



Summer school
25 juin 2012

 POLITECNICO DI MILANO

 IDISTAM
Dipartimento di Scienze e Tecnologie Integrative e Microbiologiche



UNIVERSITÀ
DEGLI STUDI
DI MILANO



PRETREATMENTS TO ENHANCE DIGESTIBILITY OF LIGNOCELLULOSIC BIOMASS

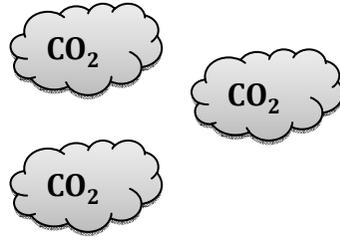
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State of art



Fossil energies: 80%



Kyoto 1997

Renewable energy directive (2009)

target :

Renewable energy

20% by 2020

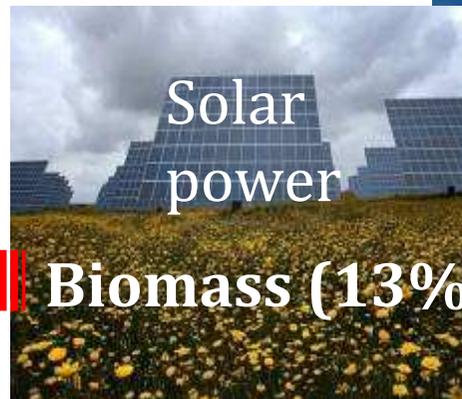
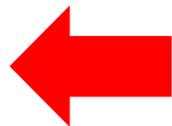


First generation bioenergy

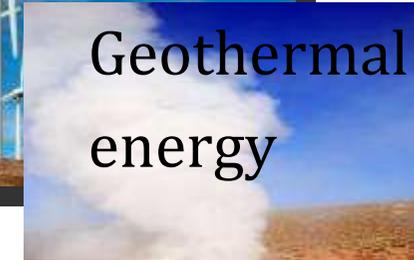


Second generation bioenergy

AD from agricultural residues and energy crops

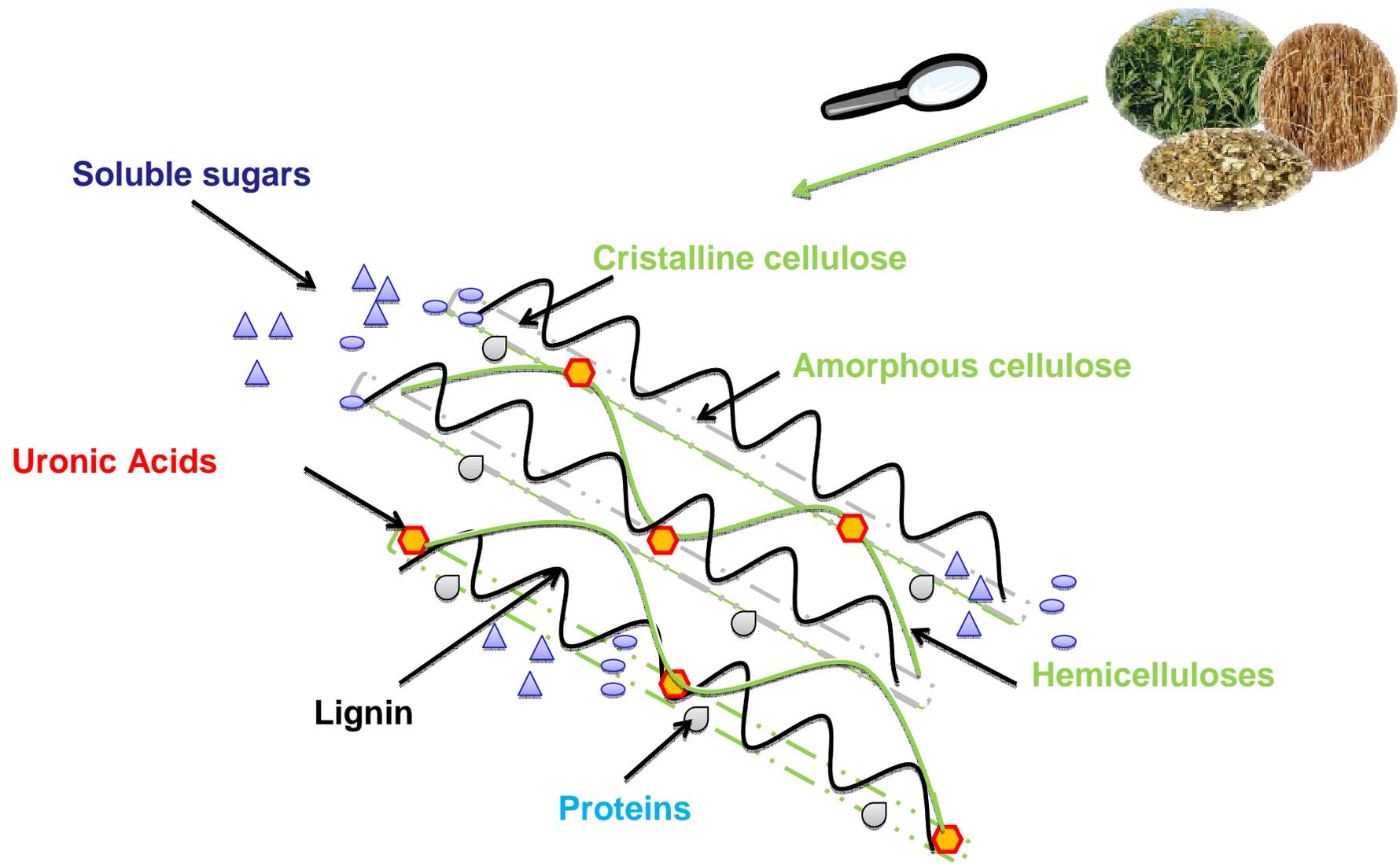


Biomass (13%)



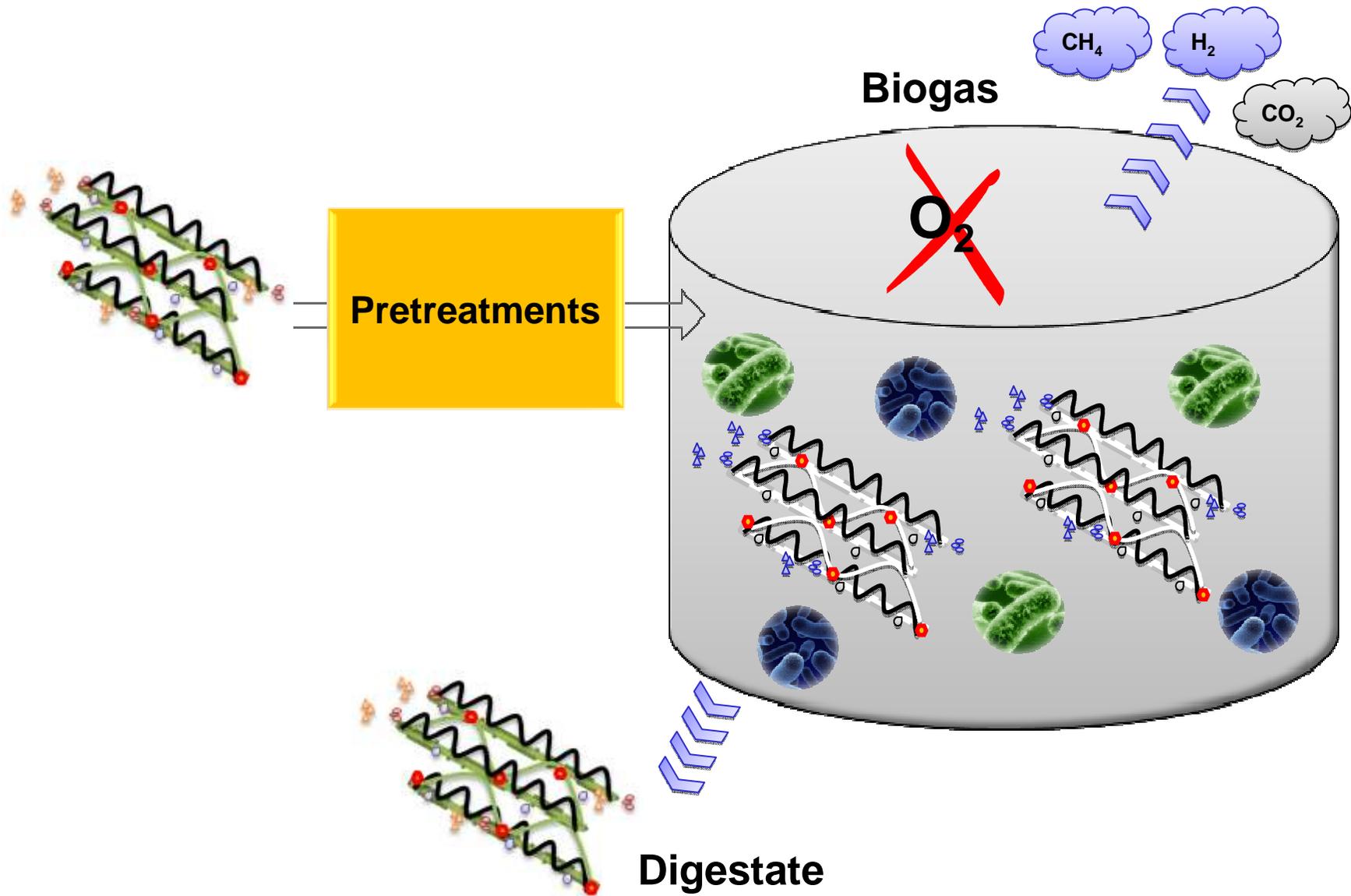


Lignocellulosic substrates



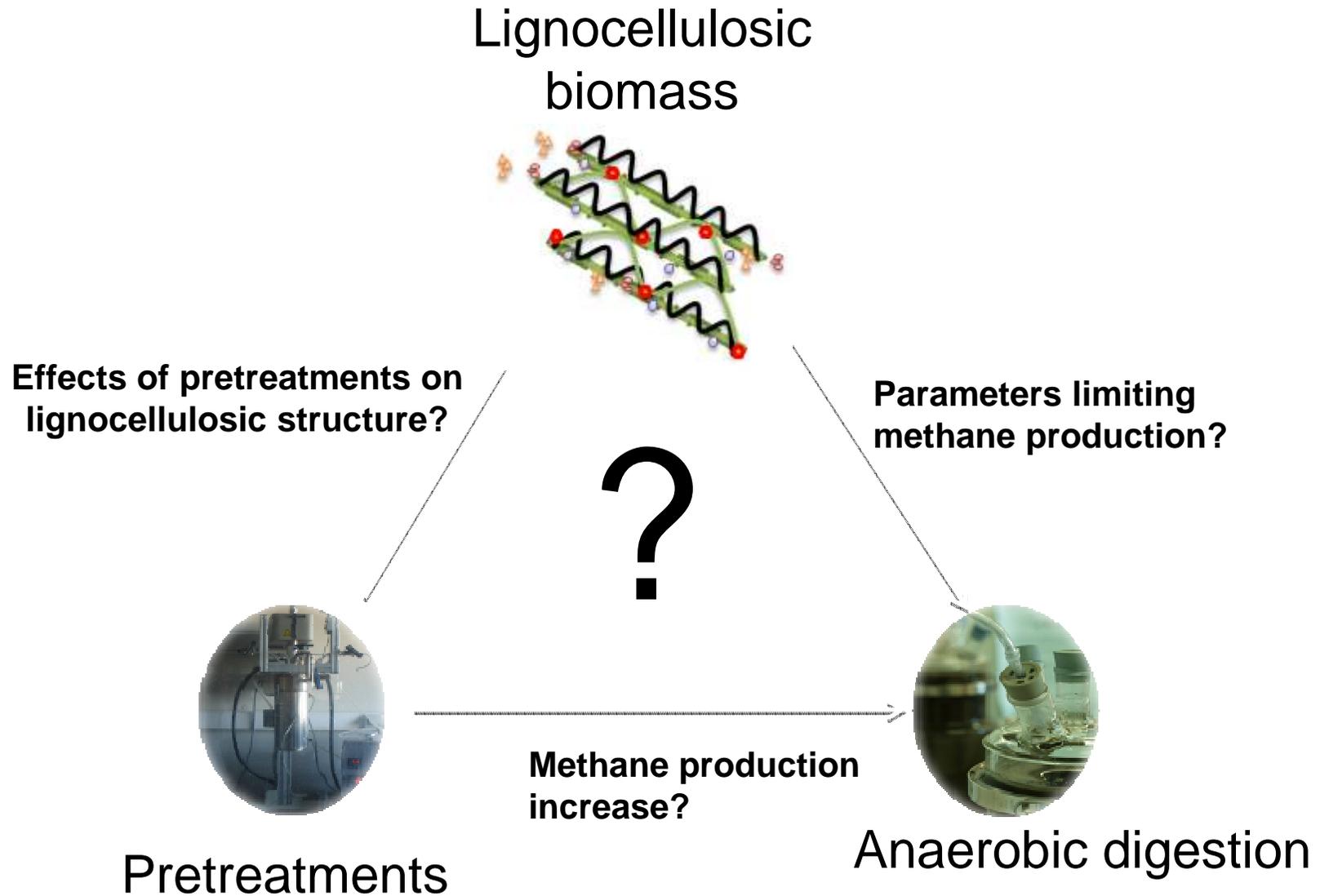


Anaerobic digestion





Aim of the research project





Pretreatments tested

Alkaline



Mechanical



Enzymatic

Thermal and thermo
alkaline



Fungal



Pretreatments conditions

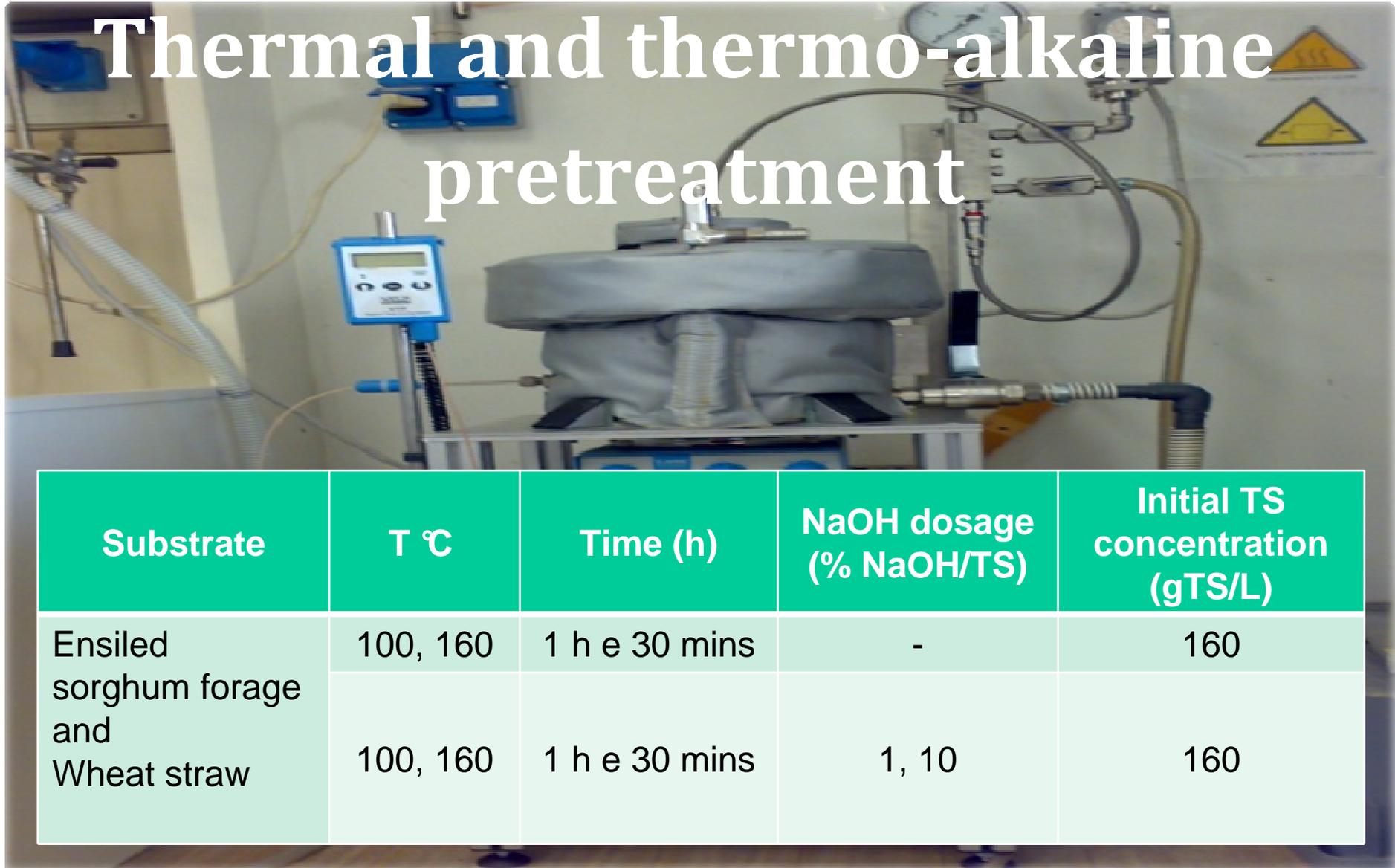
Alkaline pretreatment

| Substrate | T °C | Time (h) | NaOH dosage (% NaOH/TS) | Initial TS concentration (gTS/L) |
|---|------|----------|-------------------------|----------------------------------|
| Ensiled sorghum forage | 40 | 12, 24 | 1, 4, 10 | 160 |
| | 55 | 12, 24 | 4, 10 | 35, 160 |
| Three varieties of sorghum biomass and two of sorghum sugar | 55 | 12 | 4, 10 | 35 |
| Wheat straw | 40 | 24 | 1, 10 | 160 |
| Maize silage | 40 | 24 | 1, 3, 26 | 62 |
| | 20 | 24 | 1, 10 | 62 |



Pretreatments conditions

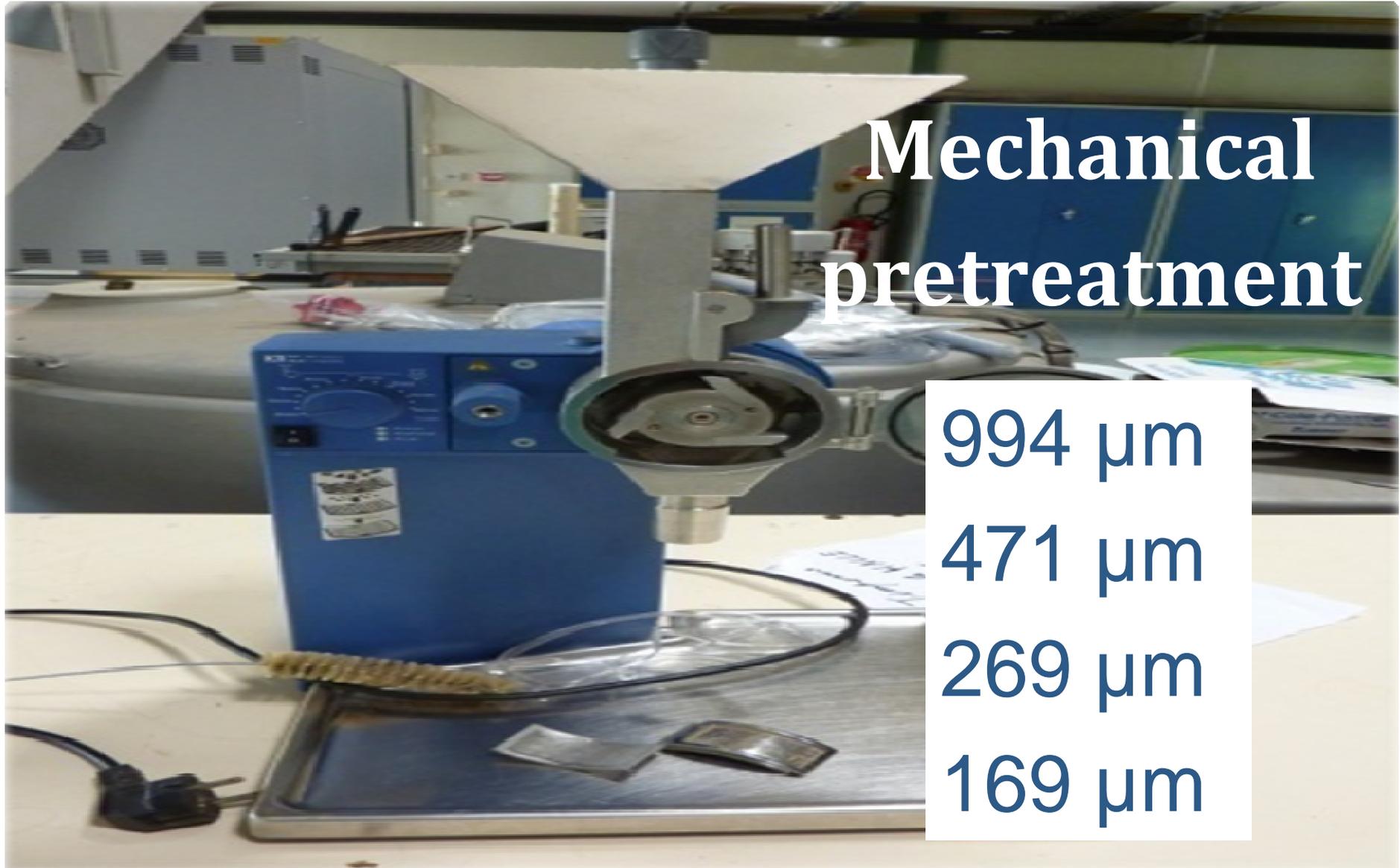
Thermal and thermo-alkaline pretreatment



| Substrate | T °C | Time (h) | NaOH dosage (% NaOH/TS) | Initial TS concentration (gTS/L) |
|--|----------|---------------|-------------------------|----------------------------------|
| Ensiled sorghum forage and Wheat straw | 100, 160 | 1 h e 30 mins | - | 160 |
| | 100, 160 | 1 h e 30 mins | 1, 10 | 160 |



Pretreatments conditions



Mechanical pretreatment

994 μm

471 μm

269 μm

169 μm

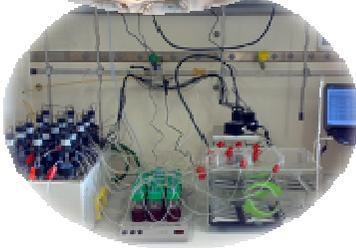


Enzymatic and combined alkaline-enzymatic pretreatment

| Substrate | T °C | Time (h) | Enzyme dosage (mL/gTS) | pH |
|--|------|----------|------------------------------|----|
| Untreated Sorghum and wheat straw | 50 | 72 | BGL+Primafast (0,12 and 0,2) | 5 |
| 10%NaOH/TS, 24h, 40°C pretreated Sorghum and wheat straw | | | | |



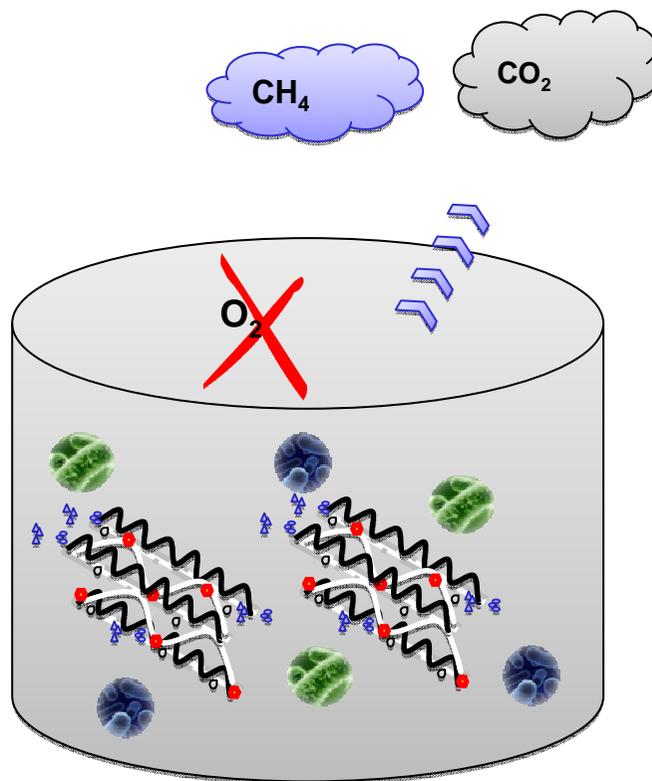
Anaerobic digestion tests



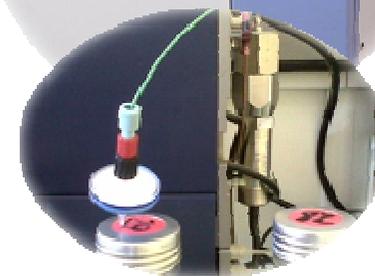
Batch tests



Reactors

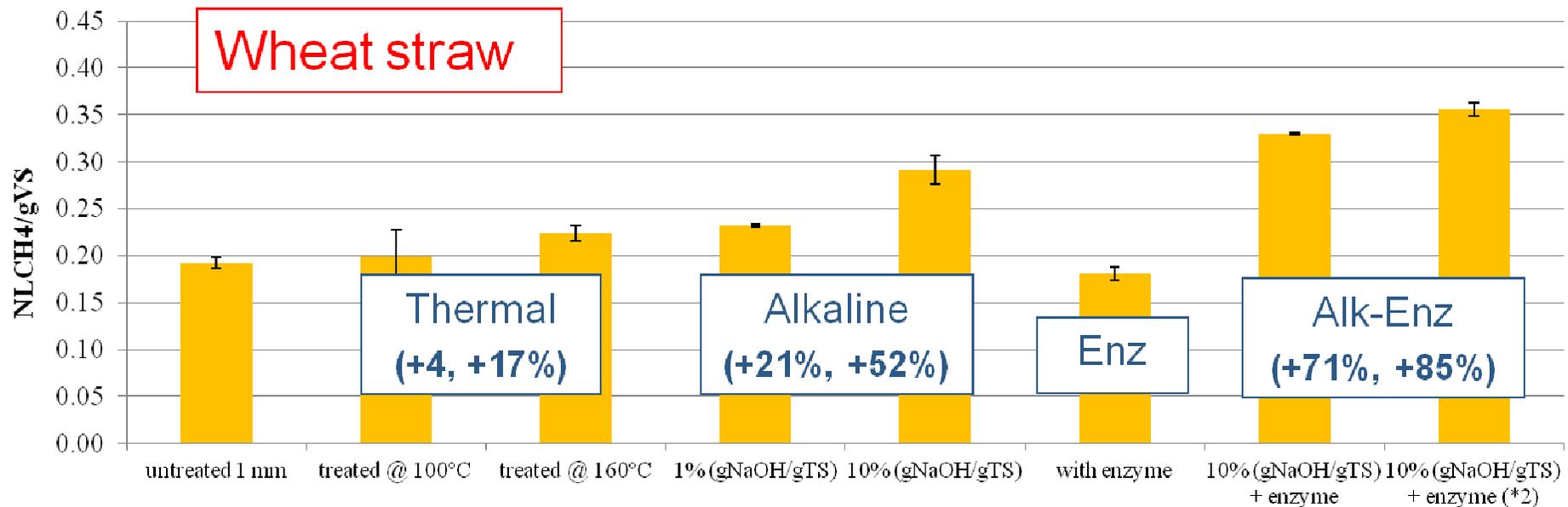
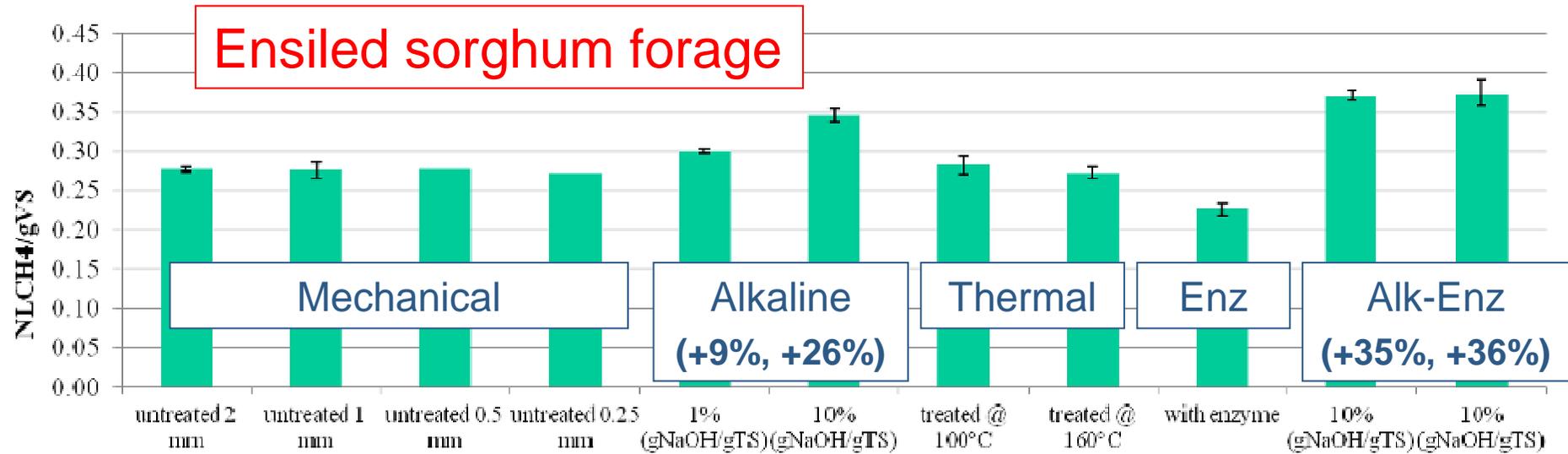


$T = 35 \pm 0.5^{\circ}\text{C}$



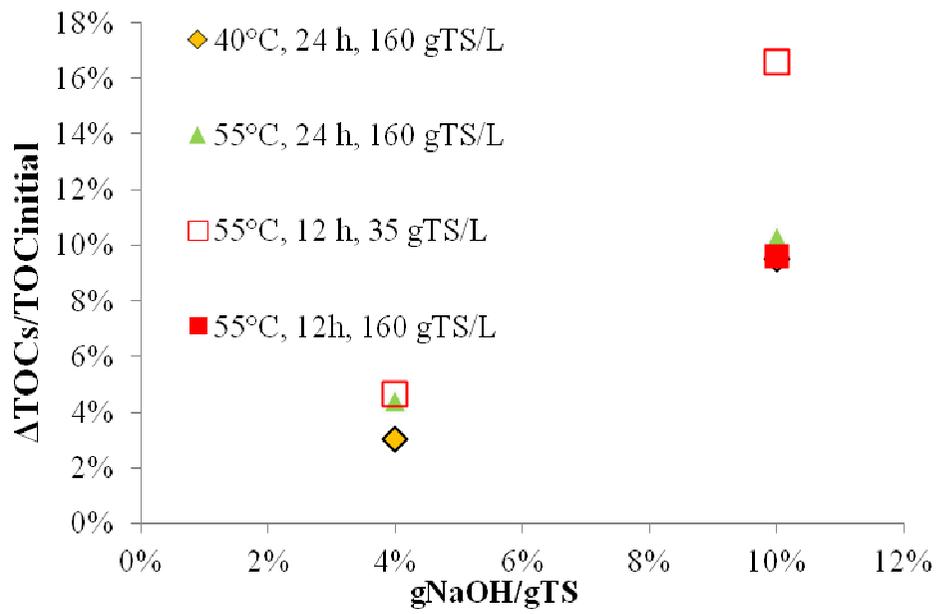
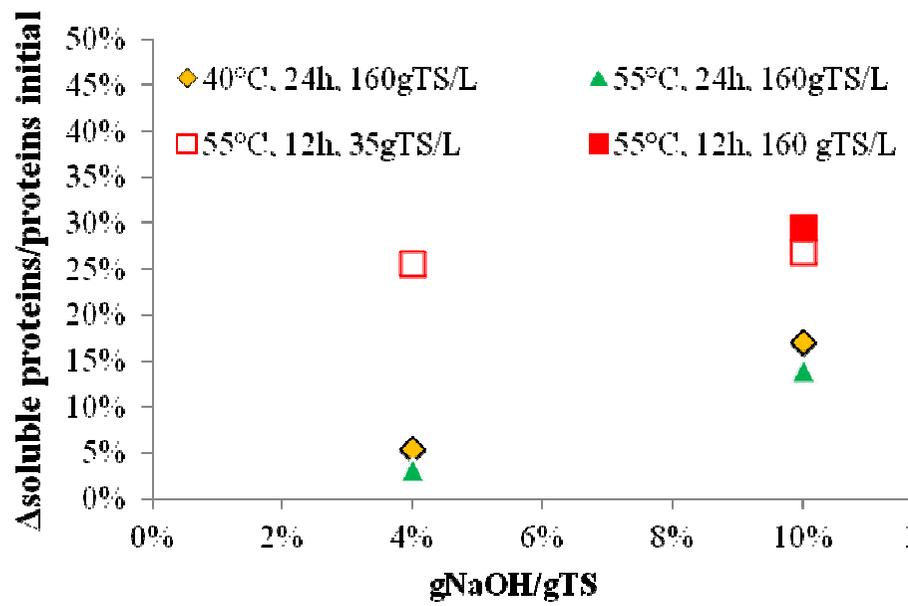
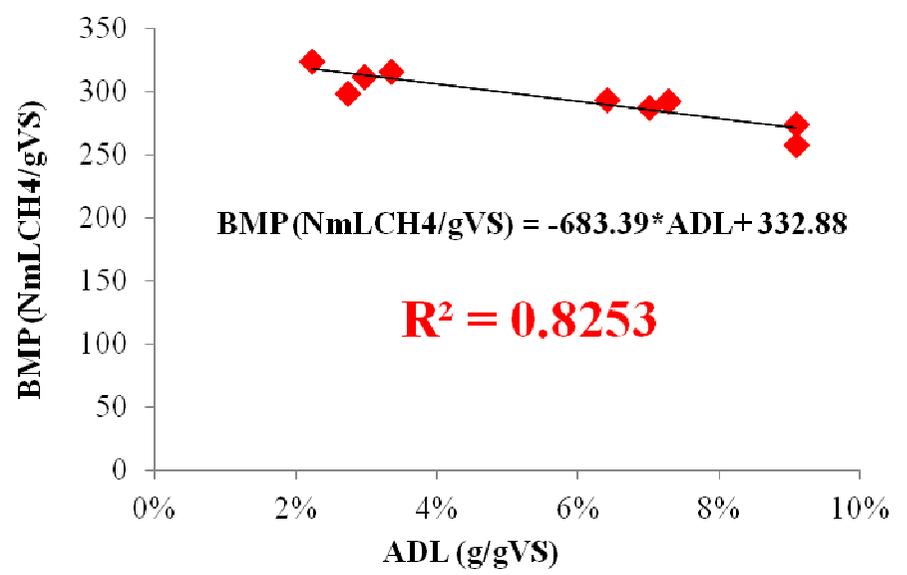
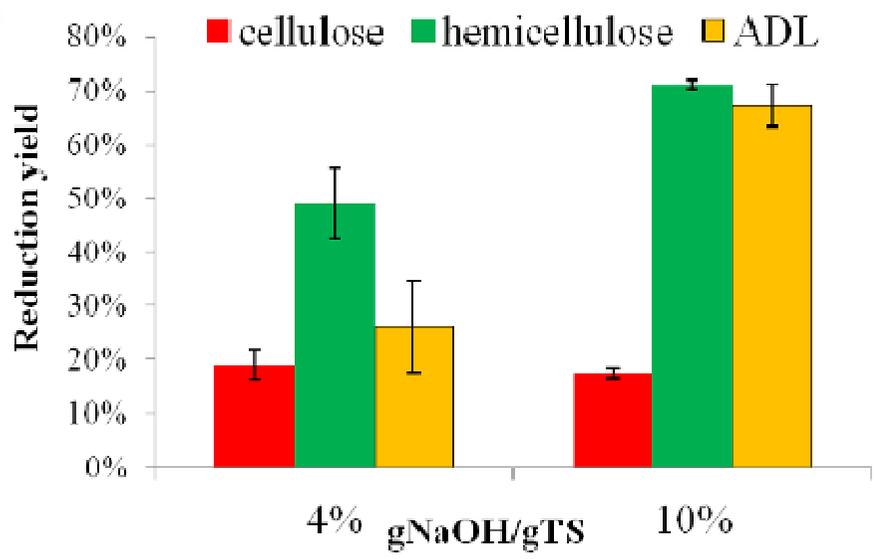


... Some results





... Some results





... Some results

| Energy produced | | | | | | | | |
|--|--------------------------|-----------|---------------------|----------------------|-------------|---------------------|---------------------|----------------------|
| Substrate | | Sorghum | | | wheat straw | | | |
| Pretreatment | | untreated | 10% NaOH 40°C | 10% NaOH 100°C | untreated | 10% NaOH 40°C | 1% NaOH 100°C | 10% NaOH 100°C |
| BMP ₃₁ (m ³ /t TS) | | 269 | 346 | 361 | 204 | 291 | 302 | 341 |
| Heat and electricity form CHP | Heat (kWh/tTS) | 1097 | 1411 | 1475 | 834 | 1189 | 1231 | 1391 |
| | Electricity (kWh/tTS) | 1082 | 1392 | 1455 | 823 | 1174 | 1215 | 1373 |
| Electric energy gain (€/tTS) | S1 (0.14 €/kWh) | 152 | 195 | 204 | 115 | 164 | 170 | 192 |
| | S2 (0.25 €/kWh) | 271 | 348 | 364 | 206 | 293 | 304 | 343 |
| | S3 (0.28 €/kWh) | 303 | 390 | 408 | 230 | 329 | 340 | 384 |
| NaOH cost (€/tTS) | | - | 41 | 41 | - | 41 | 4 | 41 |
| Heat energy requirements for pretreatment (kWh/tTS) | | - | 109 | 547 | - | 109 | 547 | 547 |
| Extra net Gain (€/tTS) | S1 (0.14 €/kWh) | - | 2 | 11 | - | 8 | 51 | 36 |
| | S2 (0.25 €/kWh) | - | 36 | 52 | - | 47 | 94 | 96 |
| | S3 (0.28 €/kWh) | - | 46 | 63 | - | 57 | 106 | 113 |



Project perspectives

- Anaerobic digestion lab-scale continue reactor for treating raw and pretreated lignocellulosic substrates
- Enhance the efficiency of anaerobic digestion of lignocellulosic substrates by fungal treatments:
 - Design of experiments with fungi (strain, medium, contact time, etc...)
 - Saccharification tests (enzymatic hydrolysis, sugars released, fibre changes, microscope analysis, etc...)
 - BMP tests