Biological treatment of waste gases

Departament of Chemical Engineering - UAB

GENOCOV

Grupo de tratamiento biológico de efluentes líquidos y gaseosos, Eliminación de Nutrientes, Olores y Compuestos Orgánicos Volátiles

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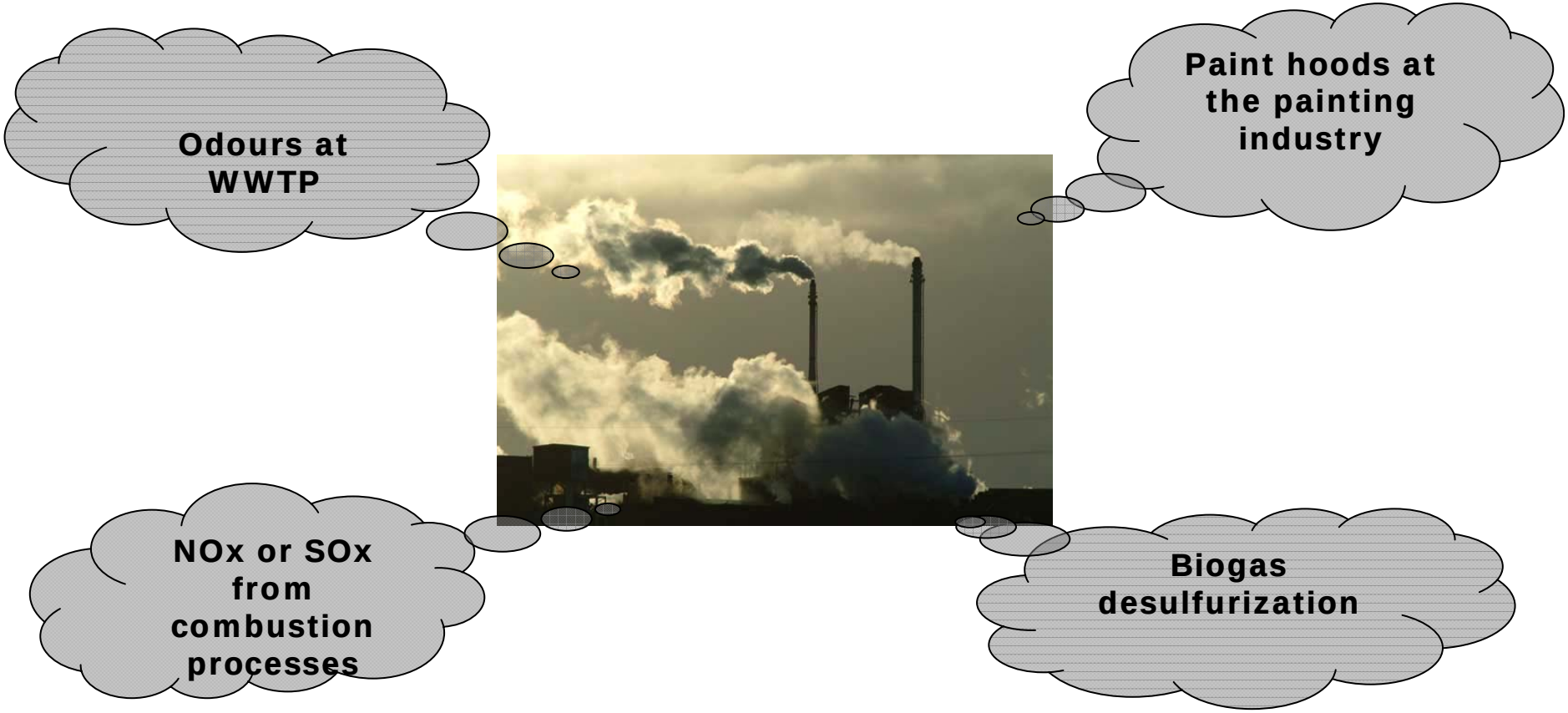
Presentation

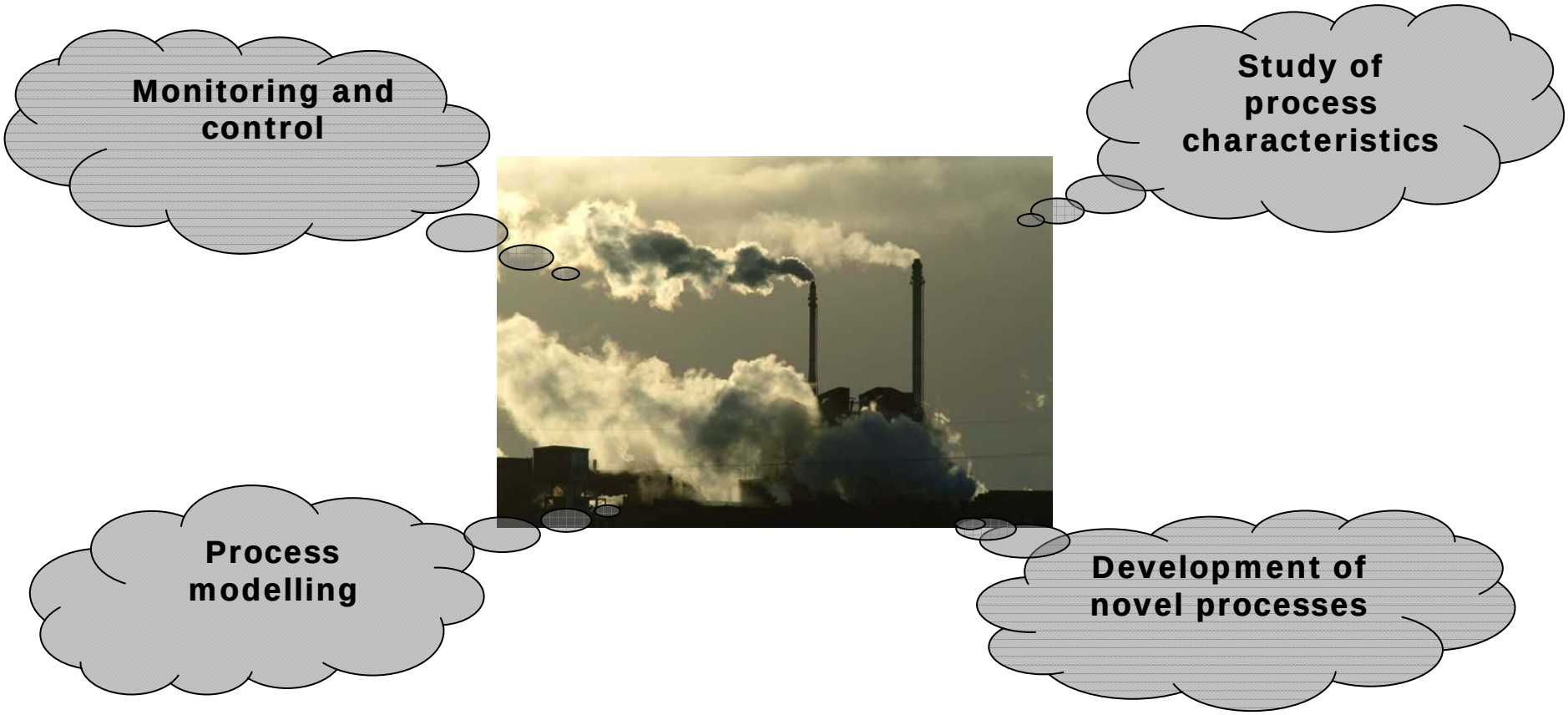
Aim: Development and characterization of reactors for the biological treatment of waste gases



Novel topic: Lots of opportunities currently covered by physical-chemical processes

Presentation

Multidisciplinary approach, but mainly from the engineering field



National Research Groups: UPC, UCA, UV, UAB (Chemistry, Genetics)
International collaboration: Duke, UT, UAM

Main research topics

- **Treatment of NH_3 (MSWTF, pig farms…)**
- **Treatment of complex mixtures of VOCs-VICs**
- **Energy-rich gases desulfurization**
- **Industrial application and technology transfer**

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Desulfurization

Physicochemical processes:

Chemical/Physical **absorption** (alkanolamines, Sulfinol™, Selexol™,etc.)

Chemical/Physical **adsorption** (iron sponge, zinc oxides, zeolites, etc.)

Direct **conversion** (Stretford®, Lo-Cat®, Claus®, etc.)

Advantages:

Well-known

High loads treatment

Disadvantages:

$$$

Low loads

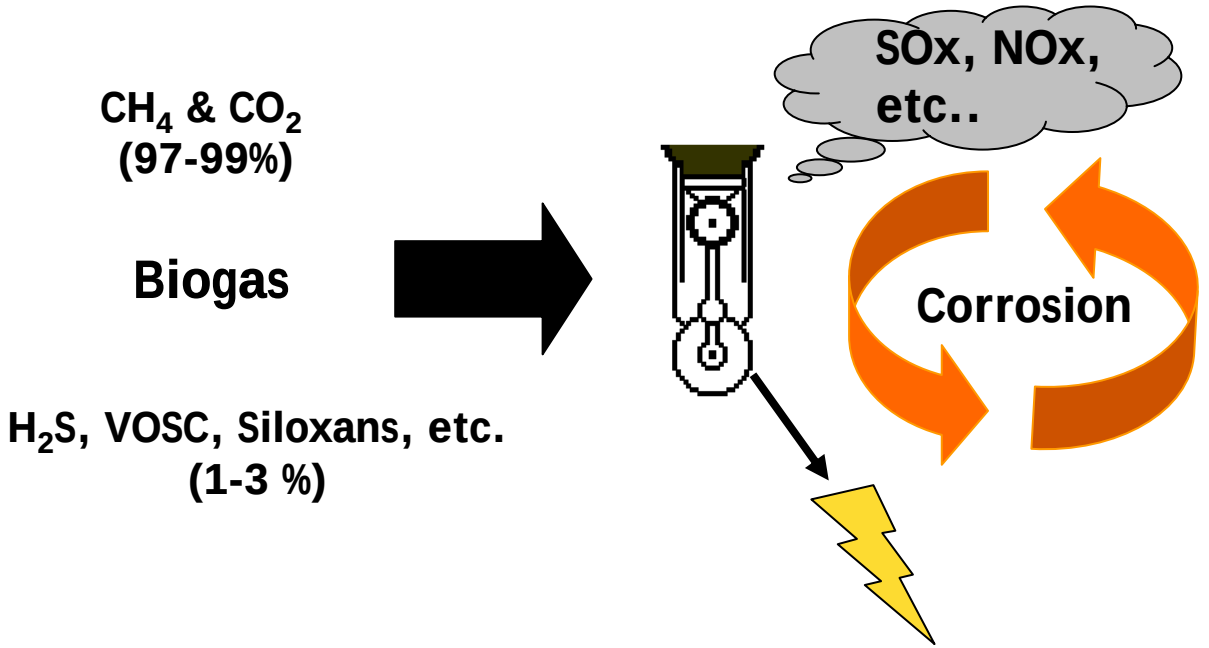
Toxics generation

Claus® H_2S oxidation plant

Biological processes are THE alternative

Research Activities – Energy-rich gases desulfurization

Biogas: fuel gas produced in many industrial facilities (WWTP) but formerly, commonly not considered for power generation ➔ flared!!



Cheap and reliable biogas clean up step

Research Activities – Energy-rich gases desulfurization

- Reactor performance assessment
- Design and operation of full-scale reactors
- Developing equipments and methodologies
- Process modelling
- Use of molecular biology techniques

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- **Reactor performance assessment**
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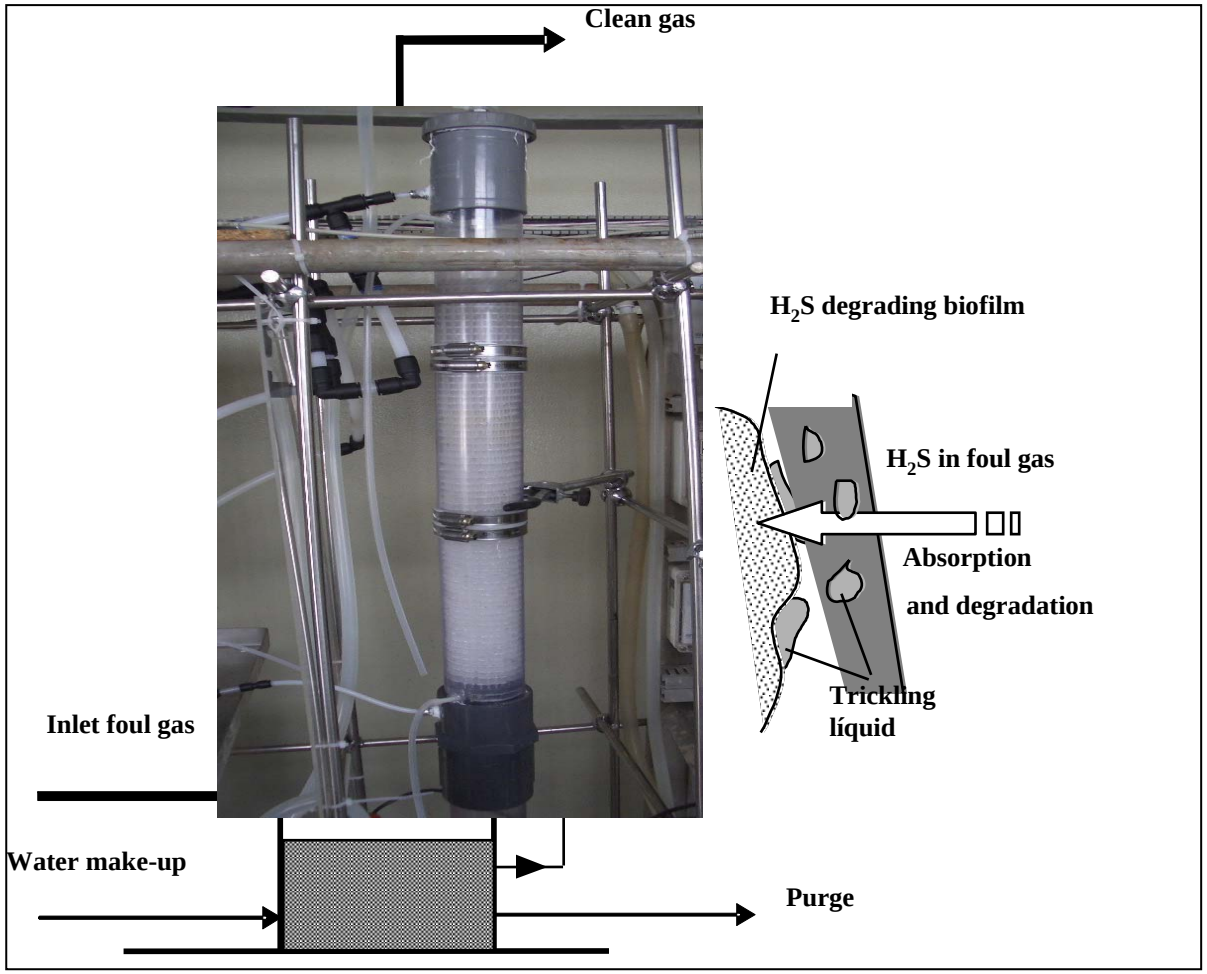
Motivation: Novel process as an alternative to physico-chemical ones

Characterization of a biotrickling filter for biogas treatment (multiphase type reactor)



Characterization of a biotrickling filter for biogas treatment

Core of the process: biological reactions

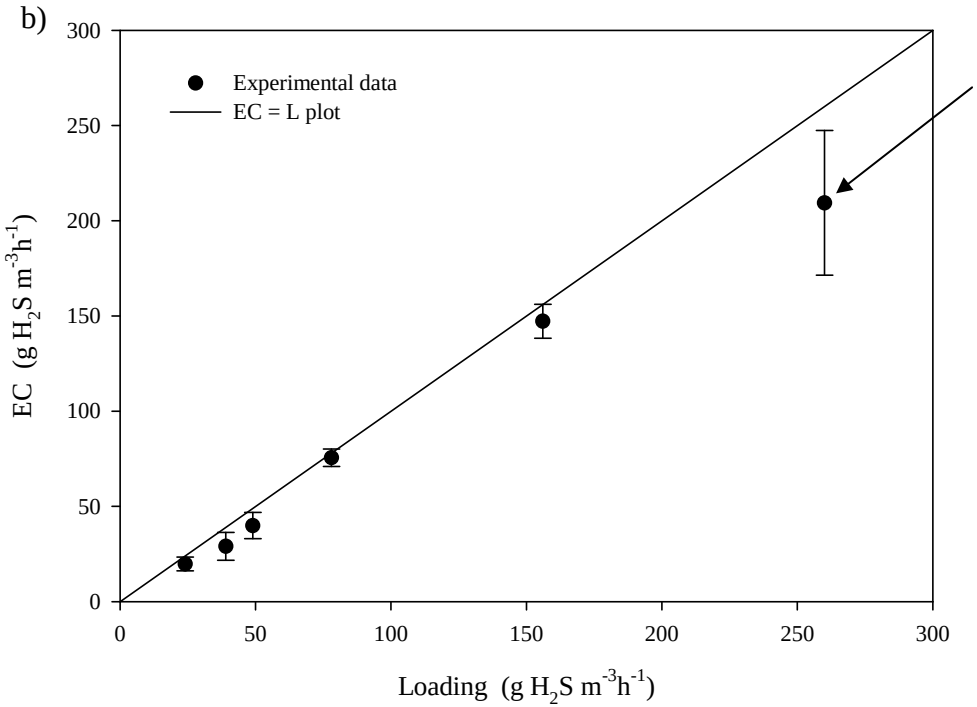
Biological Aerobic oxidation (main reactions)

Oxygen excess: $H_2S_{(l)} + 2O_2 \rightarrow SO_4^{2-} + 2H^+$

Oxygen limited: $H_2S_{(l)} + 0.5O_2 \rightarrow S^0\downarrow + H_2O$

Characterization of a biotrickling filter for biogas treatment

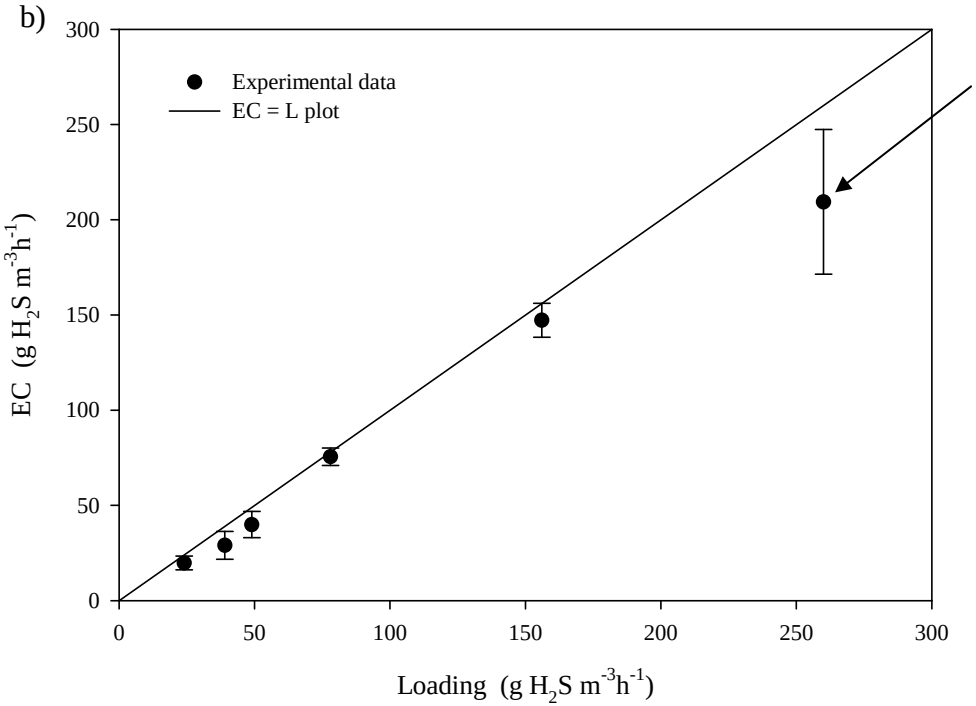
- Capacity assessment
  - Biological limitations occur?
    - Start-up, inoculation, steady-state, transient, starvation…
  - Process rates and kinetics
  - Mass balances



10000 ppm_v

Characterization of a biotrickling filter for biogas treatment

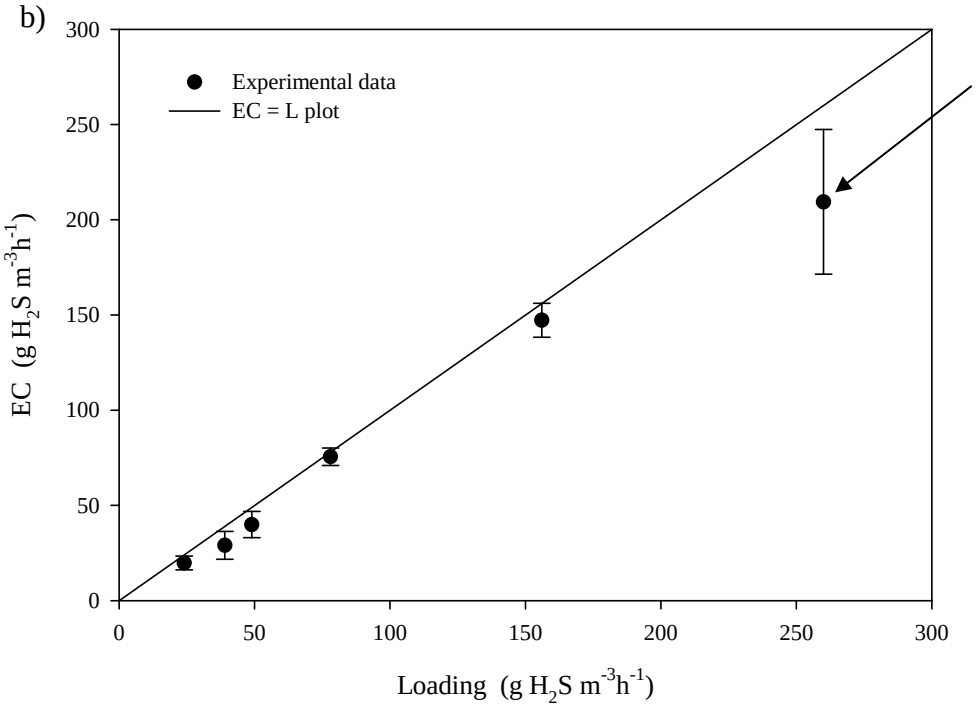
- Capacity assessment
  - Physical limitations occur?
    - Mass transfer of substrate and oxygen
    - Oxygen supply device and efficiency



10000 ppm_v

Characterization of a biotrickling filter for biogas treatment

- **Proper packing material**
  - **Packing materials characterization**
  - **Hydraulics**
  - **Separation processes → potential S accumulation**
  - **…**



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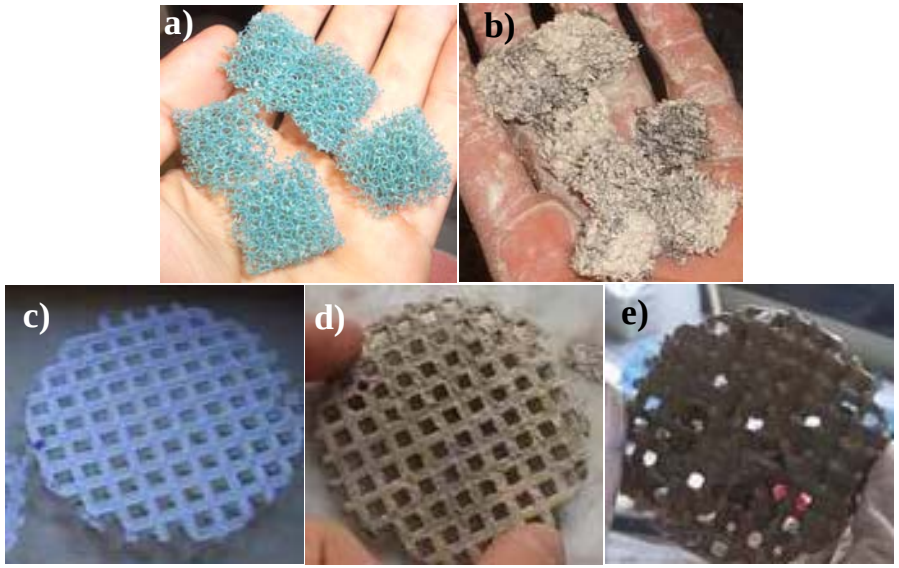

Research Activities – Energy-rich gases desulfurization

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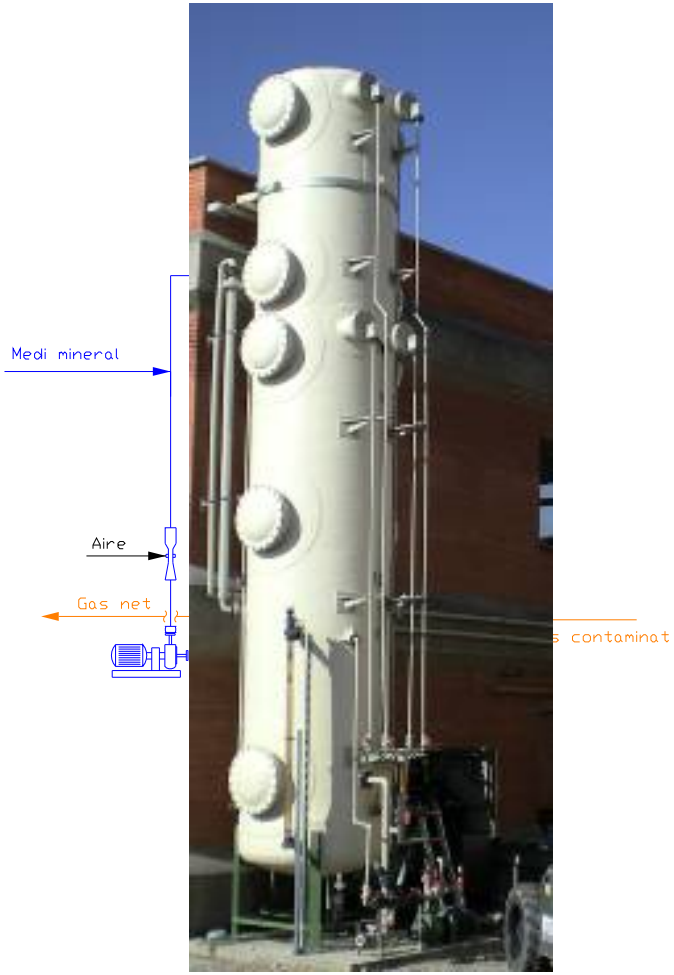
Generally throught agreements with companies. Ex: CCISA-Prototype construction



F biogas (m^3/h)	80
[H_2S] (ppm_v)	2500
EBRT (seg)	180
V (m^3)	5,15
D (m)	1,40
Reactor liquid volume (m^3)	3,00
Qrecycle (m^3/h)	5,80
Water velocity 1 (m/h)	5
Water velocity 2 (m/h)	2,5
Qair (m^3/h)	0-20
Packing material	Pall rings 1”
Specific surface area (m^2/m^3)	209

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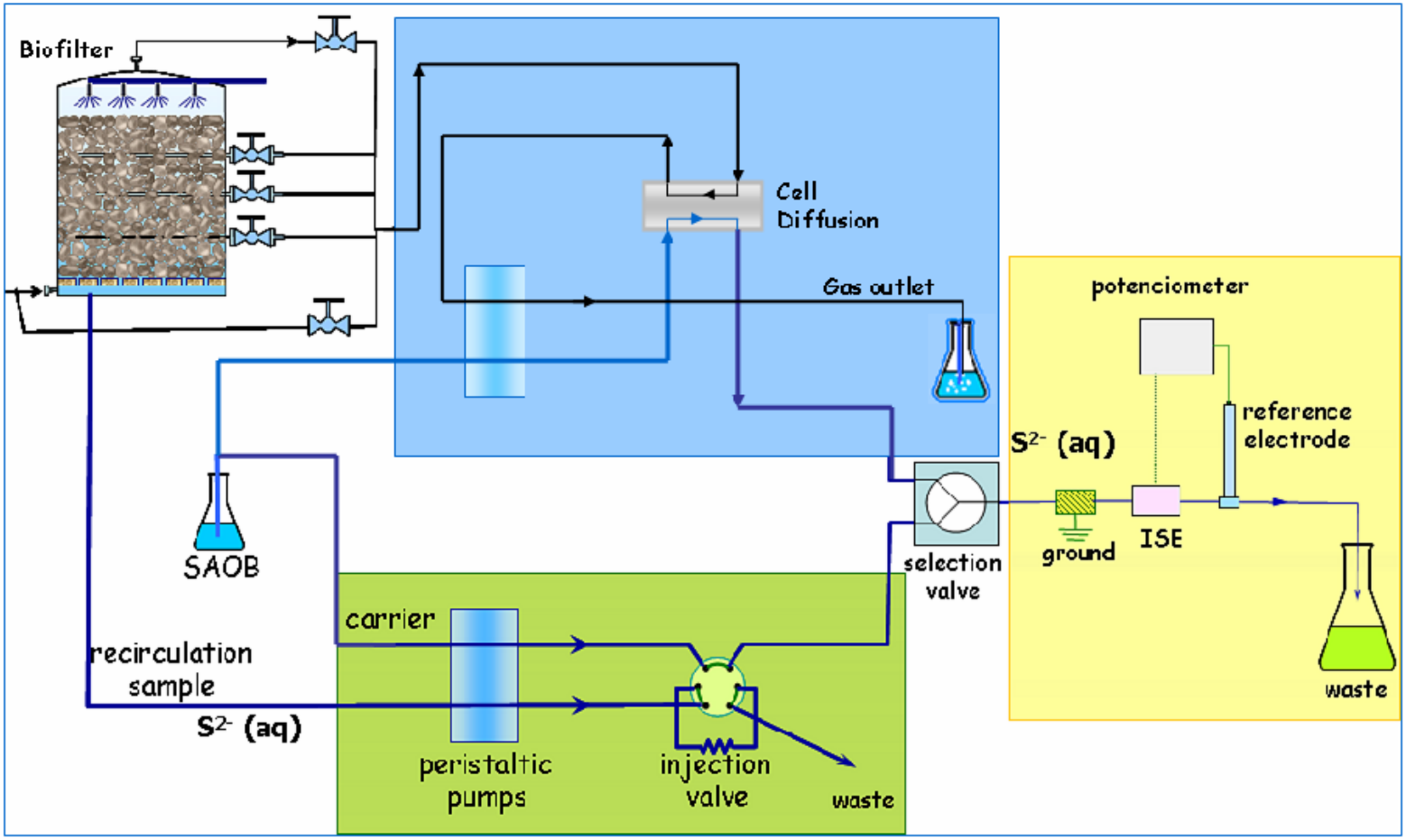
Develoment of monitoring equipments

FIA & CFA for on-line analysis: $H_2S_{(l)}/HS^-/S^{2-}$ and $H_2S_{(g)}$

Col. Chemistry Department



Use in process control: design of automatic control strategies

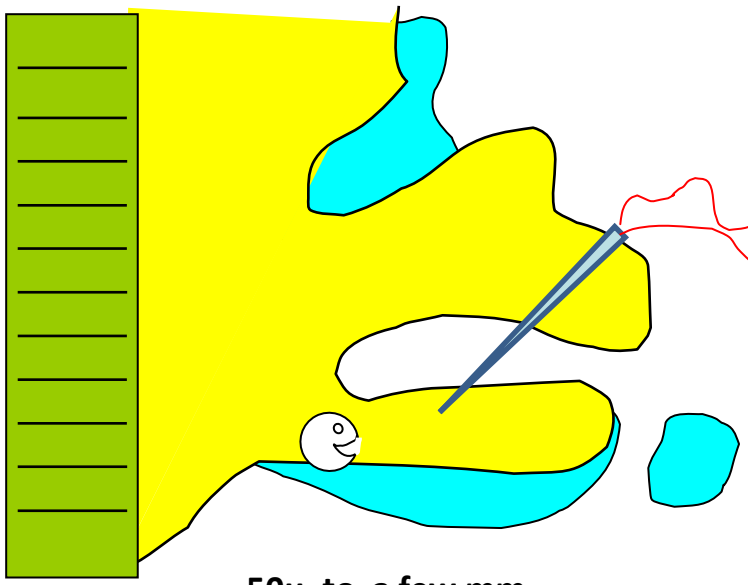
Research activities

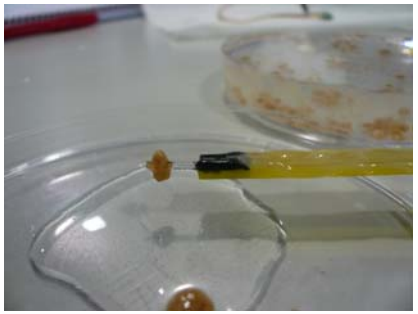
Develoment of monitoring techniques

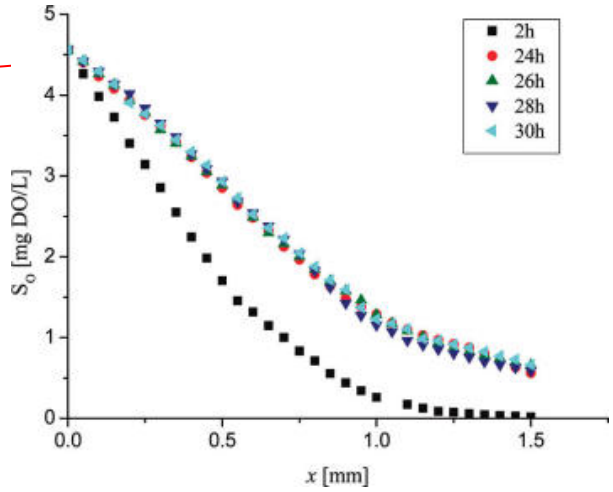
Microsensors

Col. Chemistry Department UAB

Centro Nacional Microelectrónica, CSIC



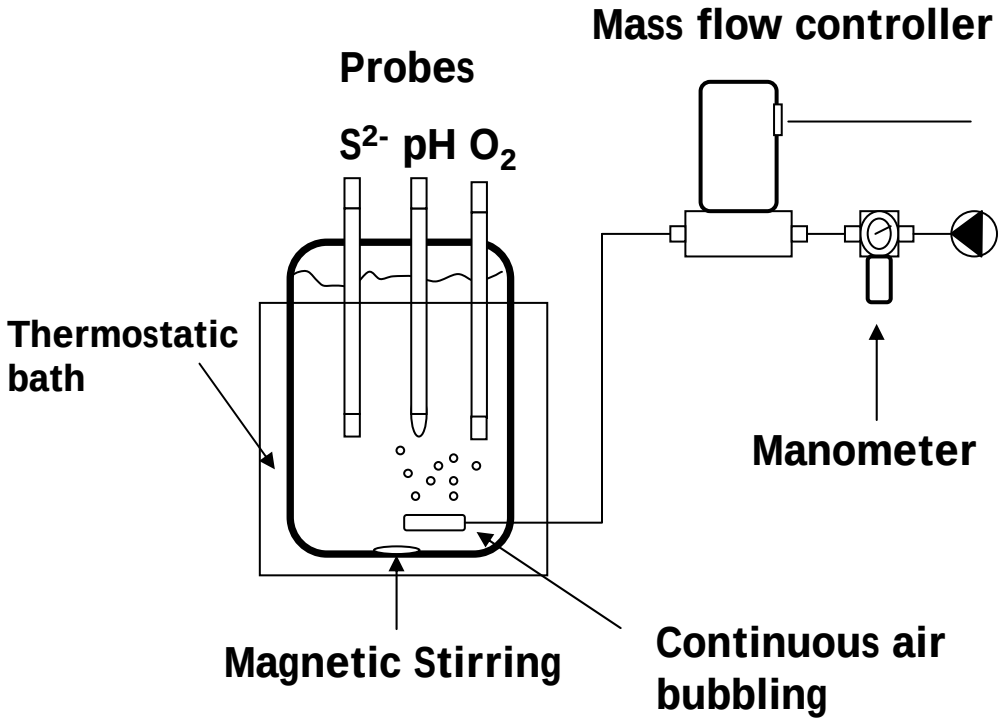


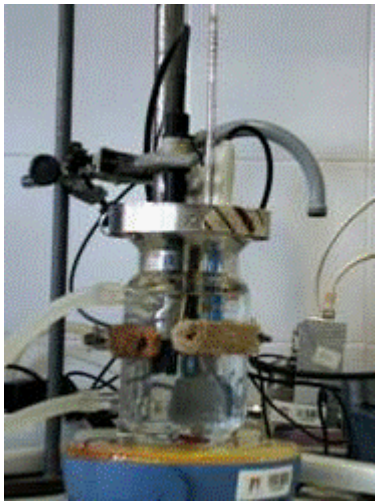


- Monitoring of oxygen concentration in biofilms

- Development of other microsensors (pH, NH_4^+…) for biofilms characterization

Respirometry





V_L= 0.3 L

- Addition of substrate pulses to a microbial population maintained under carefully controlled conditions (pH, T, OD ...)
- Monitoring of substrate and oxygen concentrations (and rates)

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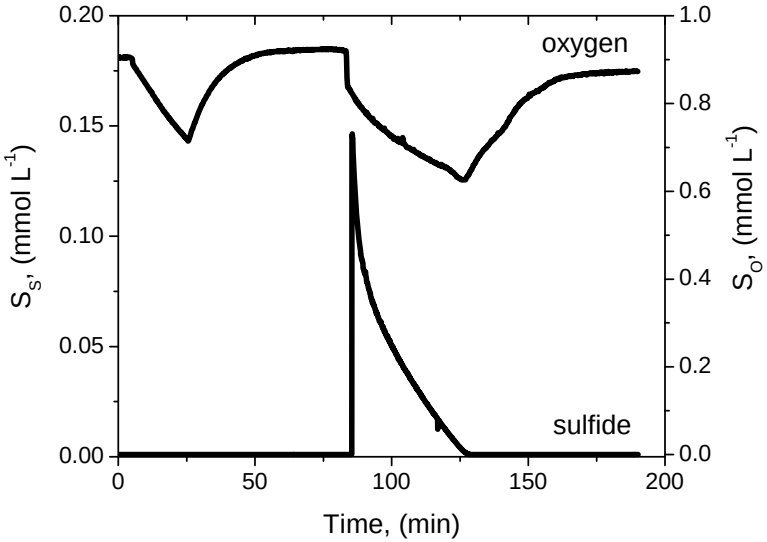
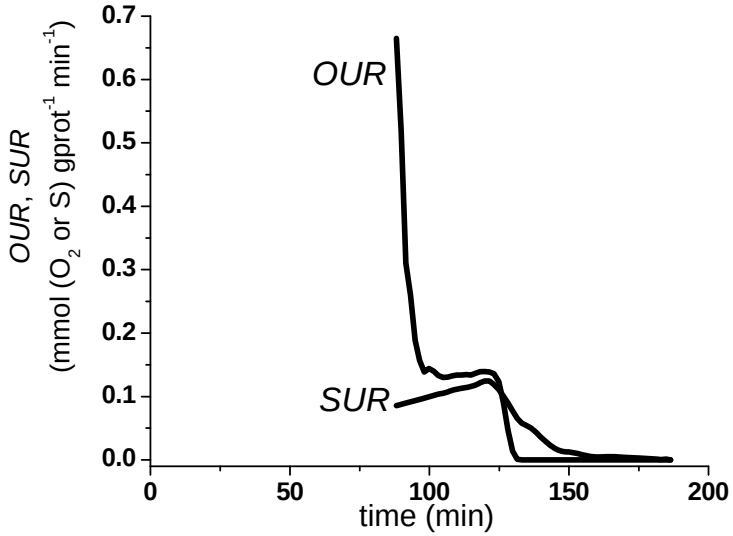
Respirometry modelling





- Development and validation of S-oxidation mathematical models

- Determination of stoichiometry and kinetic parameters of aerobic degradation rates

- Link respirometry with reactor performance, reactor modelling

(biology, kinetics, rates, mass balances, optimization , programming…)

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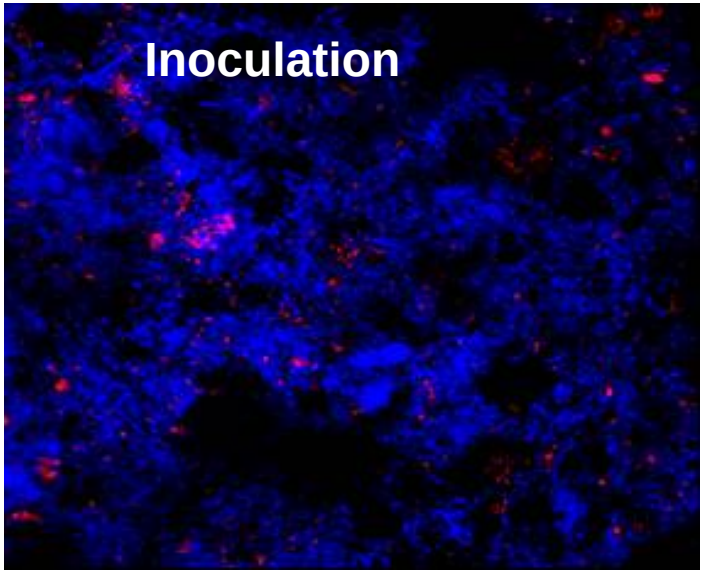
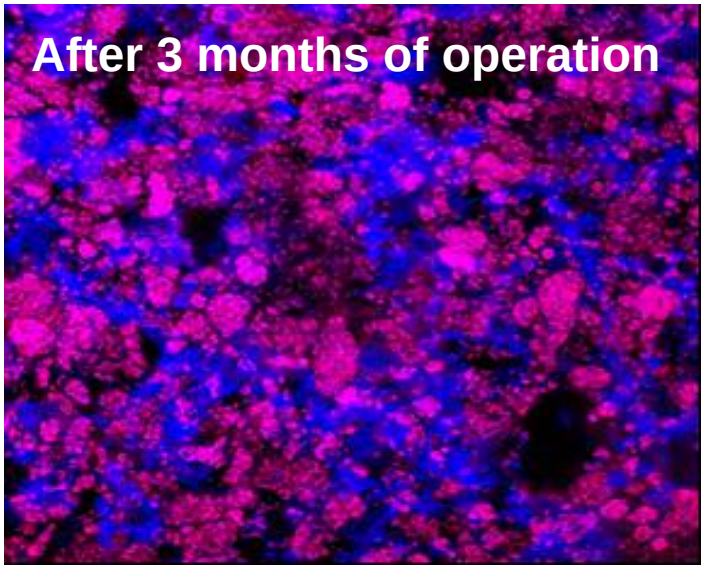
Research activities

Use of molecular biology techniques

Clone libraries → identification and classification of main species in bioreactors

FISH → Fluorescence in-situ hybridization **Col. Genetics Department**





Thiobacillus **probe (pink)** **General bacteria (blue)**

Evolution and relative quantification of main species along time and throughout the reactor

Knowledge in molecular biology tools

Future opportunities…

- Optimization of oxygen mass transfer
- Effect of additional pollutants (mercaptans)
- Anoxic desulfurization
- Use of micro/nano-sensors for biofilm monitoring

Reseach outputs…

- 20 indexed publications, last 5 years
- 43 oral and panel presentations at international conferences, last 5 years

Waste gases treatment research topic

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