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# Valuable products from End of Life Vehicles (ELV) waste by thermal and thermo-catalytic degradation

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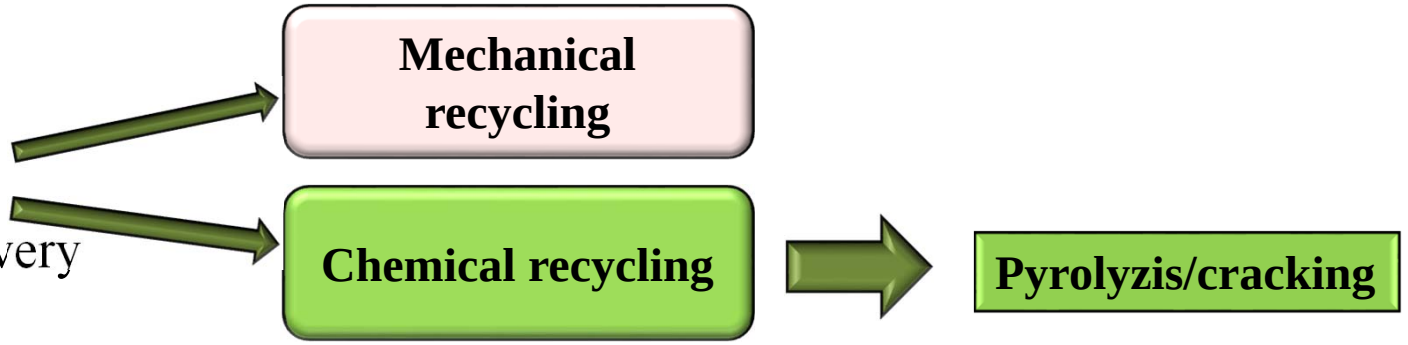
# Driving forces

**Problem**: amount of plastics waste is increasing!

**Solution:**

1. Prevention
2. Re-using
3. **Recycling**
4. Energy recovery
5. (Landfill)




**Directives:**

- 94/62/EC EU Directive: 50-65 % of the packaging waste has to be utilized, even with burning, while 25-45 % of it has to be processed by chemical- or mechanical proceeding.
- 2000/53/EK Community Directive: From 1 January 2015 95% of the waste coming from vehicles' construction material has to be utilized, 85 % in mechanical and 10 % in chemical recycling.

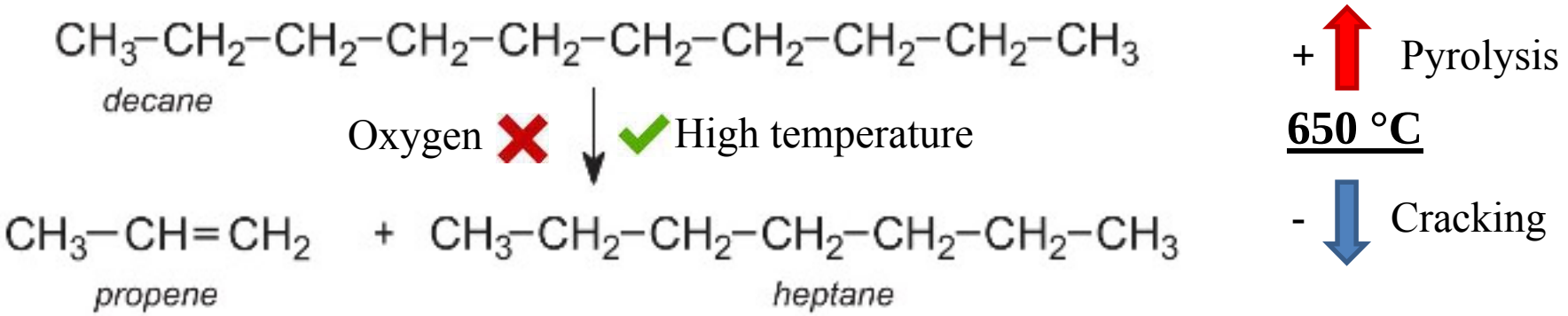
# Pyrolysis/cracking definition

**thermal decomposition of organic material at high temperature in the absence of oxygen**

Endothermic

**involves chemical change of chemical composition and physical phase**

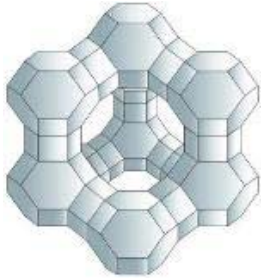
Irreversible



# Main aims

**To investigate the properties and the effect of 5 different catalysts.**

**Catalyst properties**

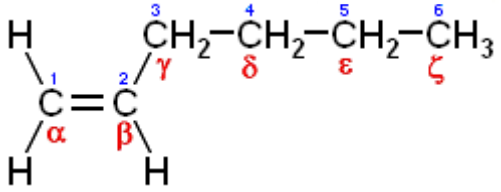


http://www.explainthatstuff.com/zeolites.html

**Product distribution**

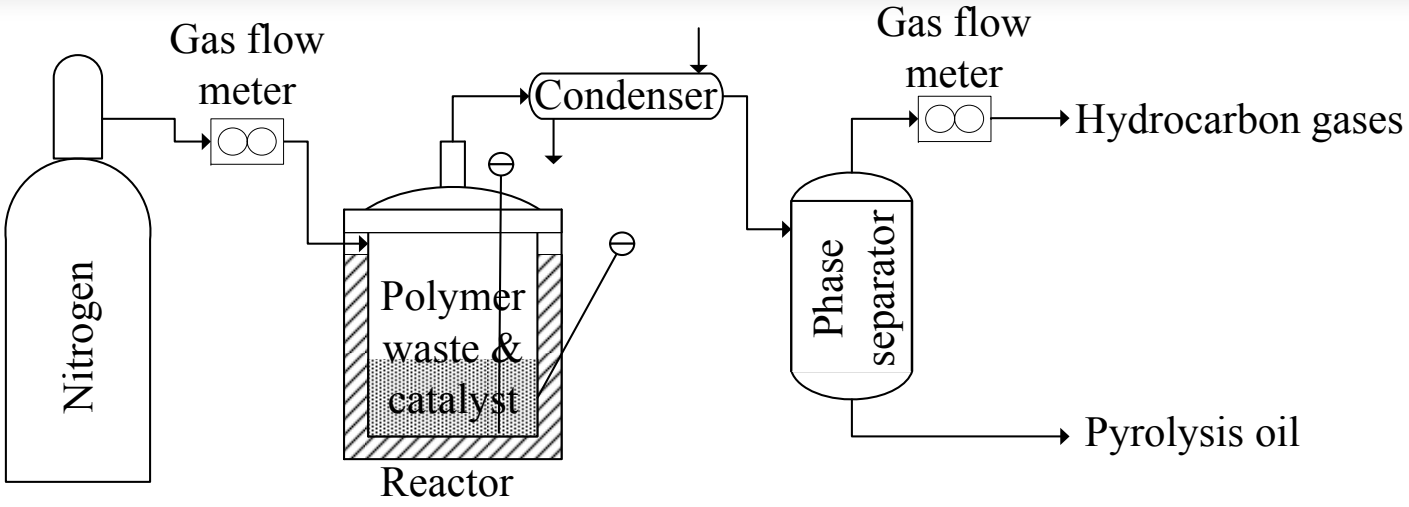
http://maytop.tk/diry/gas-natrual-647.php

**Product structure**



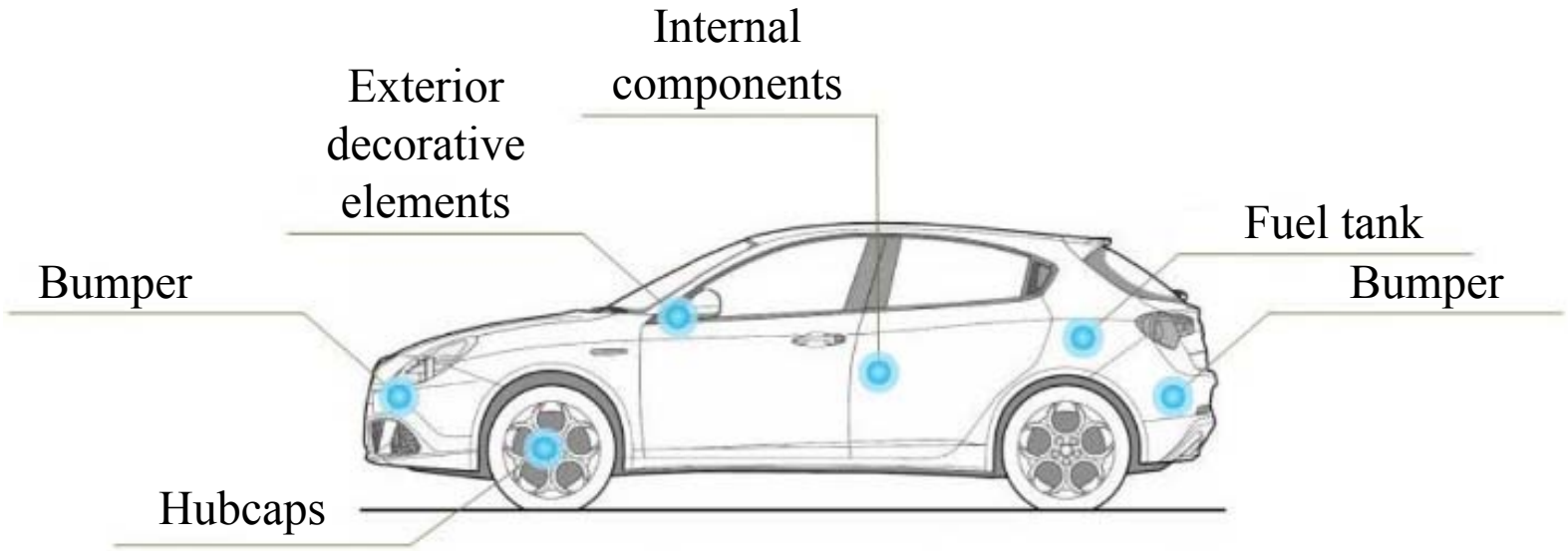

https://en.wikipedia.org/wiki/Linear_alpha_olefin

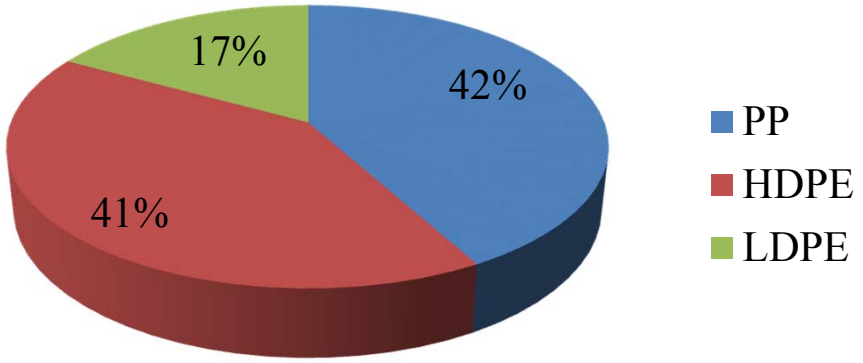
# Construction of cracking



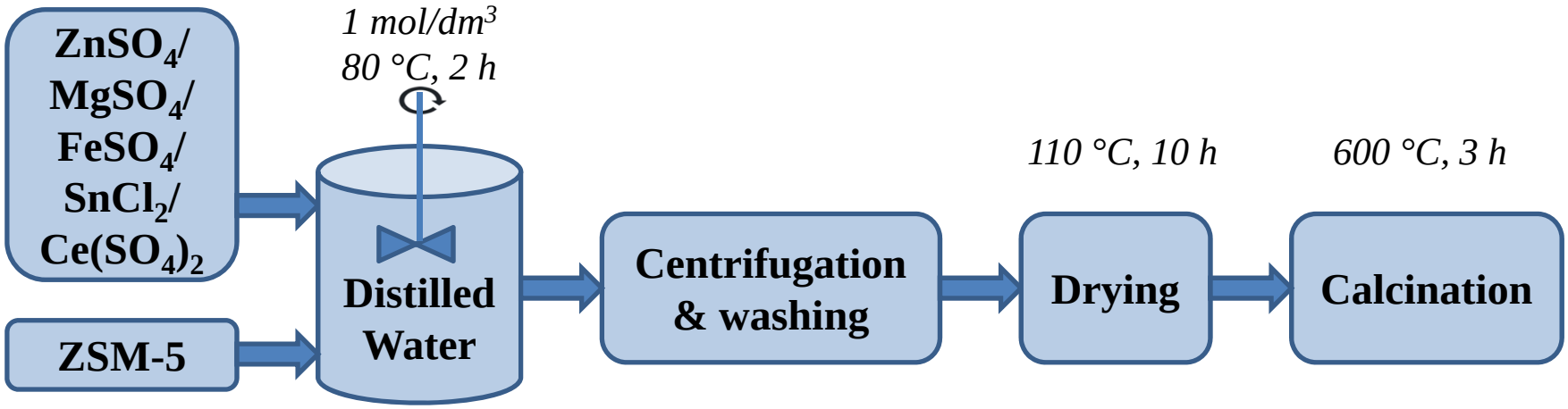

| | |
|---|---|
| **Reactor type** | Batch reactor |
| **Pressure** | Atmospheric |
| **Atmosphere** | Nitrogen |
| **Temperature** | 425, 485 °C |
| **Cracking time** | 17 – 40 min |
| **Feedstock** | ELV („end of life vehicles”) |
| **Catalyst concentration** | 5 wt% |

# Raw materials



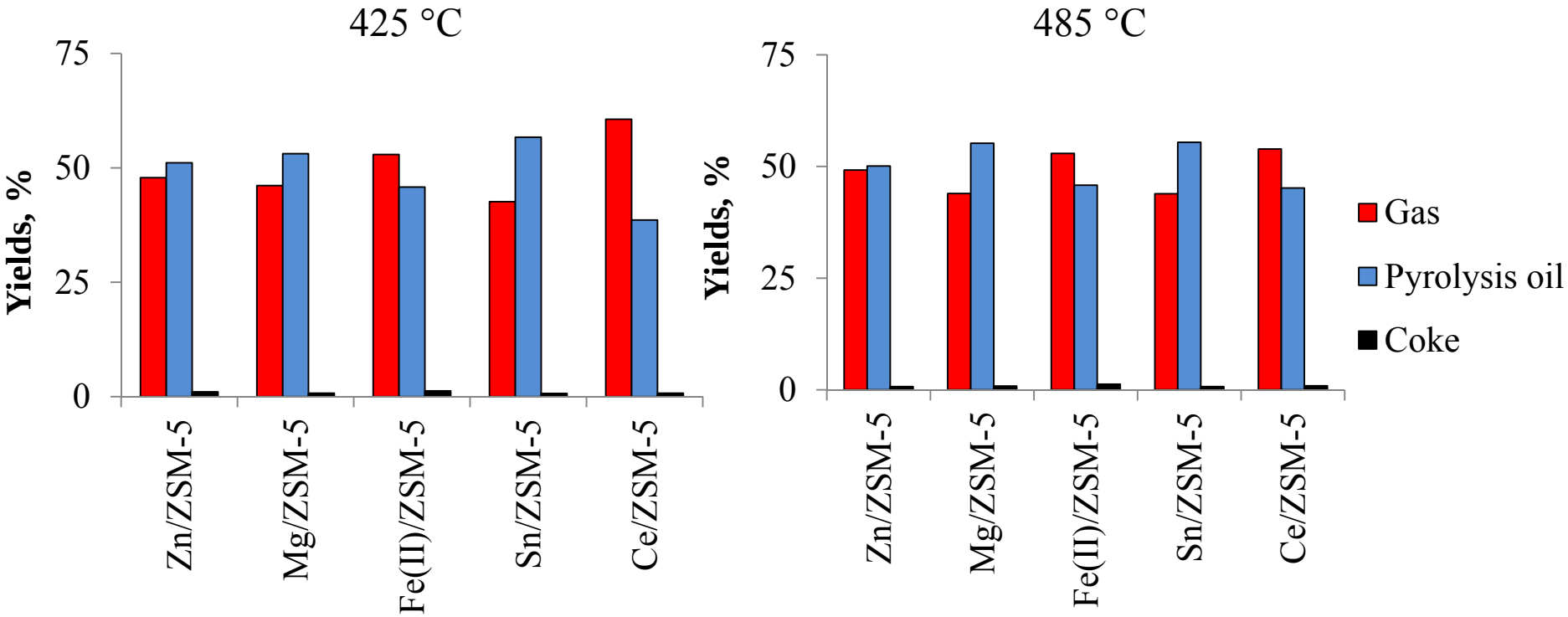



# Catalysts



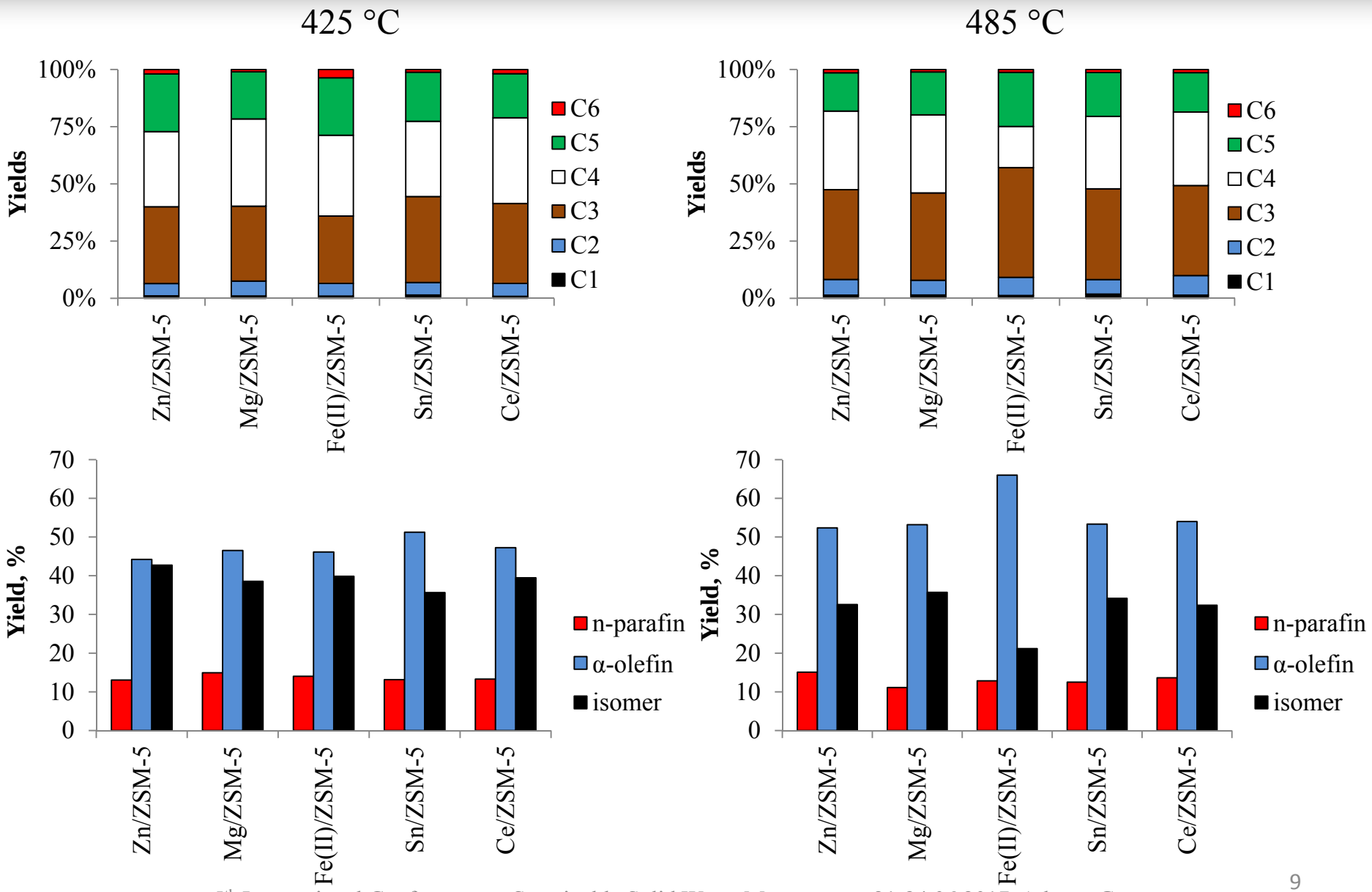

| Catalyst | $S_{BET}$ ($m^2/g$) | $S_{BJH}$ ($m^2/g$) | $D_{av}$ (nm) |
|---|---|---|---|
| **ZSM-5** | 355.4 | 90.1 | 1.74 |
| **Zn/ZSM-5** | 350.8 | 110.6 | 1.80 |
| **Mg/ZSM-5** | 345.3 | 109.2 | 1.80 |
| **Fe(II)/ZSM-5** | 354.5 | 111.7 | 1.81 |
| **Sn/ZSM-5** | 318.9 | 105.0 | 1.92 |
| **Ce/ZSM-5** | 285.4 | 91.9 | 1.79 |

# Pyrolysis yields

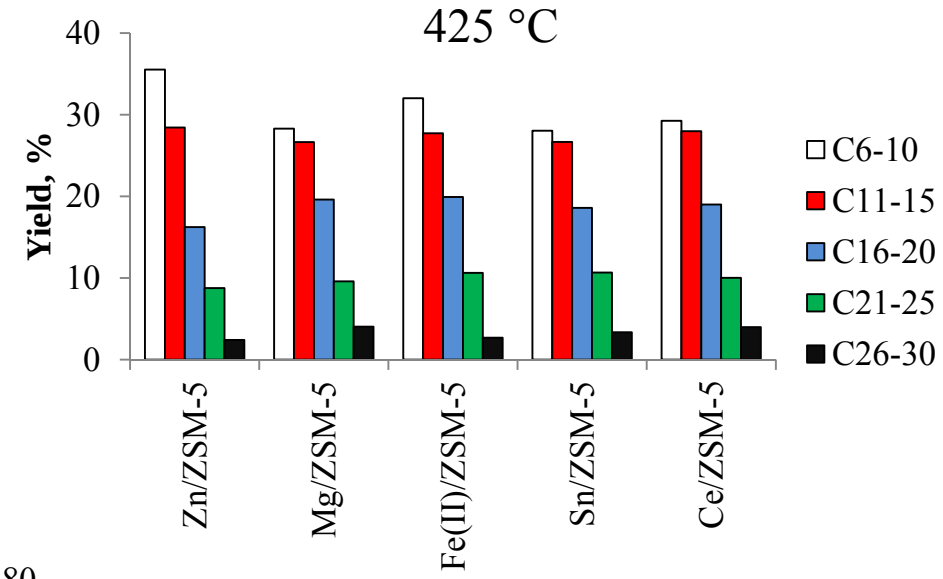


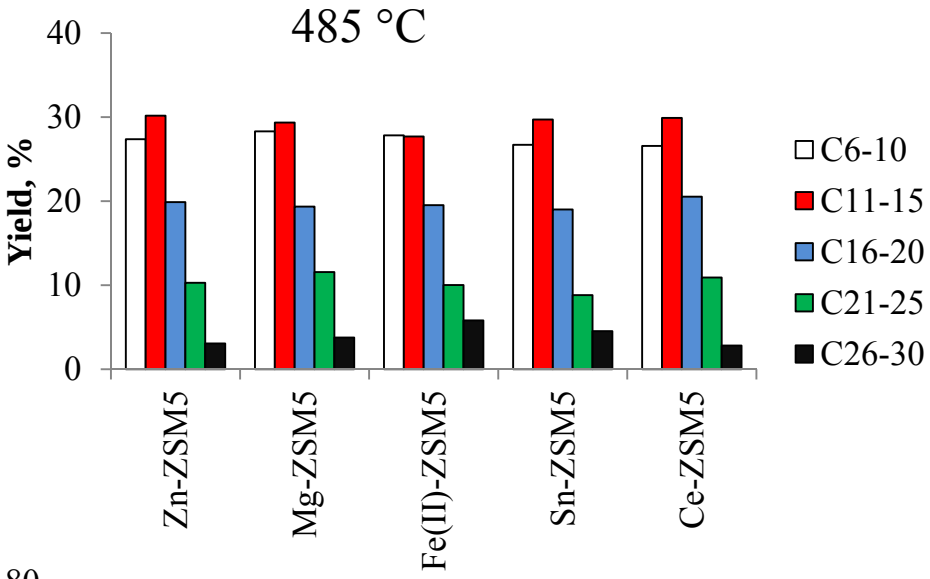

- **mainly pyrolysis oils and gases**
- **Sn/ZSM-5: maximum yield of pyrolysis oil and the minimum yield of gases**
- **Ce/ZSM-5: lowest yield of pyrolysis oil and the highest yield of gases**
- **volatile products were almost the same, only the ratios of gases and liquids changed**

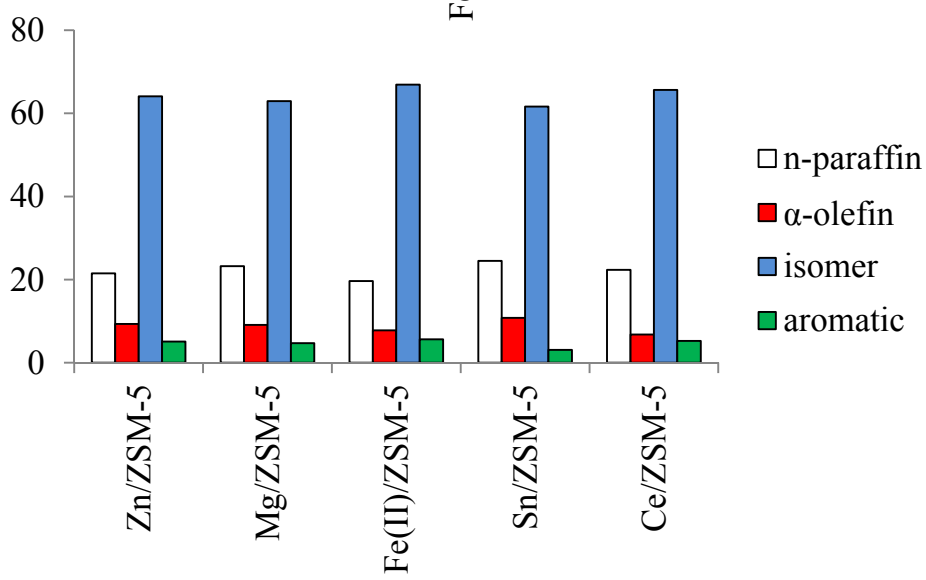
# Gases composition

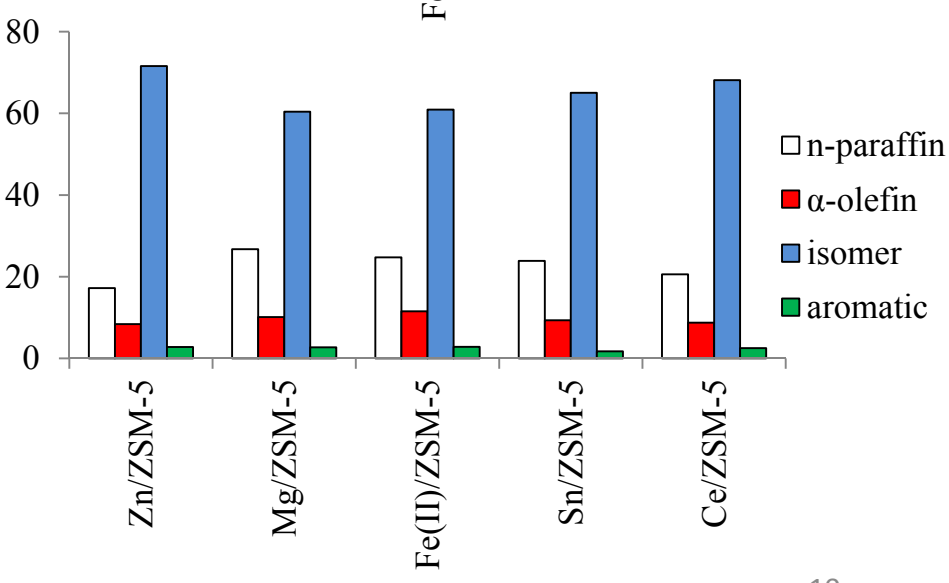


# Pyrolysis oil composition



# Products

Gas: 43 – 61 %

- Energy recovery

Oil: 39 – 57 %

- Energy recovery
- Fuel
- Chemical raw materials, eg. styrene or other plastic monomer

Residue: ~1 %

- Energy recovery
- Activated carbon raw material

# Summarize

- **ELV recycling by pyrolysis**
- **Main driving forces: waste managment & EU directives**
- **Main aim: to investigate the effect of 5 zeolite based catalysts**
- **Products further utilization:**
  - **Most gas: Ce/ZSM-5 (energy recovery)**
  - **Most pyrolysis oil: Sn/ZSM-5 (fuel)**
    - **Most aromatics compound: Fe(II)/ZSM-5 (chemical raw material)**
    - **Most paraffin: Mg/ZSM-5 (wax)**
    - **Most olefin: Fe(II)/ZSM-5 (chemical synthesis)**

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**Thank you for your attention!**