Advanced biofuels and added value products from residual quasi-homogeneous biomass: from ethanol to *drop-in* fuels

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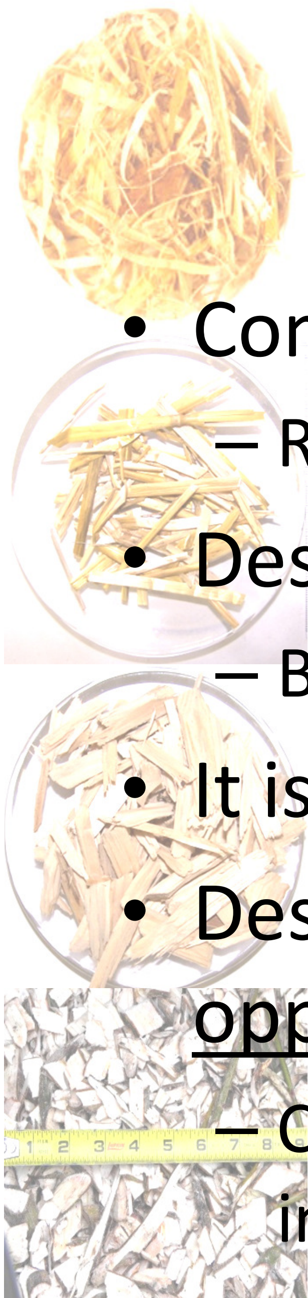
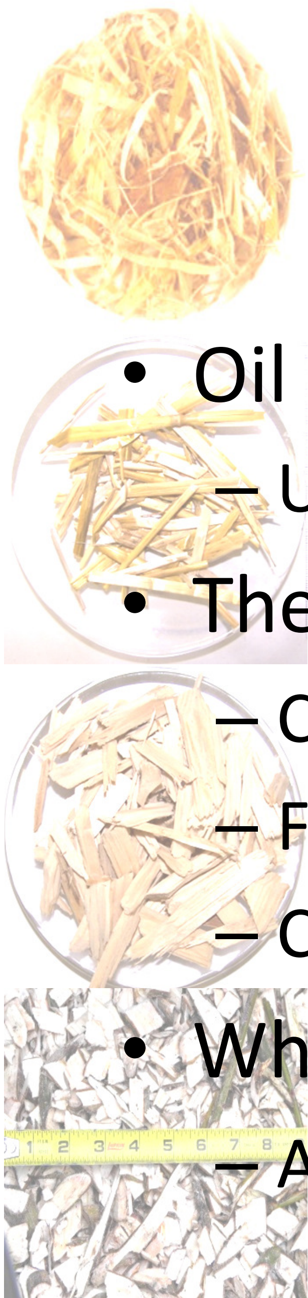
Biorefinery



- Comes from « bio » et « refinery »
  - Refine biological material
- Despite what we might think:
  - Biomass HAS a market
- It is diversified and complex
- Despite these facts – it stills represents an <u>opportunity:</u>
  - Carbon content, locally available and still as important : IT IS RENEWABLE

A lesson from the master



- Oil industry:
  - Use petroleum and refines it
- The first steps of a refinery
  - COMMODITIES (fuels)
  - For which there will always be a market
  - Commodities covers for the OPEX
- Where is the margin of profit?
  - Added value chemicals

Convert this reality

- Implementing something as a biorefinery:
  - First objective should be commodities
  - It will ensure economical viability
  - Will also cover for the OPEX of the biorefinery
- Where should be the profit?
  - Added value molécules (and it's not easy!)
- Biomass:
  - As oil: an opportunity
  - Source of renewable and « green » compounds

Biomass

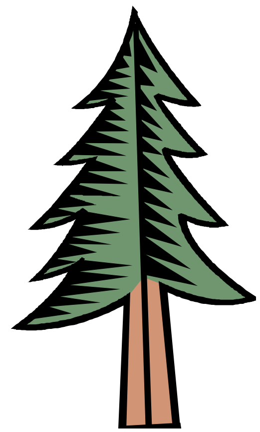
- All biomasses are rich in C [45 - 50 wt%]
- Few biomasses have an homogeneous composition
- Homogeneity will influence «conversion strategies»
- Biomass can be devided in three category:
  - **Homogeneous**
  - **Quasi-homogeneous**
  - **Non-homogeneous**

Abundance

>200 k AMT/year

-Dedicated area
-Large forest/agricul activities
-Contracts should go by:
Governments
Large corporations

25-200 k AMT/year



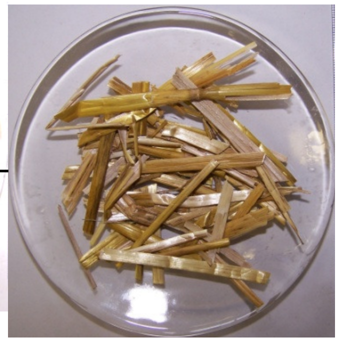
-Residual Biomass
-Available in more locations
-Contracts should go by:
Region and/or municipalities
Private

< 25-200 k TMA/year

-Urban biomass (MSW)
-Available in all cities
-Abundance depends on pop.
100k population ≈ 28 k AMT/y

Composition **VS** conversion

$$



- Cellulose
- Hemicelluloses
- Lignin
- Extracts
- Proteins

Predictable composition

→ Fractionation

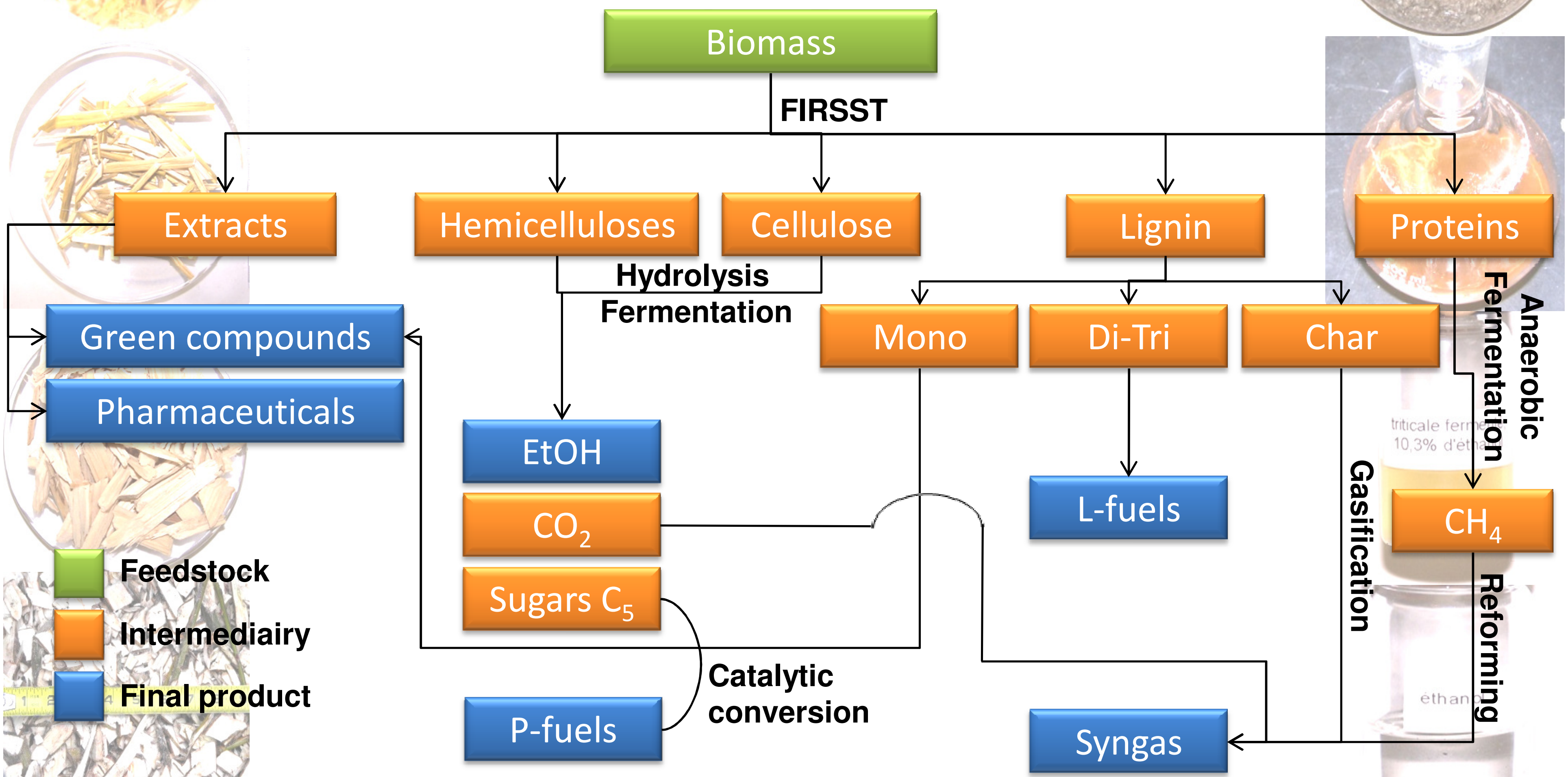
$

- Plastics (non-recyclable)
- Wood
- Paper (non-recyclable)
- Fabrics
- Etc

Unpredictable compostion

→ Gasification

UdS – CRB Biorefining Process



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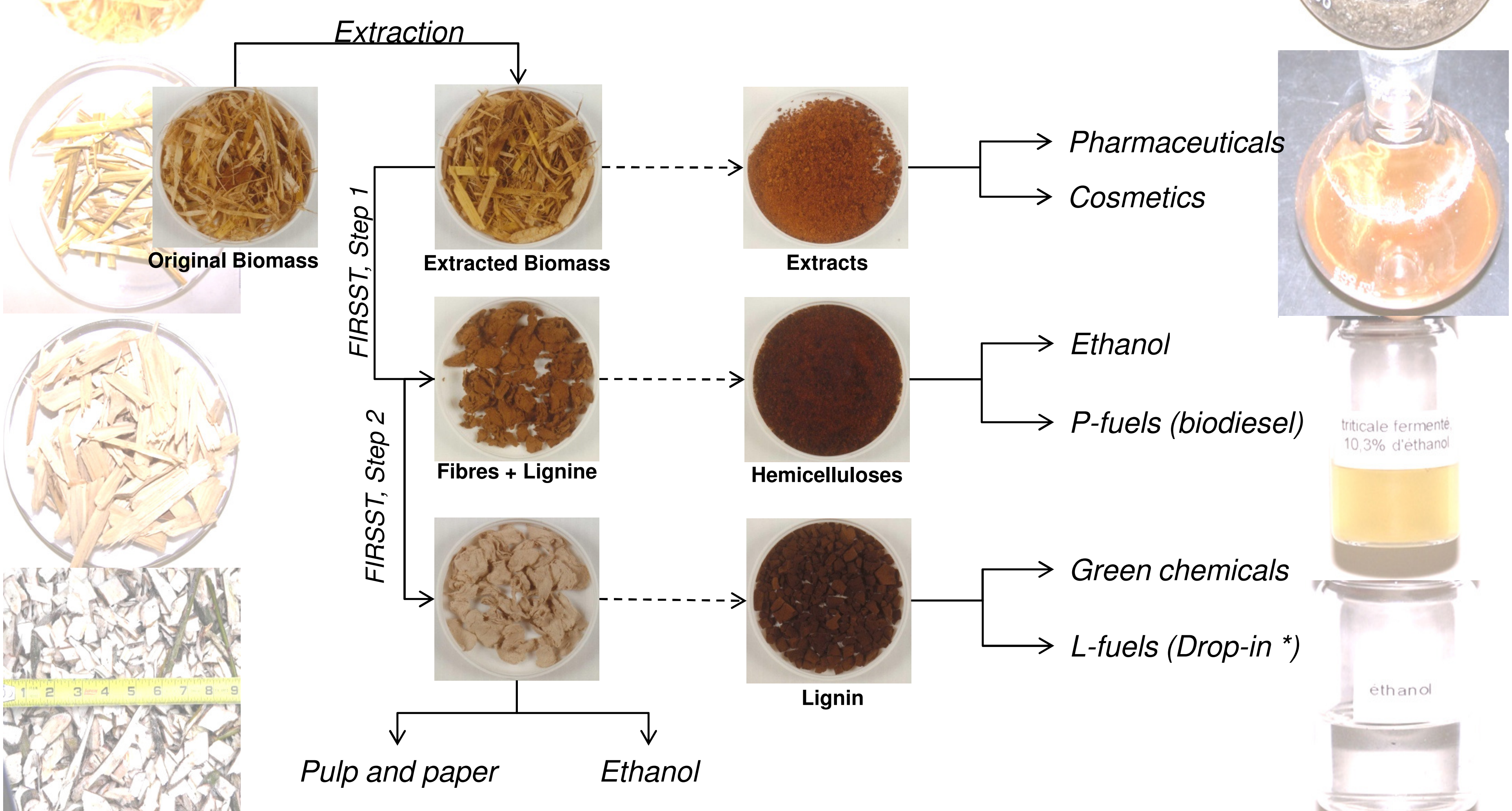
FIRSST process

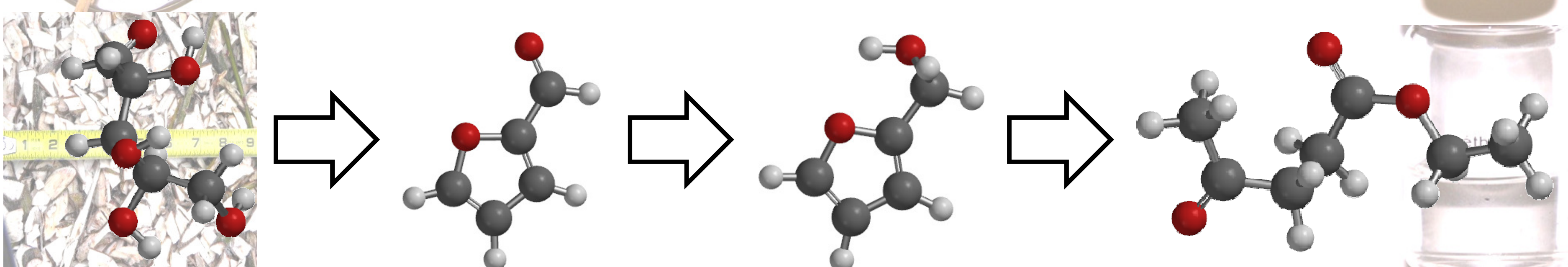


Extractives

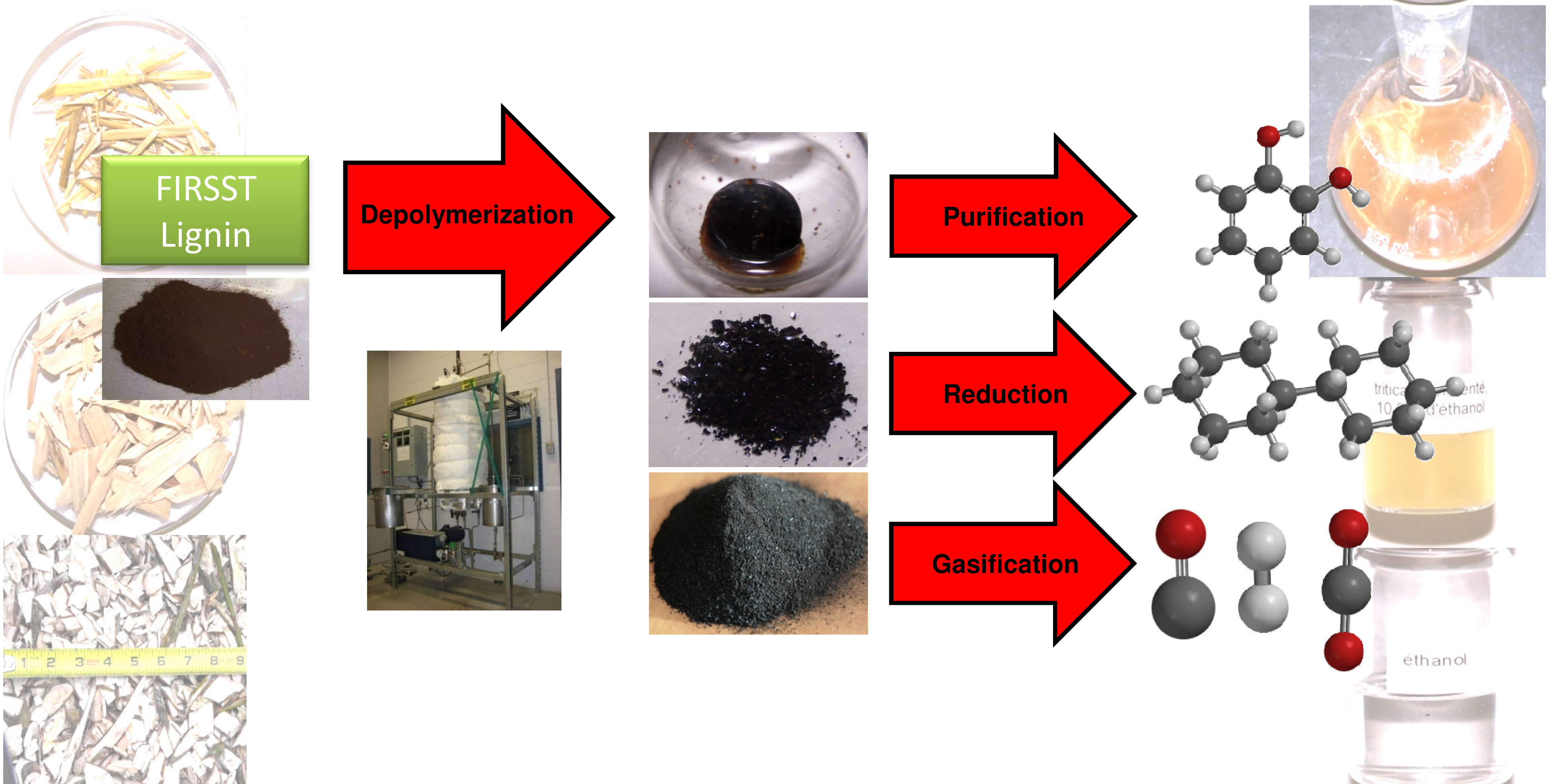
- Extraction is performed before the FIRSST process
- Important:
  - Added value products
  - Limit the inhibitors in the aqueous mixture
- Process – Emulsification-assisted extraction
- Application: Pharma/Cosmetics/Food/Gasification

P-fuels/biodiesel

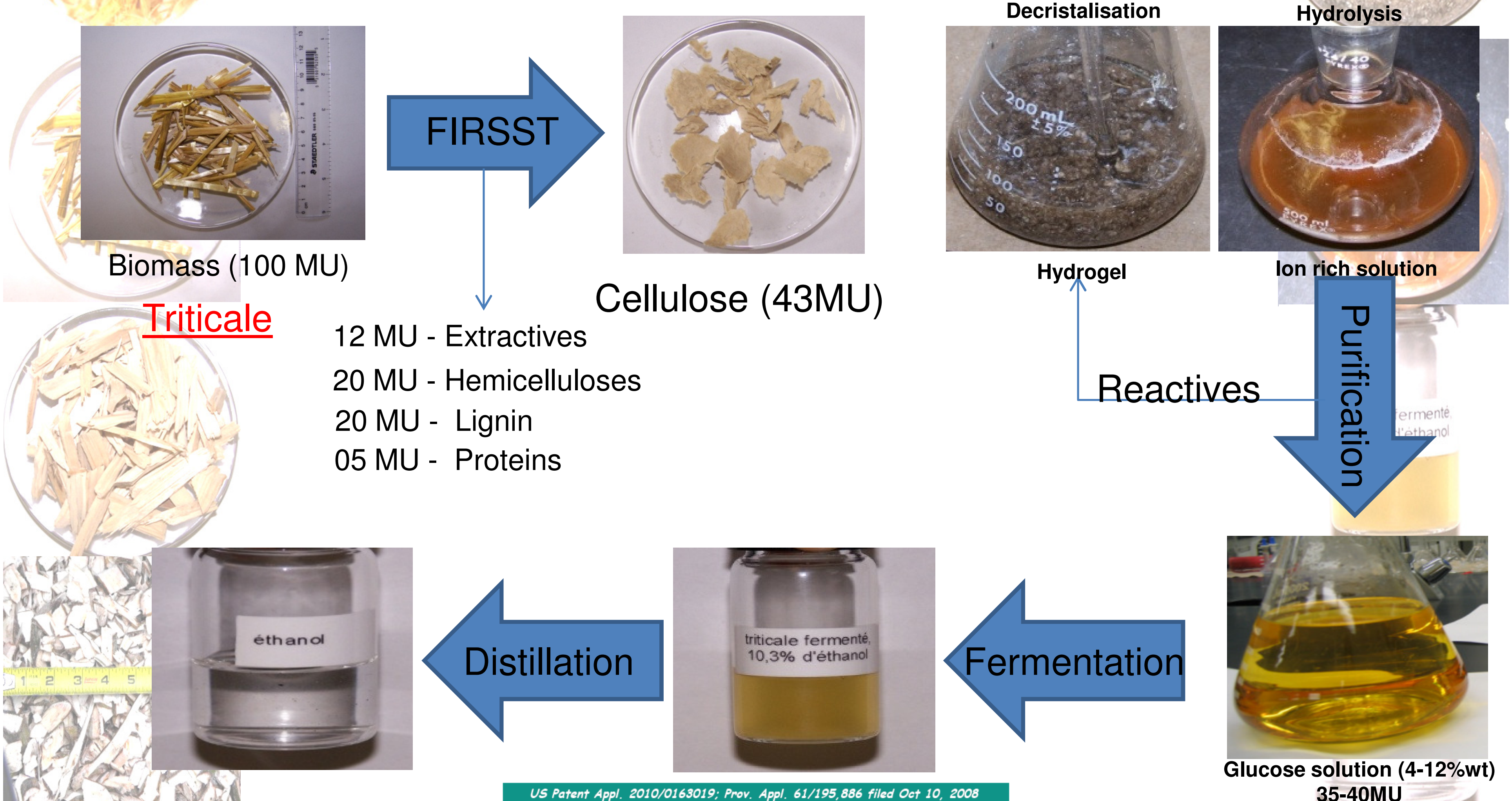
- C_5 sugars are hard to ferment
- Under acid catalyst – furfural
- Highly efficient 3 step process
  - Furfural
  - Furfurylic alcohol
  - Ethyl levulinate



L-fuels/jetfuel



Non-enzymatic hydrolysis



US Patent Appl. 2010/0163019; Prov. Appl. 61/195,886 filed Oct 10, 2008

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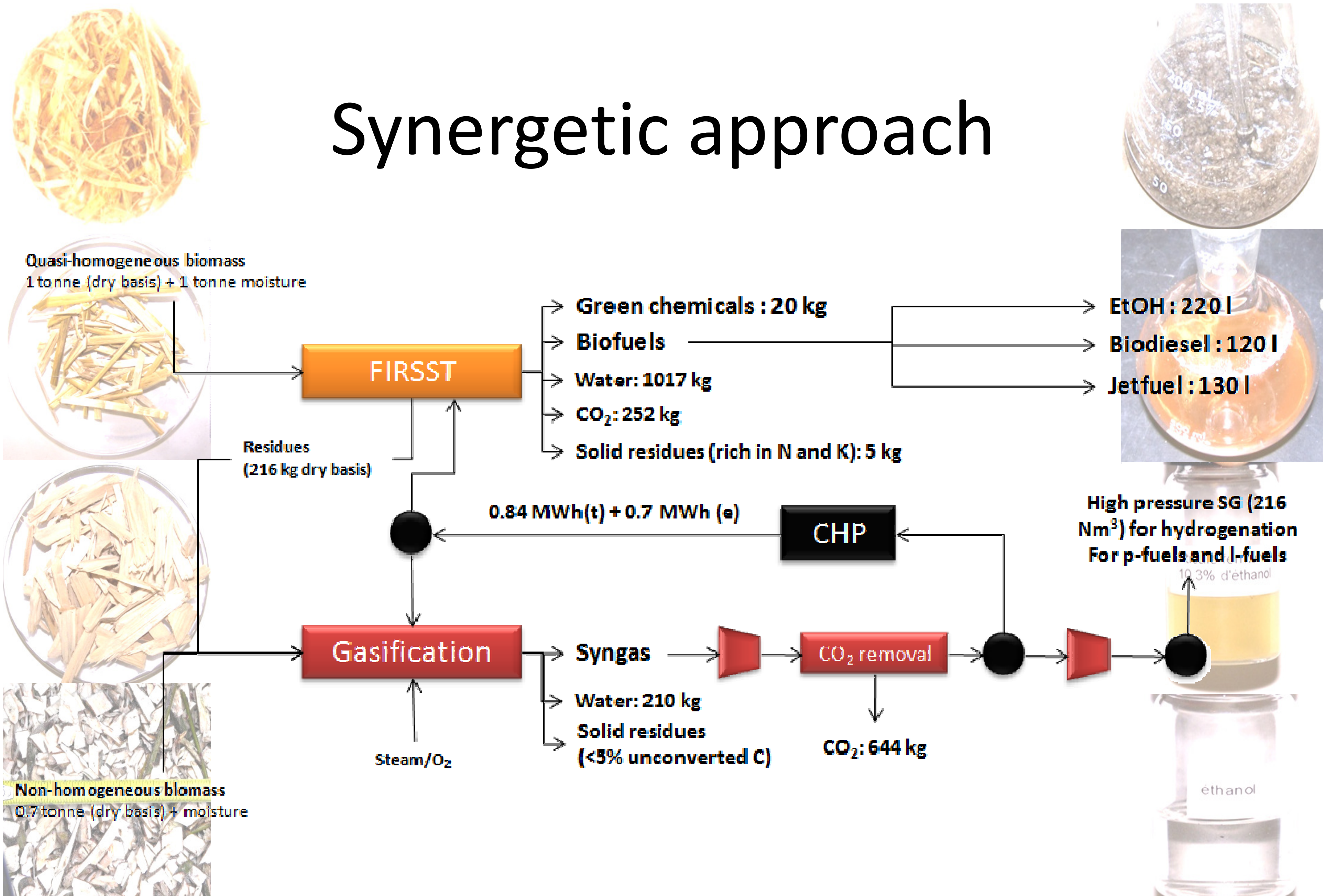
A biorefinery scenario

- Exemple : 1 tonne of agricultural residues
  (In this case triticale)
  - 221 l of EtOH (+46 l invested in p-fuels)
  - 110 l of p-fuels (biodiesel)
  - 110 l of l-fuels (bio jetfuel)
  - 25 kg of green molecules
- Energetic demand
  - 13 GJ/tonne

Synergetic approach



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Energy balance

Biomass	GJ	MWh
1 AMT residual lignocellulosic biomass	18	5.0
0.7 AMT non-homogeneous biomass	14	3.9
Total : **1.7 AMT**	**32**	**8.9**

Products (agricultural residues as an example)	GJ	MWh
Ethanol (216 l – 167 kg)	5.1	1.41
P-fuels : Ethyl Levulinate (124 l – 126 kg)	3.3	0.92
L-fuels : Propylcyclohexane (100l – 88 kg)	3.5	0.97
Residual syngas		0.3
Lignin derived chemicals (31 kg)		0.2
Total Output		**3.80**

TOTAL EFFICIENCY 42% and up to 45%

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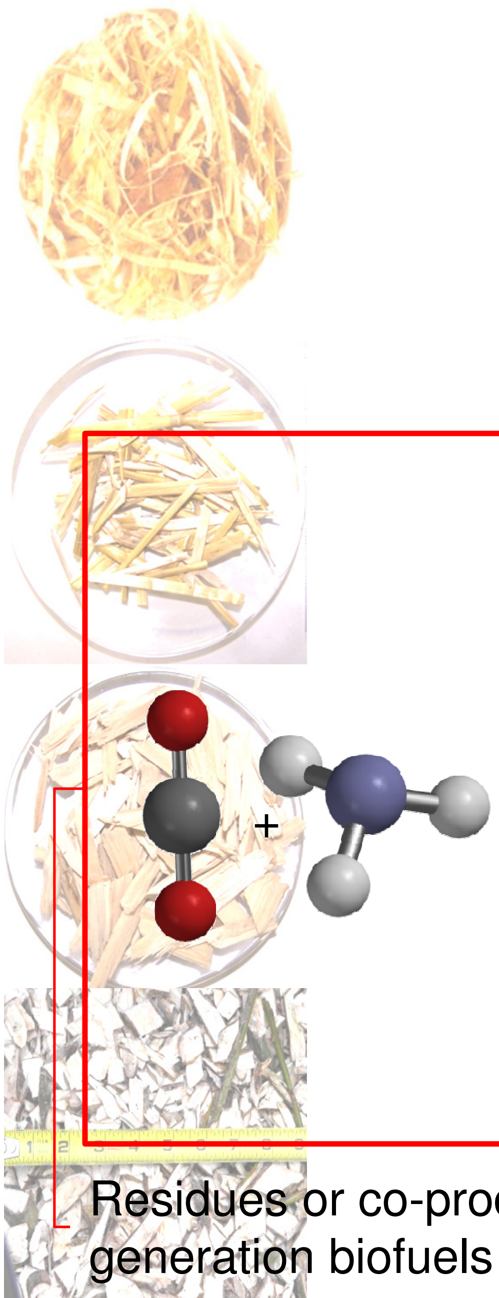
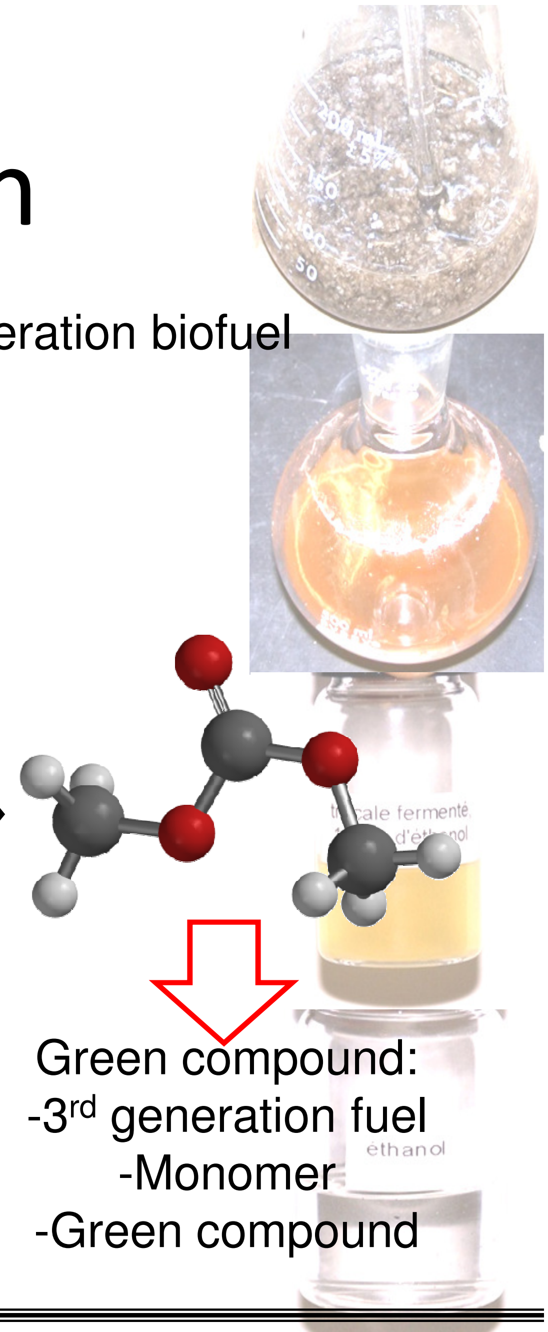
« Negative » Carbon footprint

- The Chair’s approach
  - Complete utilisation of carbon
  - Including CO_2
- From this the biorefineries:
  - Will only produce biofuels and green molecules
- Three approaches are considered:
  - Thermochemical
  - Chemical
  - Biological

Chemical approach



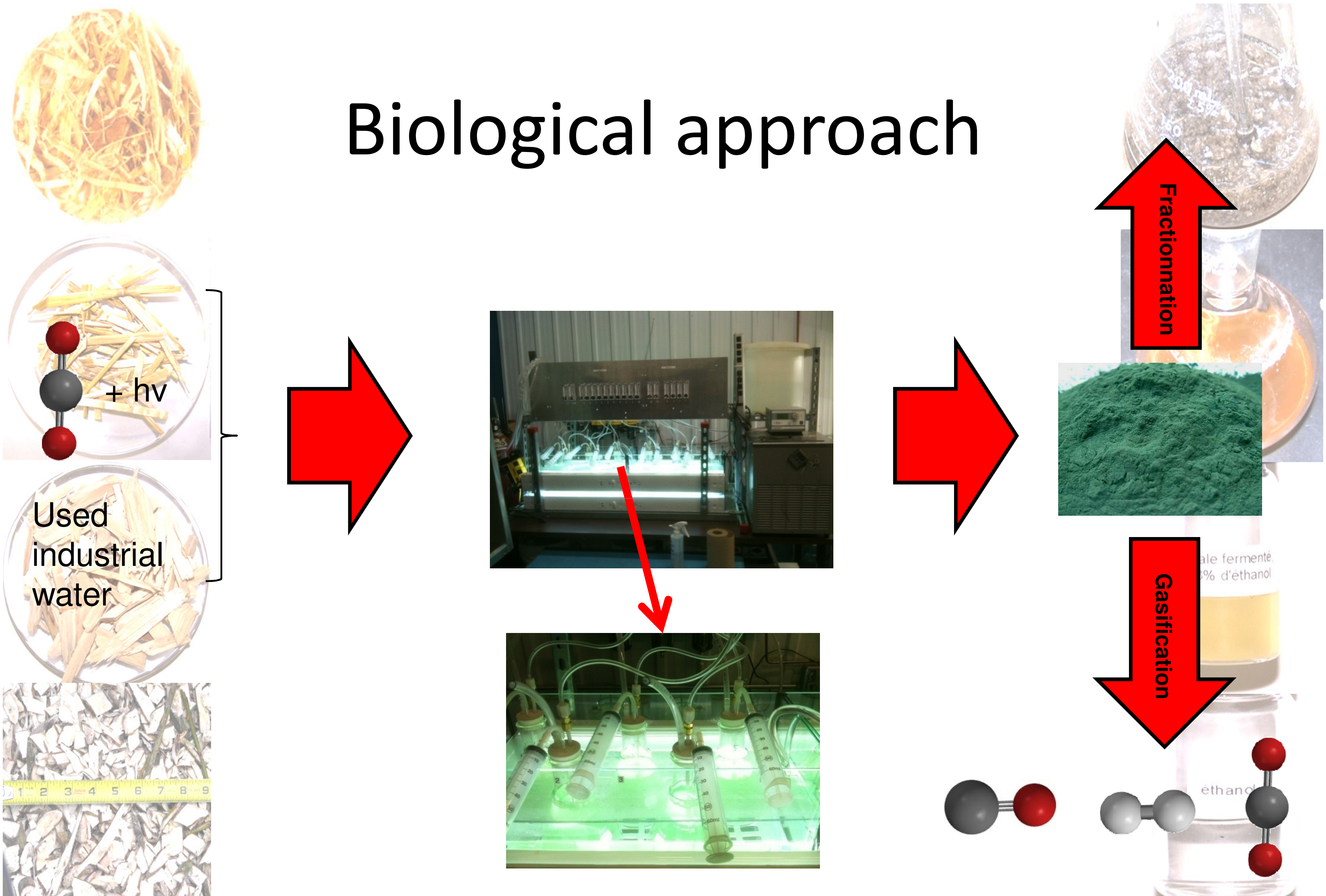
Products from the second generation biofuel industries



Residues or co-product from 1st and 2nd generation biofuels industries

Green compound:
-3rd generation fuel
-Monomer
-Green compound

Biological approach



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