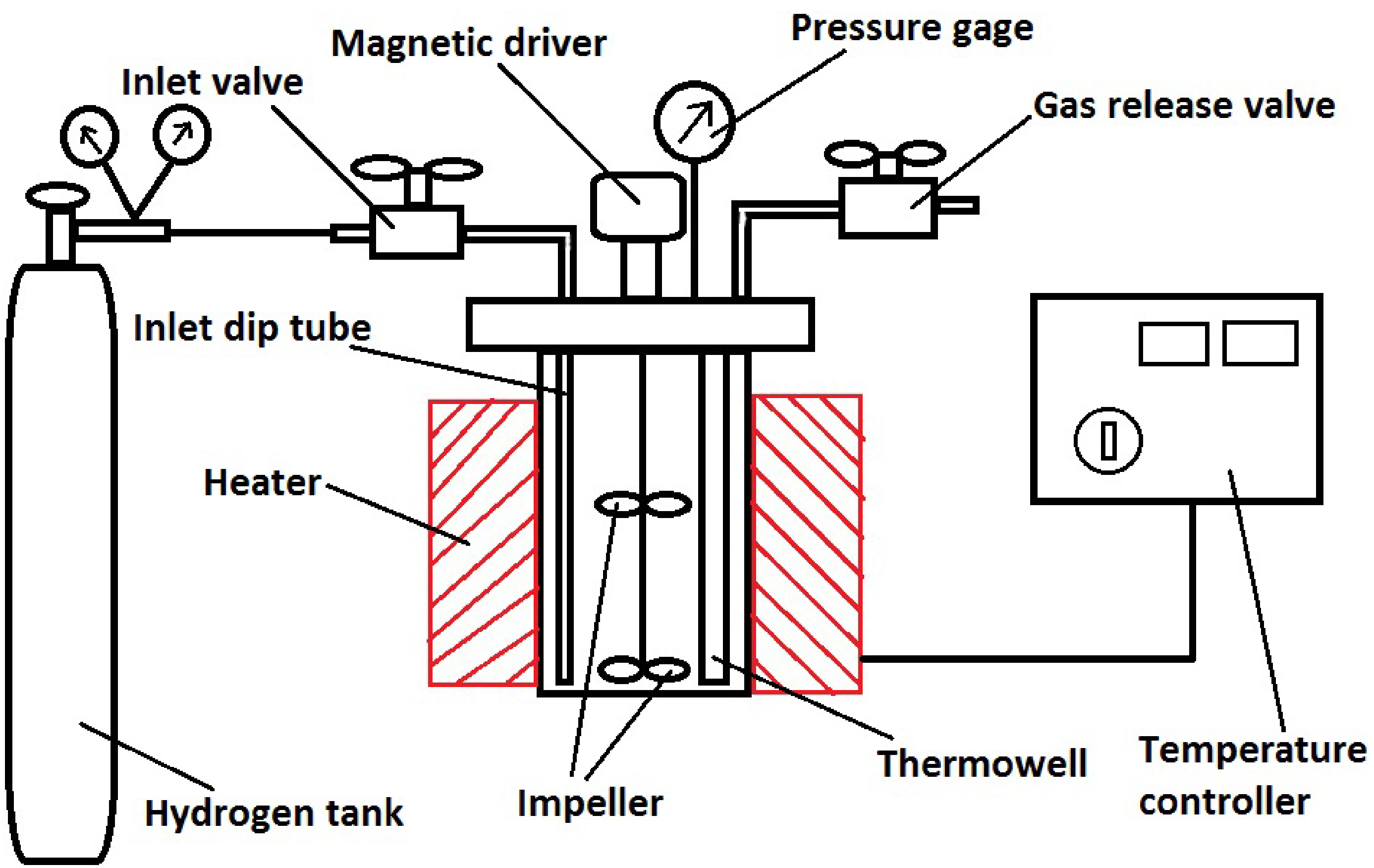
2- Aldol condensation

3- Hydrodeoxygenation

- **Our novel process**:

One-pot synthesis of hydrocarbons using multifunctional Ni/RM

Hydrodeoxygenation reaction



Experimental condition:

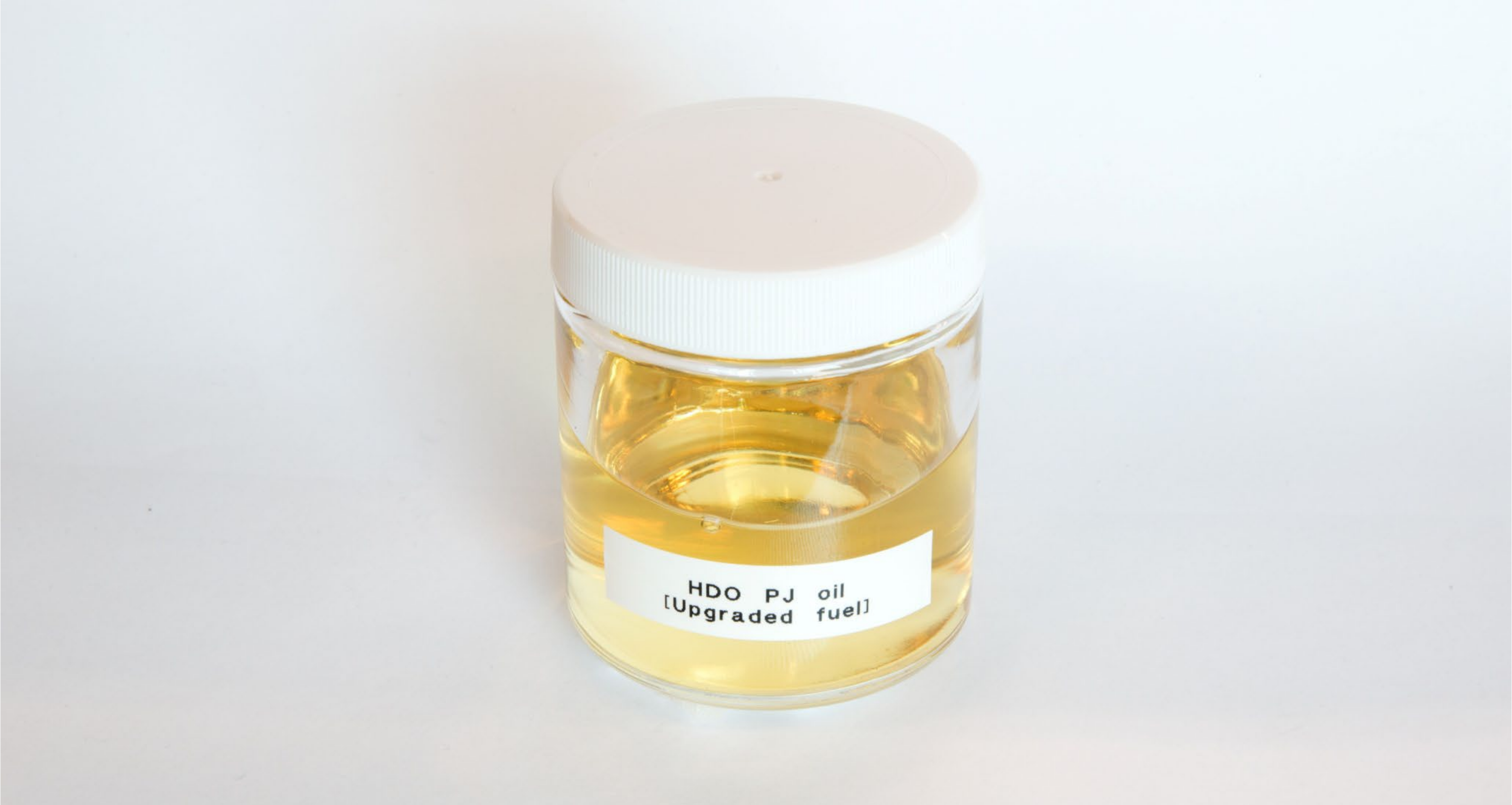
Reaction time = 30 minutes

Temperature = 350 °C

H_2 cold pressure = 900 psi

85% water

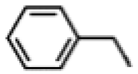
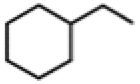
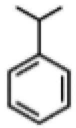
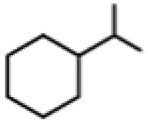
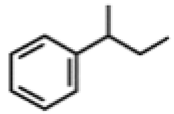
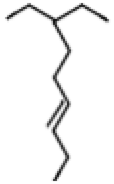
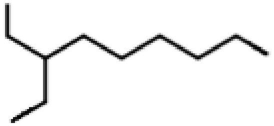
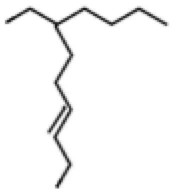
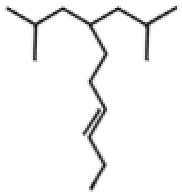
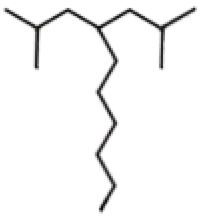
Catalyst / reactant (wt./wt.) = 0.15



Upgraded fuel

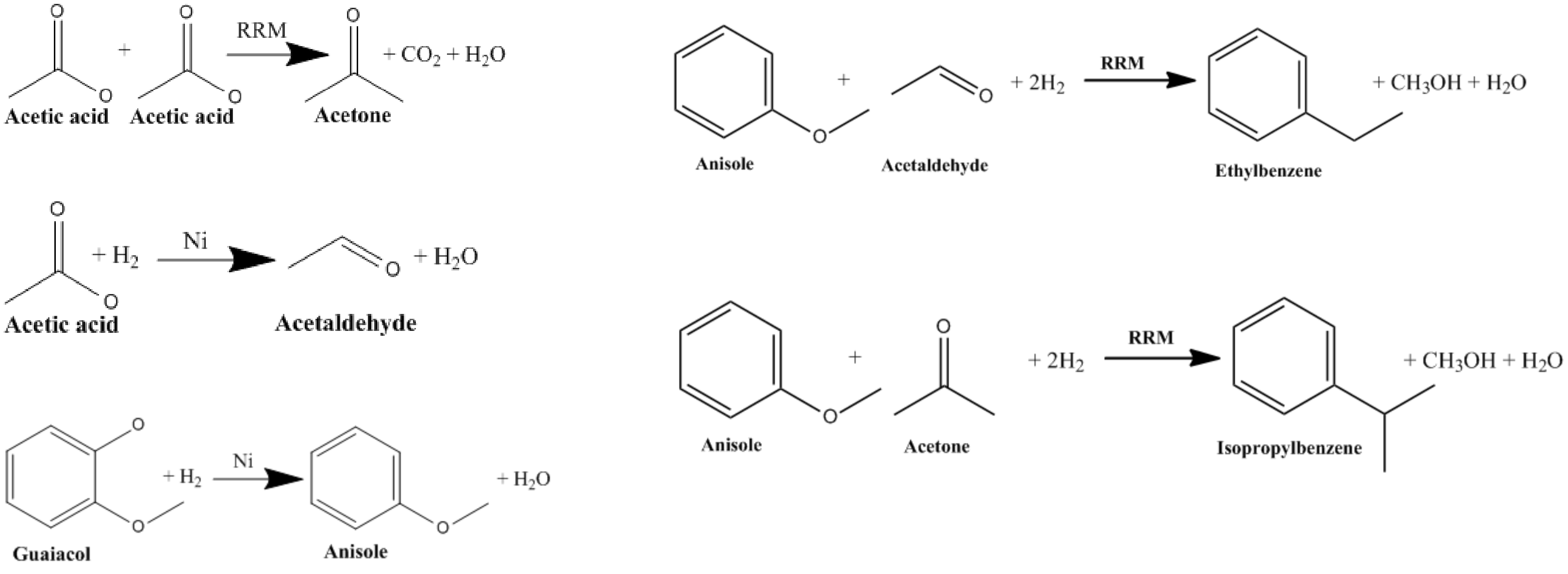
Table of synthesized hydrocarbons (guaiacol reactions)

- Structures were confirmed using GC-MS and NMR

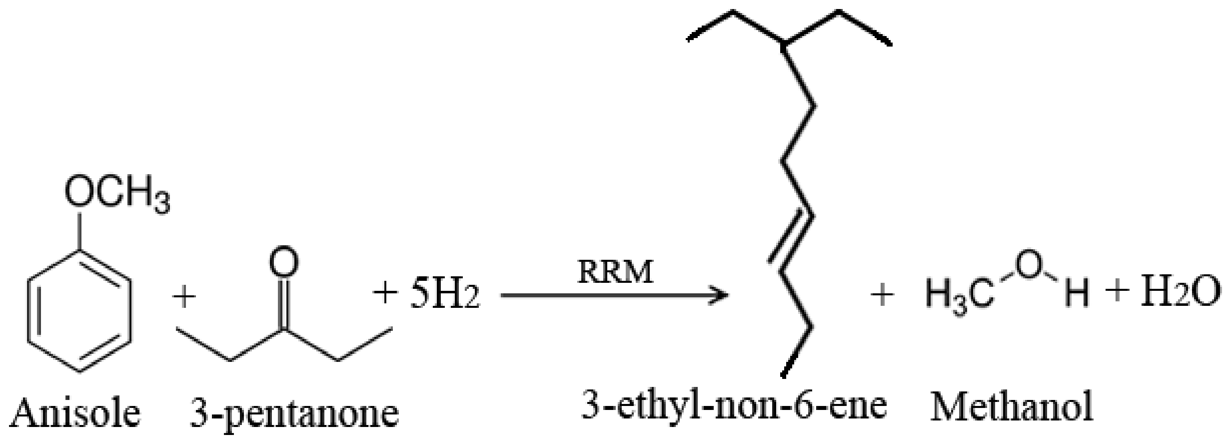
Carbonyl alkylation products			Hydrogenation products		
Formula	Catalyst	Structure	Formula	Catalyst	Structure
C_8H_{10}	RRM		C_8H_{16}	Ni	
C_9H_{12}	RRM		C_9H_{18}	Ni	
$C_{10}H_{14}$	RRM		$C_{10}H_{22}$	Ni	
$C_{11}H_{22}$	RRM		$C_{11}H_{24}$	Ni	
$C_{13}H_{26}$	RRM		$C_{13}H_{28}$	Ni	
$C_{15}H_{30}$	RRM		$C_{15}H_{32}$	Ni	

Synthesis of hydrocarbons: guaiacol reactions

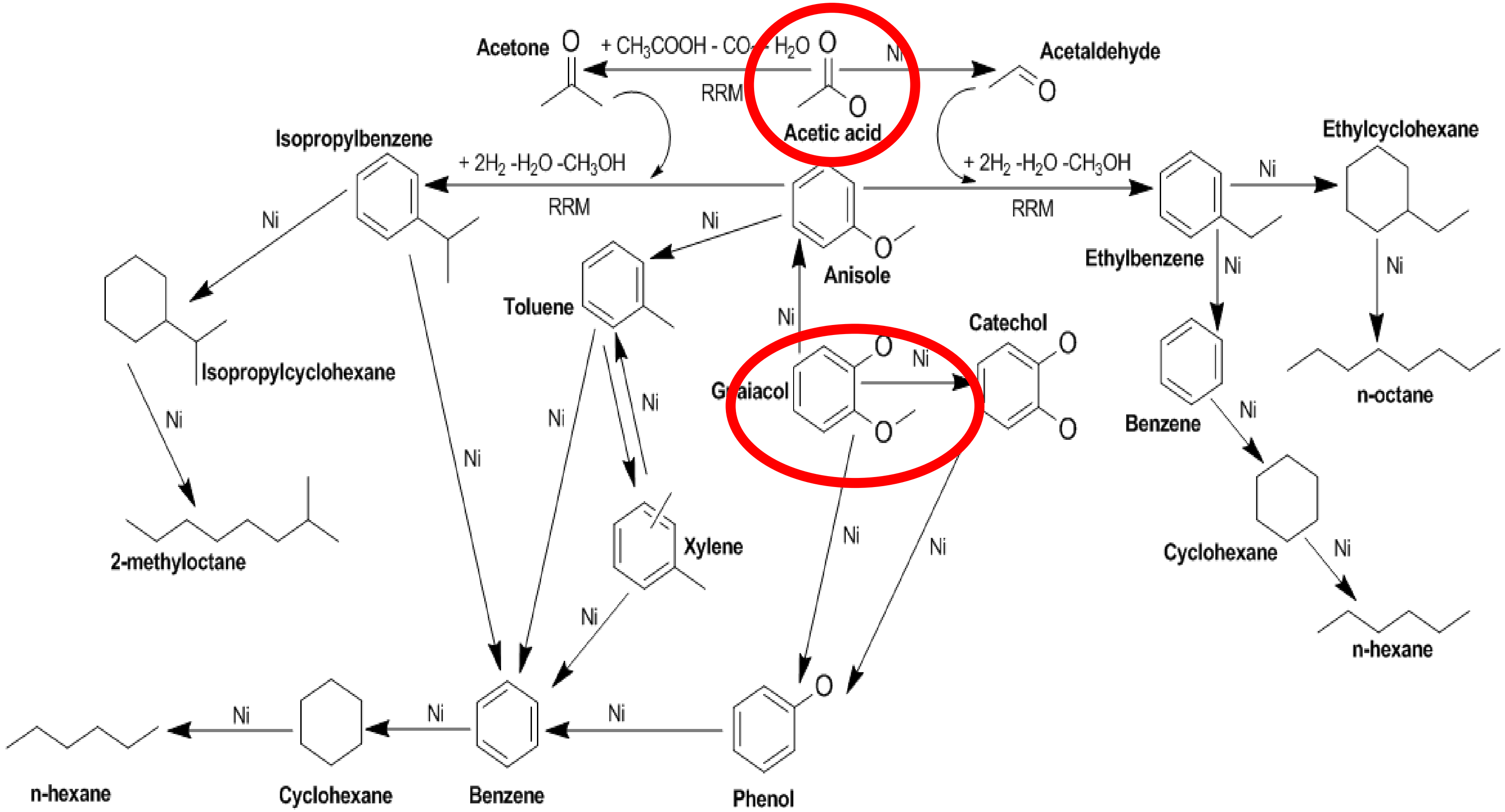
- Ketonization – partial reduction – carbonyl alkylation



Synthesis of hydrocarbons: guaiacol reactions

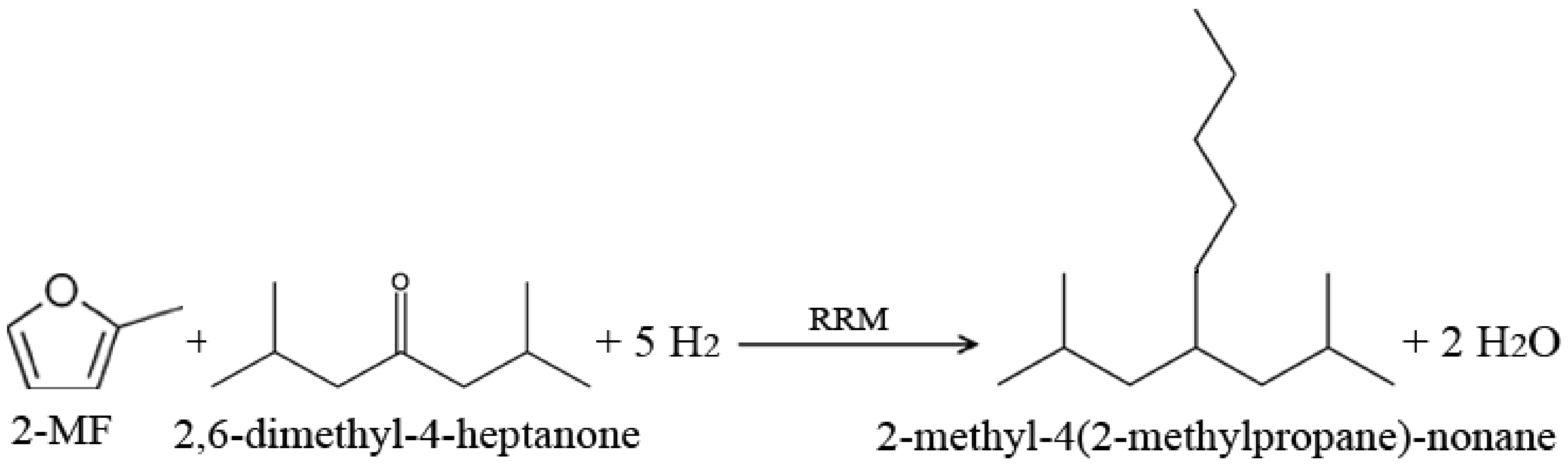


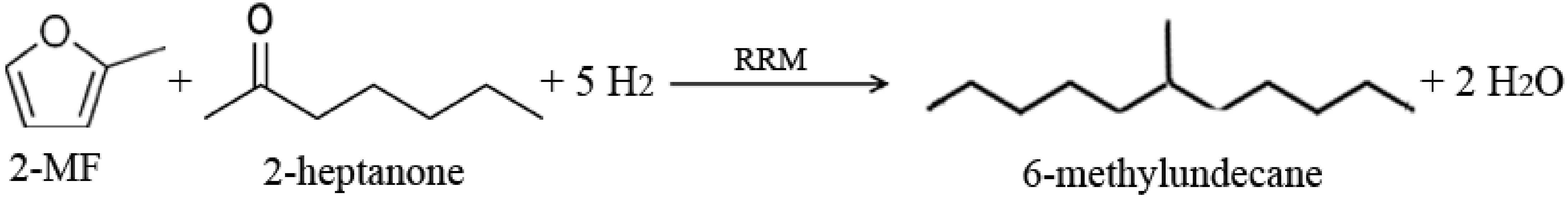
Reaction network : Guaiacol-based (on Ni/RM)



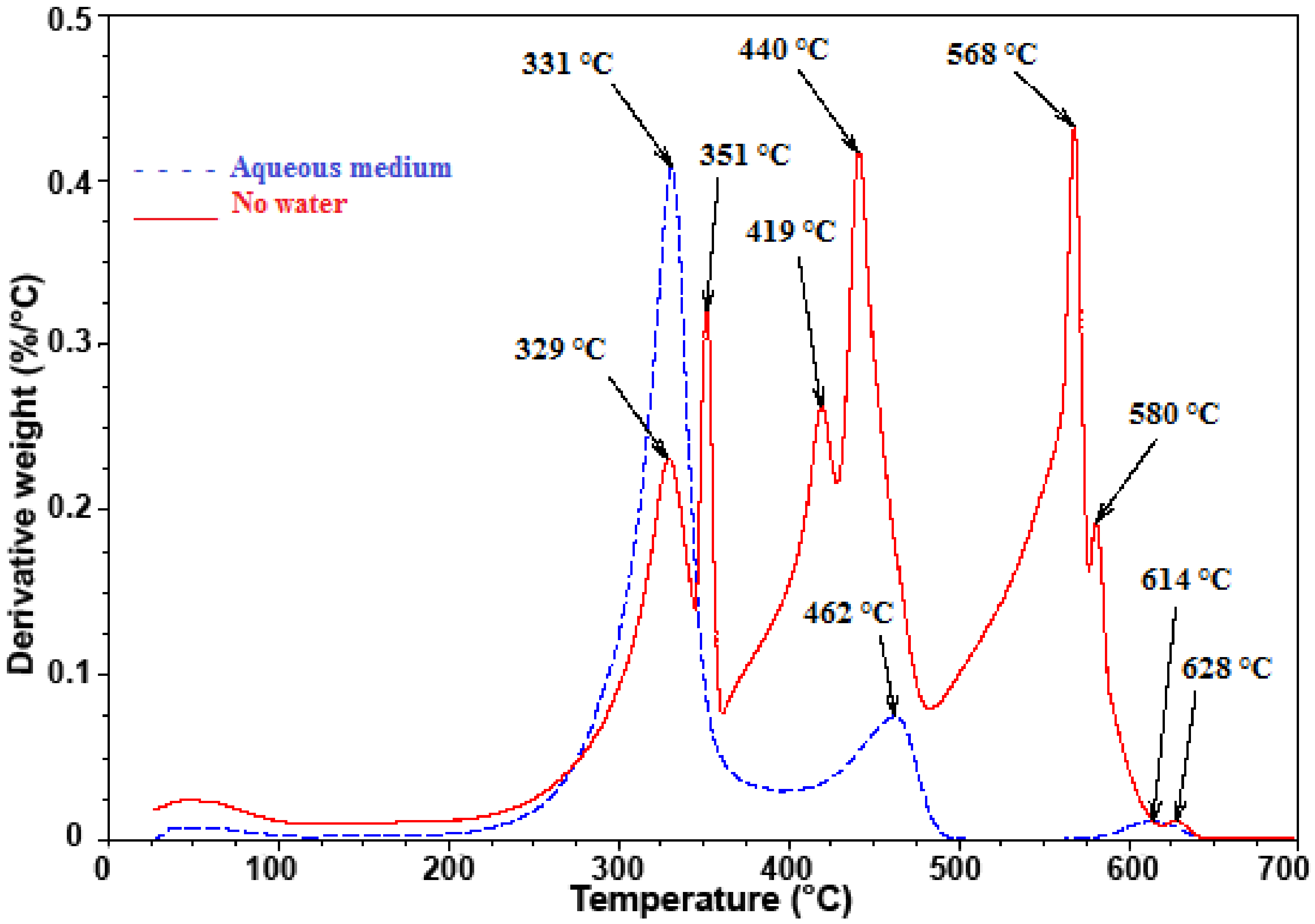
F.A. Agblevor, H. Jahromi “Aqueous phase synthesis of hydrocarbons from reactions of guaiacol and low molecular weight oxygenates”, ChemCatChem.

Synthesis of hydrocarbons: furfural reactions





Effect of aqueous phase on coke formation



Reaction of Guaiacol + Acetic acid

Conclusion

- One-pot carbonyl alkylation-hydrodeoxygenation for production of liquid hydrocarbons from catalytic pyrolysis oil was demonstrated
- Synthesis of C_6 to C_{15} hydrocarbons through unique catalytic activity was the origin of the hydrocarbons from the catalytic pyrolysis oils
- The composition of the upgraded catalytic pyrolysis oil hydrocarbons were similar to those found in petroleum jet fuels
- Aqueous medium reduced coke formation and made separation of products very easy
- 100% conversion, high selectivity, and excellent yield were achieved

Acknowledgement

- USTAR Program is acknowledged for funding support.
- Western Sun Grant Program is acknowledge for funding support

THANK YOU!

Upgrading techniques

- Bio-oil negative properties
- Steam reforming
- Supercritical fluids
- Esterification
- Hydrodeoxygenation (HDO)