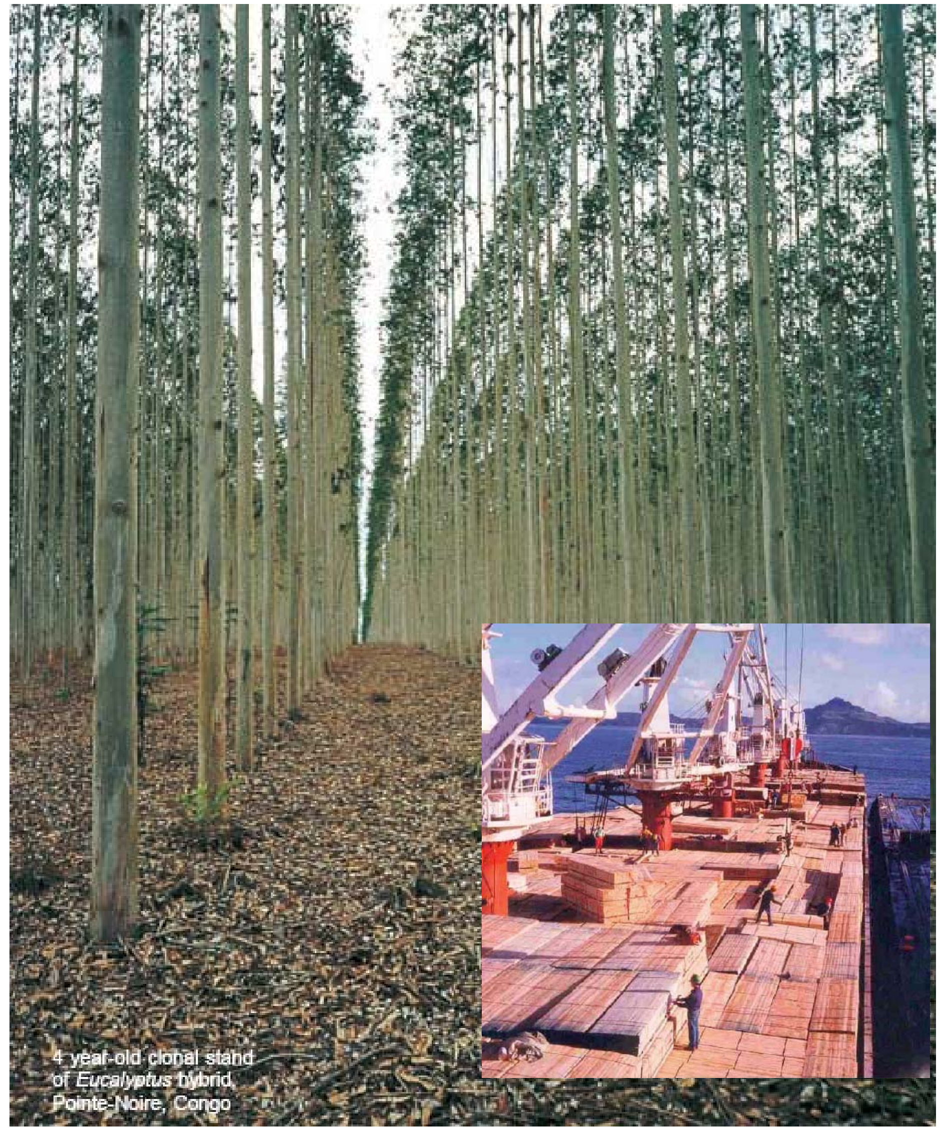
Most Abundant Bio Feedstocks

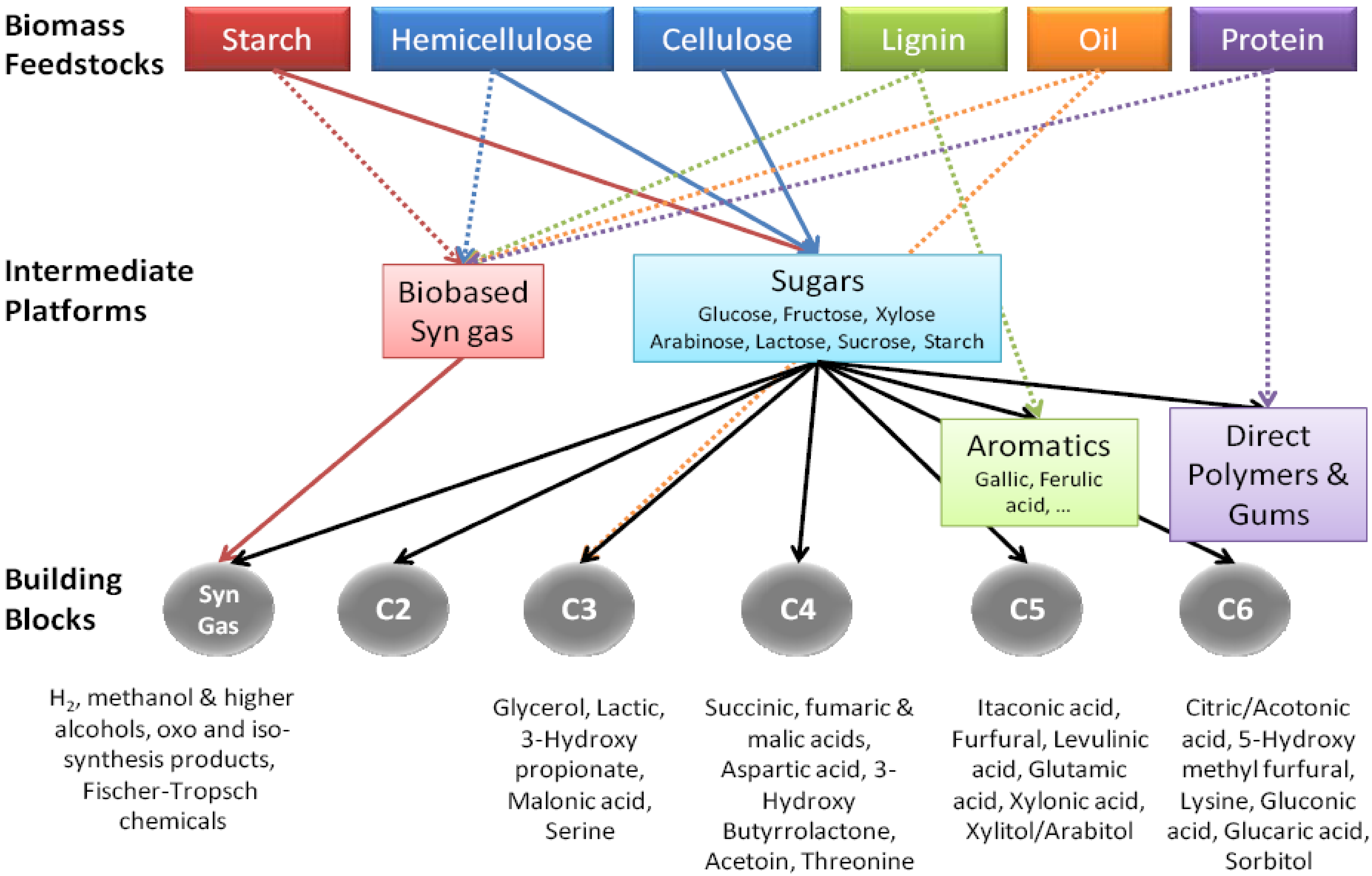
– depending on geographical location and local politics

- Trees
- Forest residues
- Grasses
- Agricultural crops
- Animal waste
- Municipal waste
- Algae (Alger, Levä)

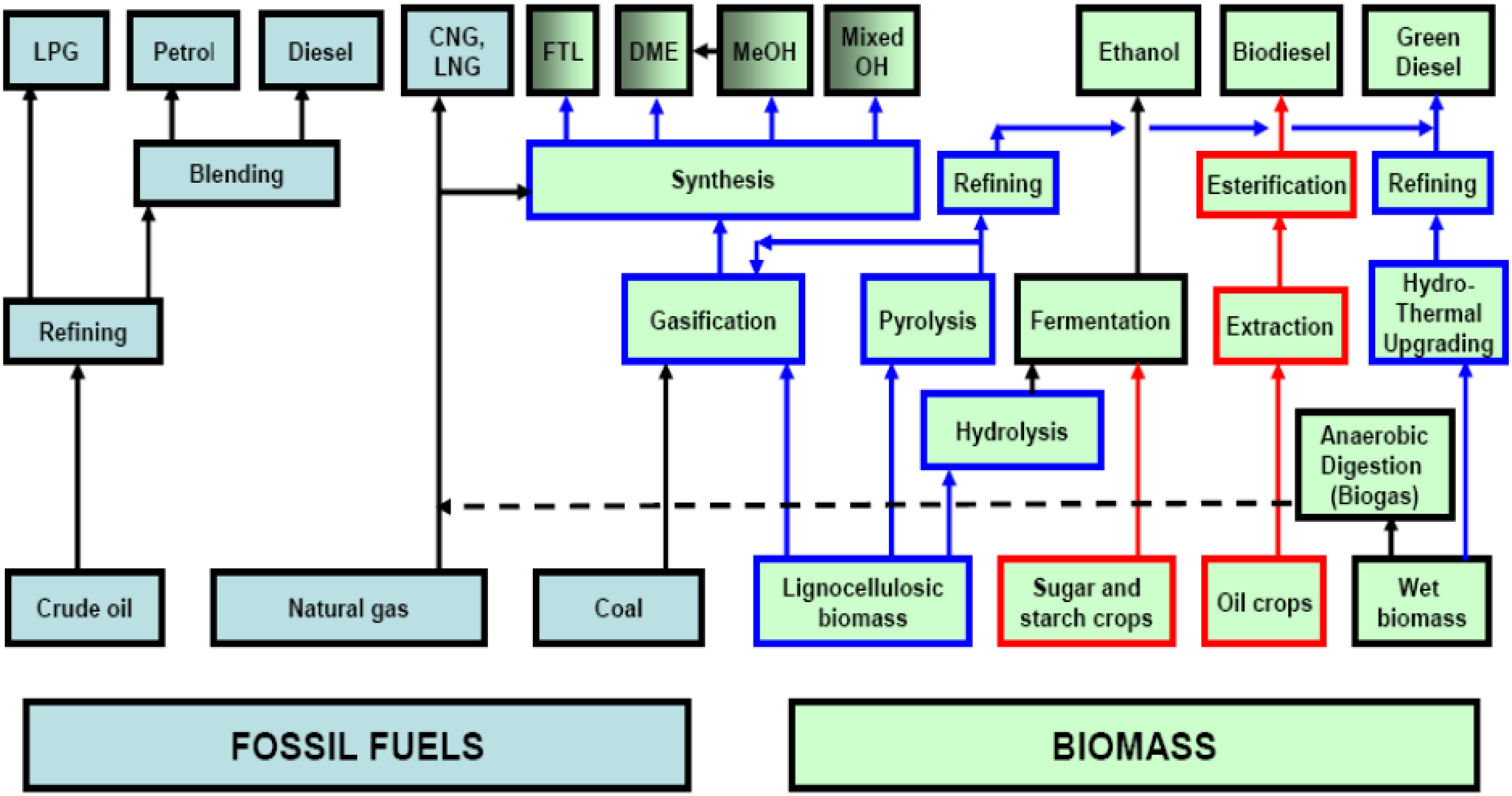


www.cifor.cgiar.org/publications/
pdf_files/Books/ForestPerspective.pdf

Product flow-chart for biomass feedstocks



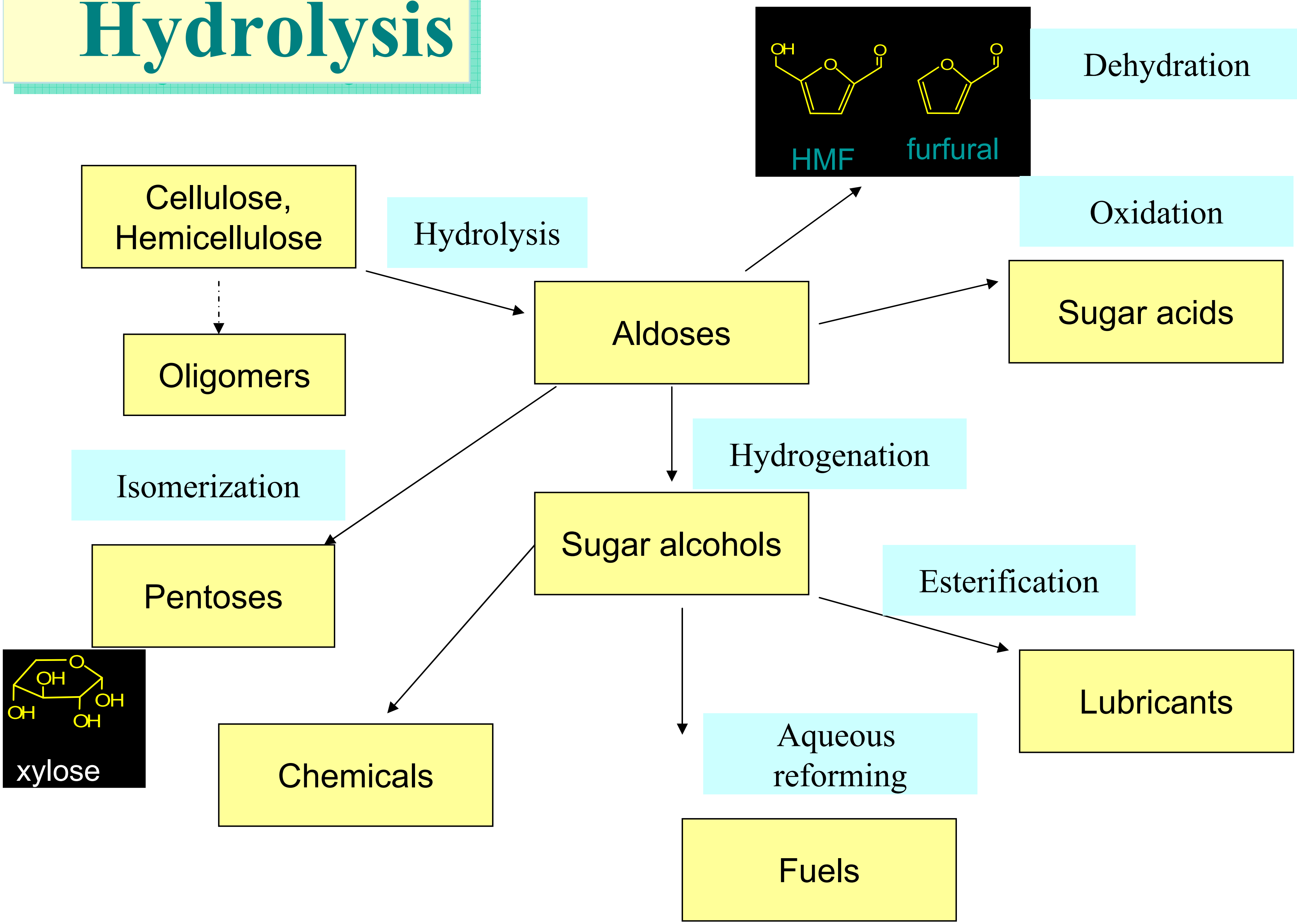
Biofuel production pathways



Treatment of wood

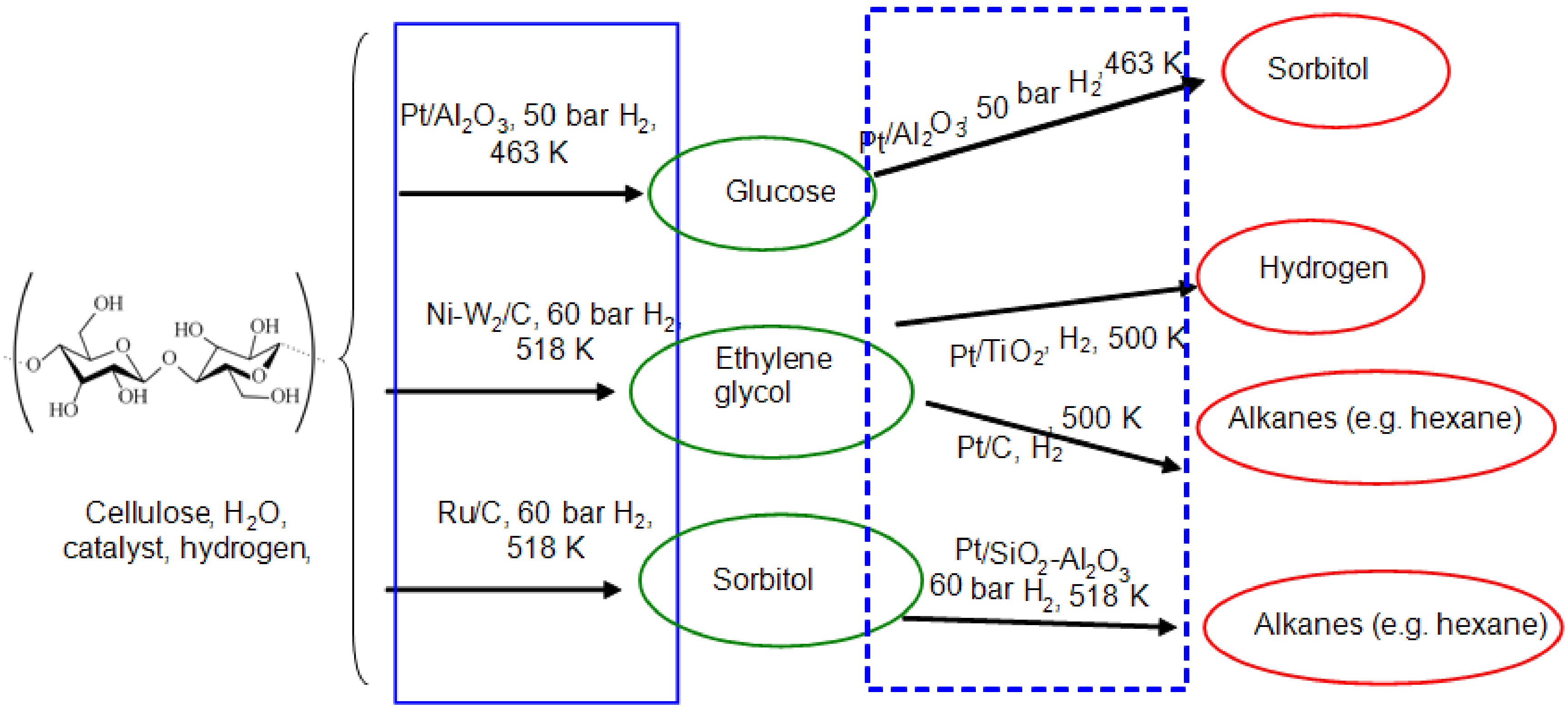
- **Gasification**
- **Pyrolysis**
- **Depolymerization** to get low molecular mass components (sugars, phenols, furfurol, etc.), e.g. **building blocks**
- **Delignification (cellulose, derivatives, paper)**
- **Extraction of valuable chemicals (bioactive components)**

Hydrolysis



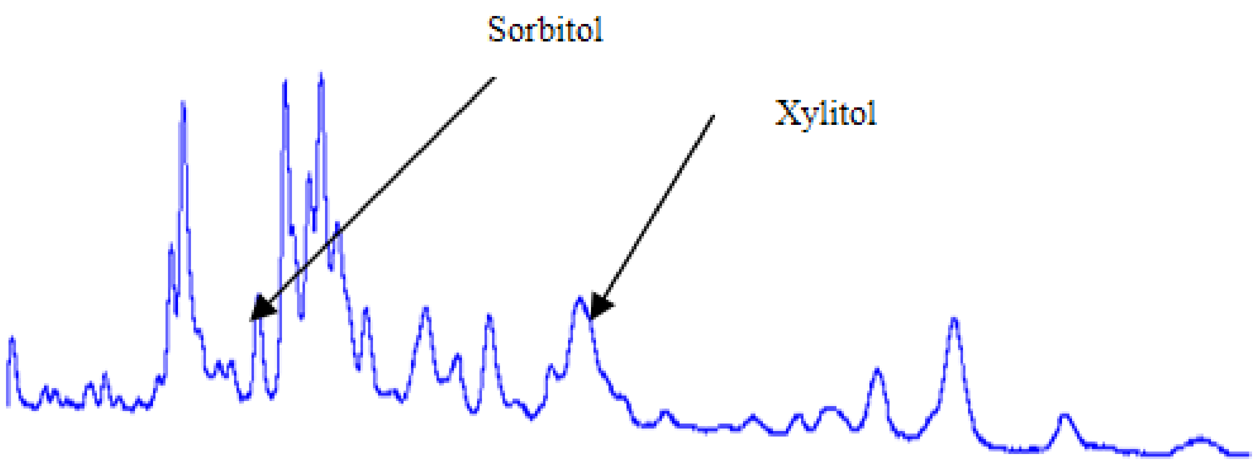
HMF
furfural
Dehydration
Cellulose, Hemicellulose
Hydrolysis
Oxidation
Aldoses
Sugar acids
Oligomers
Hydrogenation
Isomerization
Sugar alcohols
Esterification
Pentoses
OH
OH
OH
OH
xylose
Lubricants
Aqueous reforming
Chemicals
Fuels

Hydrolytic hydrogenation



A. Fukuoka, P.L. Dhepe, Angew. Chem. Int. Ed. **2006**, 45, 5161

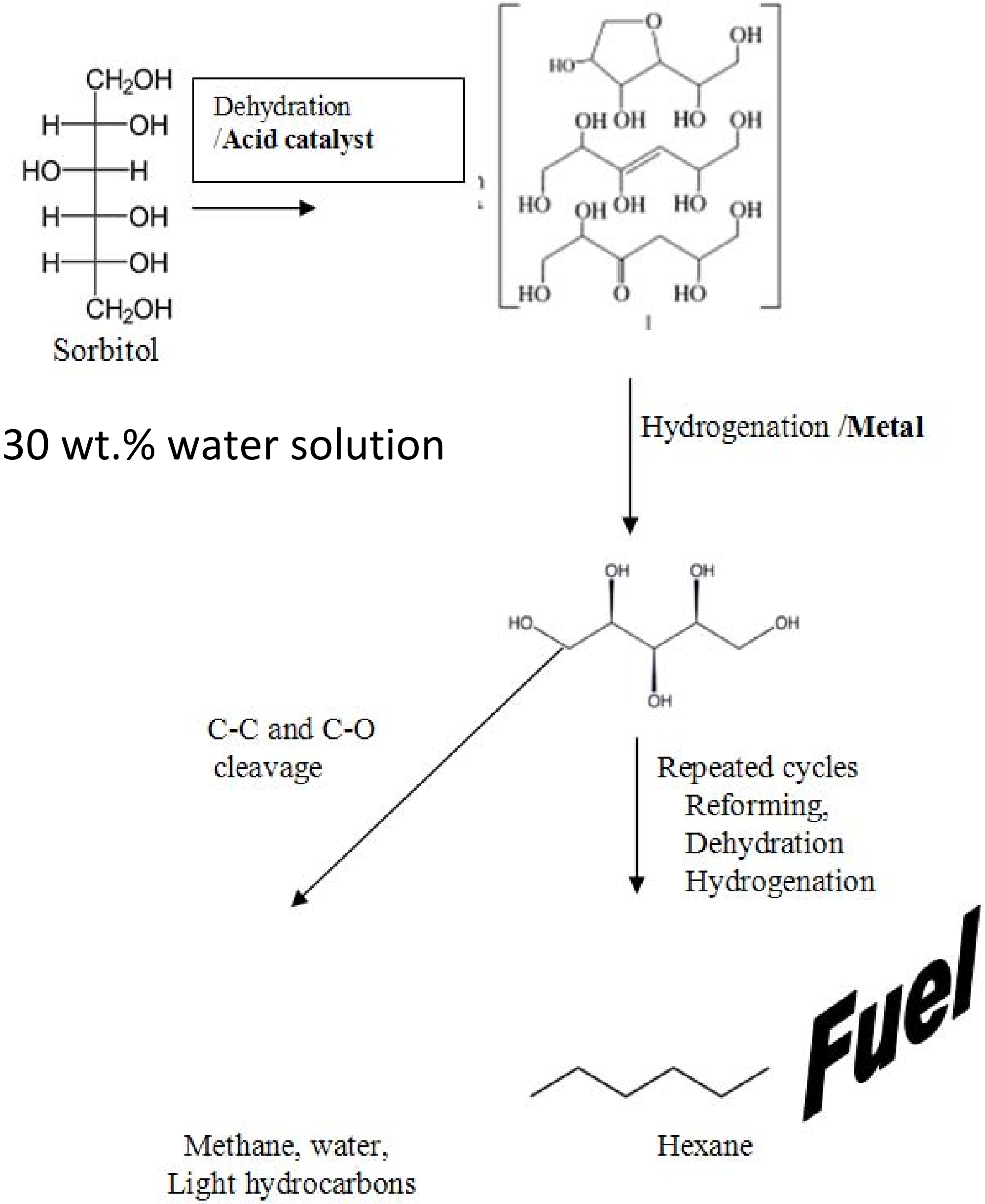
A. A. Balandin, N.A. Vasyunina, S.V. Chepigo, G. S. Barysheva, Doklady Akademii Nauk SSSR, **1959**, 128, 941



Hydrolytic hydrogenation of cellulose on Pt-MCM-48

M. Käldström

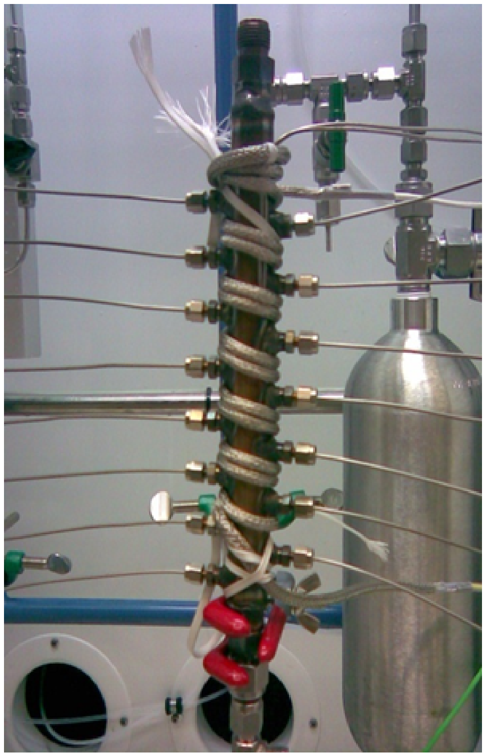
Aqueous phase reforming

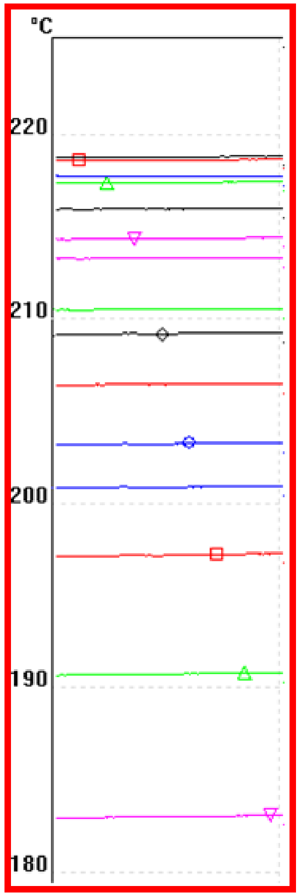


10-30 wt.% water solution

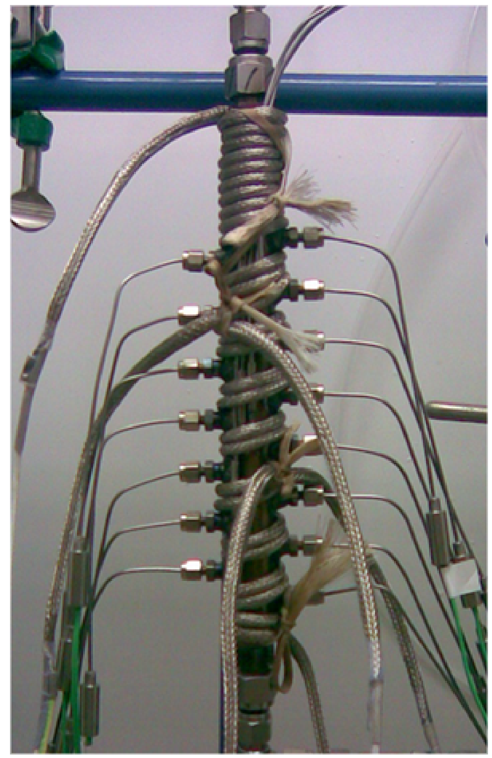
A. Tokarev, A. Kirilin

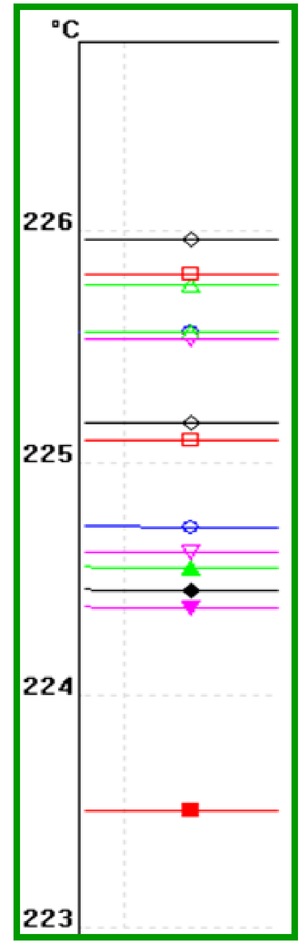
Initial state: 1 heater

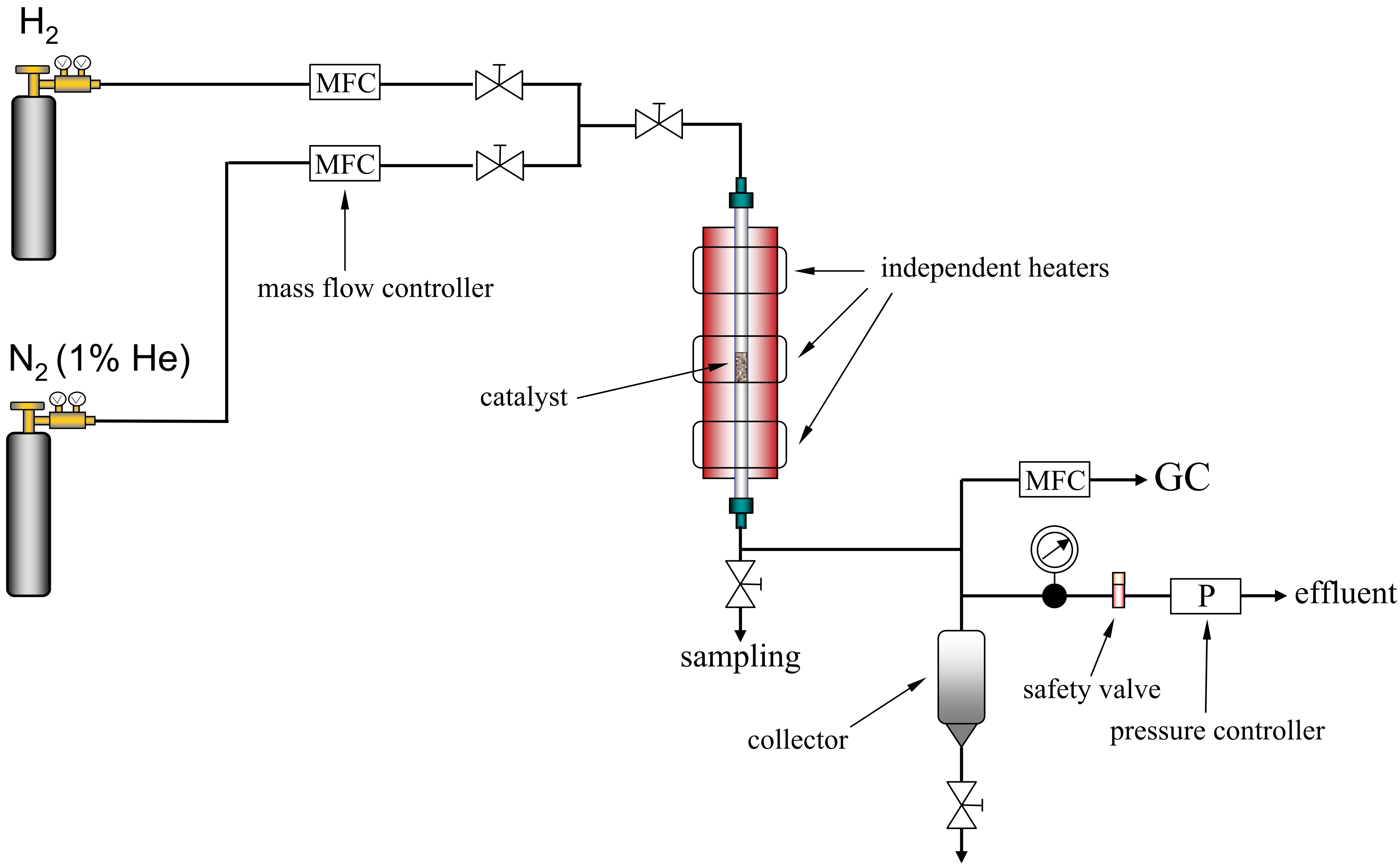




Current state:
3 independent heaters

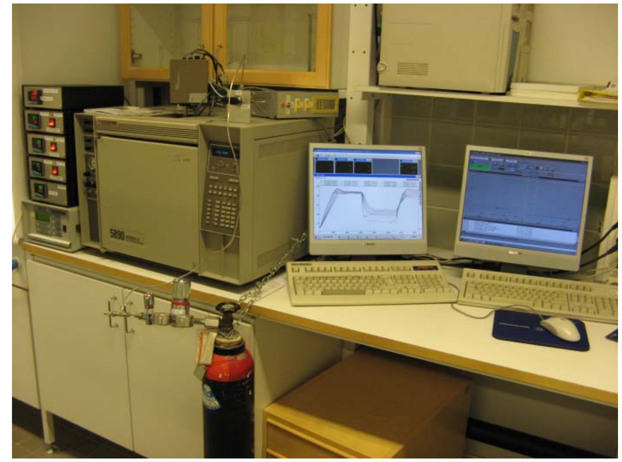




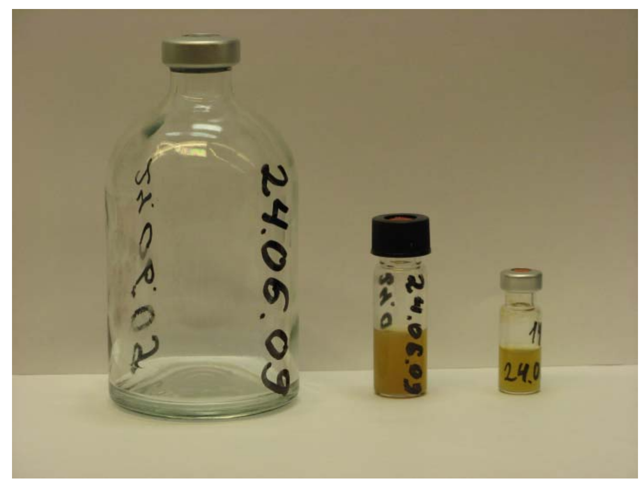

H2
N2 (1% He)
MFC
MFC
mass flow controller
independent heaters
catalyst
MFC
GC
P
effluent
sampling
collector
safety valve
pressure controller

Analysis of products

3rd version

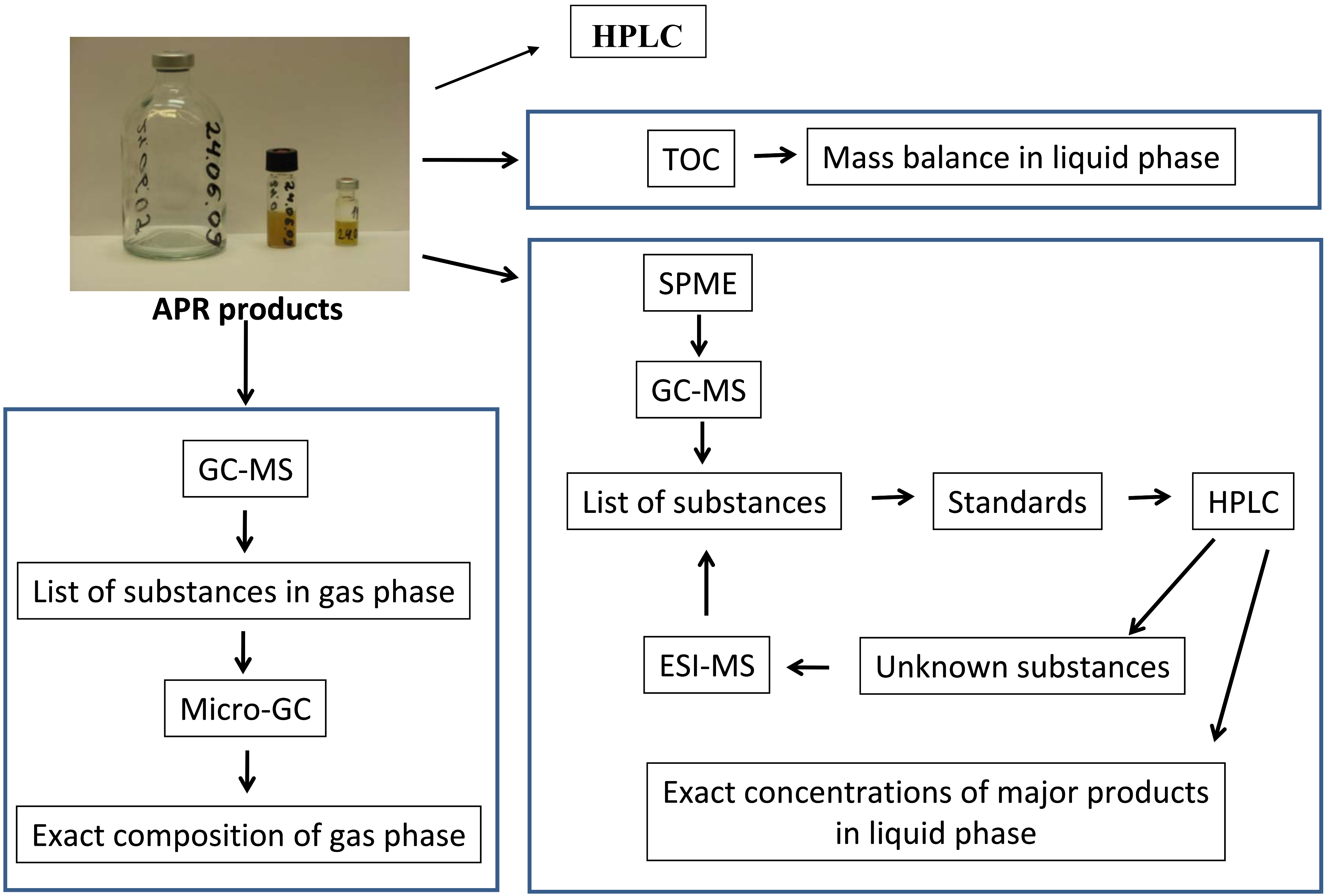


On-line



Off-line

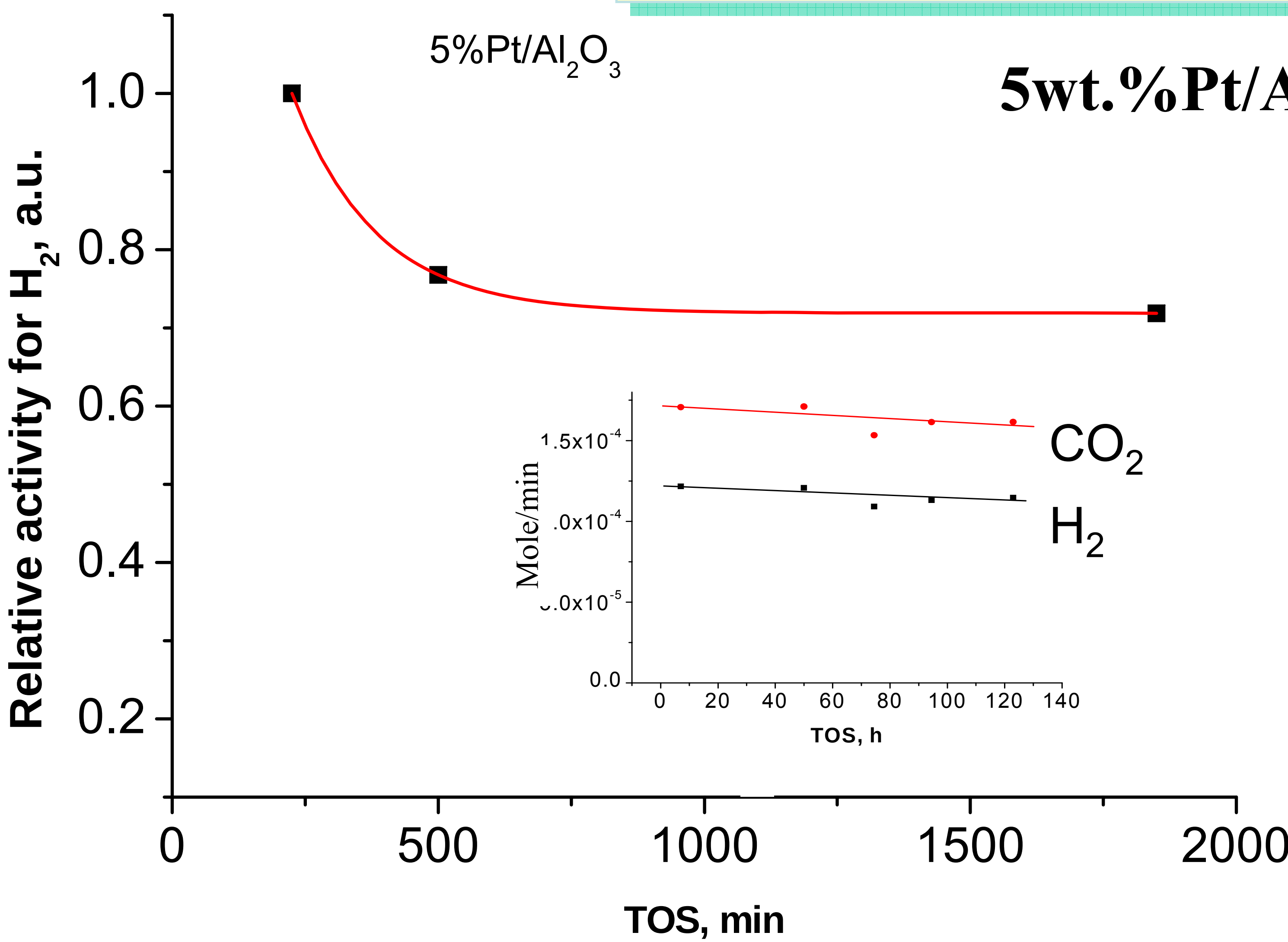
A. Tokarev



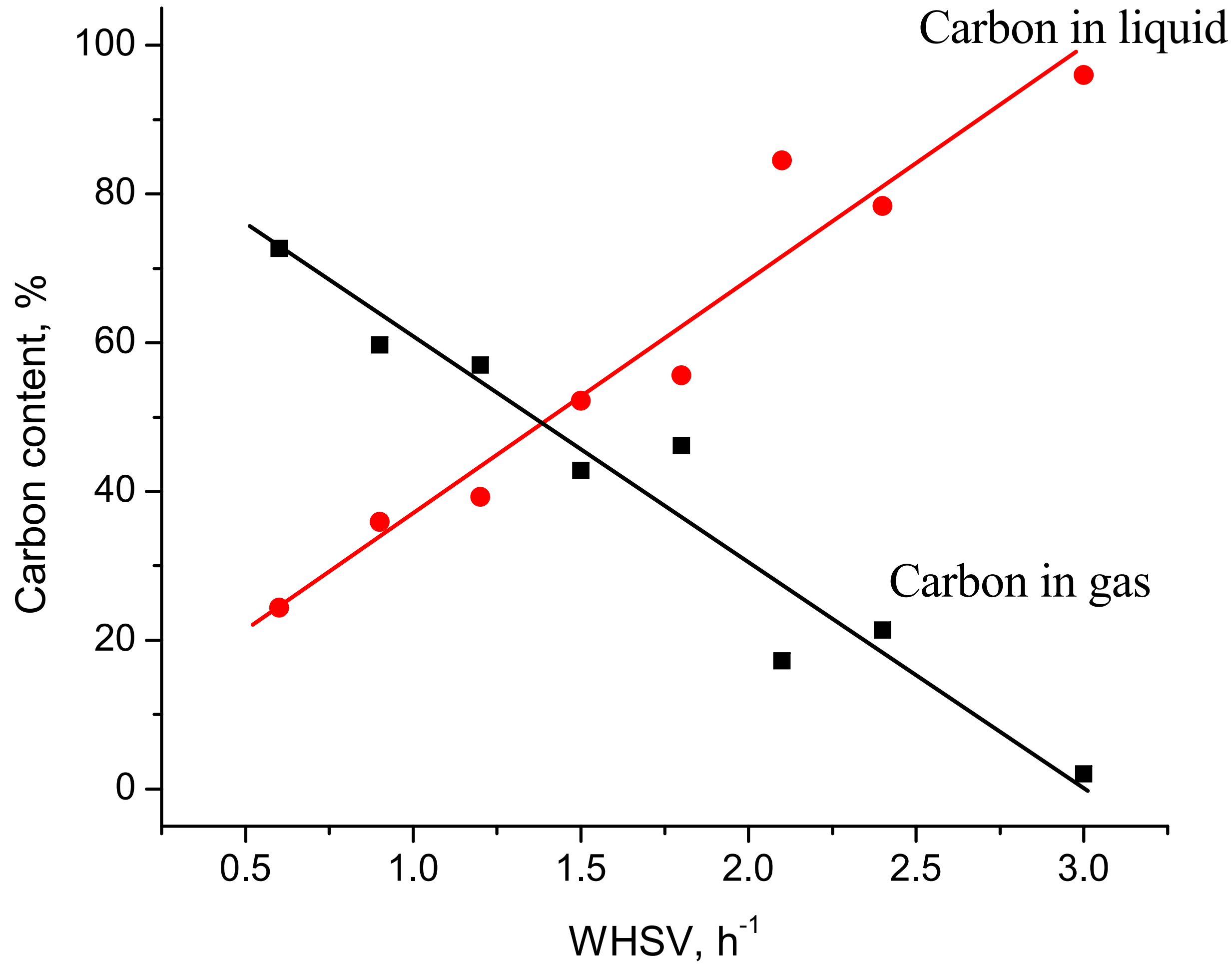
HPLC
TOC
Mass balance in liquid phase
APR products
SPME
GC-MS
List of substances
Standards
HPLC
ESI-MS
Unknown substances
Exact concentrations of major products in liquid phase
GC-MS
List of substances in gas phase
Micro-GC
Exact composition of gas phase

Time-on-stream

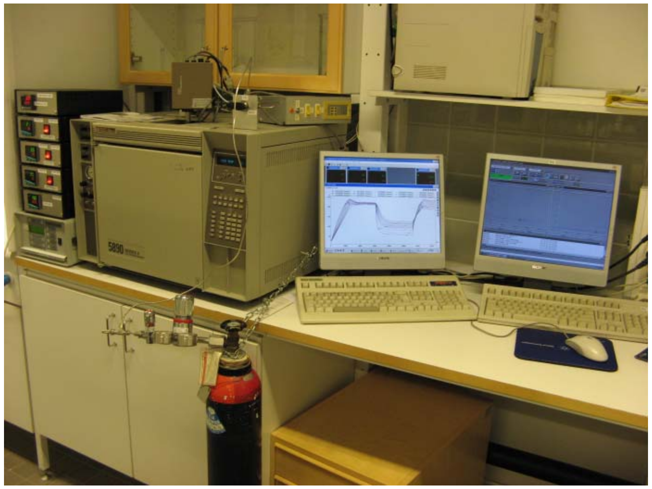
5wt.%Pt/Al$_2$O$_3$



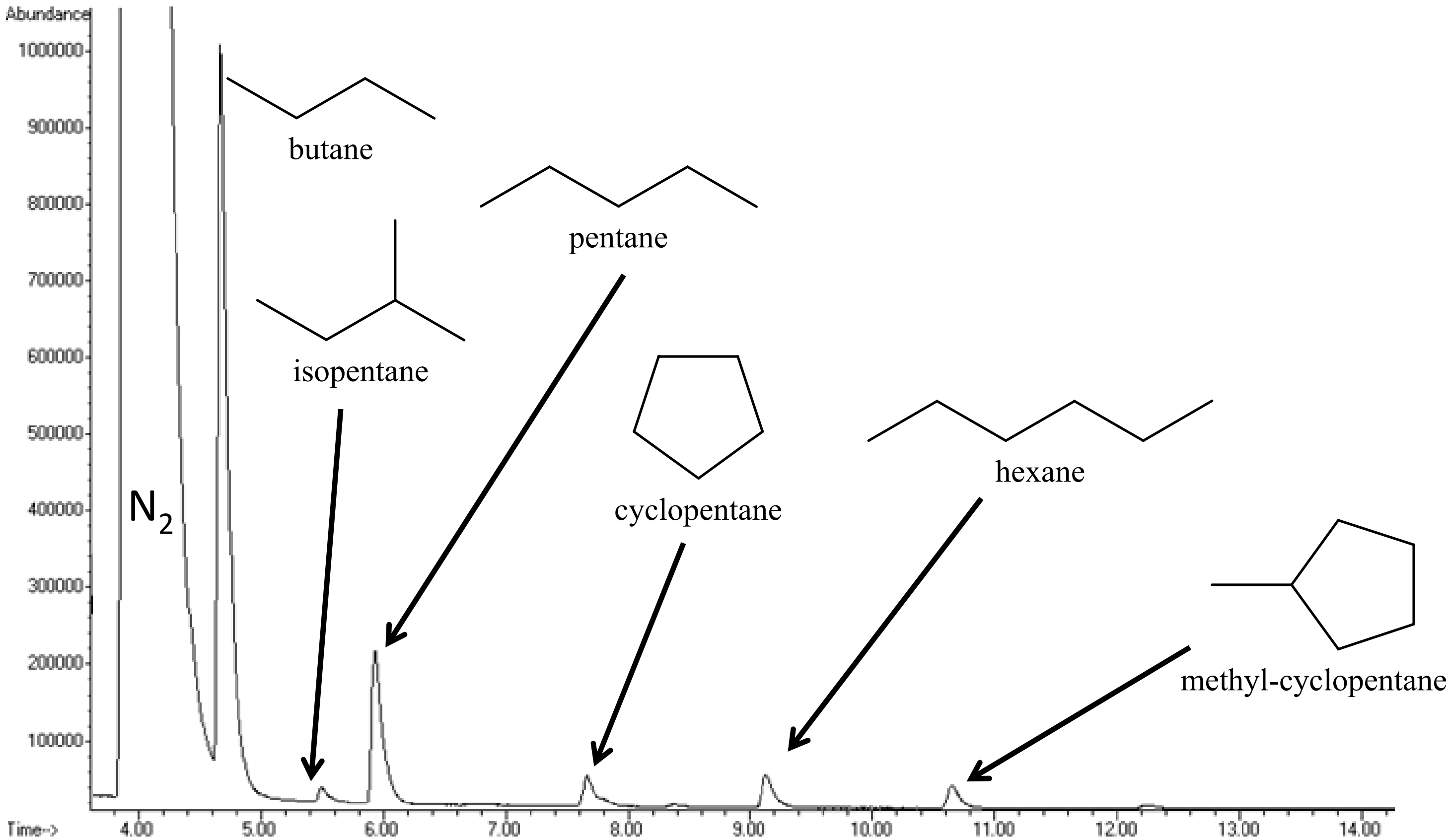
In-situ reduction at 250°C. V'(sorbitol) = 0.1ml/min, V'(N2) = 30 ml /min, 225°C



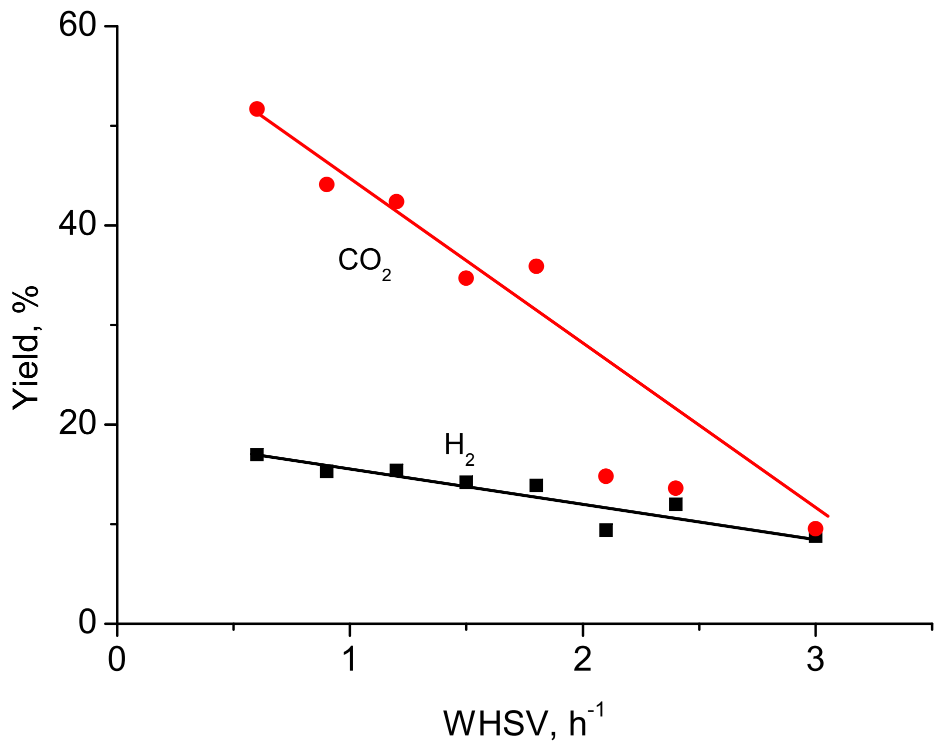
225°C, 29.3 bar, 10 wt.% sorbitol solution, 30 ml/min nitrogen flow rate.Pt/Al_2O_3

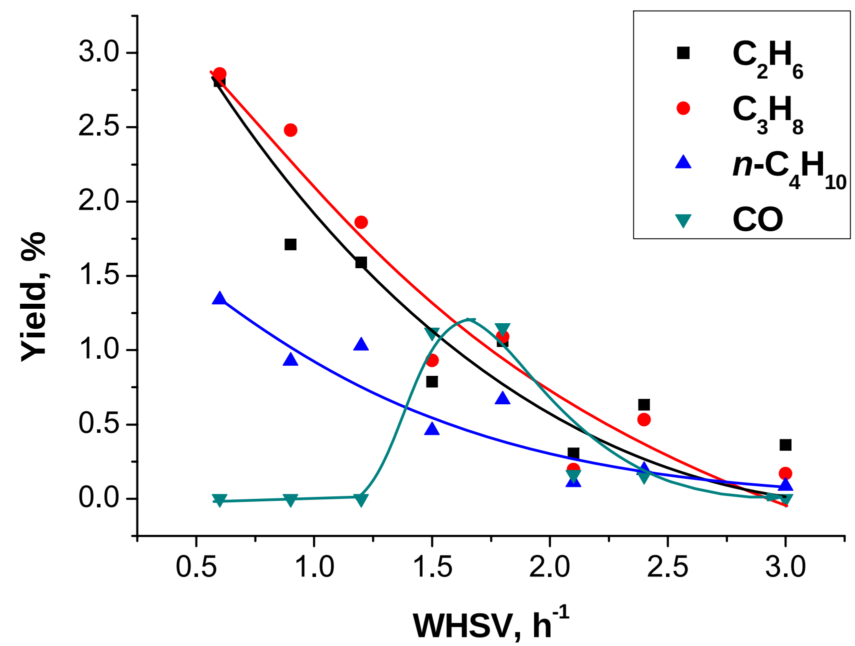


Gas-phase



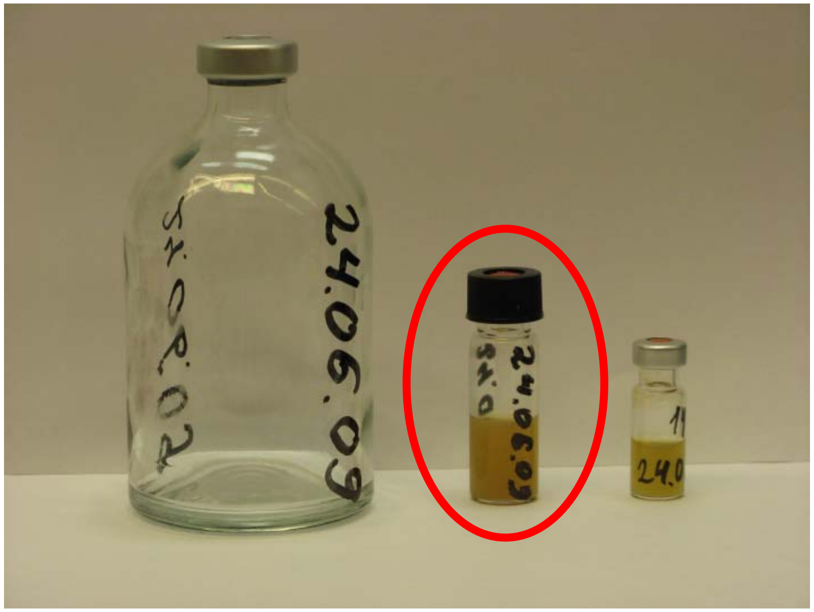
A. Tokarev

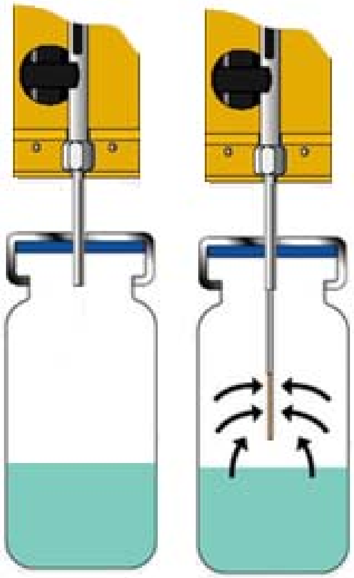




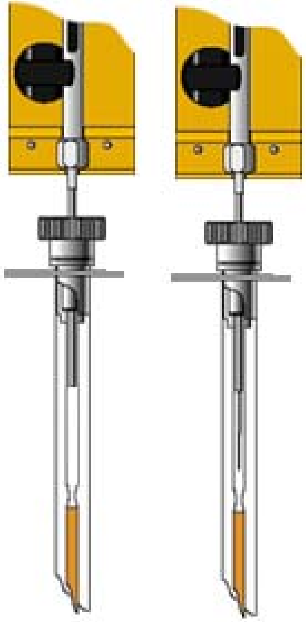
225°C, 29.3 bar, 10 wt.% sorbitol solution, 30 ml/min nitrogen flow rate.Pt/Al_2O_3

Soild phase micro extraction



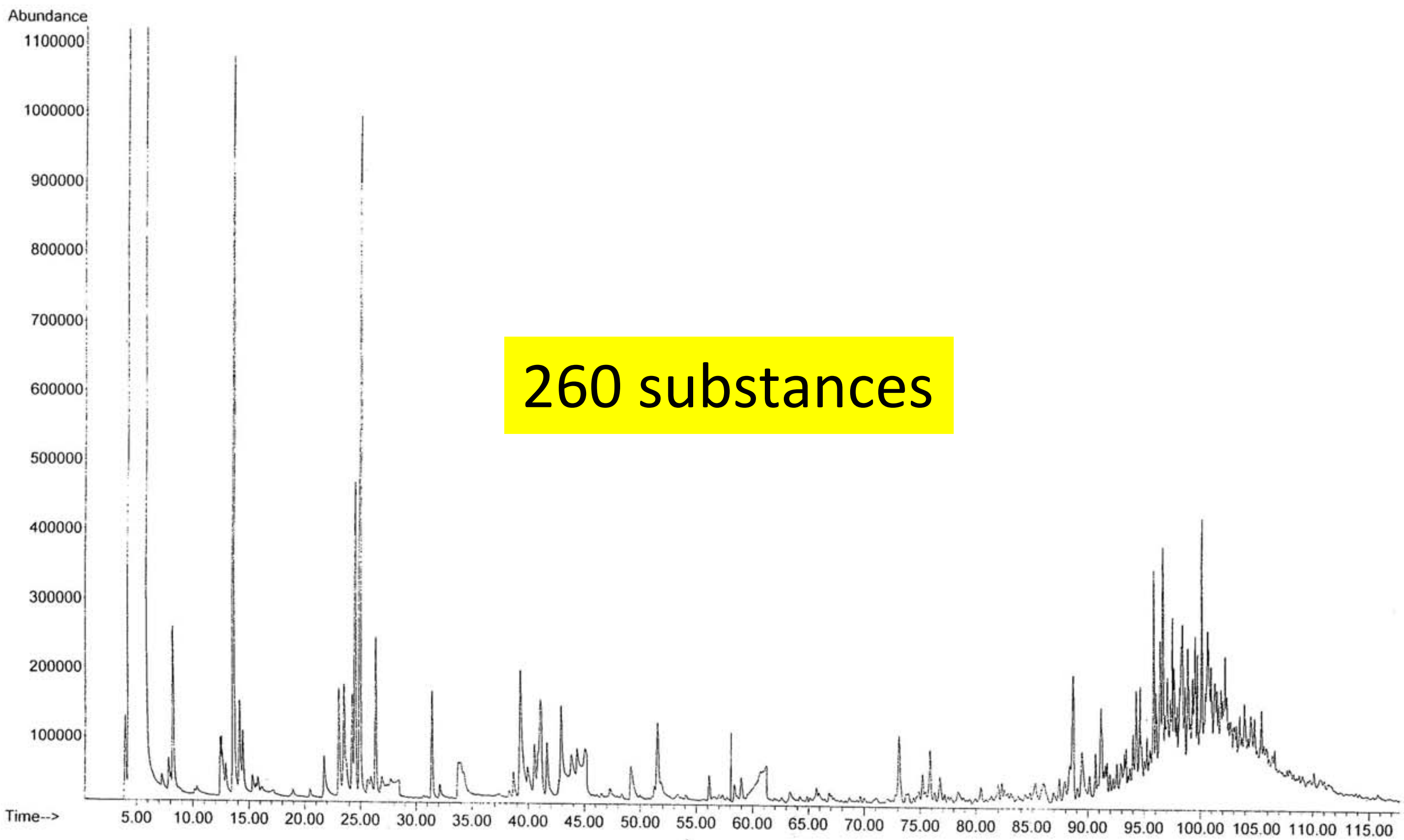


<u>Adsorption</u>
magnet stirrer
50 ^{o}C, 30 min

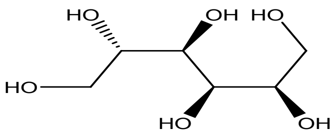


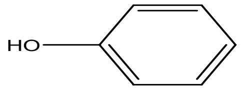
<u>Desorption</u>
T-ramp from 30 to
200^{o}C in 30 min

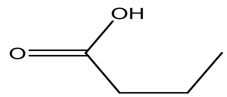
SPME & GC-MS

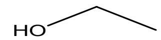

Abundance
1100000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
Time-->
5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00 55.00 60.00 65.00 70.00 75.00 80.00 85.00 90.00 95.00 100.00 105.00 110.00 115.00
260 substances

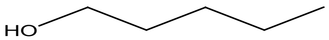
SPME & GC-MS: Top 25

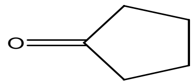

sorbitol

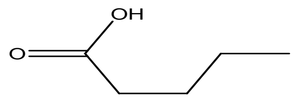

phenol

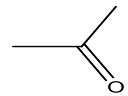

butanoic acid

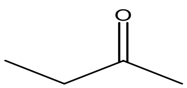

ethanol

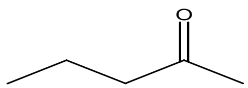

1-pentanol

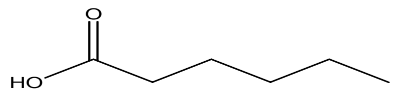

cyclopentanone

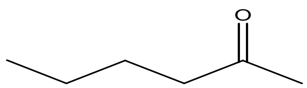

pentanoic acid

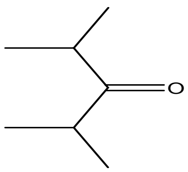

Acetone

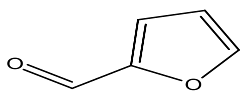

2-butanone

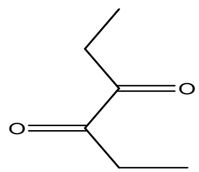

2-pentanone

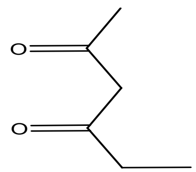

hexanoic acid

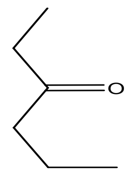

2-hexanone

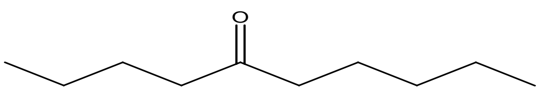

2.4-dimethyl 3-pentanone

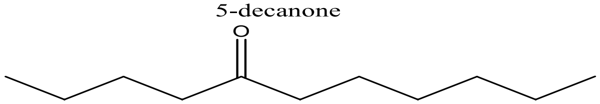

furfural

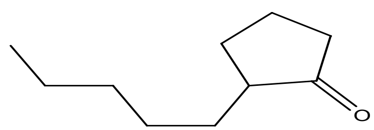

3.4-hexanedione

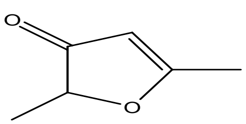

2.4-hexanedione

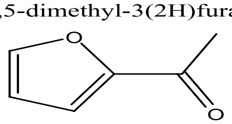

3-hexanone

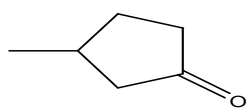

5-decanone

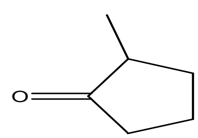

5-undecanone


2-pentylcyclopentanone

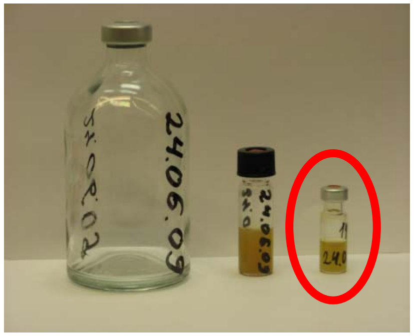

2,5-dimethyl-3(2H)furanone

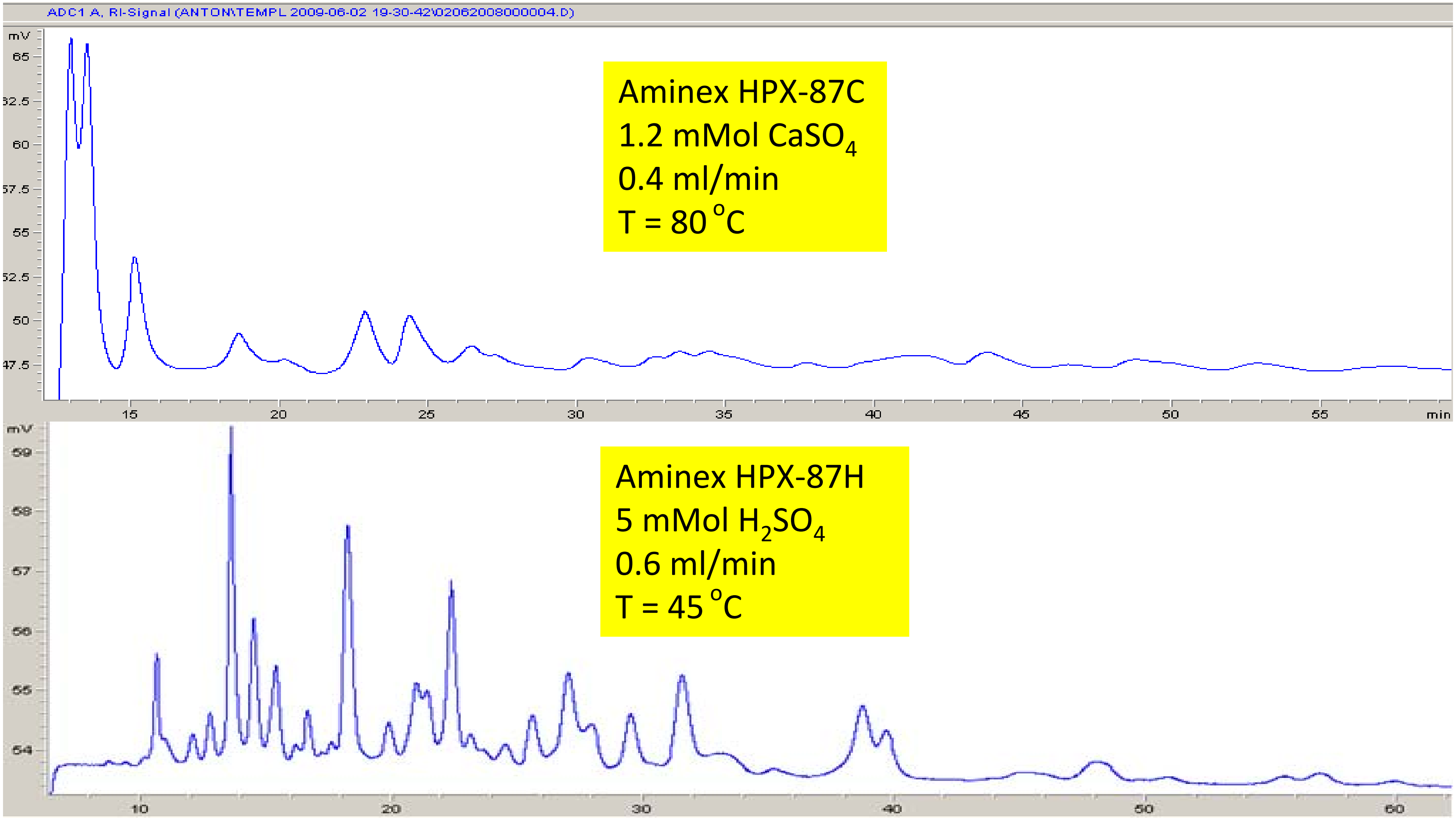

Ethanone, 1-(2-furanyl)-


3-methylcyclopentanone

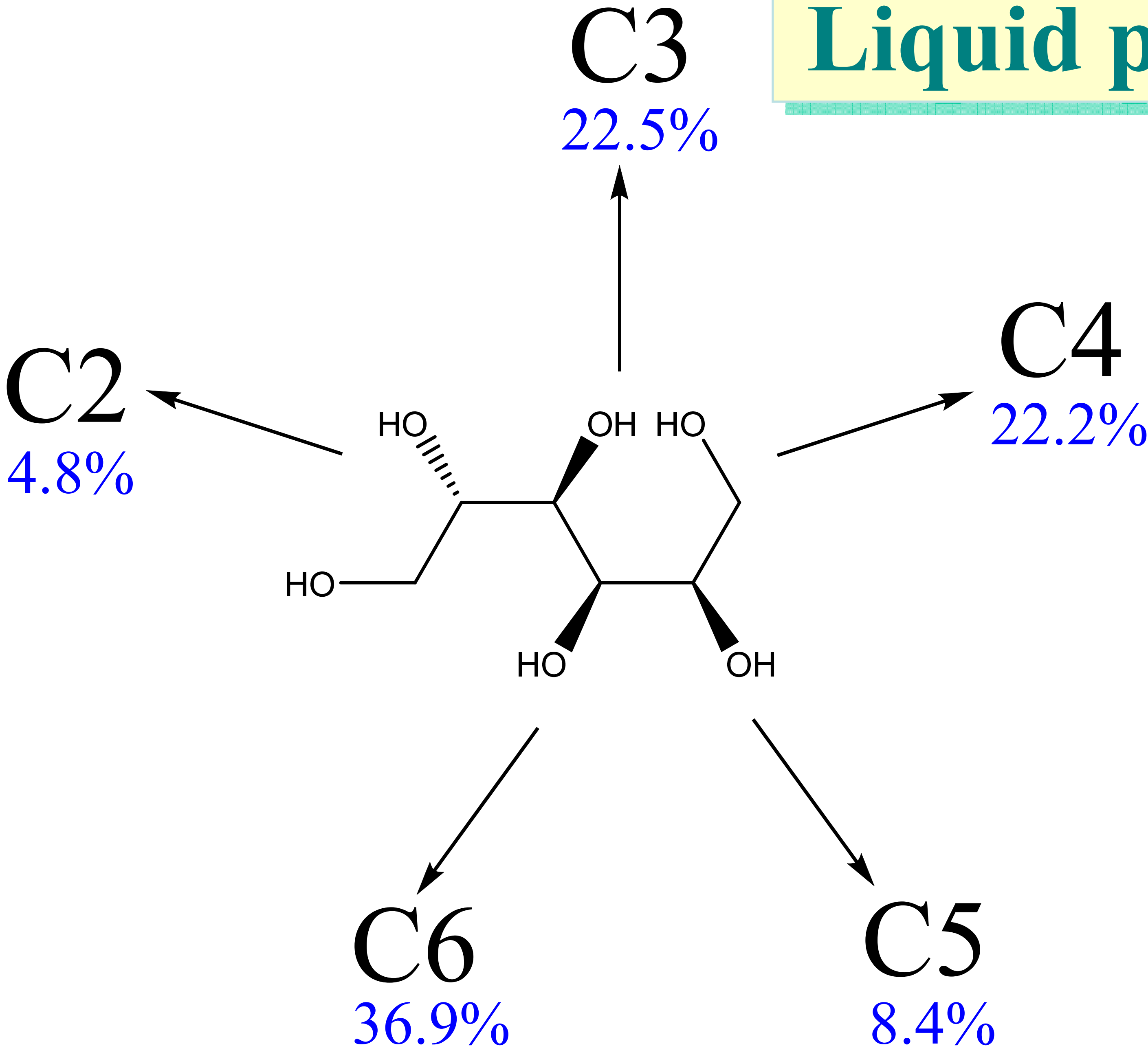

2-methylcyclopentanone

HPLC


24.06.09


ADC1 A, RI-Signal (ANTON\TEMPL 2009-06-02 19-30-42\02062008000004.D)
mV
min
Aminex HPX-87C
1.2 mMol $CaSO_4$
0.4 ml/min
T = 80 °C
Aminex HPX-87H
5 mMol H_2SO_4
0.6 ml/min
T = 45 °C

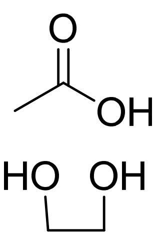
Liquid phase



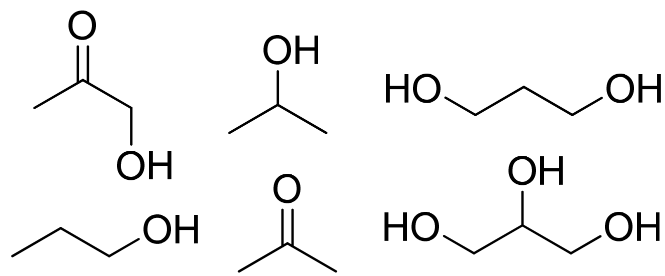
A. Kirilin

Liquid phase

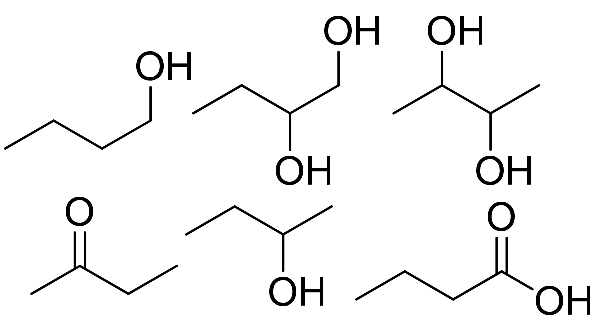
C2



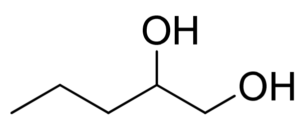
C3



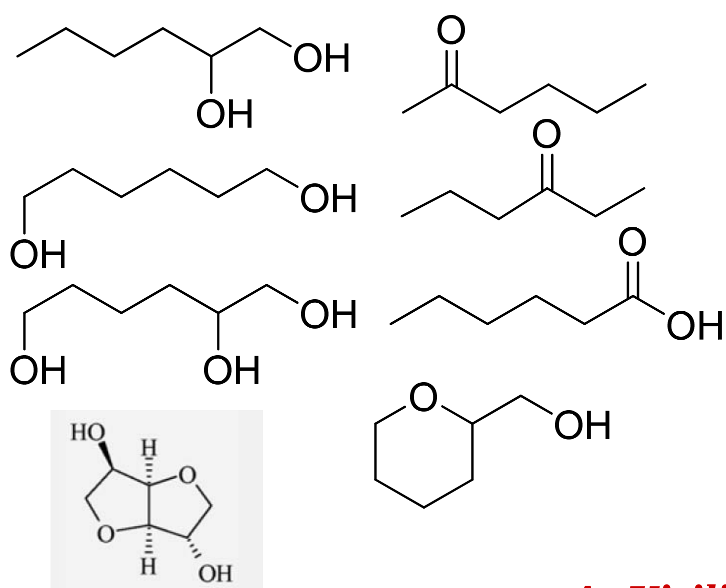
C4



C5



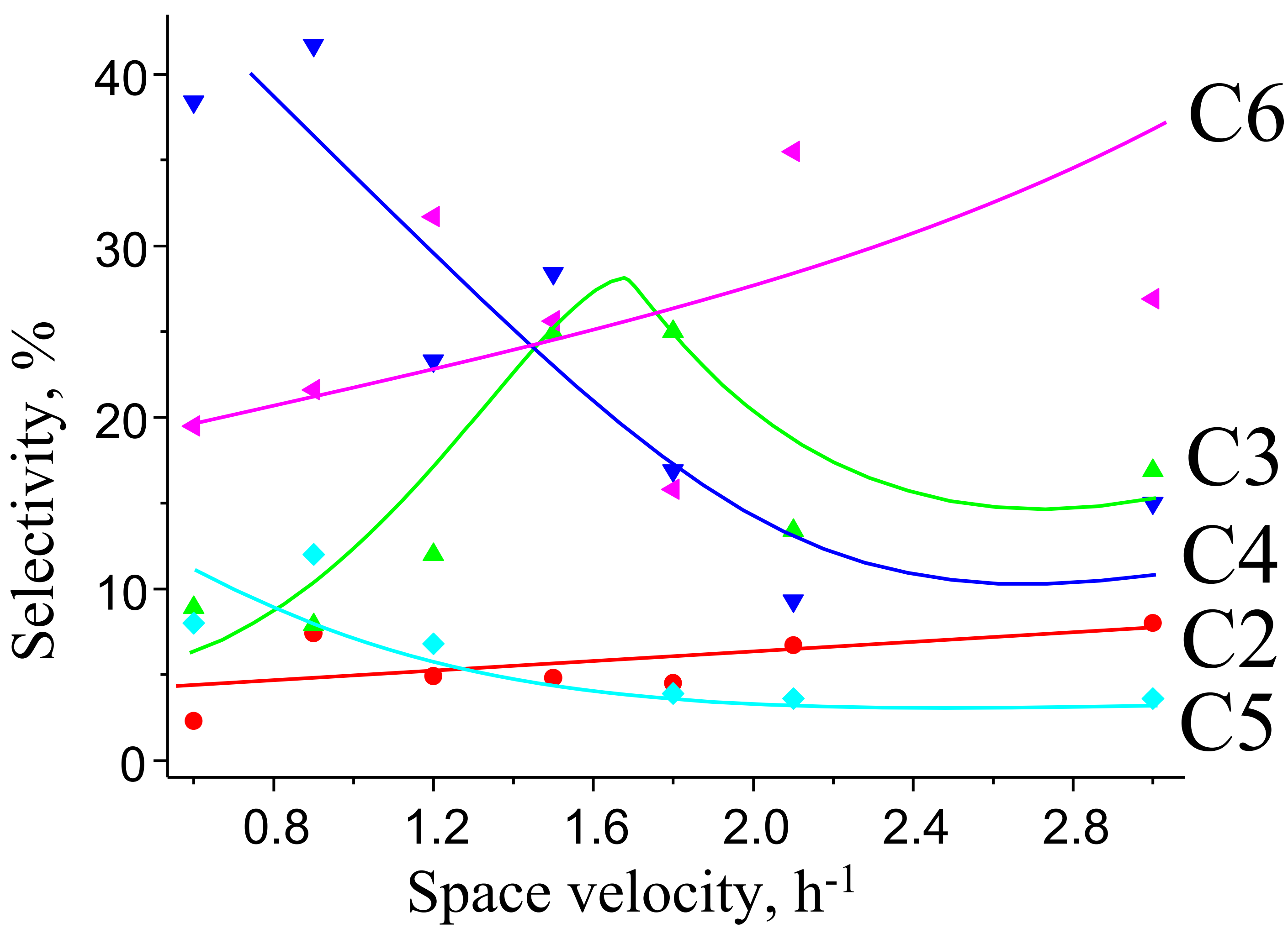
C6



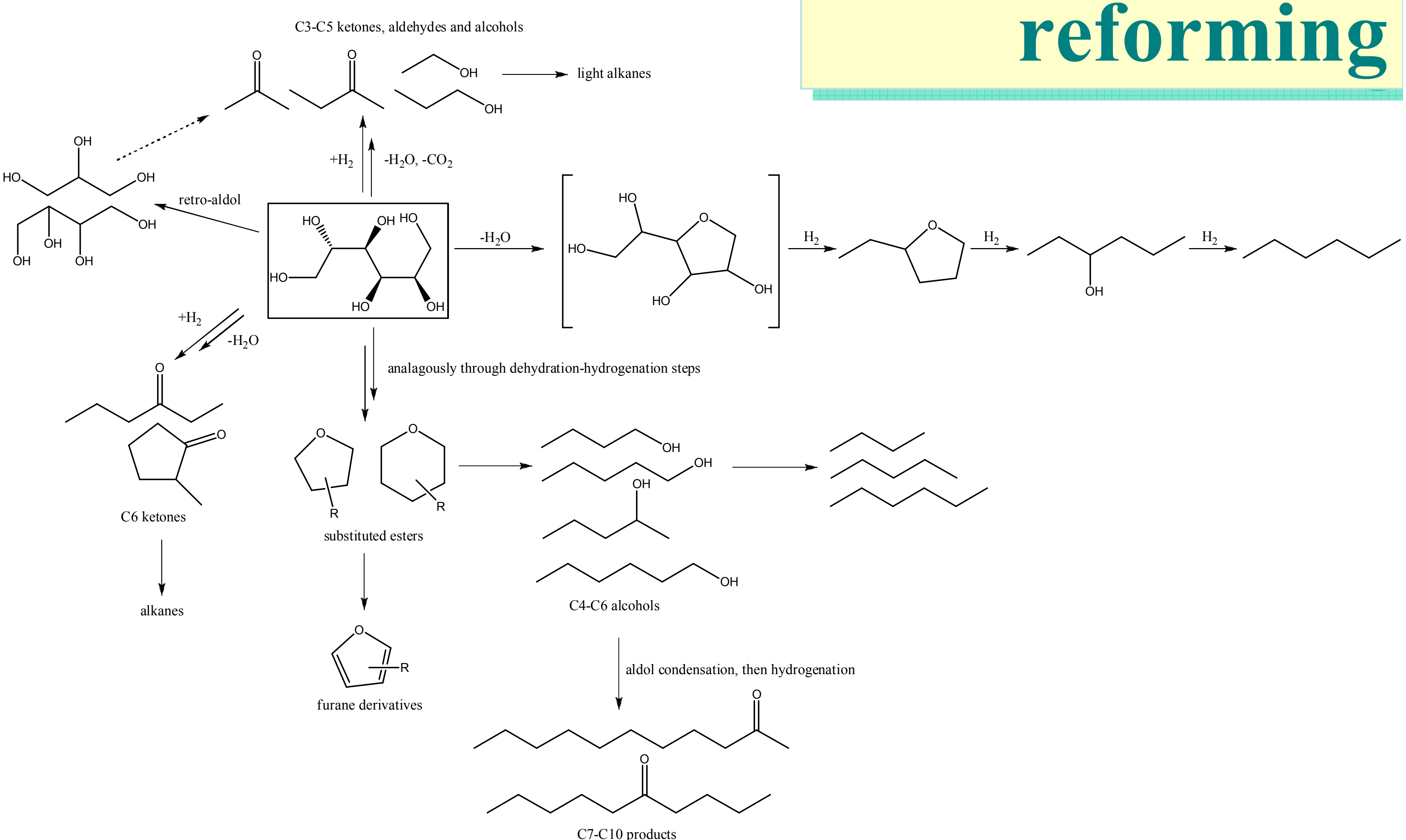
isosorbide

A. Kirilin

Liquid phase



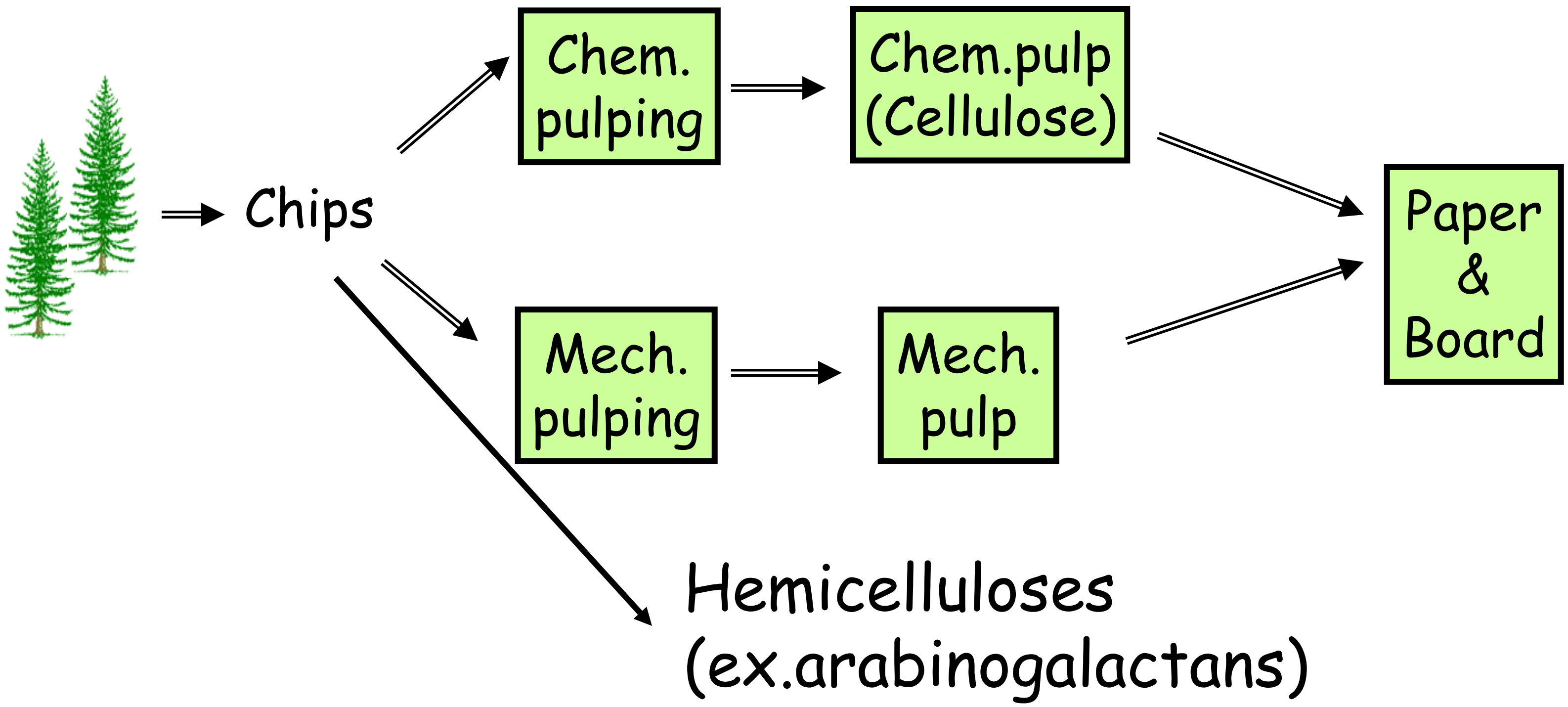
Aqueous phase reforming



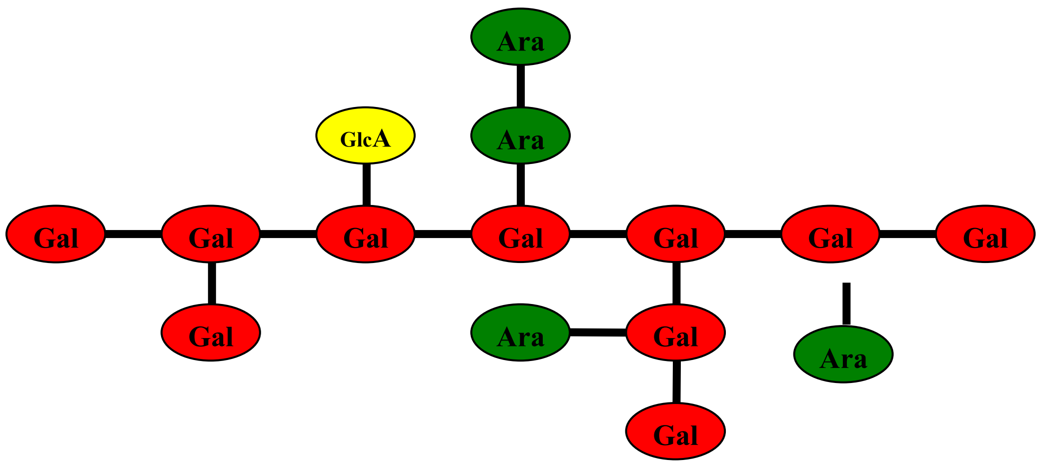
A. Kirilin

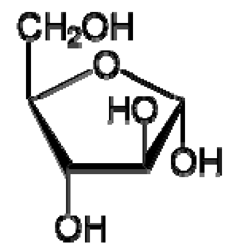
Hemicellulose

Many opportunities

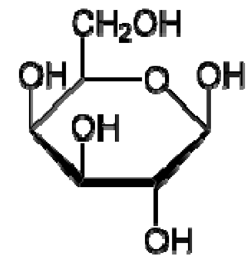


Arabinogalactans

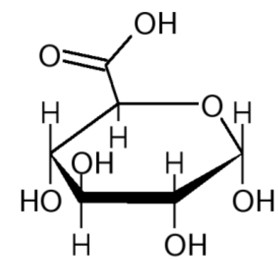




Ara



Gal

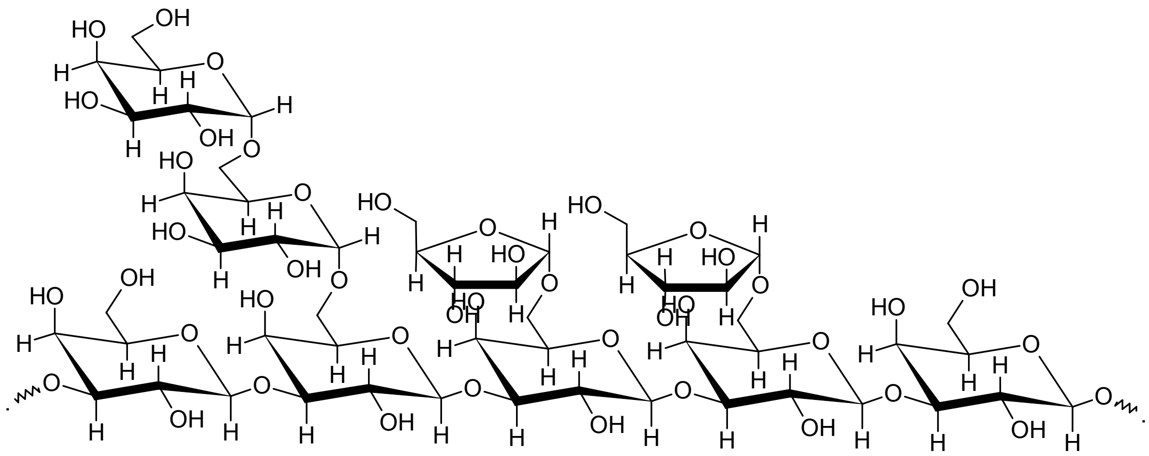


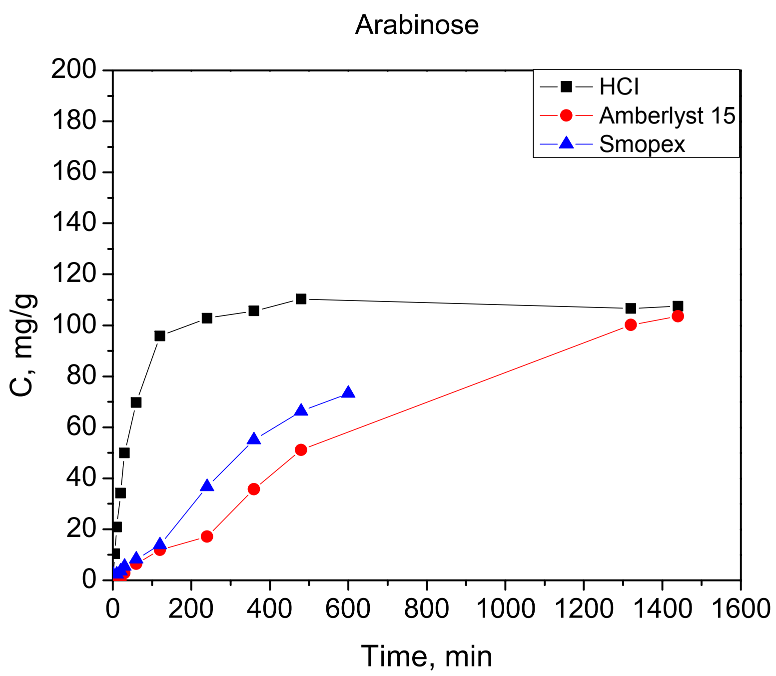
- Backbone: β-galactopyranose
- D-galactopyranose, L-arabinofuranose and D-glucuronic acid side chains.

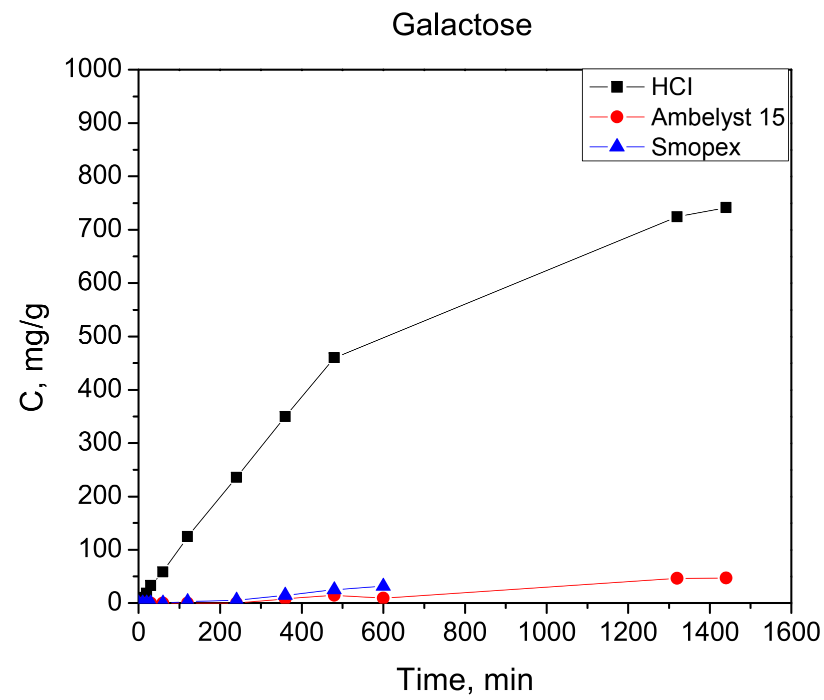
- **Potential for many products !**

Ara:Gal:GlcA ~ 19:80:2
Molar mass 20,000 – 100,000

Hydrolysis



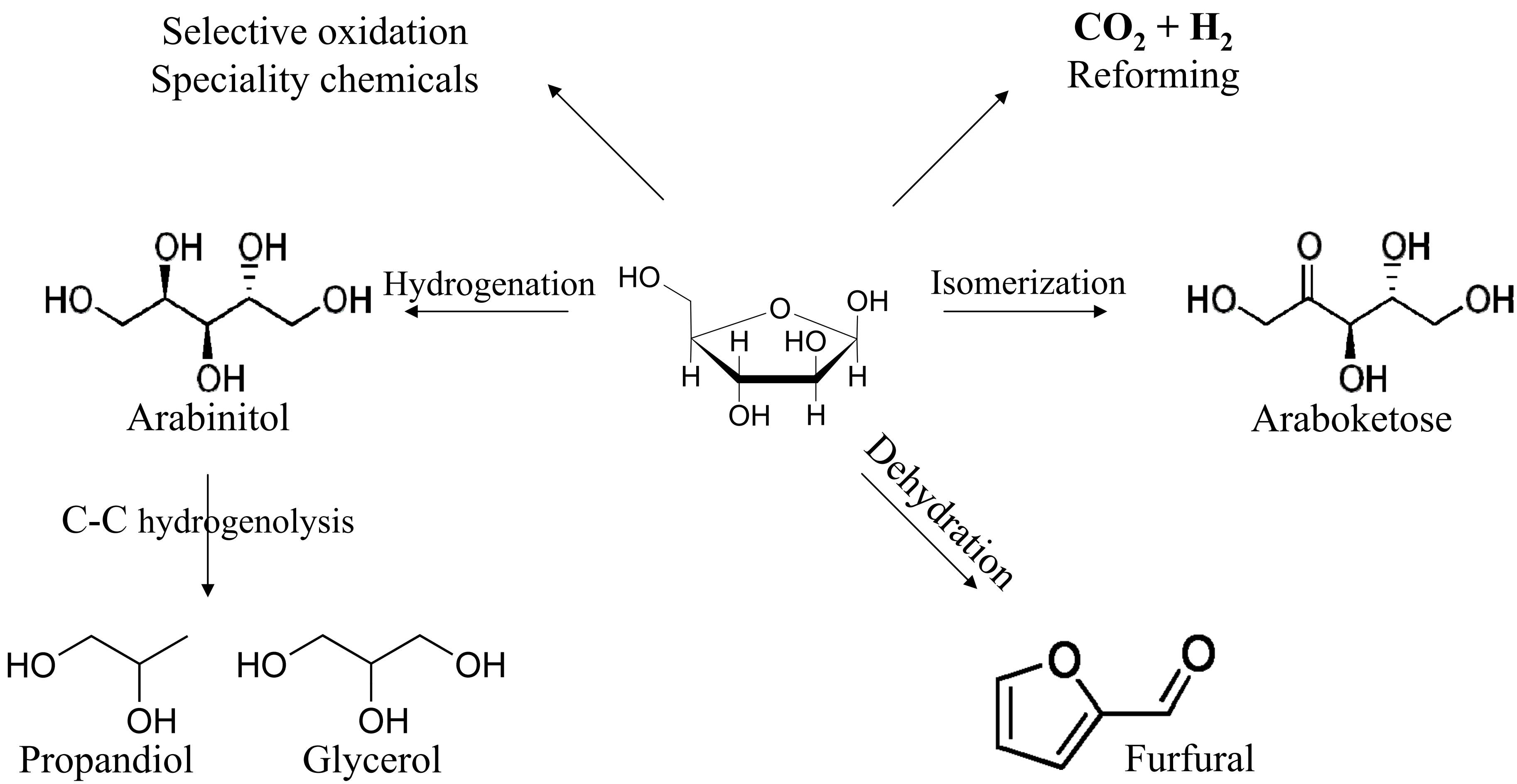




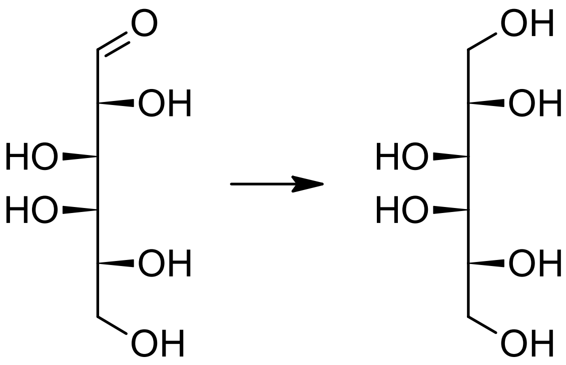
Selective cleavage

B. Kusema

Transformation of monomers



Hydrogenation

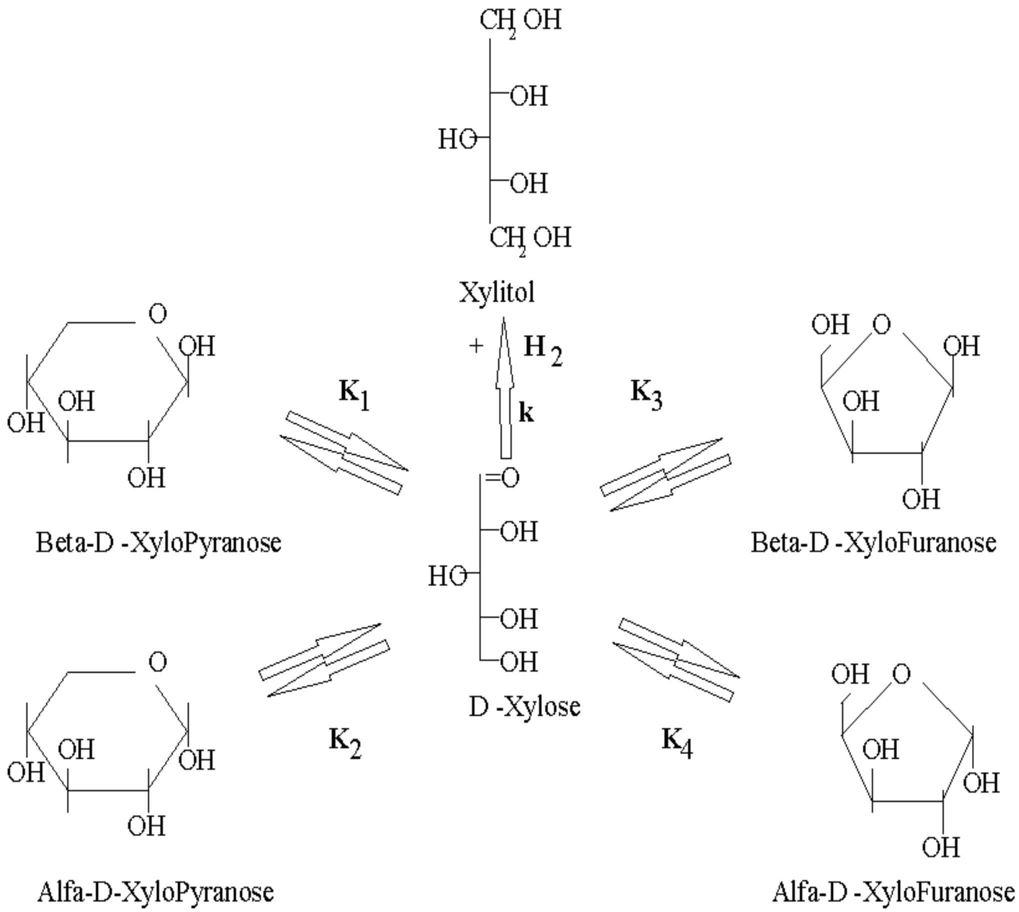


D-Galactose D-Galactitol

V. Sifontes

Ru/C (Sibunit)

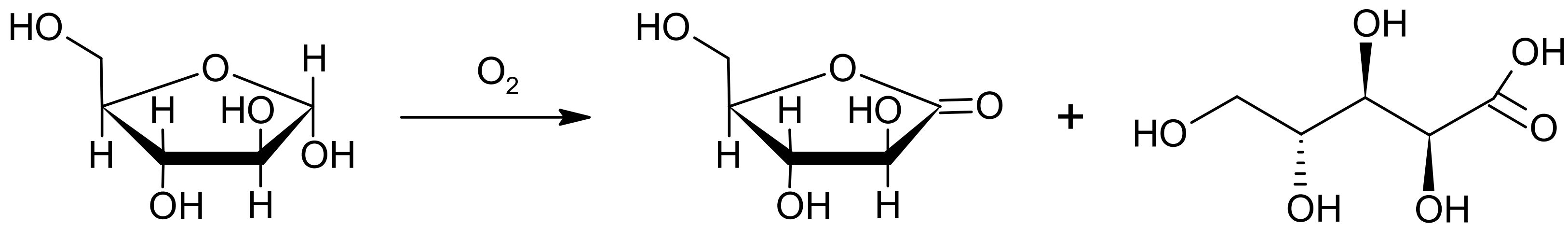
Xylitol



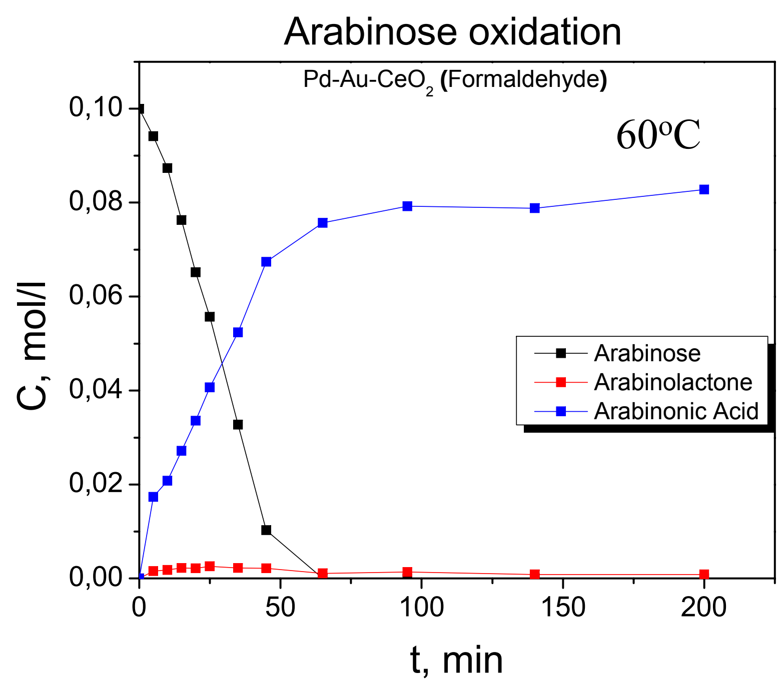
CH2 OH
OH
HO
OH
CH2 OH
Xylitol
+ H2
k
K1
K2
K3
K4
=O
OH
HO
OH
OH
D -Xylose
Beta-D -XyloPyranose
Alfa-D-XyloPyranose
Beta-D -XyloFuranose
Alfa-D -XyloFuranose

Trident
XYLI DENT
XyliFresh
XyliFresh
XYLISH
XYLITOL

Arabinose oxidation

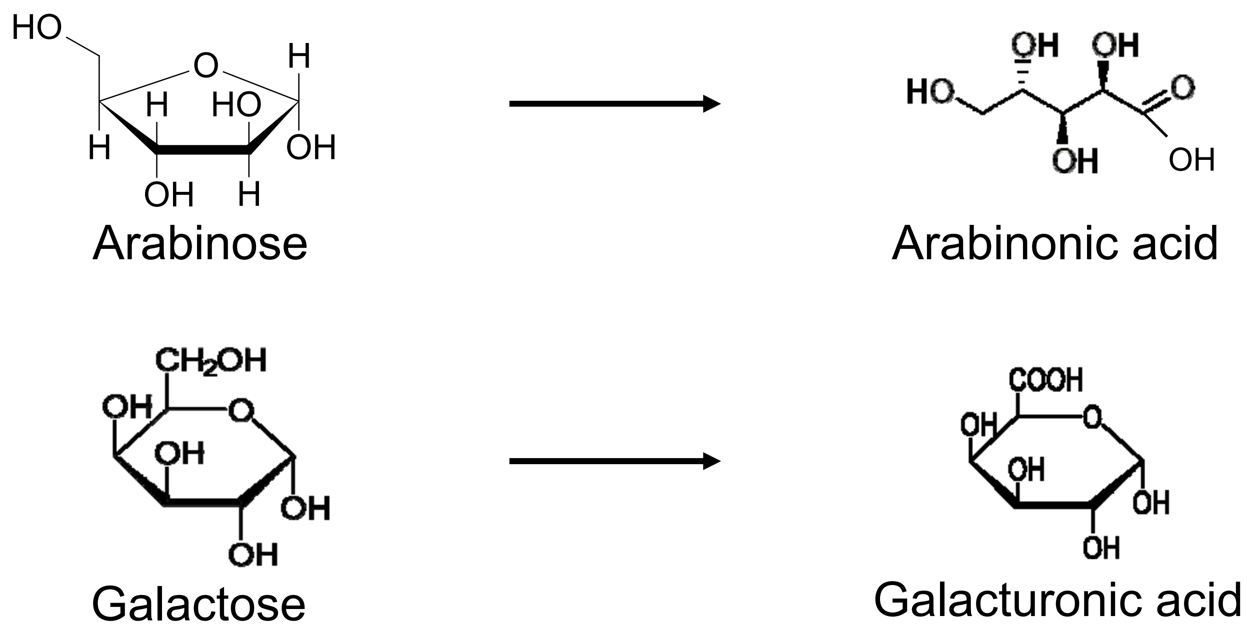


arabinolactone   arabinonic acid



B. Kusema

Oxidation of aldehydes/alcohols



- Temperature 60°C
- pH 6 - 10
- O_2 flow rate 2.5 ml/min
- P atm.

Preparation

Impregnation: Not Good!

Au has a lower melting point and a lower affinity for metal oxides than Pd and Pt.

Also, during calcination of $HAuCl_4$, chloride ion markedly enhances the coagulation of gold particles

Preparation

- Co-precipitation: well-mixed precursors, for example, hydroxide, oxide, with the metal component of the support by coprecipitation.

- These precursor mixtures are then transformed during calcination in air at temperatures above 550K into metallic Au particles strongly attached to the crystalline metal oxides such as Fe_2O_3, Co_3O4.

Deposition-precipitation

- Deposition of Au compounds, Au hydroxide, to the surface of a metal oxide

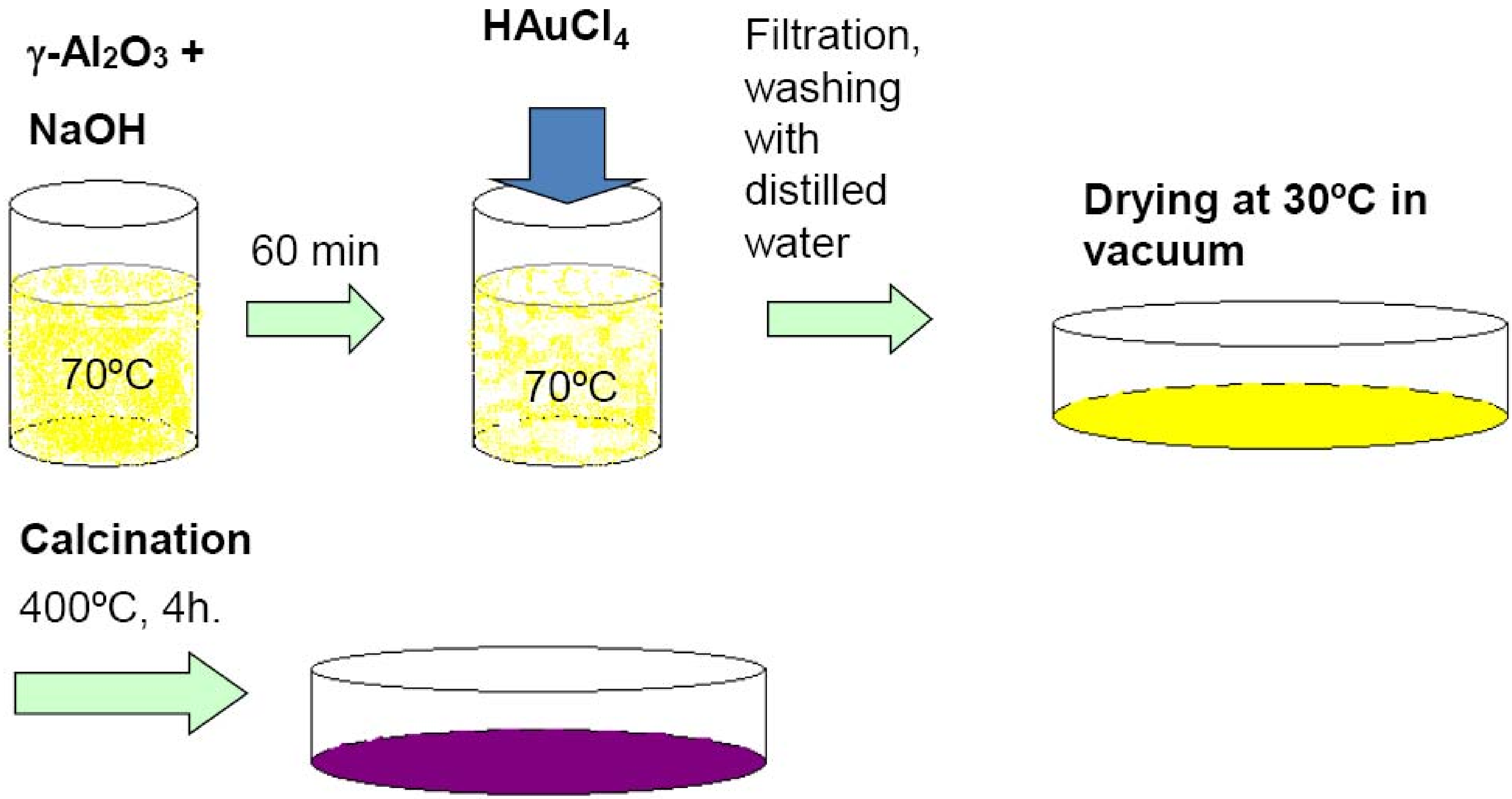
- Due to the amphoteric properties of $Au(OH)_3$, the pH of aqueous $HAuCl_4$ solution is adjusted at a fixed point in the range of 6 to 10, and is selected primarily based on the isoelectric points (IEP) of the metal oxide supports.

Deposition-precipitation

- Deposition of Au compounds, Au hydroxide, to the surface of a metal oxide

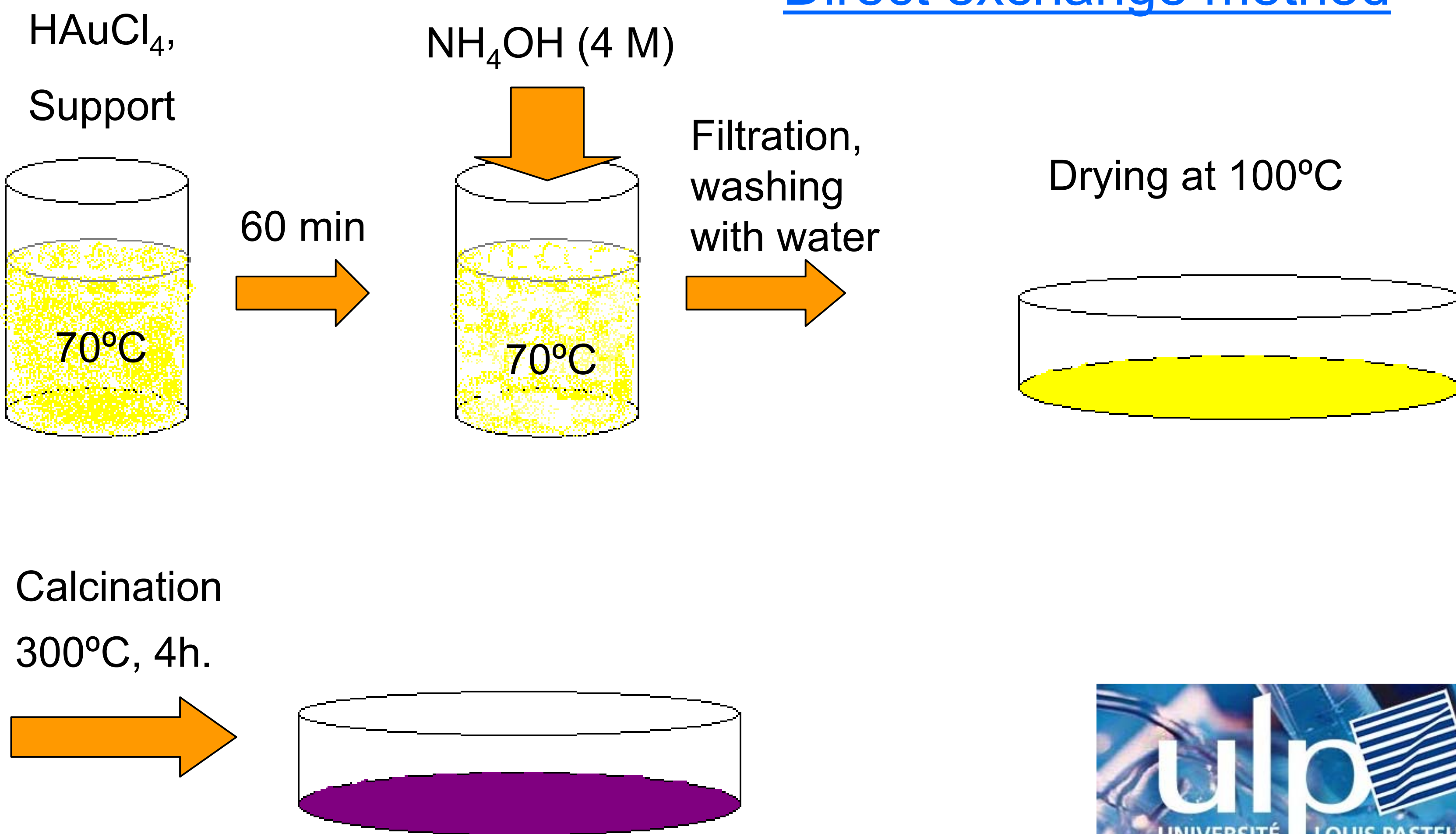
- It is not applicable to metal oxides, the IEPs of which are below 5, and to activated carbon. Gold hydroxide cannot be deposited on SiO_2(IEP=2); SiO_2-Al_2O_3 (IEP=1).

Conventional DP



Gold on metal oxides

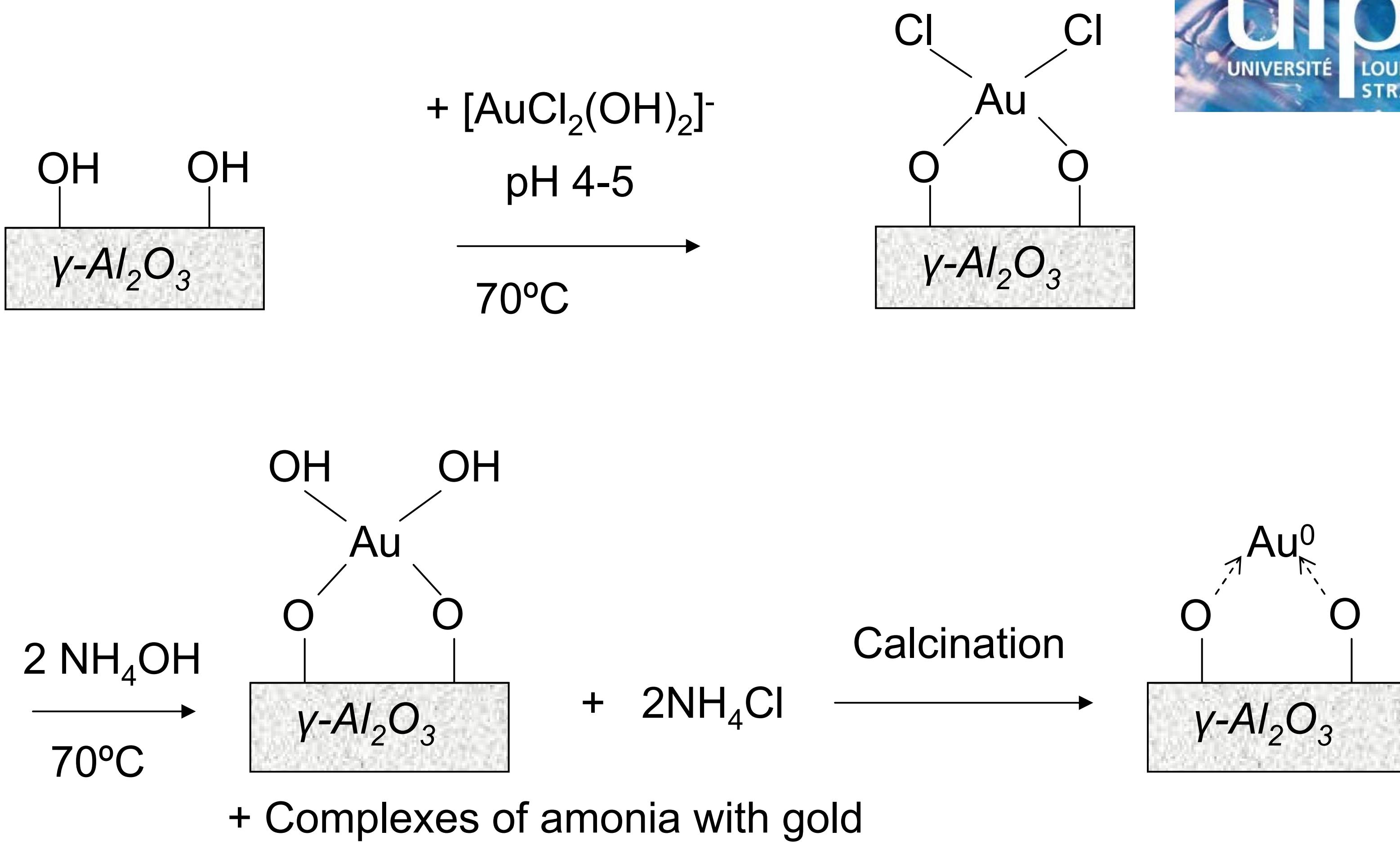
Direct exchange method



S. Ivanova, V. Pitchon, C. Petit, J. Mol. Catal. A: Chem. 256 (2006) 278

Direct exchange

Scheme of the active component formation

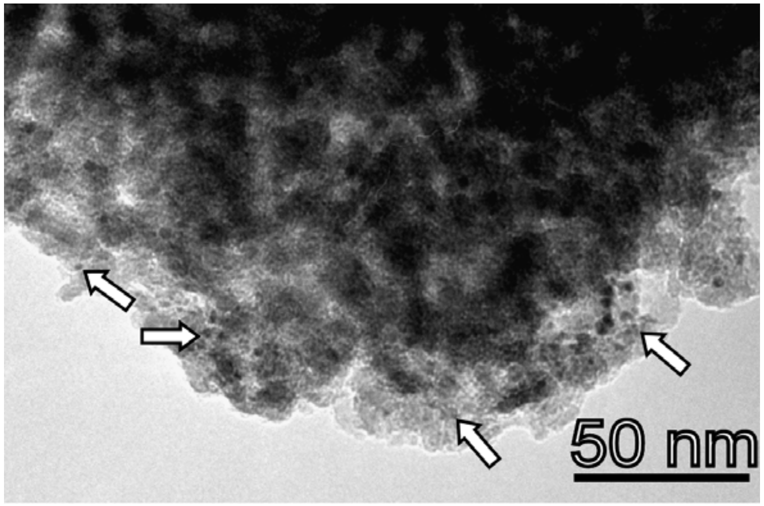


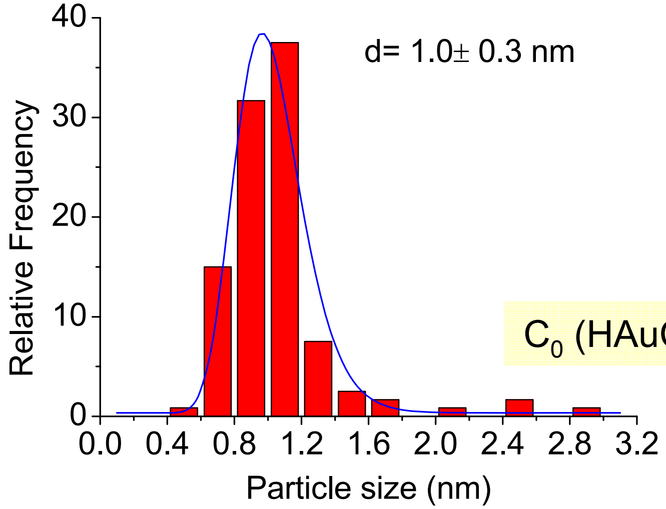
Can be applied for Al_2O_3, TiO_2, CeO_2, ZrO_2 only

Olga Simakova, 2009

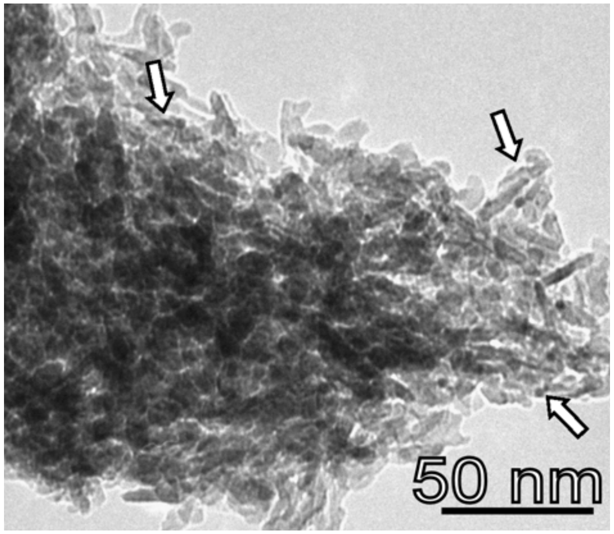
Changing dispersion

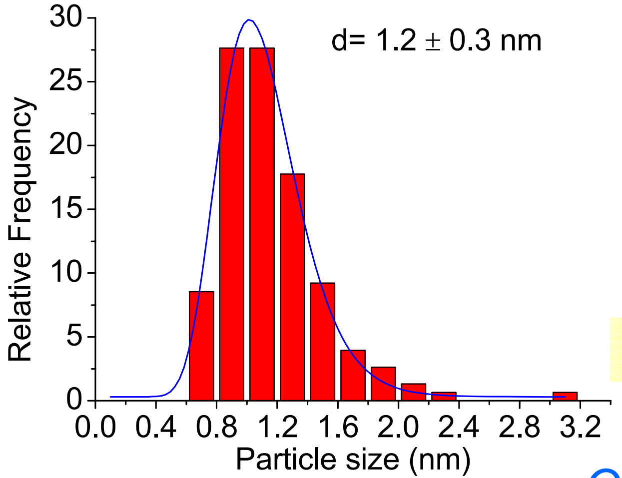
2 wt. % Au/Al_2O_3





C_0 ($HAuCl_4$) = $5 \cdot 10^{-4}$ M



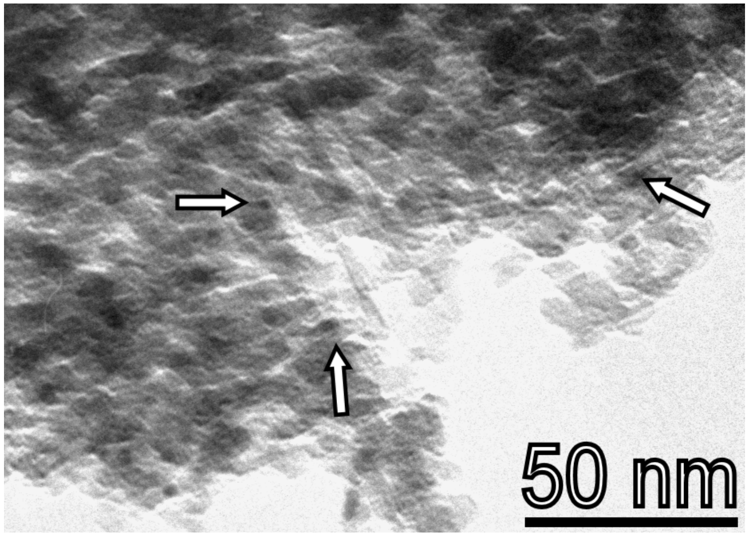


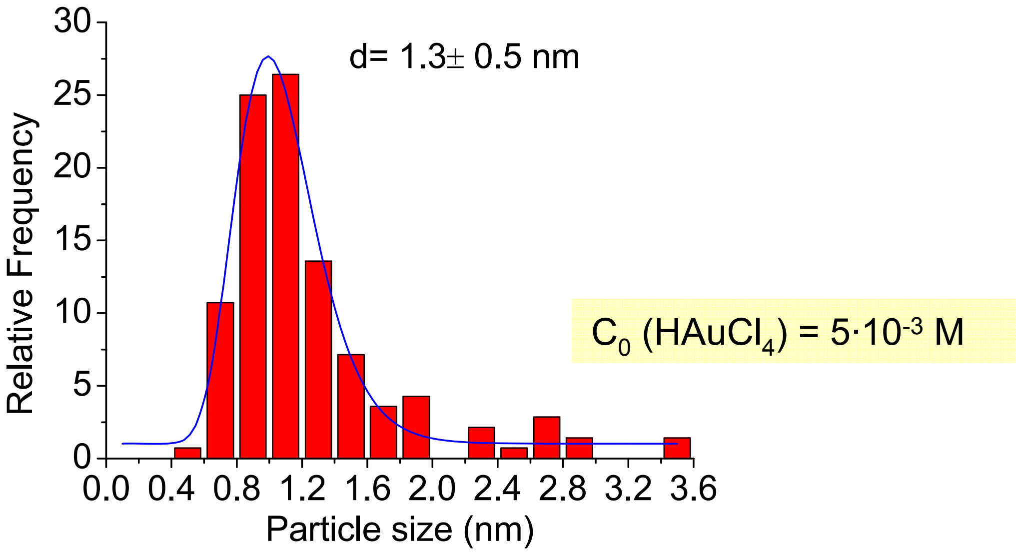
C_0 ($HAuCl_4$) = 10^{-3} M

Olga Simakova, 2009

Changing dispersion

2 wt. % Au/Al_2O_3



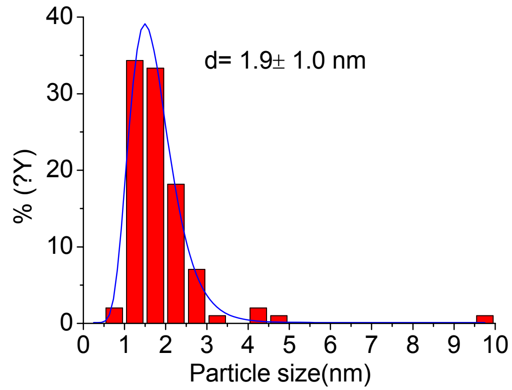


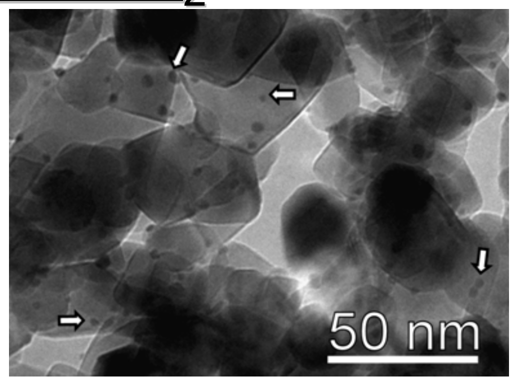
Increasing of concentration of $HAuCl_4$ solution results in increasing of supported gold particle size

Olga Simakova, 2009

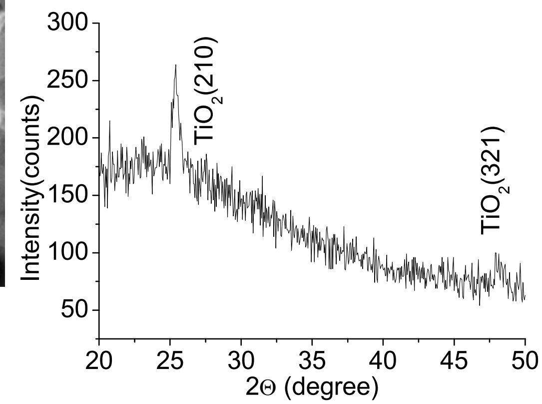
Changing dispersion

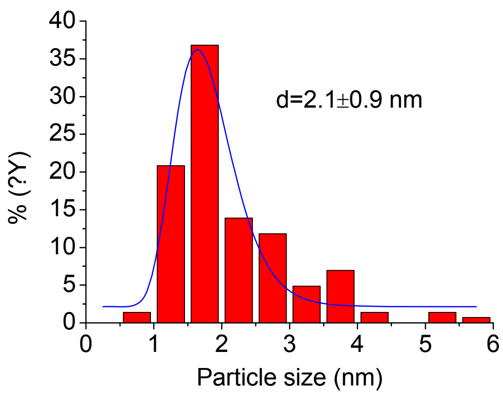
2 wt. % Au/TiO_2

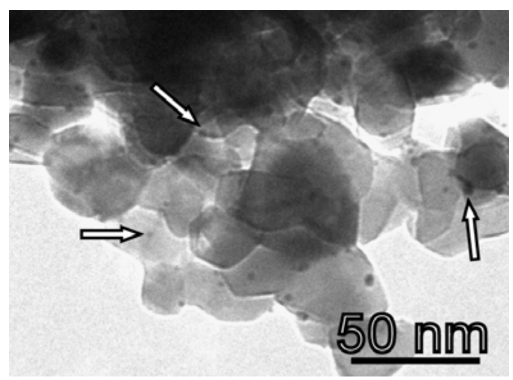




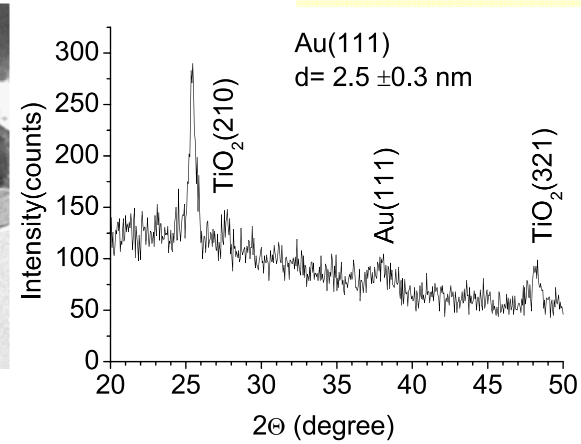
C_0 ($HAuCl_4$) = $5{\cdot}10^{-4}$ M







C_0 ($HAuCl_4$) = 10^{-3} M

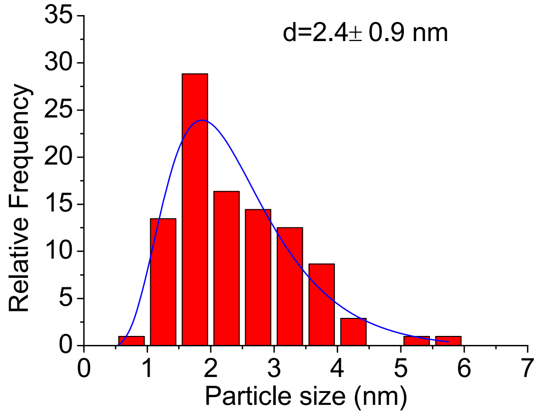


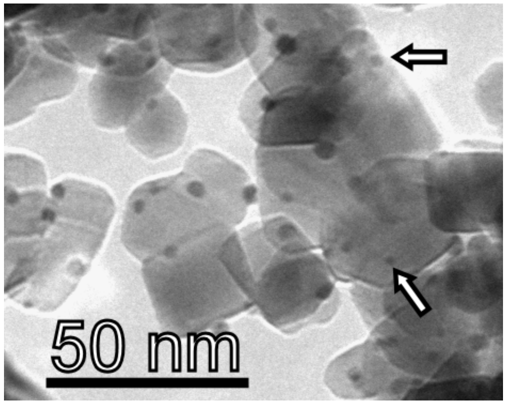
Olga Simakova, 2009

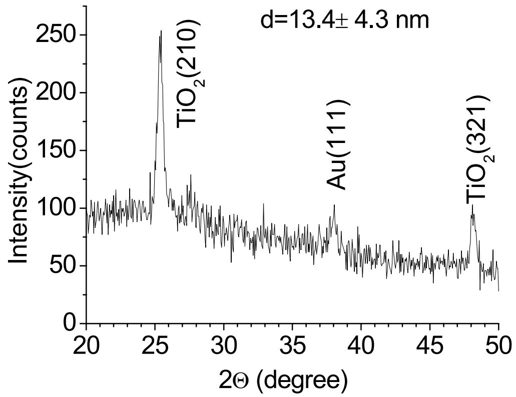
Changing dispersion

2 wt. % Au/TiO_2

C_0 ($HAuCl_4$) = $5 \cdot 10^{-3}$ M







Increasing of concentration of $HAuCl_4$ solution results in increasing of supported gold particle size

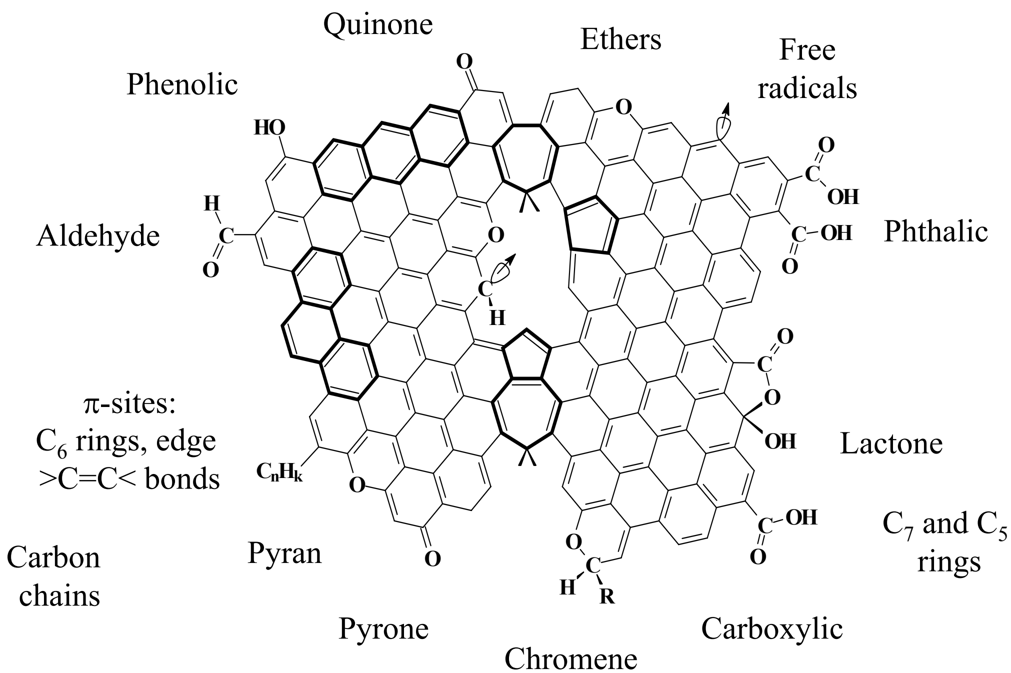
Olga Simakova, 2009

Gold on carbon

Mesoporous carbon material Sibunit
(S_{BET} = 450 m^2/g, micropore area 37.7 m^2/g)

Surface chemical groups

specific to polycrystalline quasi-graphitic carbons

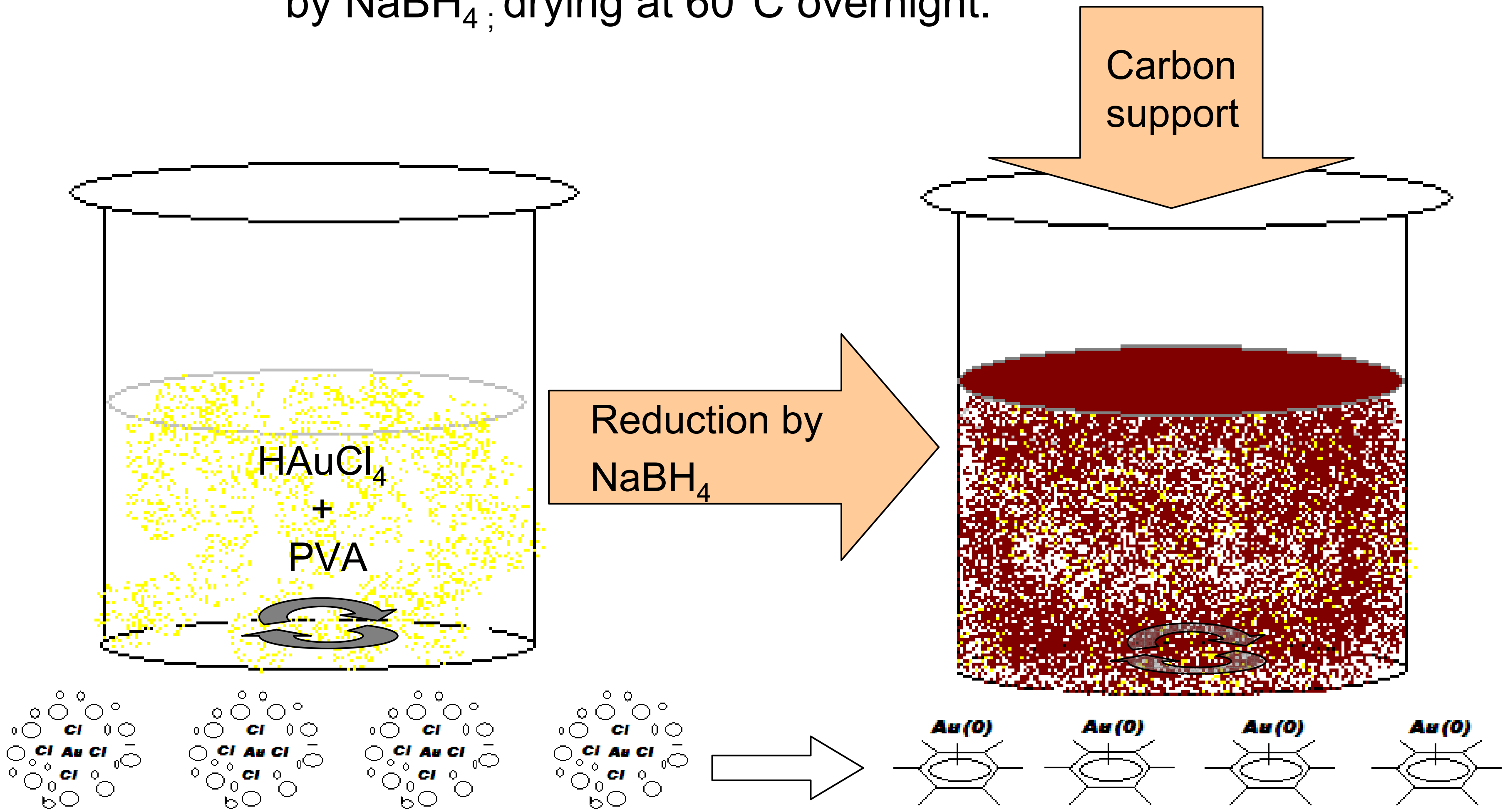


Oxidation of carbon by
5 wt. % HNO_3 12h, at 25^0C

Olga Simakova, 2009

1 wt% Au/carbon

- Gold sols formation with polyvinyl alcohol (PVA); reduction by $NaBH_4$; drying at 60°C overnight.

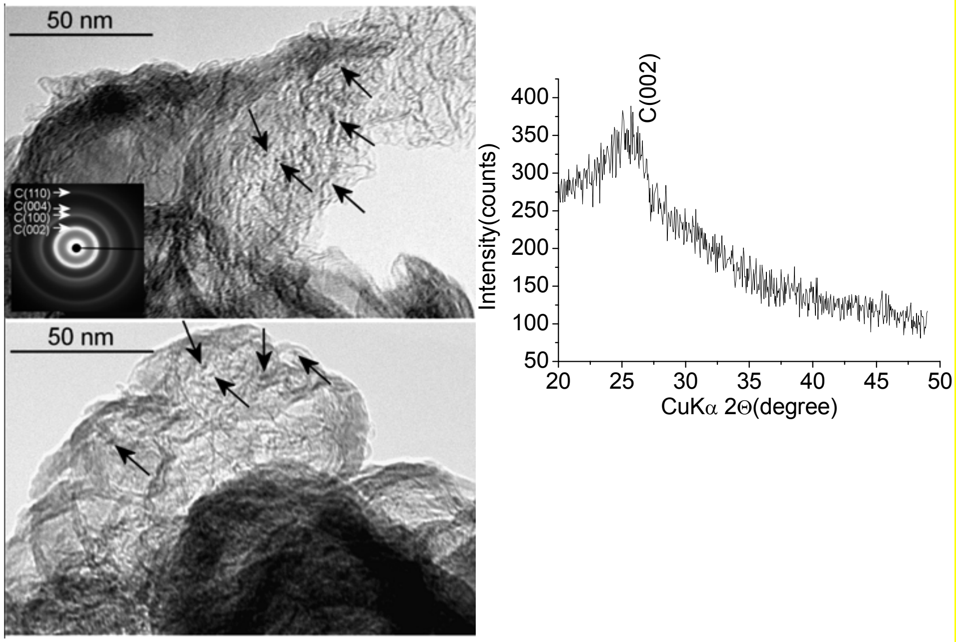


F.Porta et al. // Cat. Today, 61 (2000), 165-172

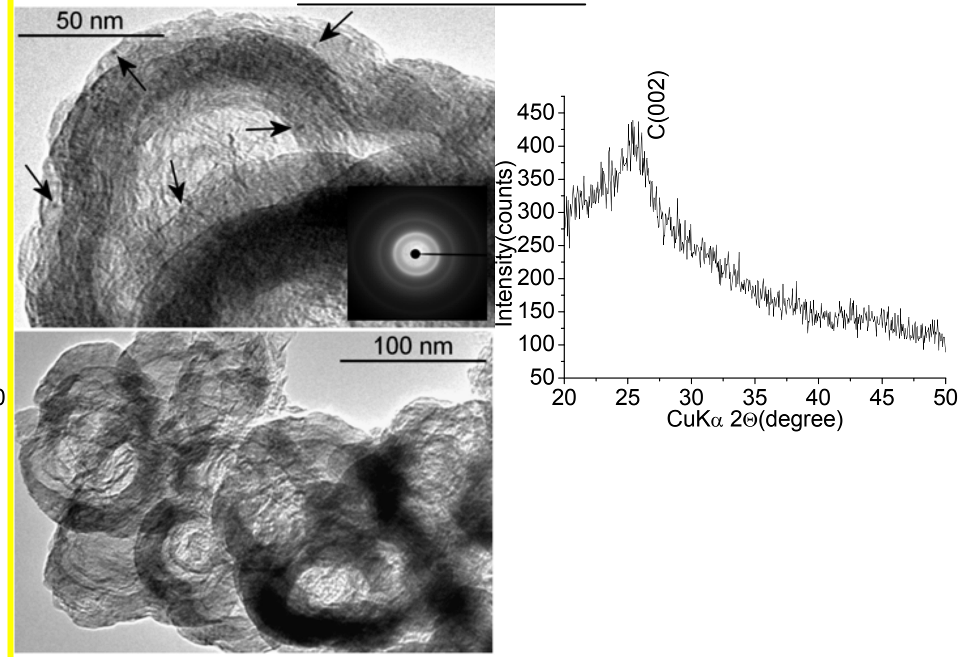
Olga Simakova, 2009

1 wt% Au/carbon

1 wt. % Au/Non-oxidized carbon



1 wt. % Au/Oxidized carbon



The same size of supported gold particles

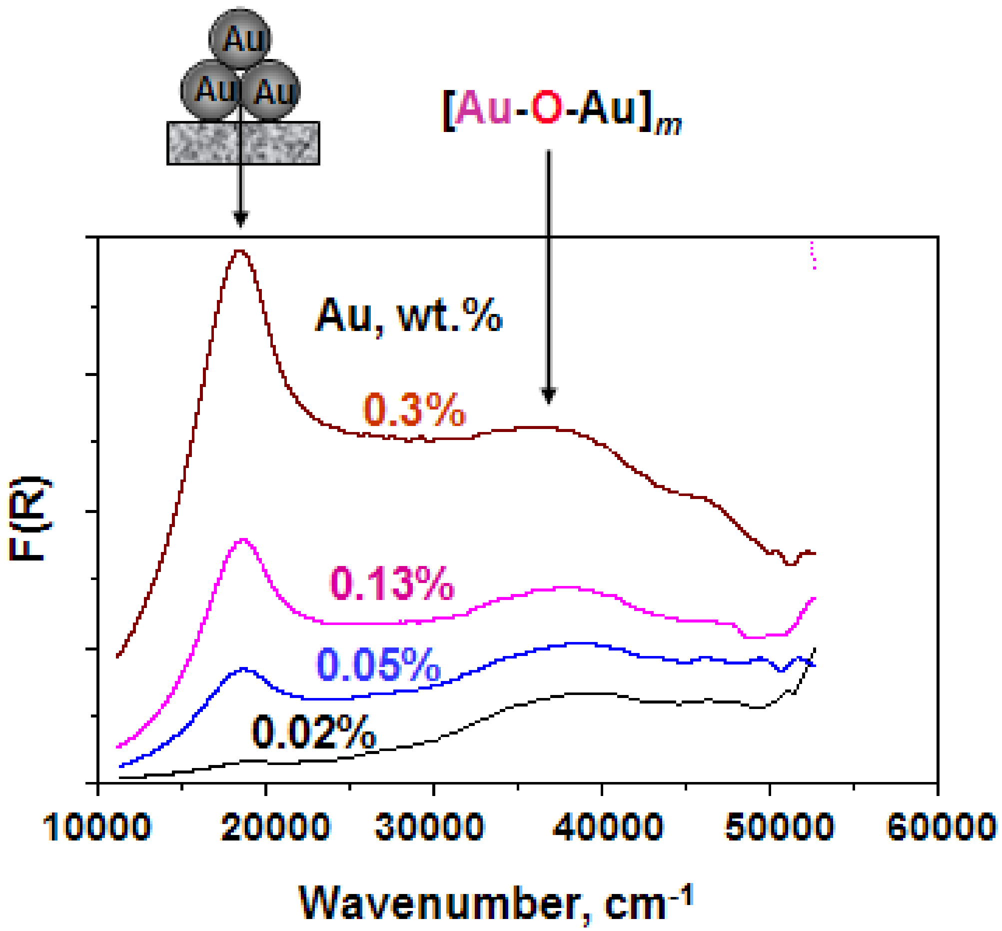
d_{Au} = 1-2 nm

Olga Simakova, 2009

Characterization

- XPS
- UV-vis
- TEM
- Chemisorption does not work!

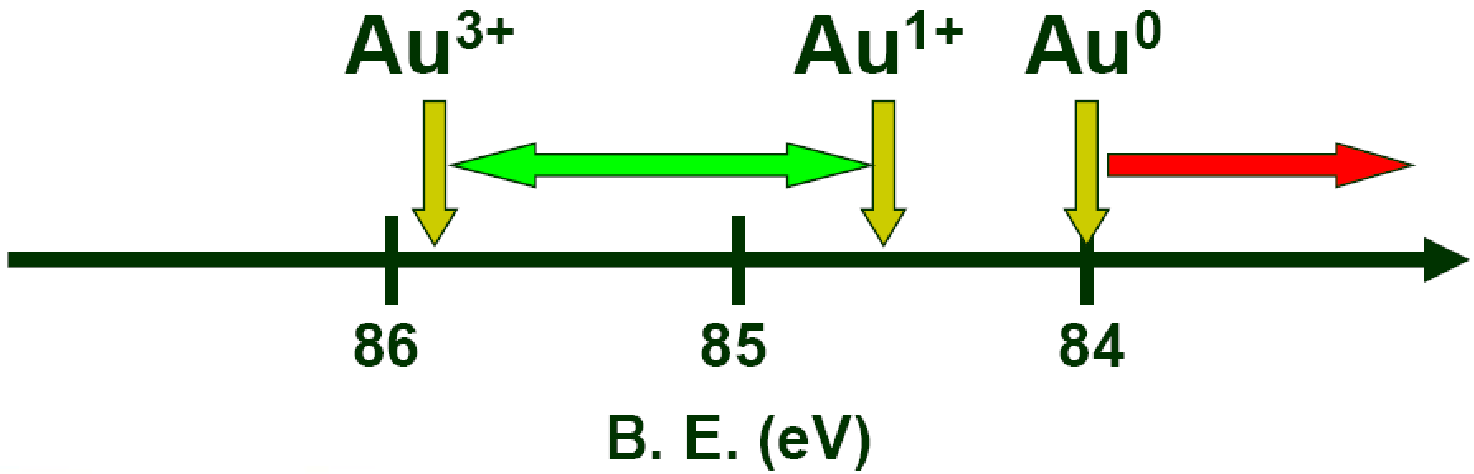
UV-vis



Au
Au
Au
[Au-O-Au]$_m$
Au, wt.%
0.3%
0.13%
0.05%
0.02%
F(R)
10000
20000
30000
40000
50000
60000
Wavenumber, cm^{-1}

Au 4f

XPS

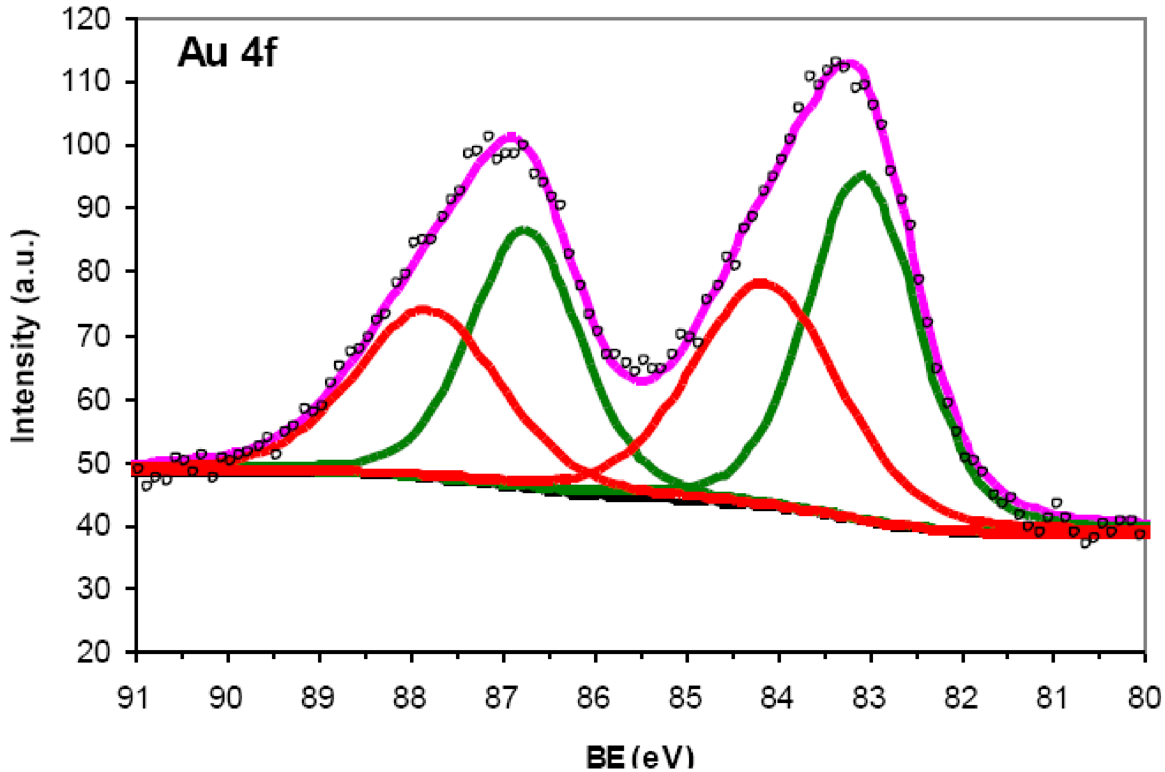


PHI Quantum 2000 Scanning ESCA Microprobe spectrometer with Al anode

Betiana Campo, 2009

1% Au/SiO_2

XPS



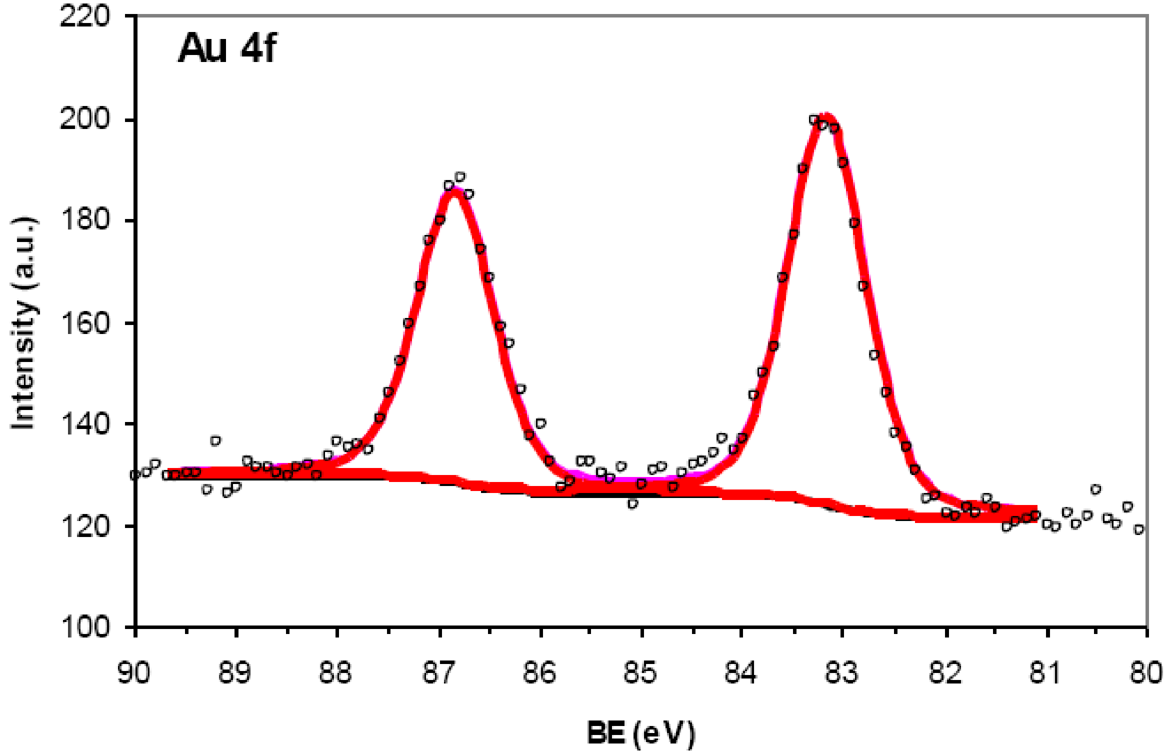
Particle size lower than 2 nm

	Position (eV)	
	$4f_{5/2}$	$4f_{7/2}$
Au^0	87.8	84.1
$Au^{\delta-}$	86.7	83.0

Betiana Campo, 2009

1% Au/TiO_2

XPS

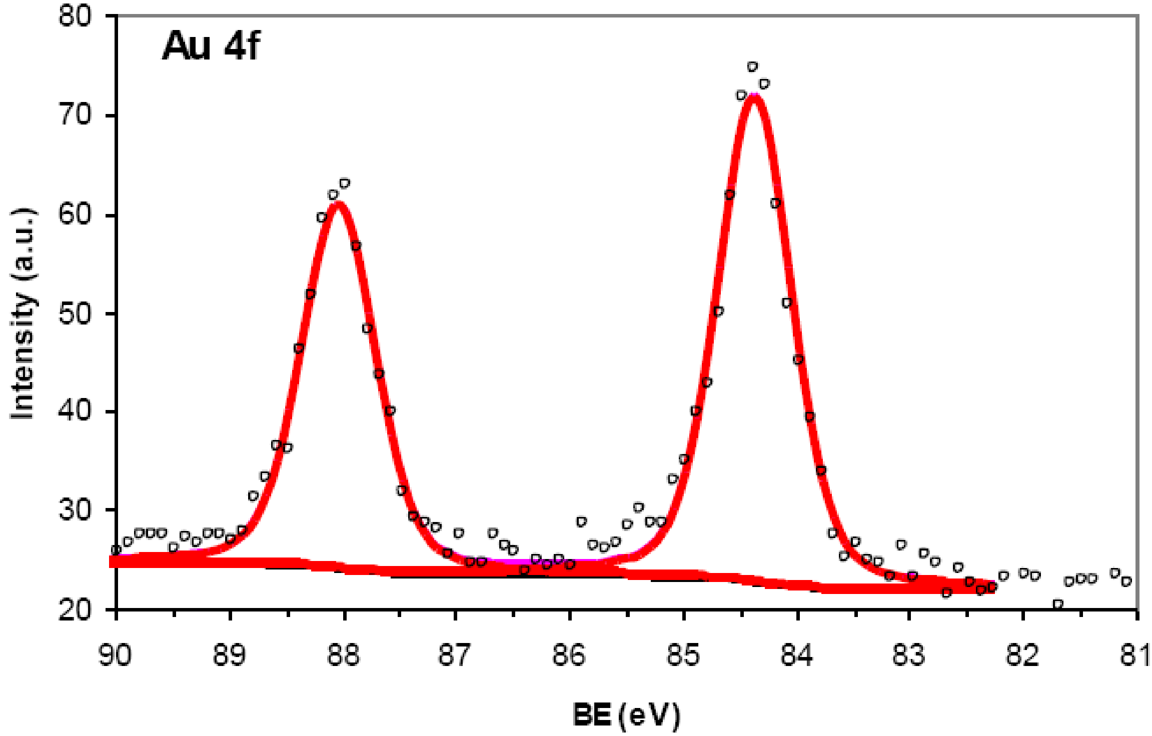


	Position (eV)	
	4f $_{5/2}$	**4f$_{7/2}$**
Au$^{\delta-}$	86.9	83.2

Betiana Campo, 2009

1% Au/C (PVA)

XPS



	Position (eV)	
	$4f_{5/2}$	**$4f_{7/2}$**
Au^0	88.0	84.3

Betiana Campo, 2009

Catalysts: cluster size

- 2% Au/Al_2O_3 Direct ion exchange (DIE)
  Deposition-precipitation with urea (DPU)
  Impregnation

- Calcination temperature (DIE) 300°C
  400°C
  500°C
  600°C

Olga Simakova, Bright Kusema, Betiana Campo

Characterization

- Size of particles (TEM)
  -average Au particles 1-20 nm

- Metal loading (ICP)
  -2.0 wt. % Au

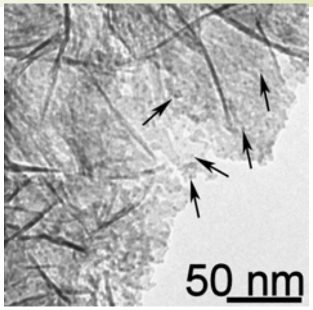
- Electronic state of gold species (XPS)
  -metallic gold species

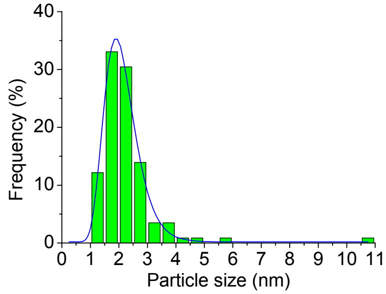
- Catlytic activity in sugar oxidation

Olga Simakova, Bright Kusema, Betiana Campo

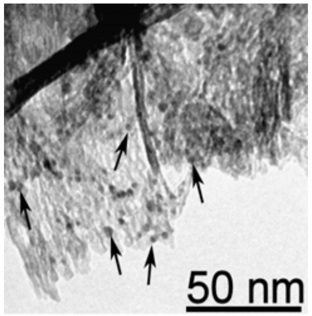
2% Au/Al_2O_3

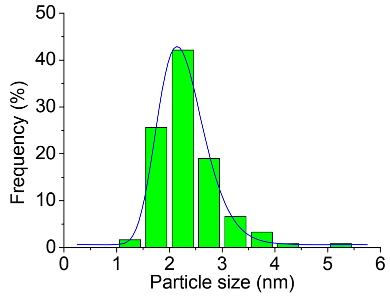
DIE 2.2 ± 1.0 nm





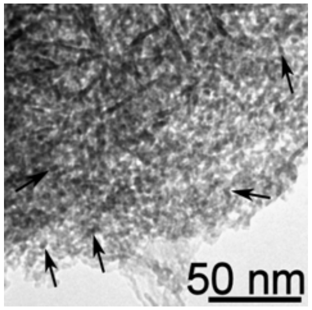
DPU 2.3 ± 0.6 nm.

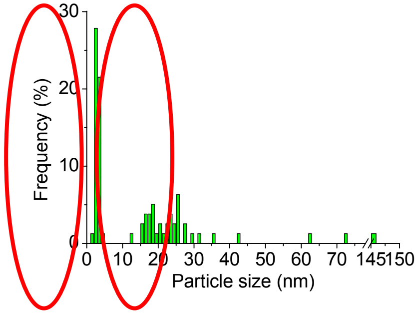




IMP 2.9 ± 0.6 nm

28.1 ± 22.9 nm

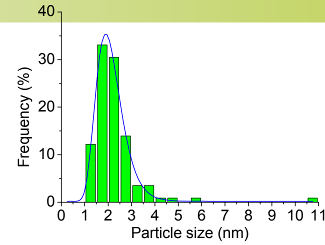




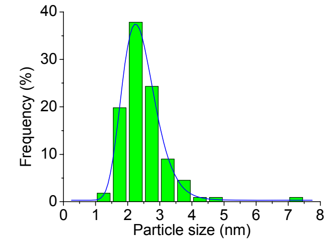
Olga Simakova, Bright Kusema, Betiana Campo

2% Au/Al_2O_3

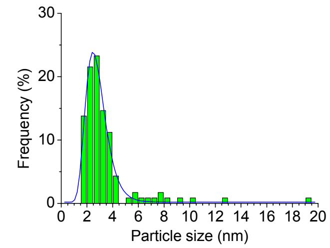
DIE 300°C 2.2 ± 1.0 nm



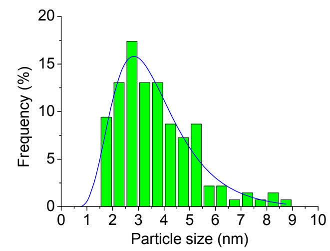
DIE 400°C 2.7 ± 0.7 nm



DIE 500°C 3.4 ± 2.3 nm

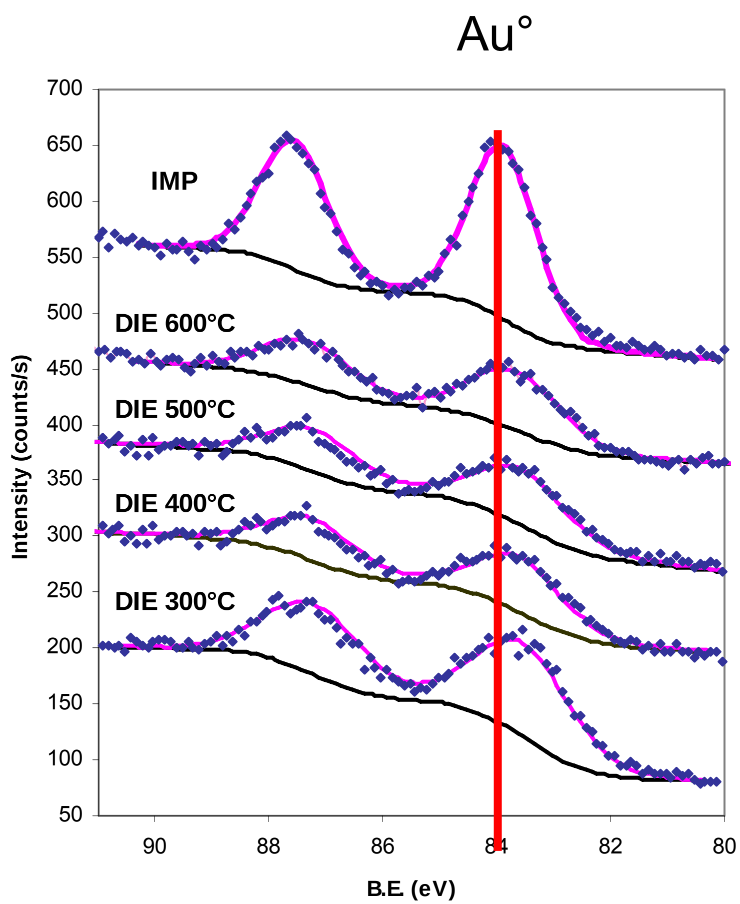


DIE 600°C 3.7 ± 1.5 nm

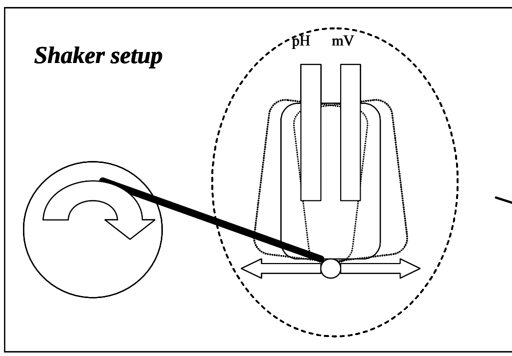


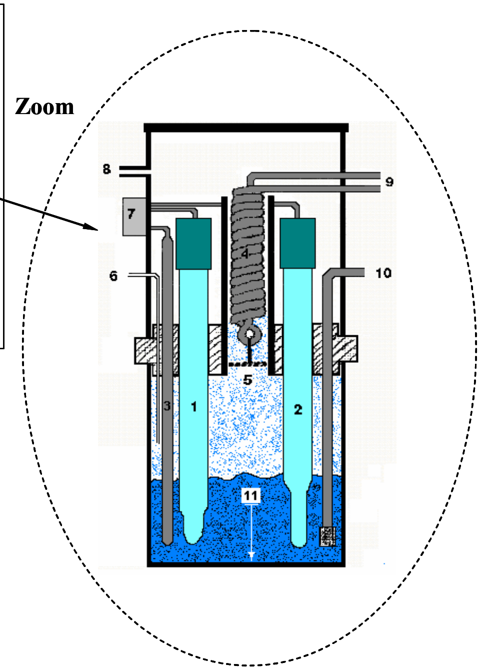
Olga Simakova, Bright Kusema, Betiana Campo

XPS – Fresh catalyst



Olga Simakova, Bright Kusema, Betiana Campo

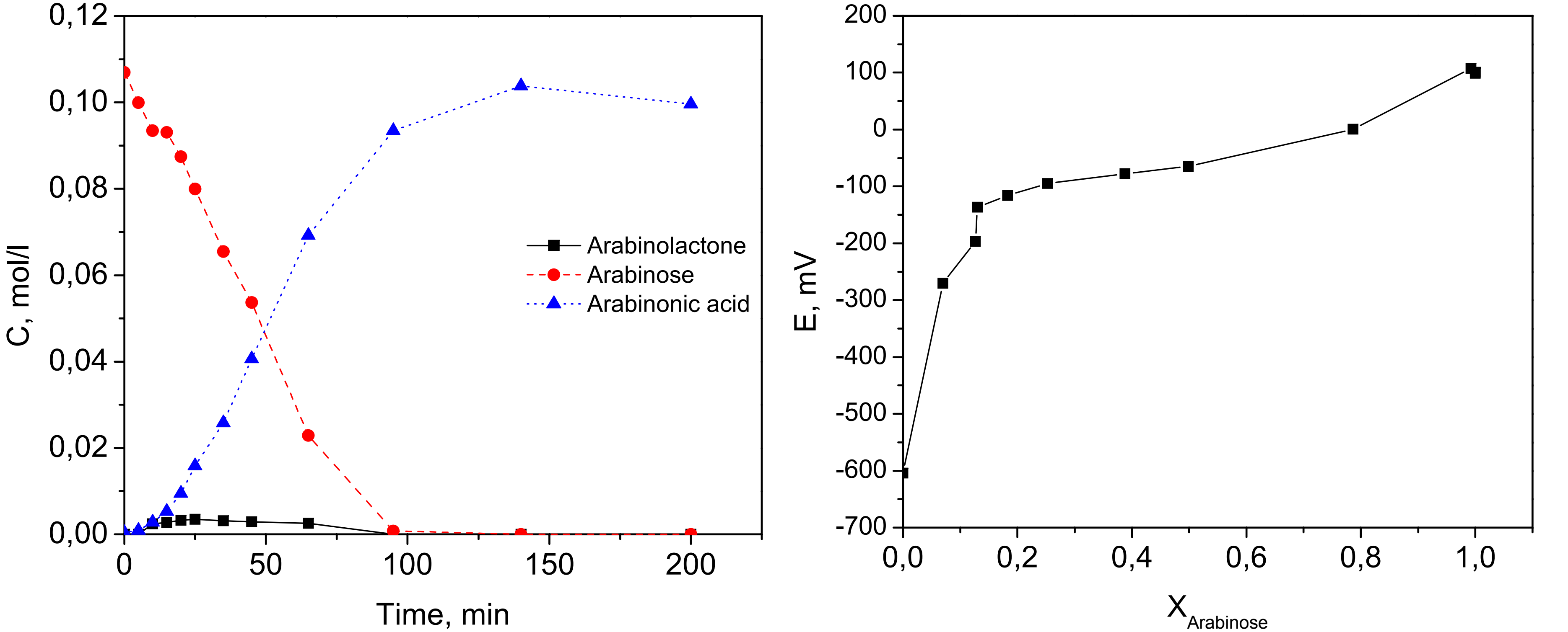




1 - pH electrode
2 - Ag/AgCl reference electrode
3 – thermocouple
4 - cooling coil
5 - grid
6 - alkaline inlet (for pH-stat)
7 - electronics socket
8 - gas outlet
9 - inlets for cooling water
10 - gas inlet
11 - electrode collector (shell of reactor)

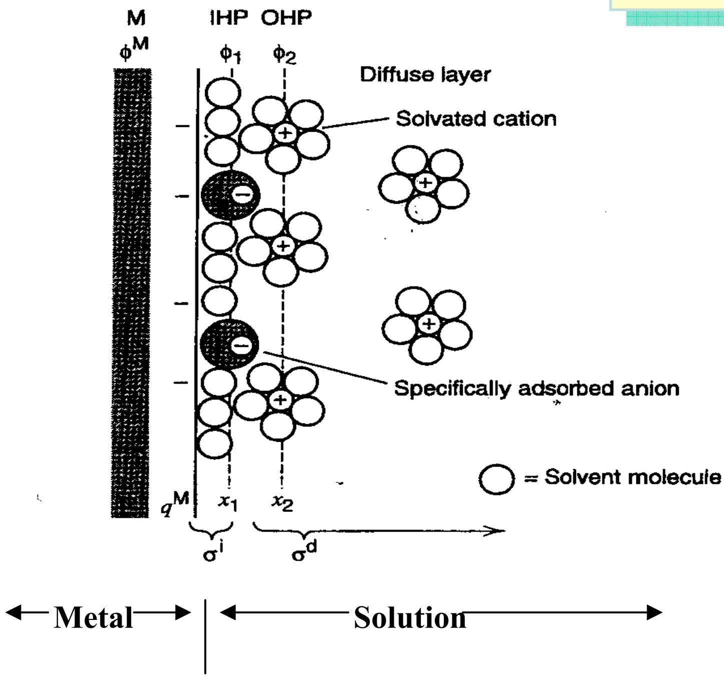
Bright Kusema

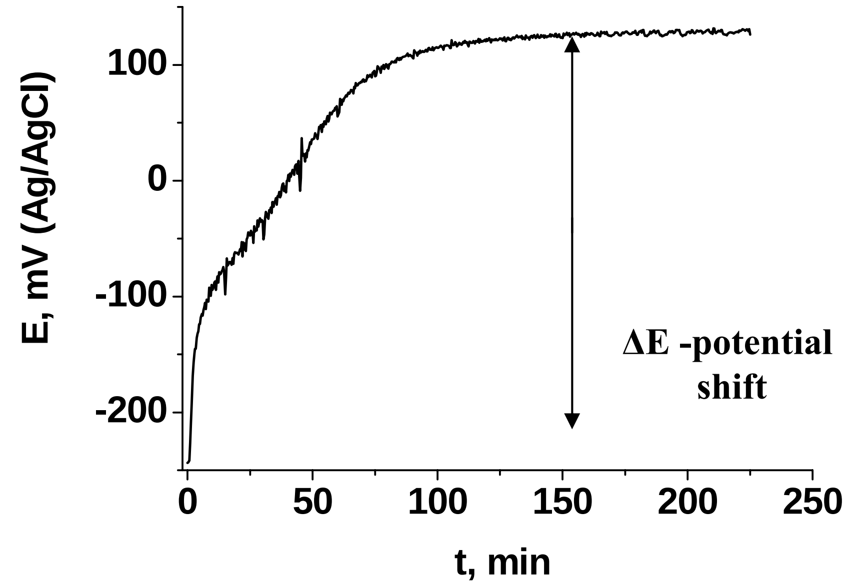
Results

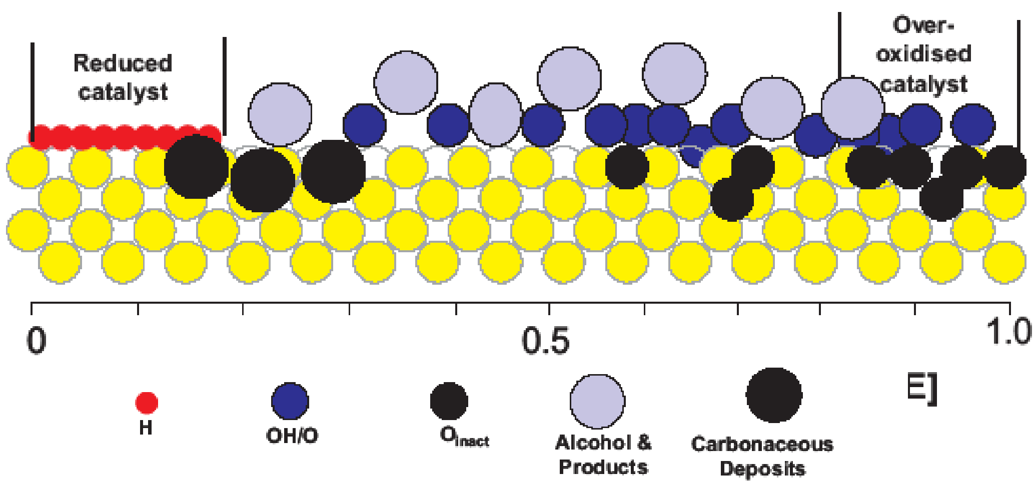


- Kinetic curves; E(mV) vs. $X_{Arabinose}$
- 2% Au/Al_2O_3, T = 60°C, pH 8, O_2 2.5 ml/min.

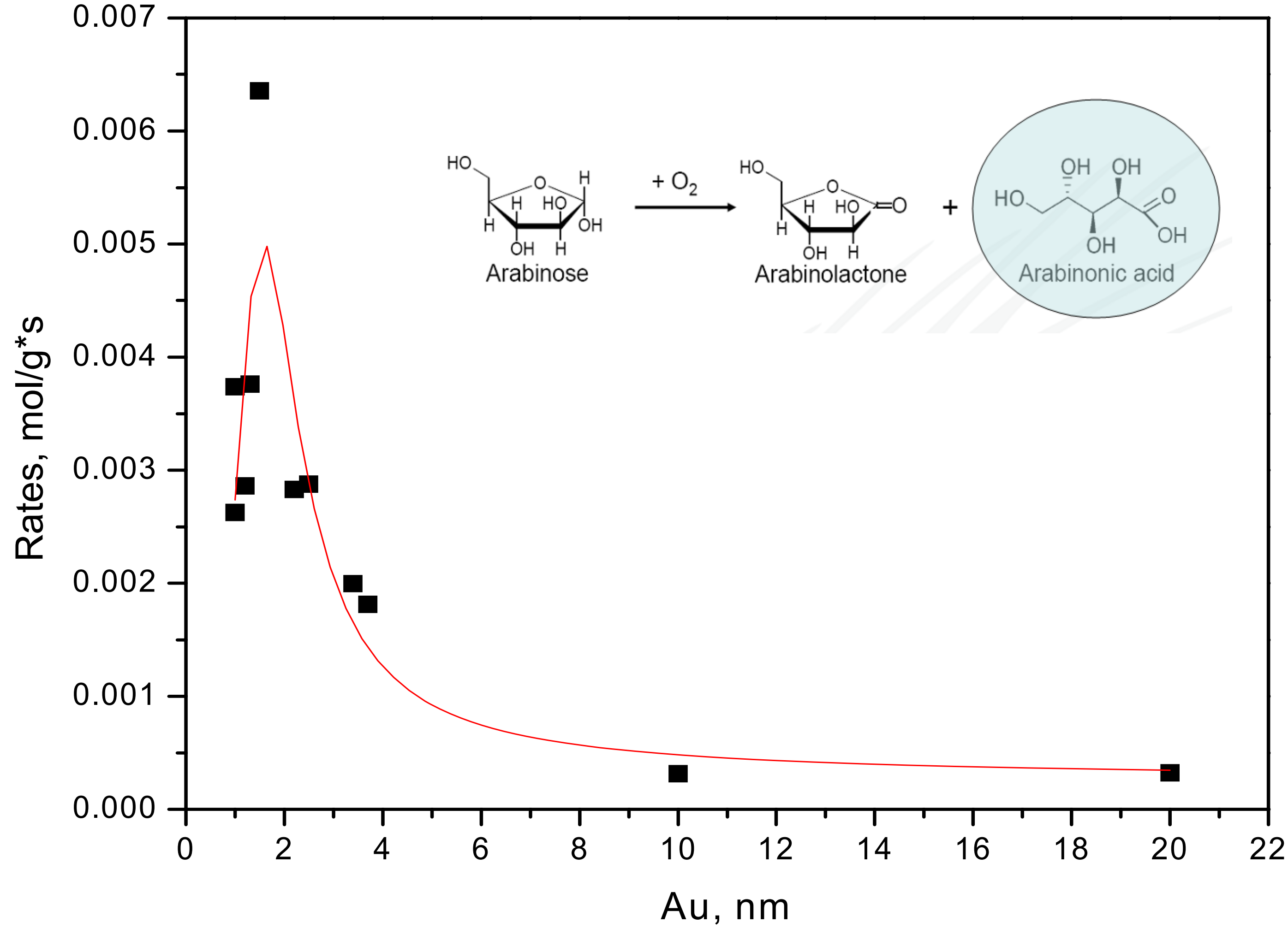
Catalyst potential







Dependence of activity on cluster size



Olga Simakova, Bright Kusema, Betiana Campo

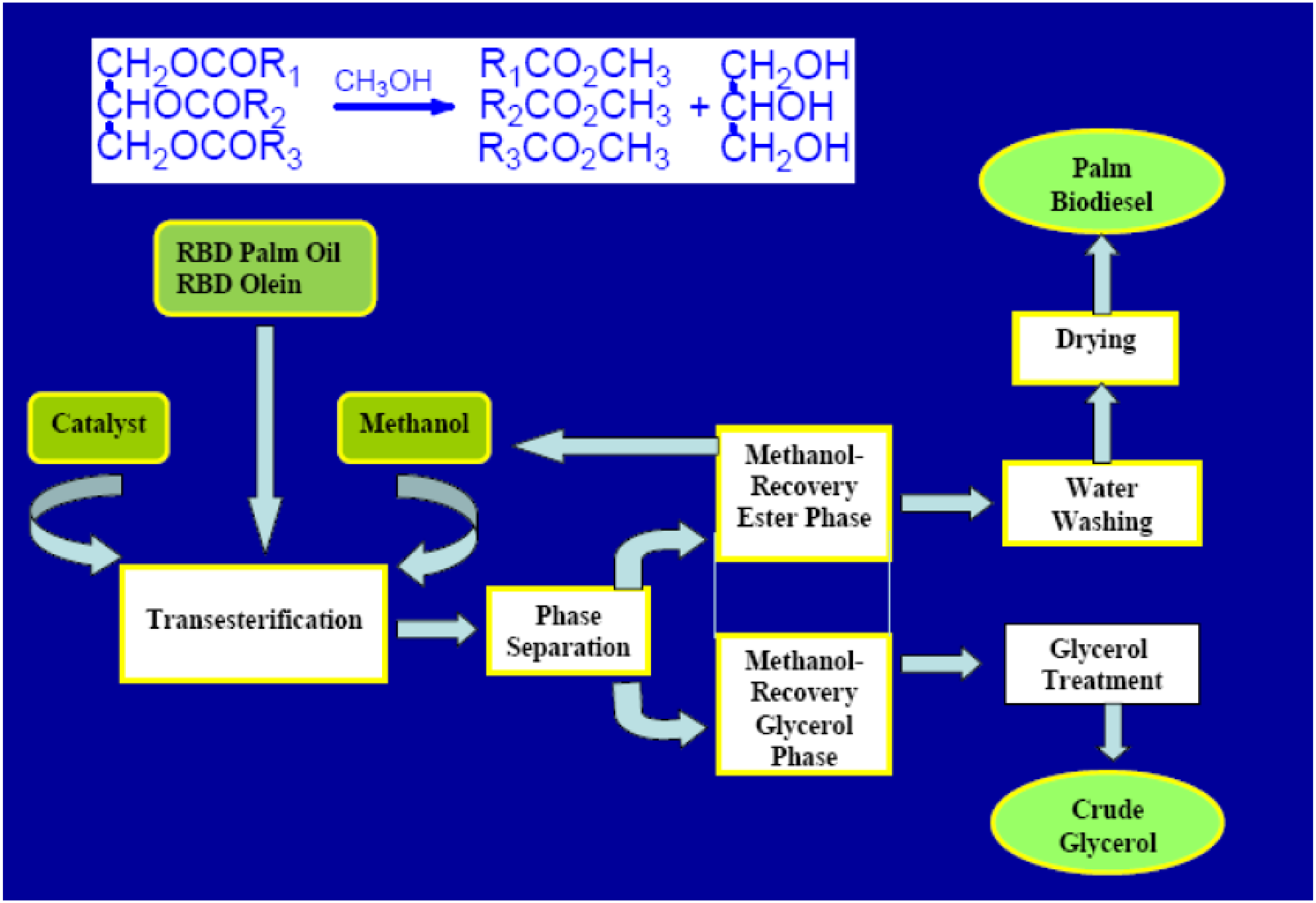
Treatment of wood

- **Gasification**
- **Pyrolysis**
- **Depolymerization** to get low molecular mass components (sugars, phenols, furfurol, etc.), e.g. **building blocks**
- **Delignification (cellulose, derivatives, paper)**
- **Extraction of valuable chemicals (bioactive components)**

The use of vegetable oils as engine fuels may seem insignificant today but the such oils may become, in the course of time, as important as petroleum and the coal tar products of the present time.

-Rudolph Diesel, 1912

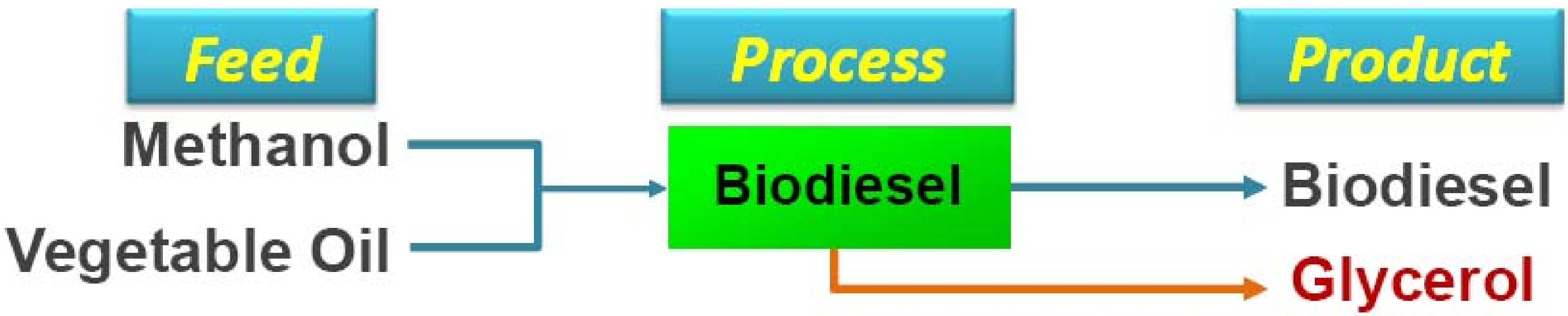
Biodiesel process chart



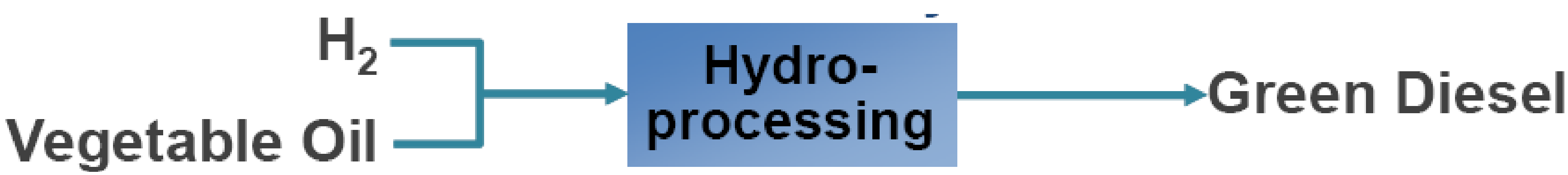
Biodiesel technology

- **Transesterification reaction** – Predominantly uses homogeneous base catalysts e.g. sodium methoxide, sodium hydroxide and potassium hydroxide.
- **Differences between commercial processes**:
  - *Reactor Design*: Continuous Stirred Tank Reactor (CSTR), Loop Reactor, Tubular Reactor.
  - *Purification Step*: Residual catalysts and soap need to be removed from biodiesel and glycerol. (**main drawback**)
- **Purification processes**: Water washing process and adsorbent treatment process (water-free process):
  - *Water washing process* – need waste water treatment plants.
  - *Evaporate and recover water for re-use*: energy intensive.
  - *Adsorbent treatment process e.g. Magnesium Silicate* – high cost of adsorbent and disposal of spent adsorbents
- **Eliminate catalyst cleaning up step and simplify biodiesel and glycerol purification (solid catalysts, enzymatic transesterification)**

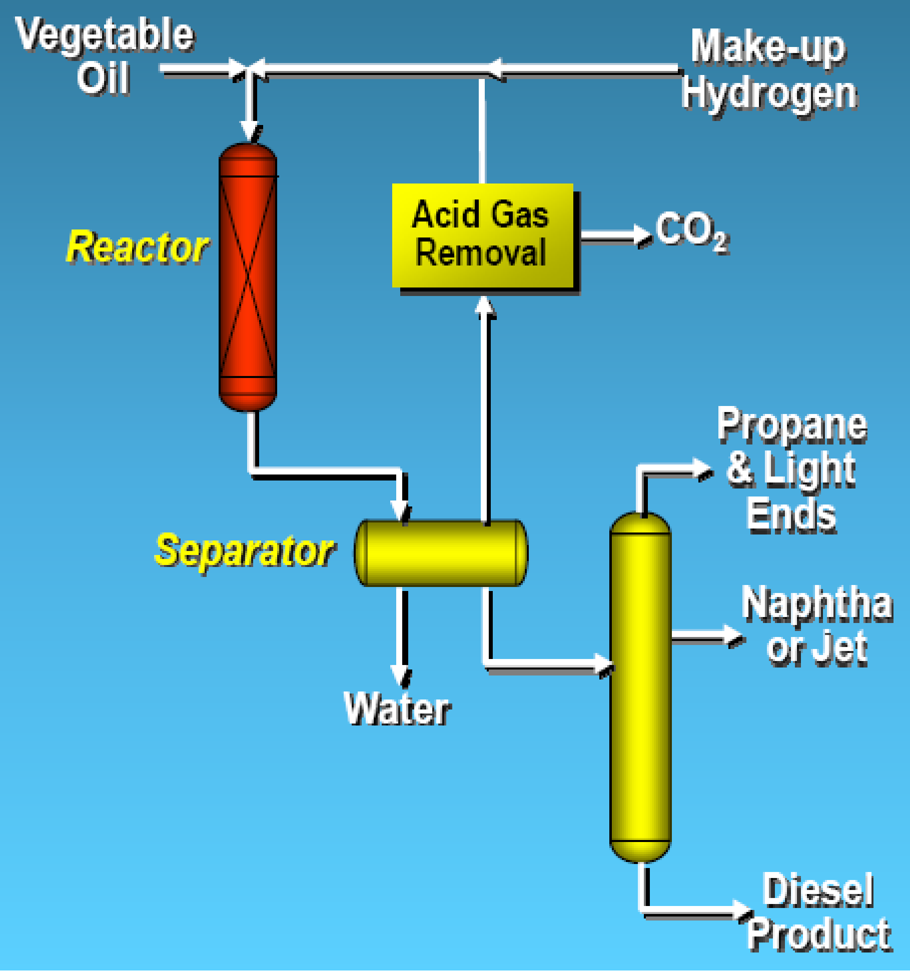
Green diesel



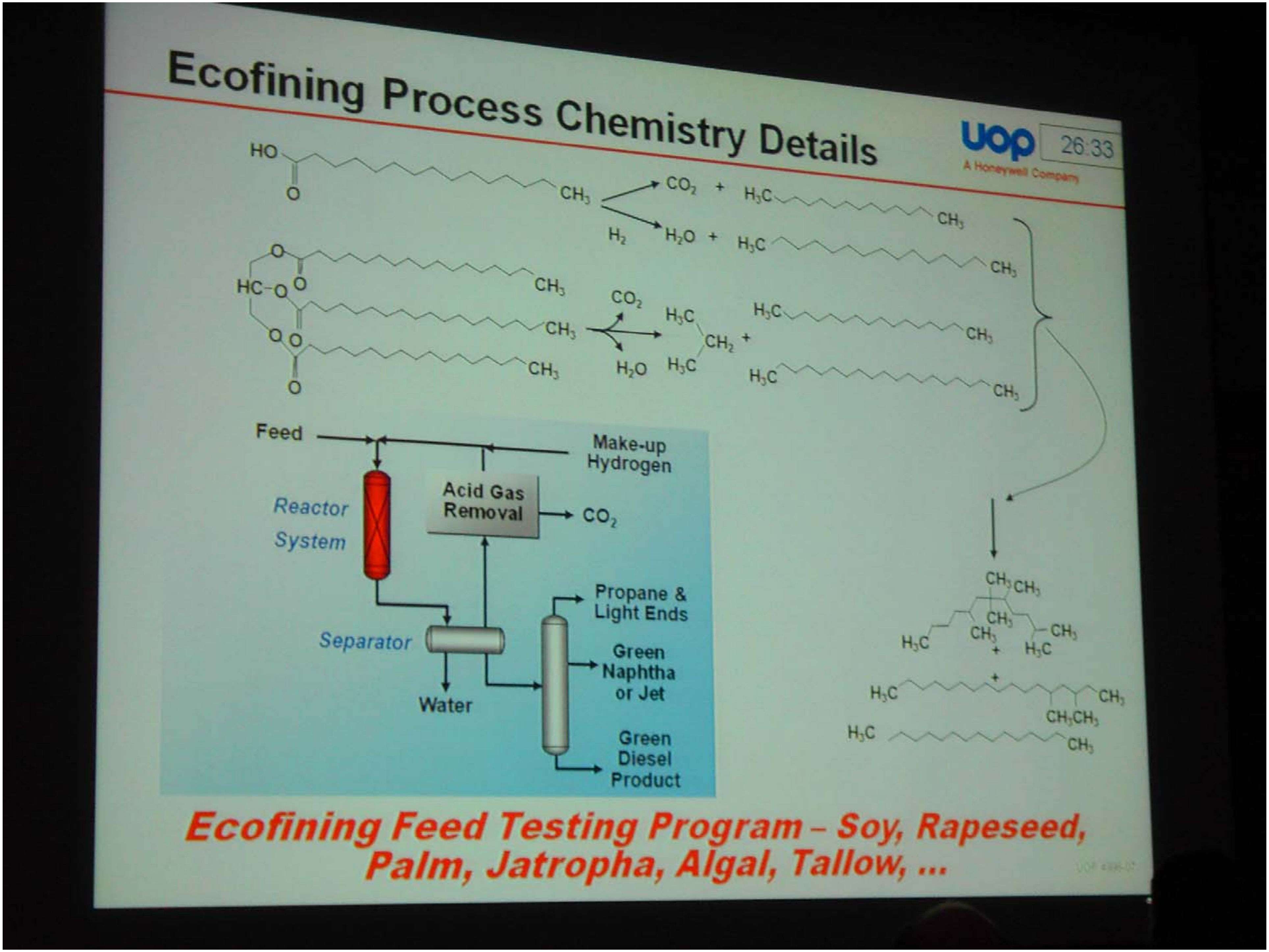
- 8 vol-% of product is low value glycerol
- Requires methanol as a feedstock, higher priced vegetable oil



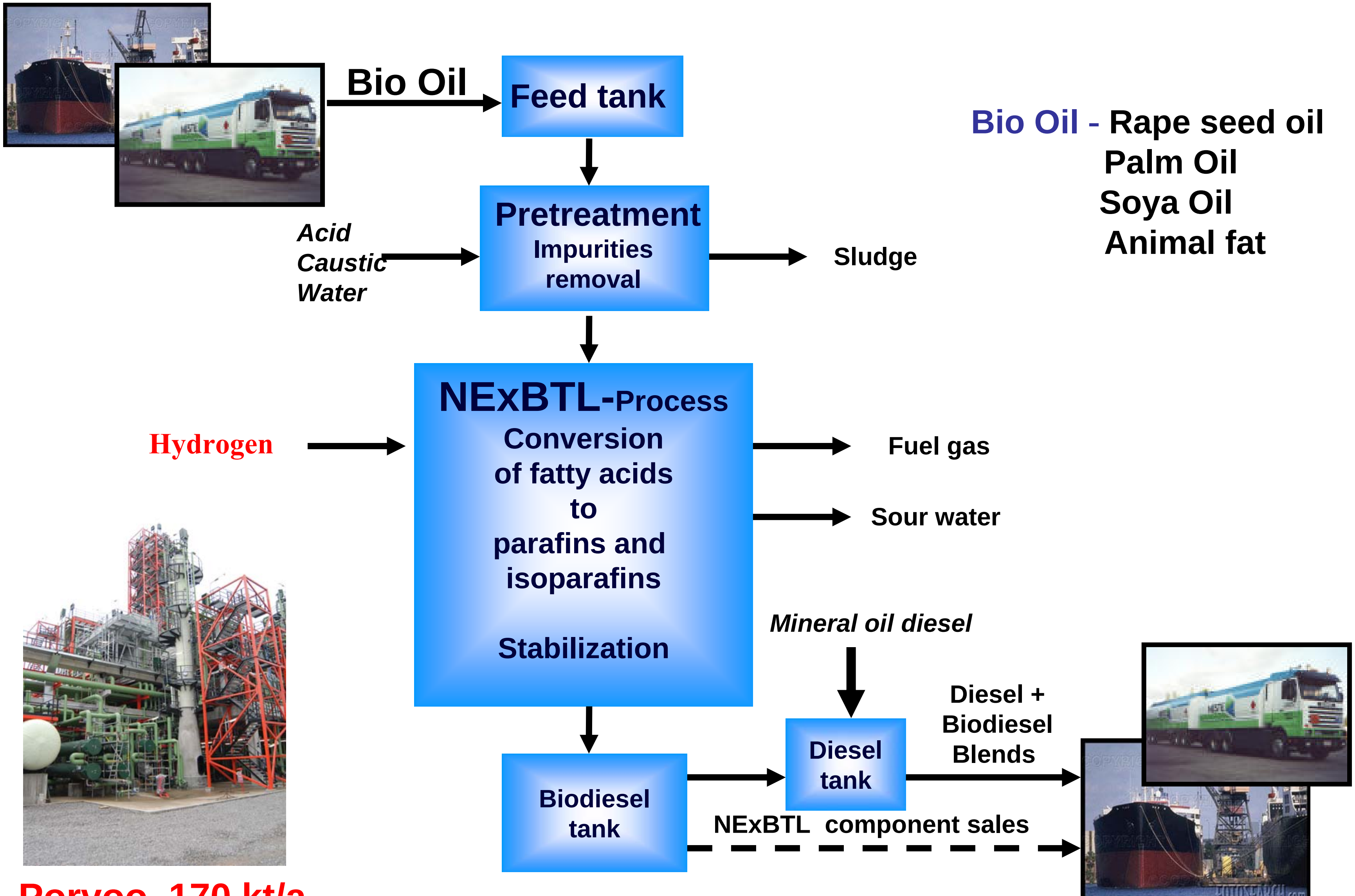
- Equivalent volume yield of diesel fuel
- Uses available hydrogen as a feedstock
- No low value liquid by-products
- Can process fatty acids in lower cost vegetable oils



- Upgrade vegetable oil using hydroprocessing
- Product is an high cetane diesel blending component
- Hydrocarbon product, not an oxygenated compound
- Co-production of propane, naphtha, and high quality jet fuel possible


Ecofining Process Chemistry Details
uop
A Honeywell Company
26:33
HO
O
CH3
CO2 + H3C
CH3
H2
H2O + H3C
CH3
O
HC-O O
O
CH3
CO2
H3C
H3C
CH3
CH3
CH2 +
O O
CH3
H2O
H3C
H3C
CH3
O
Feed
Make-up Hydrogen
Acid Gas Removal
CO2
Reactor System
Separator
Water
Propane & Light Ends
Green Naphtha or Jet
Green Diesel Product
CH3 CH3
CH3
CH3
CH3
H3C
H3C
+
+
H3C
CH3
CH3CH3
H3C
CH3
Ecofining Feed Testing Program – Soy, Rapeseed, Palm, Jatropha, Algal, Tallow, ...

REFINERY BASED NEXBTL UNIT



Porvoo, 170 kt/a

NESTE OIL

Fuel Property comparison

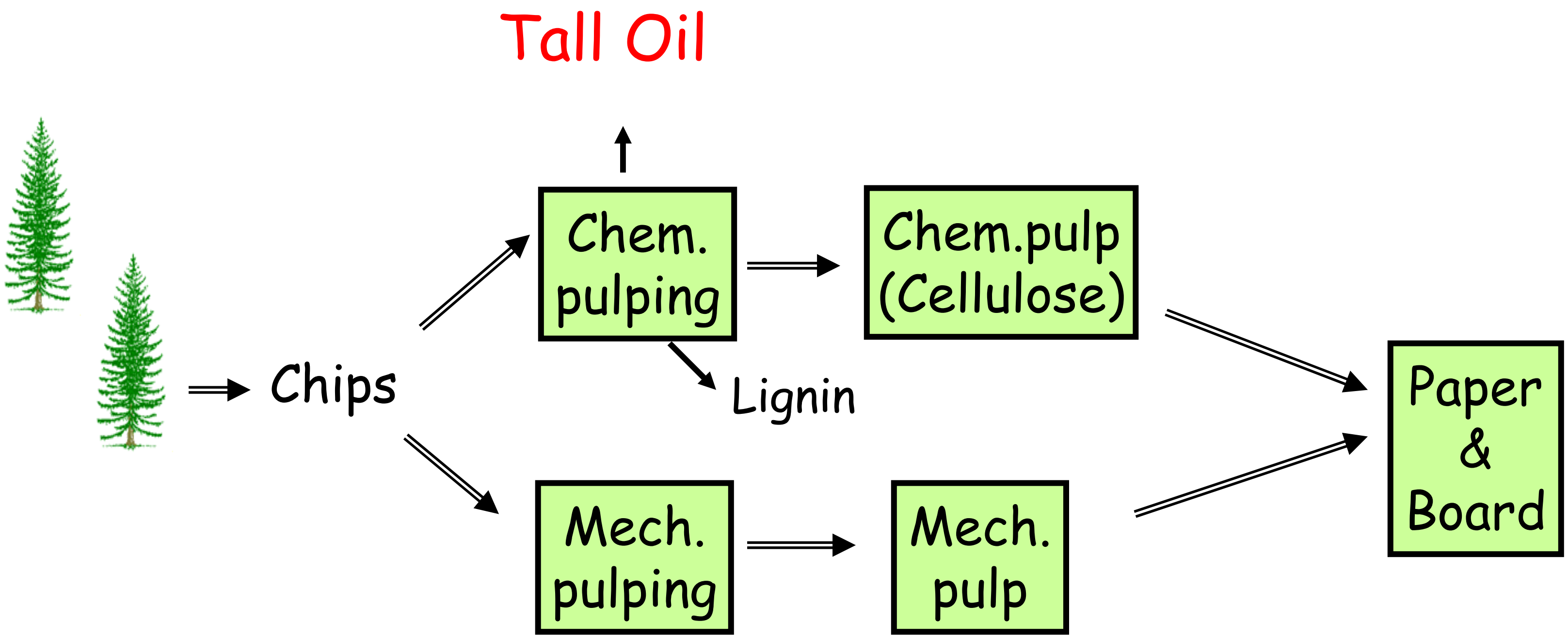
	NExBTL	GTL	FAME (RME)	Sulfur free Diesel fuel (summer)
Density at +15°C (kg/m^3)	775 ... 785	770 ... 785	≈ 885	≈ 835
Viscosity at +40°C (mm^2/s)	2.9 ... 3.5	3.2 ... 4.5	≈ 4.5	≈ 3.5
Cetane number	≈ 84 ... 99 *	≈ 73 ... 81	≈ 51	≈ 53**
Cloud point (°C)	≈ - 5 ... - 30	≈ 0 ... - 25	≈ - 5	≈ - 5
Heating value (lower) (MJ/kg)	≈ 44	≈ 43	≈ 38	≈ 43
Heating value (MJ/l)	≈ 34	≈ 34	≈ 34	≈ 36
Polyaromatic content (wt-%)	0	0	0	≈ 4
Oxygen content (wt-%)	0	0	≈ 11	0
Sulfur content (mg/kg)	< 10 (< 1)	< 10	< 10	< 10
Carbon / hydrogen	≈ 5.6	≈ 5.6		≈ 6.0

*) Blending cetane number
**) ASTM specification > 40

Feedstocks: bio-oil

Feedstock	Oil yield / ha	1 ton biodiesel to vegetable oil	ha equivalent
Rapeseed EU25	1.18	1	0.85
Soybean Oil	0.49	1	2.02
Palm Oil	4.05	1	0.25
Sunflower Oil	0.62	1	1.63

Feedstocks: wood based oil

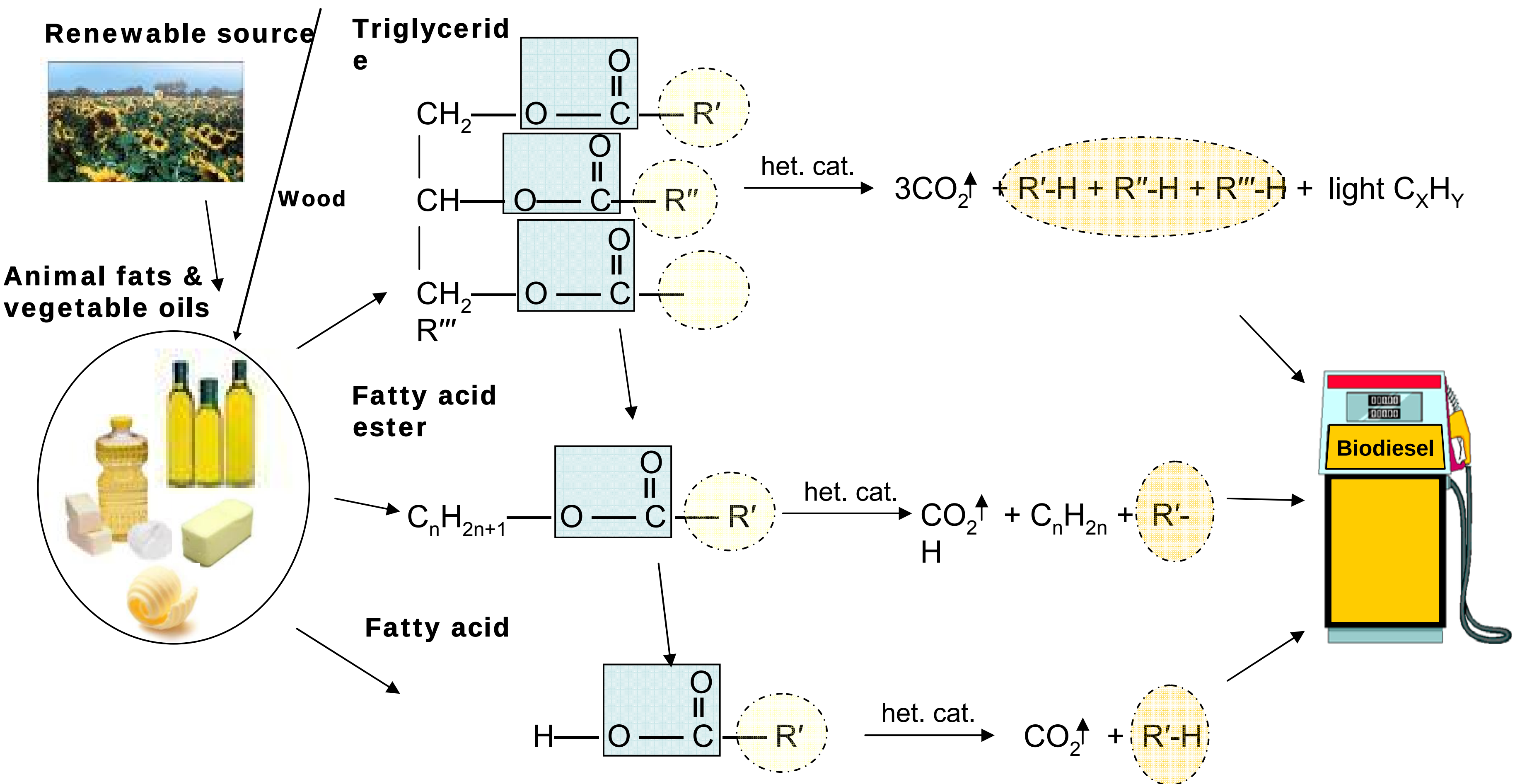


Tall oil

Resinous yellow-black oily liquid composed mainly of a mixture of rosin acids, fatty acids and sterols; obtained as a byproduct in the treatment of pine pulp.

Rauma, Finland

DEOXYGENATION CHEMICAL PROCESSES



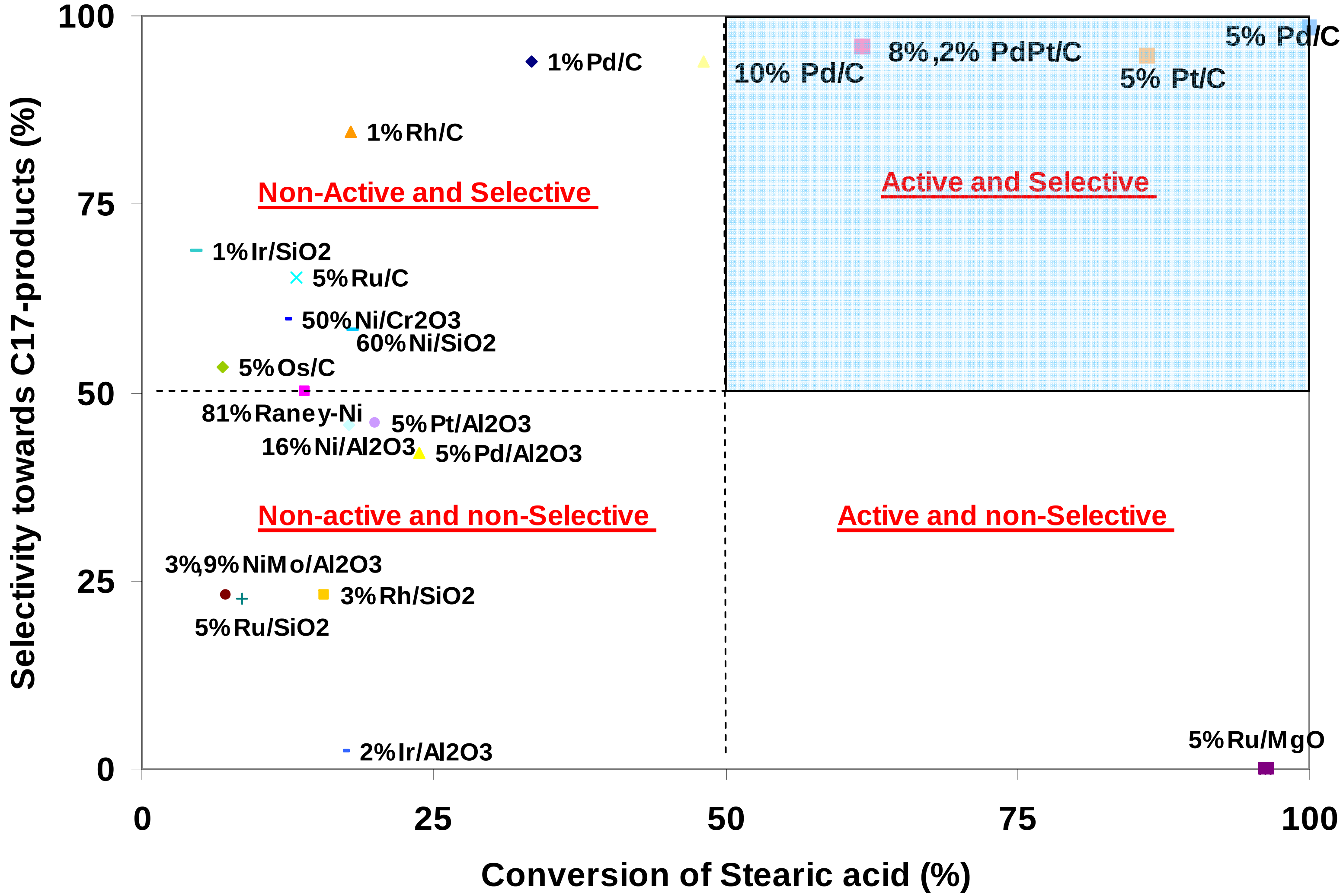
C_nH_{2n+1} = Ester alkyl group (C1-C4)

R′, R′′, R′′′ = Fatty acid alkyl chain, (saturated and unsaturated, C5-C23)

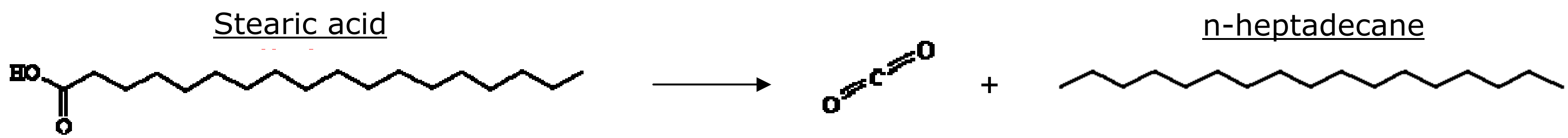
- Over 70 tested catalysts
  - with a wide variety of metal and support combinations
    - metals
      - Pd, Pt, Rh, Os, Ni, Mo, Ru and Ir
    - support
      - metal oxides (Cr_2O_3, Al_2O_3, SiO_2 and MgO)
      - zeolites (ZSM-5, Mordenite, BETA and Y)
      - mesoporous materials (MCM-21 and MCM-41)
      - carboneous material (activated carbons and carbon cloths)
  - with different metal contents

Catalyst screening in the deoxygenation of stearic acid

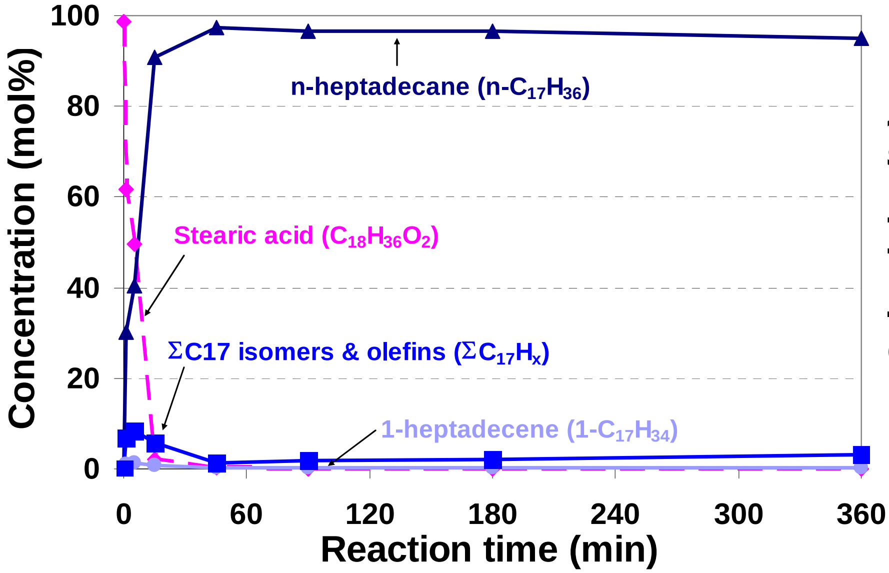
Reaction conditions: 0.15 mol/l Stearic acid in dodecane, 1g of catalyst, P= 6 bar (He) and T = 300˚C

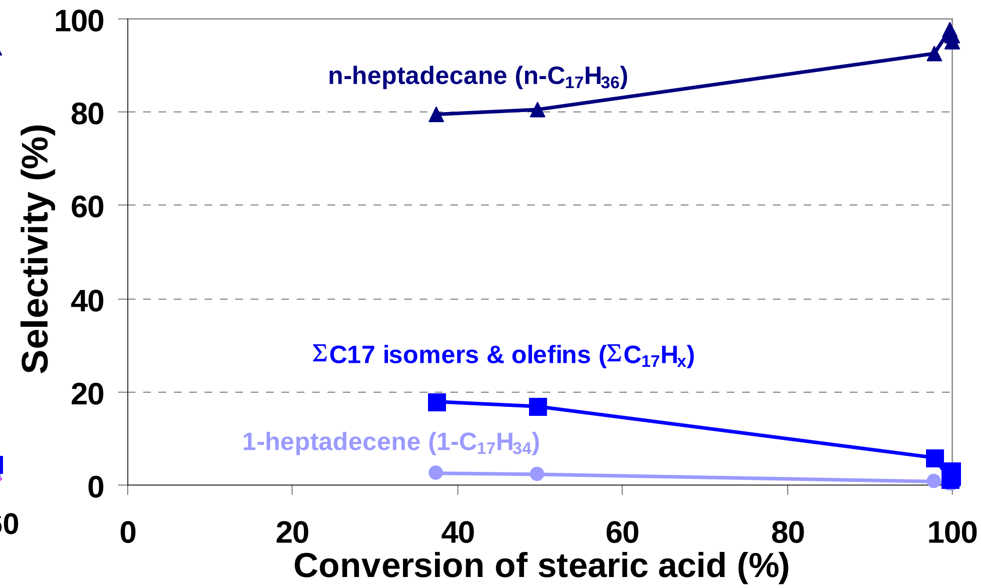


5% Pd/C



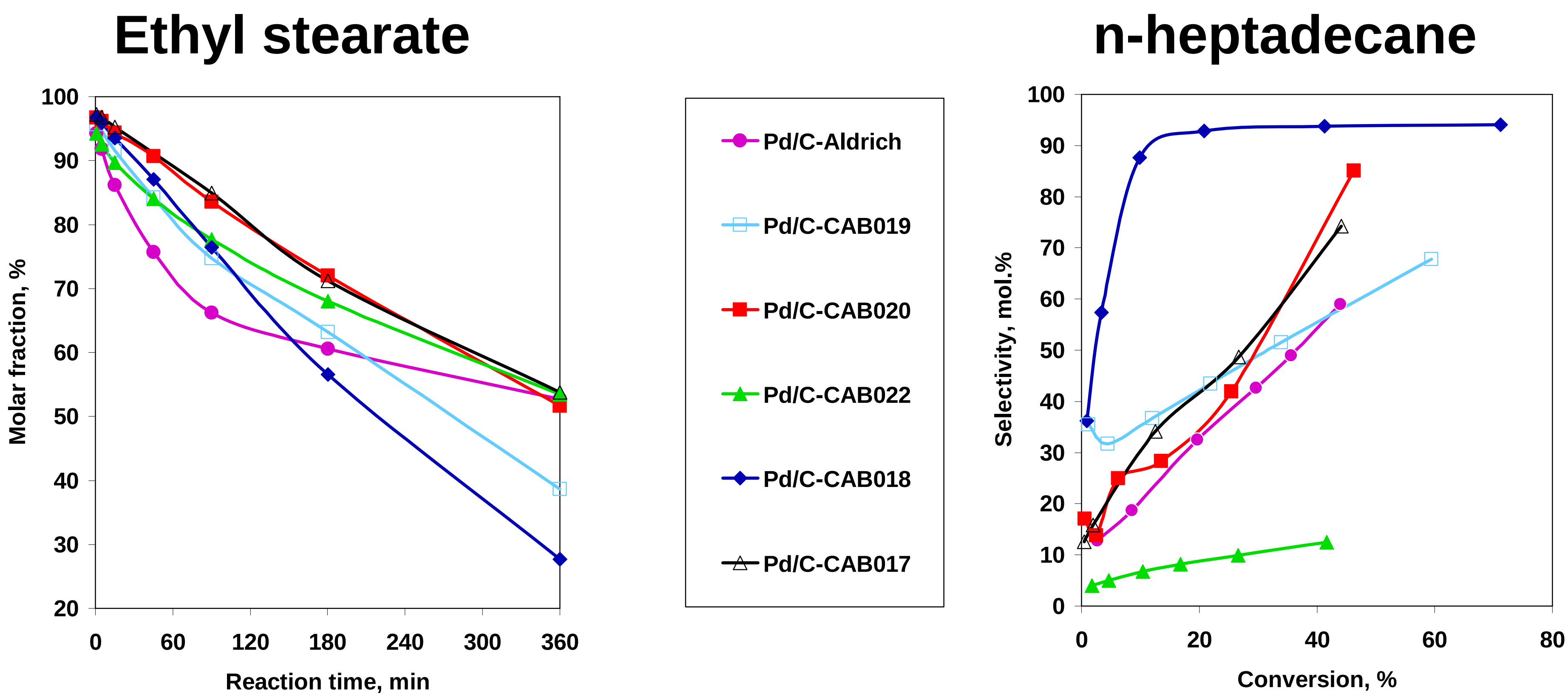
Reaction conditions: 0.15 mol/l Stearic acid in dodecane, 1g Pd/C, P= 6 bar (He) and T=300˚C





Catalyst development

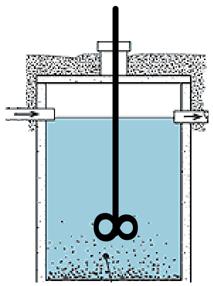
- over 20 prepared 5% Pd/C catalysts
  - with different activated carbon supports
    - birch, peat and coal based
  - with a wide variety of preparation techniques
    - metal deposition (impregnation and precipitation)
    - carbon activation (heat and chemical treatment)

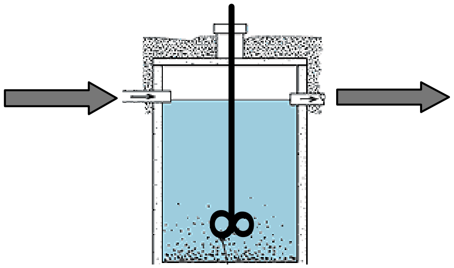


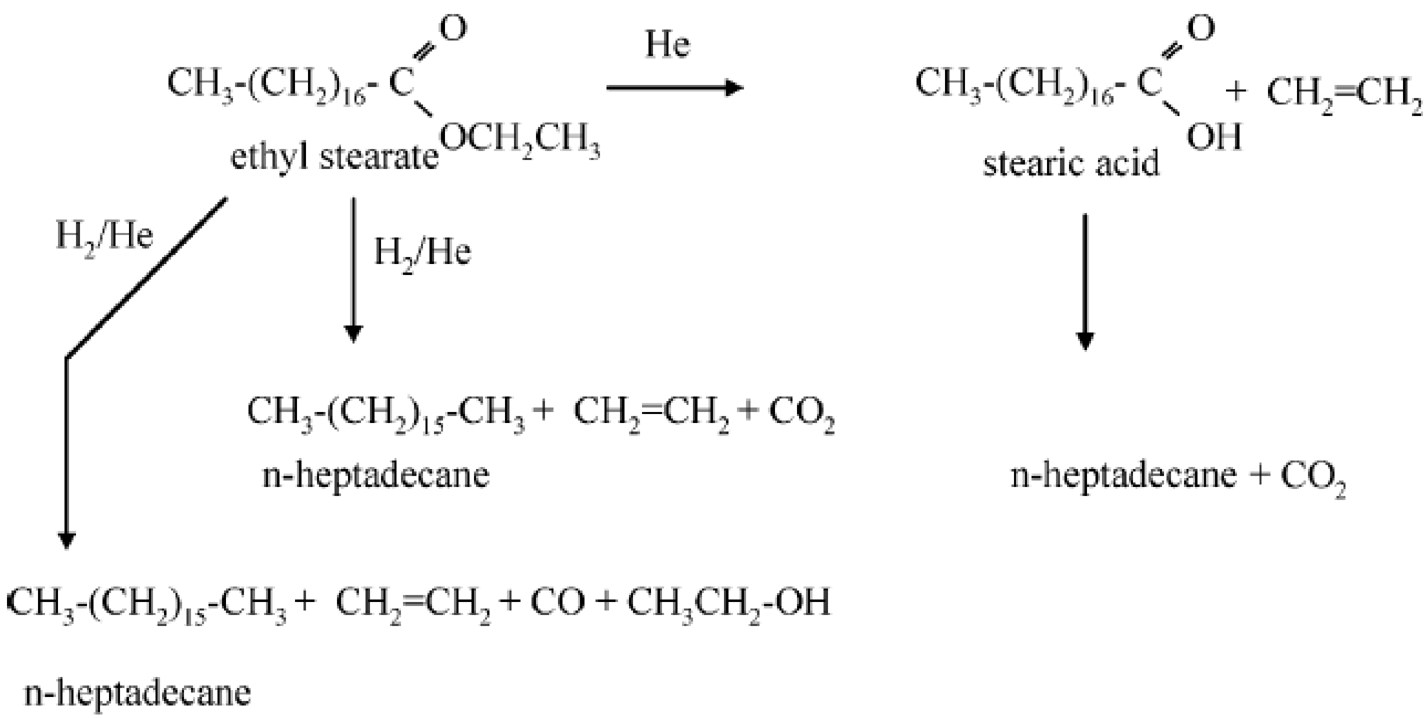
Reaction conditions: 0.1 mol/l Ethyl stearate in dodecane, 1g Pd/C, P= 7.5 bar (H_2) and T=320˚C

Optimization

- Effect of
  - temperature
  - pressure
  - reactant concentration
  - solvent
  - atmosphere
  - catalyst mass and metal content
  - catalyst pretreatment



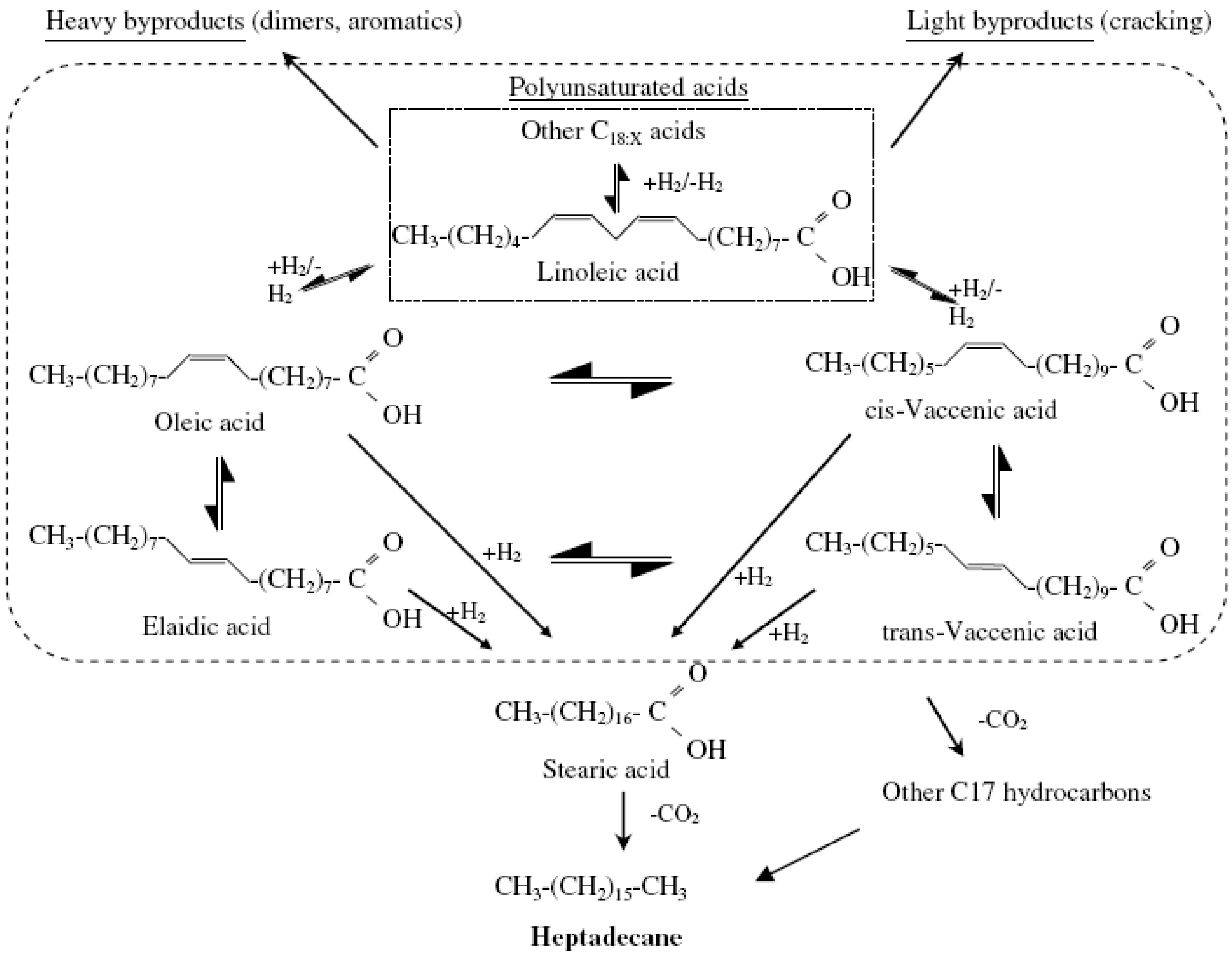


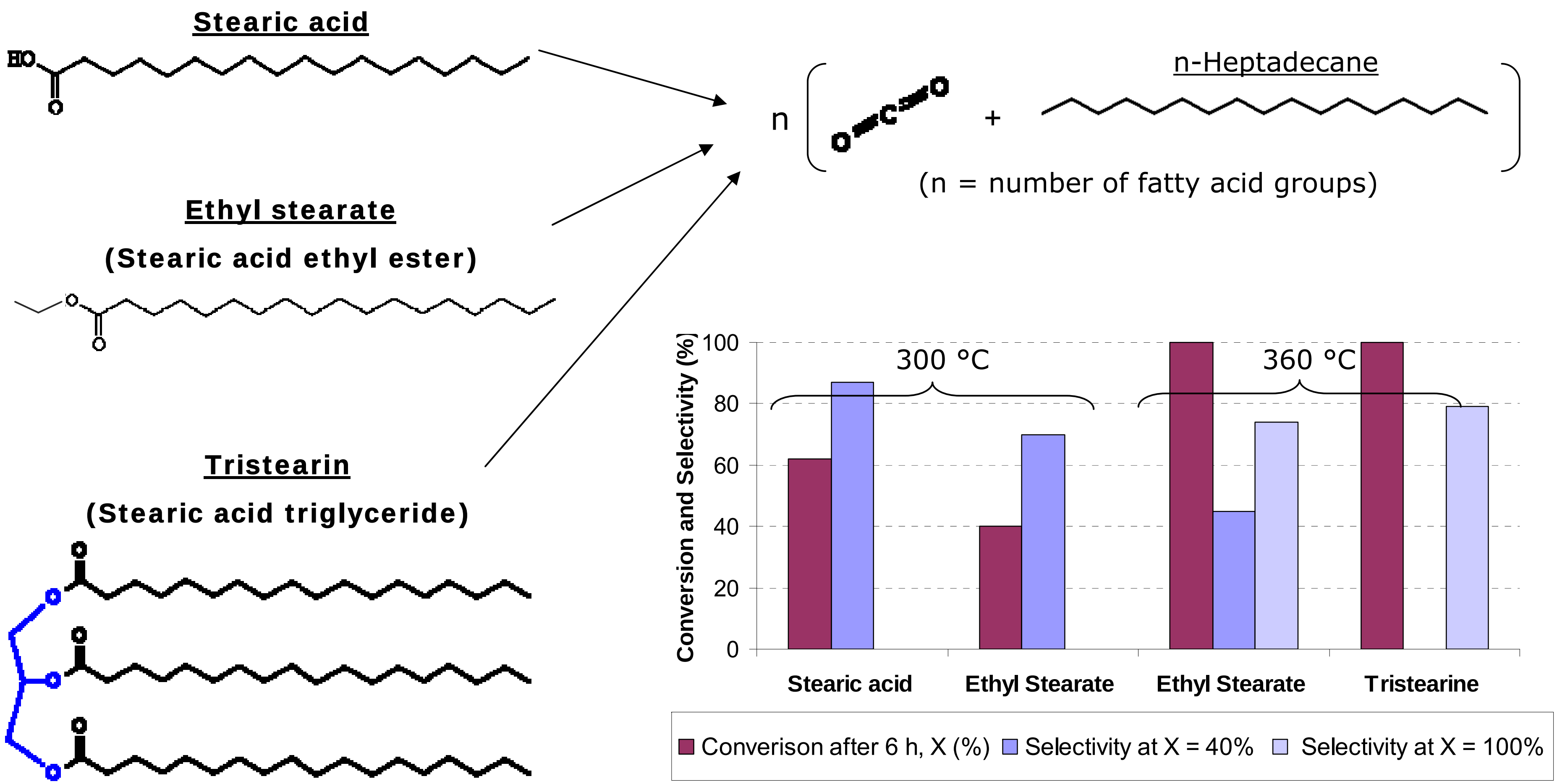


Energy & Fuels **2007,** *21,* 30−41

Catalytic Deoxygenation of Fatty Acids and Their Derivatives

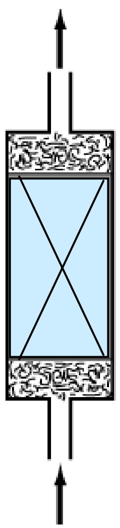
Päivi Mäki-Arvela, Iva Kubickova, Mathias Snåre, Kari Eränen, and Dmitry Yu. Murzin*
Process Chemistry Centre, Åbo Akademi University, Biskopsgatan 8, FIN-20500 Turku, Finland


Heavy byproducts (dimers, aromatics)
Light byproducts (cracking)
Polyunsaturated acids
Other C18:X acids
+H2/-H2
CH3-(CH2)4- -(CH2)7- C O OH
Linoleic acid
+H2/-H2
+H2/-H2
CH3-(CH2)7- -(CH2)7- C O OH
Oleic acid
CH3-(CH2)5- -(CH2)9- C O OH
cis-Vaccenic acid
CH3-(CH2)7- -(CH2)7- C O OH
Elaidic acid
CH3-(CH2)5- -(CH2)9- C O OH
trans-Vaccenic acid
+H2
+H2
+H2
+H2
CH3-(CH2)16- C O OH
Stearic acid
-CO2
-CO2
Other C17 hydrocarbons
CH3-(CH2)15-CH3
Heptadecane

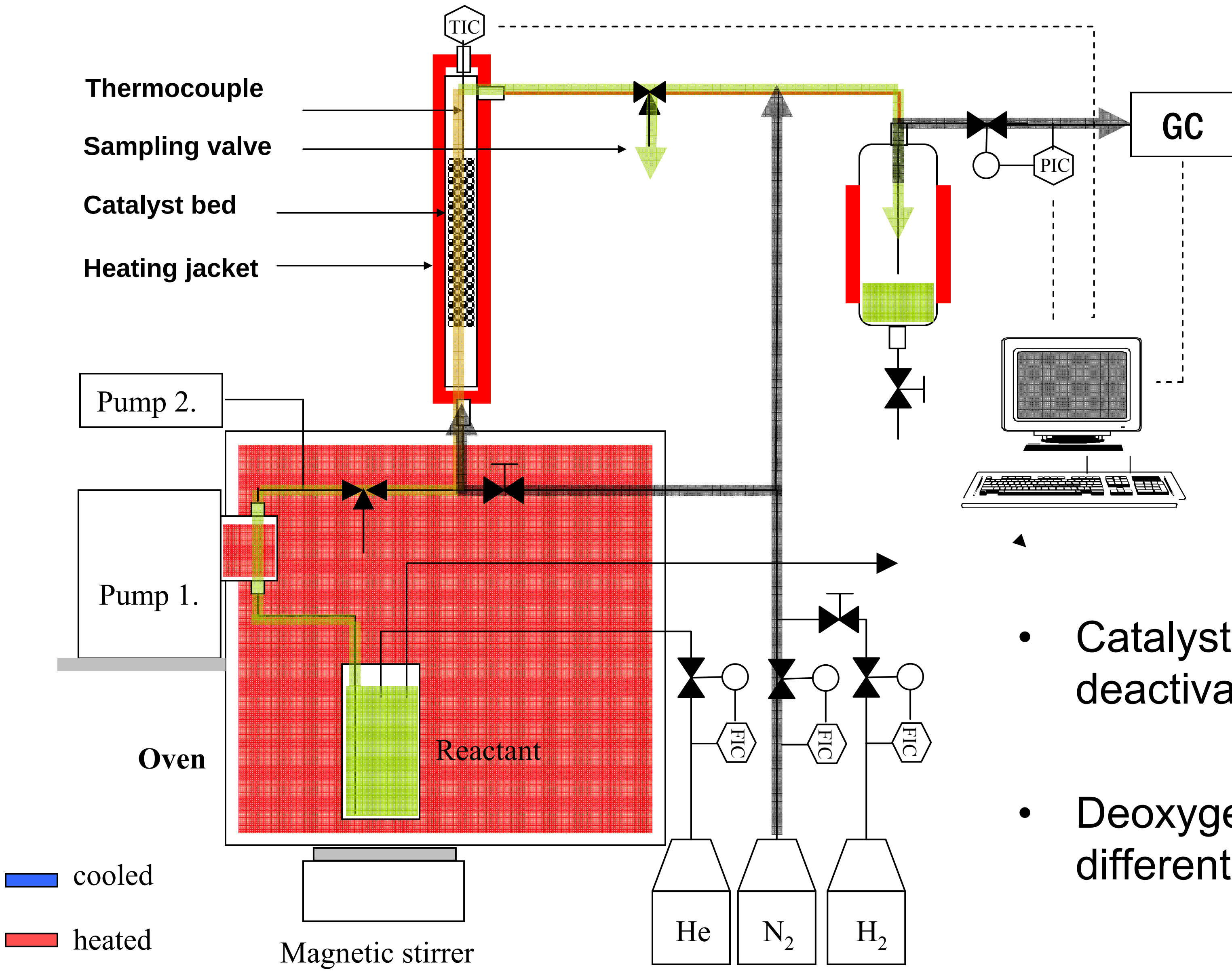


Reaction conditions: 1.6 mol/l feed in dodecane, 1g Pd/C, $P_{300^\circ C}$ = 17, $P_{360^\circ C}$ = 40 bar in Ar +H_2(5%) atmosphere

Fixed bed reactor

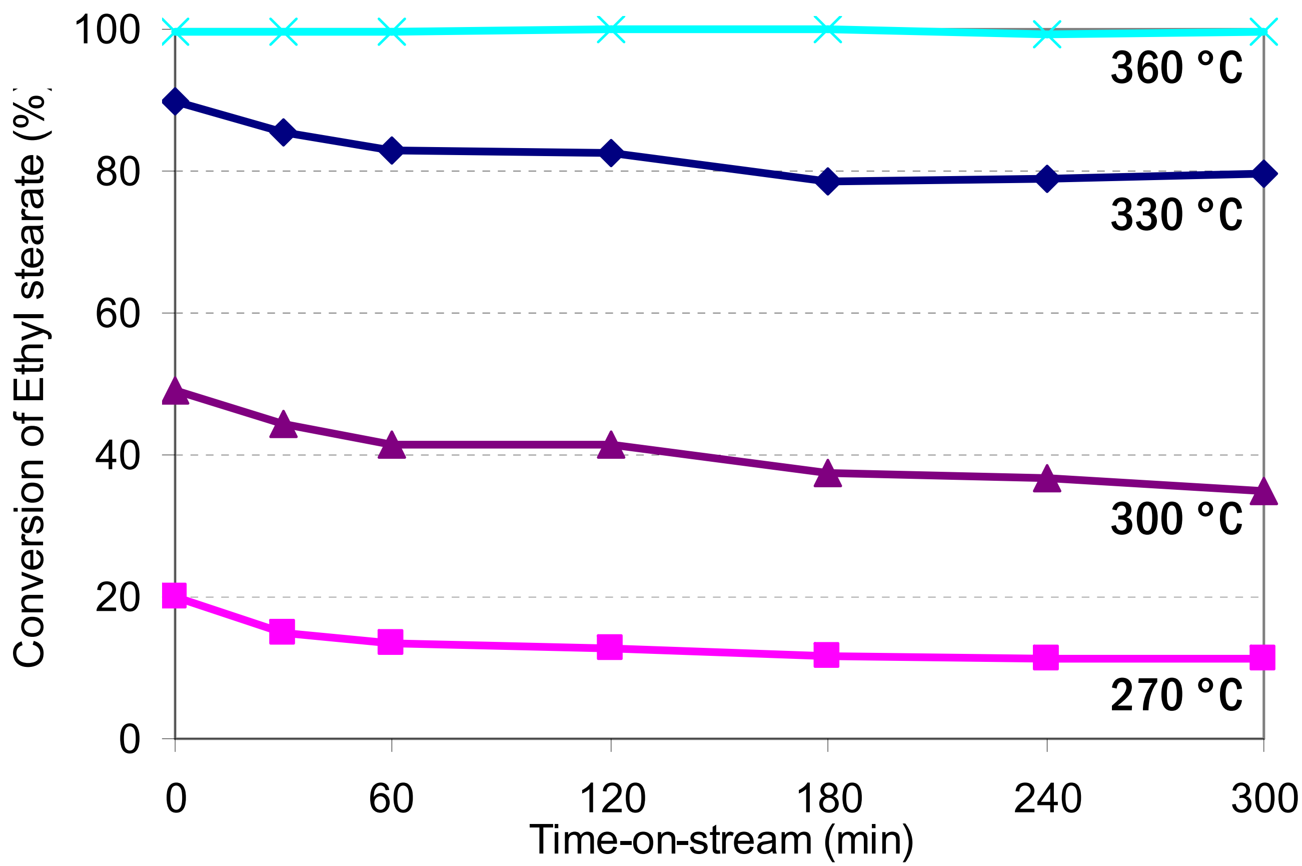


Deactivation?
Mass transfer?



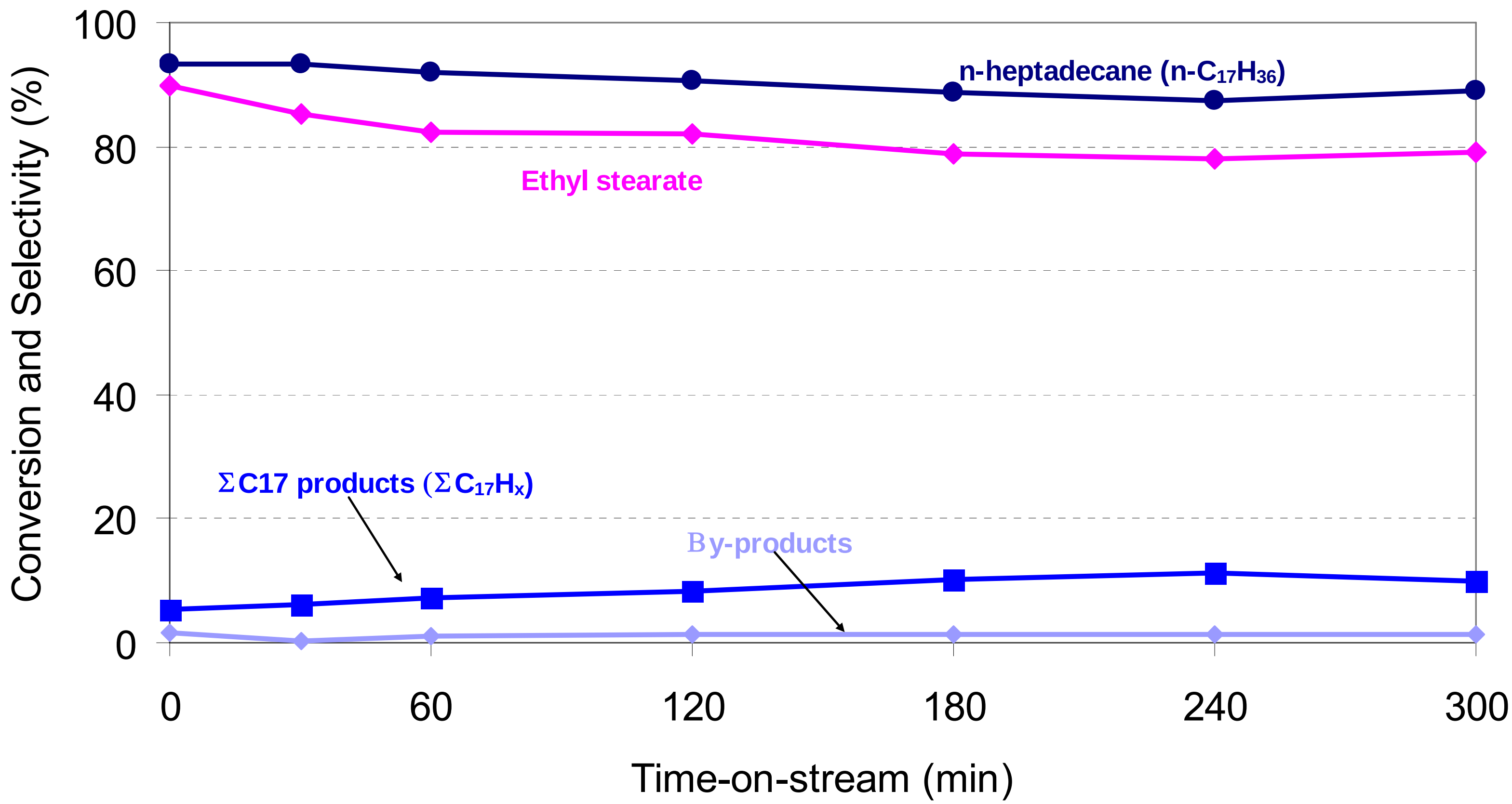
- Catalyst stability and deactivation
- Deoxygenation of different feedstocks

Continous decarboxylation of ethyl stearate



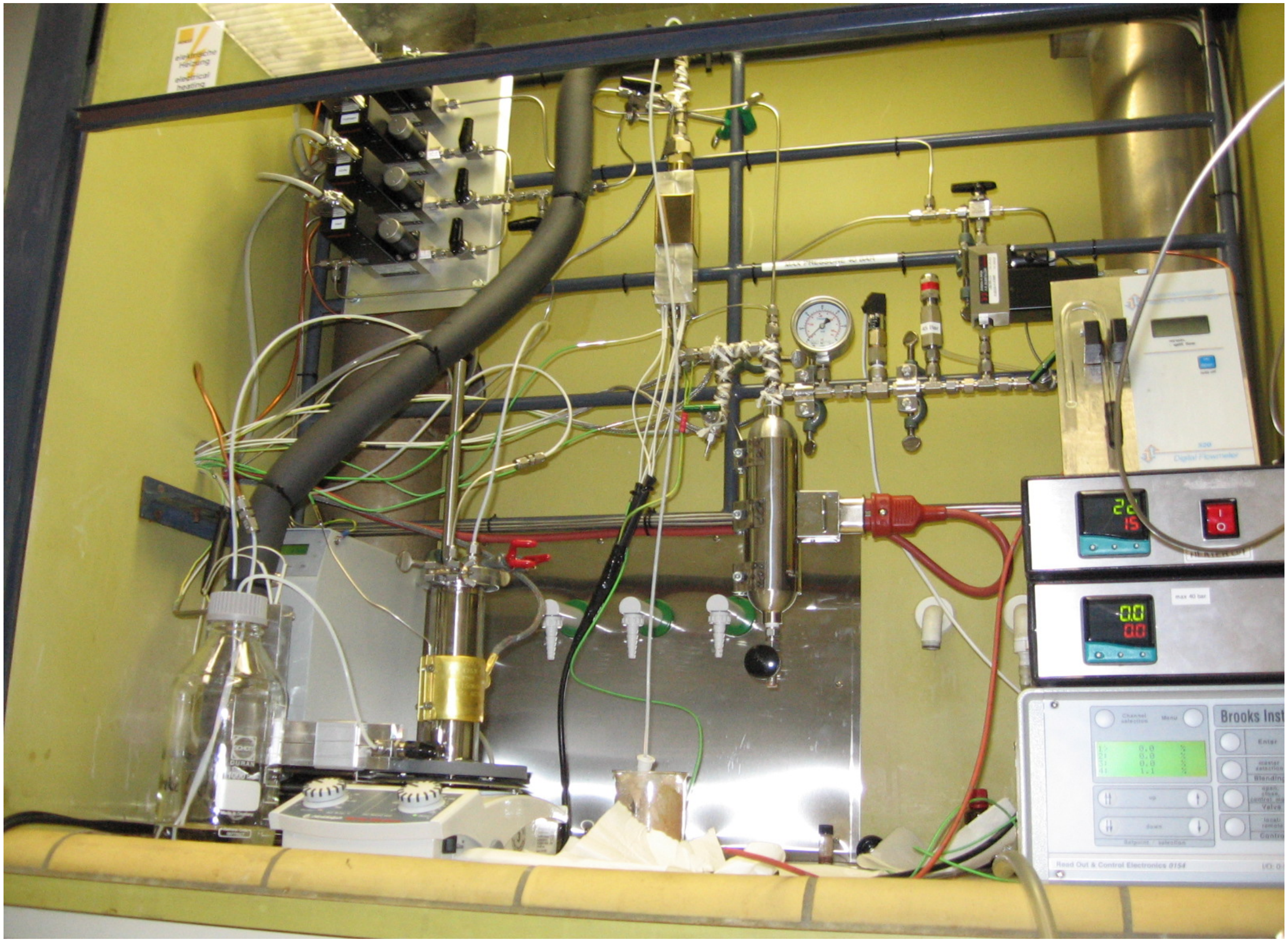
Reaction conditions: 0.16 mol/l Ethyl stearate in hexadecane, 0.4g Pd/C, V'=0.1 ml/min

Continous decarboxylation of ethyl stearate

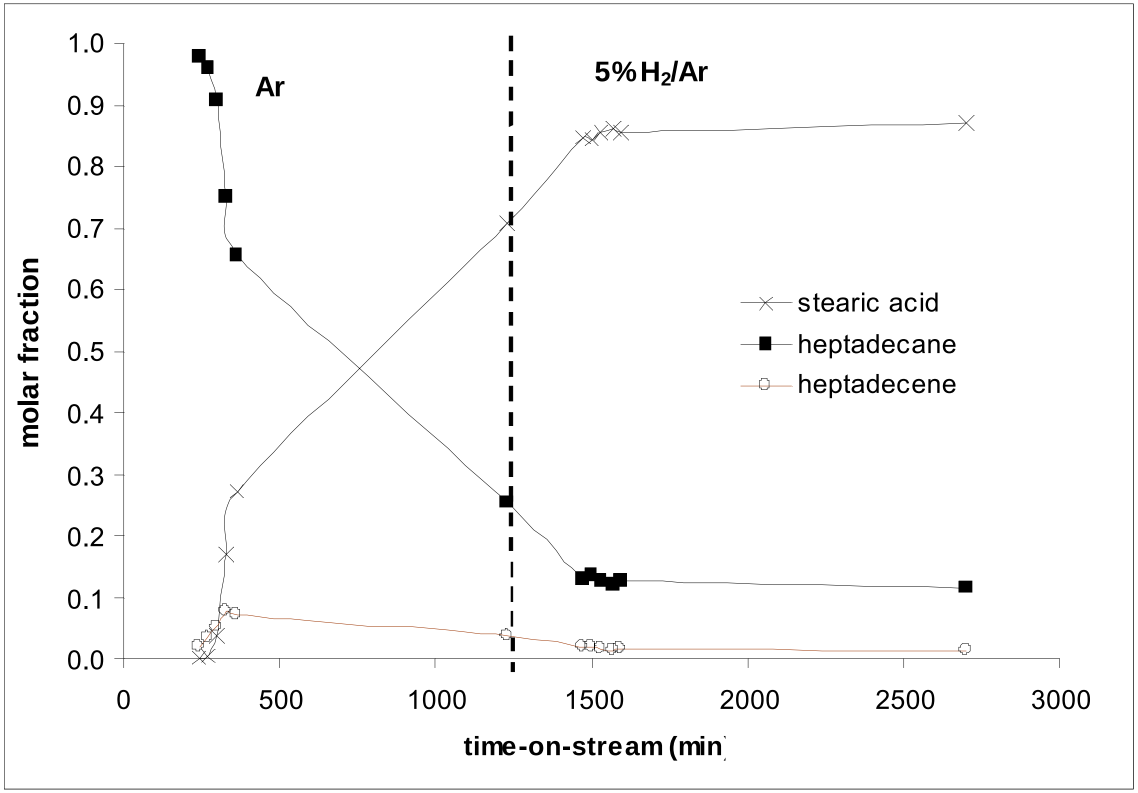


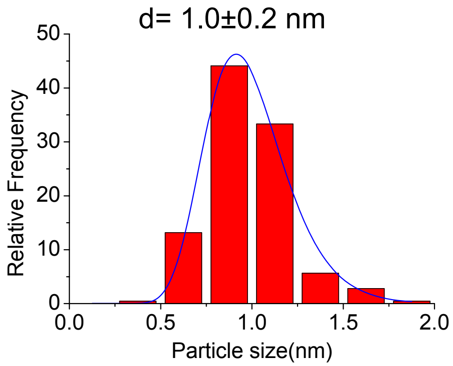
Reaction conditions: 0.16 mol/l Ethyl stearate in hexadecane, 0.4g Pd/C, V'=0.1 ml/min, T = 330˚C and P = 5 bar

Trickle bed



Deoxygenation: neat stearic acid





5 wt-% Pd/Sibunit, reaction temperature 360 ^{o}C, reaction pressure 10 bar (first argon, then 5% hydrogen in argon), volumetric flow rate of stearic acid 0.075 ml/min.

S. Lestari, P. Mäki-Arvela, H. Bernas, O. Simakova, R. Sjöholm, J. Beltramini, G.Q. Max Lu, J. Myllyoja, I. Simakova, D.Yu. Murzin, Catalytic deoxygenation of stearic acid in a continuous reactor over a mesoporous carbon Pd catalyst, *Energy and Fuels*, **2009**, *23*, 3842-3845.

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 July 2006 (20.07.2006)

PCT

(10) International Publication Number
WO 2006/075057 A3

(71) **Applicant** *(for all designated States except US)*: **NESTE OIL OYJ** [FI/FI]; Keilaranta 8, FI-02150 Espoo (FI).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **MURZIN, Dmitry Yu.** [RU/FI]; Valkiapääkatu 2 D 27, FI-20610 Turku (FI). **KUBICKOVA, Iva** [CZ/CZ]; Podkrusnohorska 1033, 43601 Litvinov (CZ). **SNÅRE, Mathias** [FI/FI]; Kellonsoittajankatu 3-7 F 127, FI-20500 Turku (FI). **MÄKI-ARVELA, Päivi** [FI/FI]; Hurtinkatu 7 C 11, FI-20610 Turku (FI). **MYLLYOJA, Jukka** [FI/FI]; Lammastie 14 C 12, FI-01710 Vantaa (FI).

(54) **Title:** METHOD FOR THE MANUFACTURE OF HYDROCARBONS

(57) **Abstract:** Feedstock originating from renewable sources is converted to hydrocarbons in diesel fuel distillation range by contacting with a supported catalyst comprising VIII group metal/metals, whereby the consumption of hydrogen is decreased.