27febbraio 2019 Incontro del Gruppo di lavoro sui BIOFILM

Società dei Naturalisti in Napoli, via mezzocannone 8

Ore 9.30

UNIVERSITA' degli Studi di Napoli Federico II
Dipartimento di Ingegneria Chimica dei Materiali
e della Produzione Industriale
(**DICMaPI**)/
Istituto di Ricerche sulla Combustione (IRC) - CNR

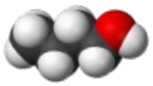
gruppo di lavoro

Componenti:

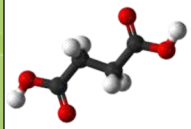
- Antonio Marzocchella (DICMaPI)
- Piero Salatino (DICMaPI)
- Francesca Raganati (DICMaPI)
- Maria Elena Russo (IRC-CNR)

Tematiche di interesse

- Previous activities on **biofilm reactors**
  - *Phenol degradation by* Pseudomonas OX1*biofilms*
  - *Butanol production by Clostridium acetobutylicum biofilms*



- **Biobutanol** production in a series of 4 biofilm reactors

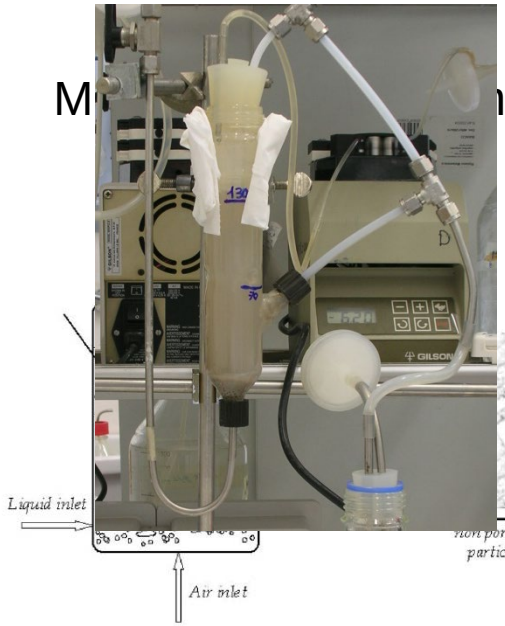


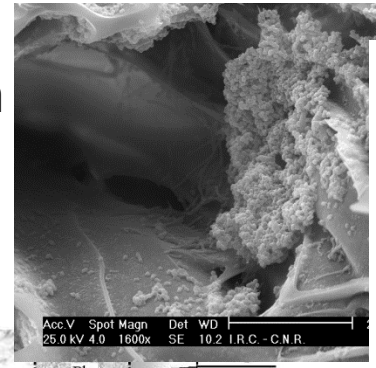
- **Succinic acid** production
  - *Packed bed biofilm reactor (PBBR)*
  - *Fluidized bed biofilm reactor (FBBR)*

2004

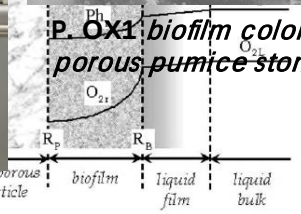
Aerobic biofilm reactors: phenol degradation by *Pseudomonas stutzeri*

Lab scale biofilm reactors: degradation of phenol and azo-dyes by *Pseudomonas OX1* biofilm on porous grannular supports





P. OX1 *biofilm colony on porous pumice stone*



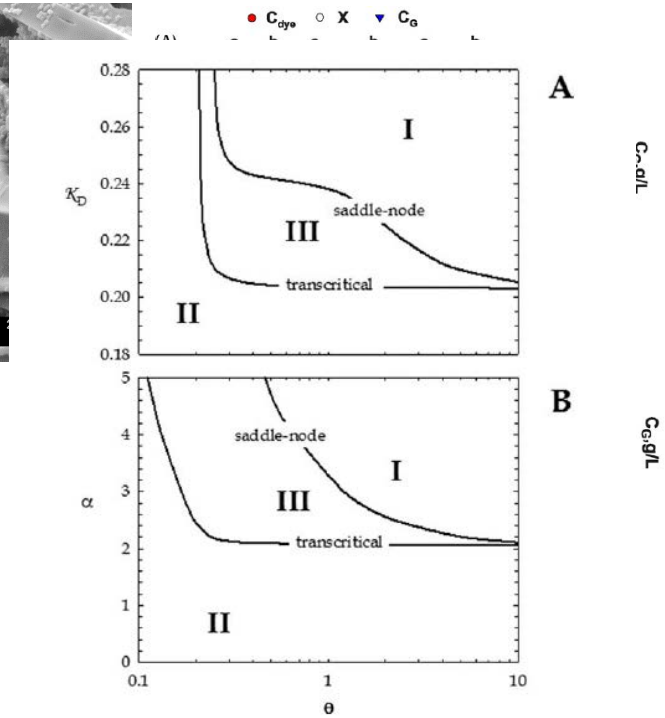
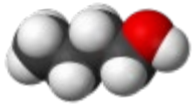


Figure 6. Bifurcation maps: (A) θ vs. $\mathcal{K}_D$ ($\alpha = 2$, $\mathcal{K}_L = 200$); (B) θ vs. α ($\mathcal{K}_D = 0.2$, $\mathcal{K}_L = 200$). Roman numerals indicate the number of steady-state solutions.

2011

[1] Viggiani et al. (2006) J Biotechnol 123: 464–477
[2] Lodato et al. (2007) Enz Microb Technol 41: 646–652
[3] Russo et al. (2008). Journal of Biotechnology 135: 295–303
[4] Olivieri et al (2011). Biotechnol. Prog. 27(6): 1599-1613

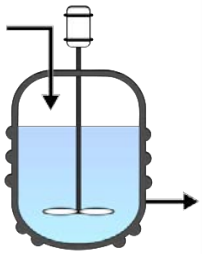
ACETONE – BUTANOL – ETHANOL production by *Clostridium acetobutylicum*

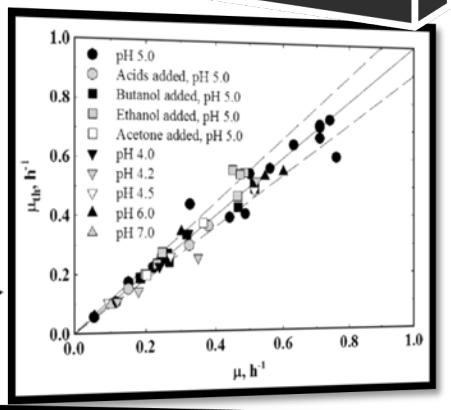


2006

2010

Acidogenesis Kinetics



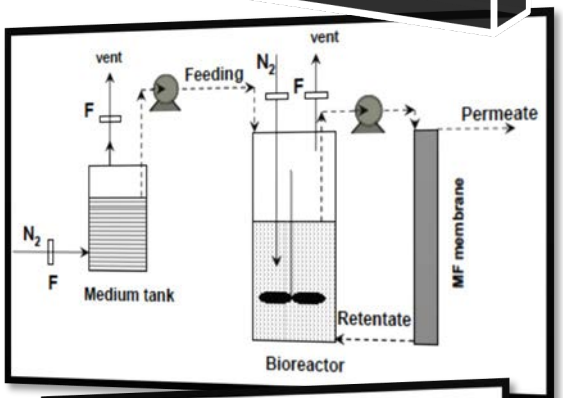


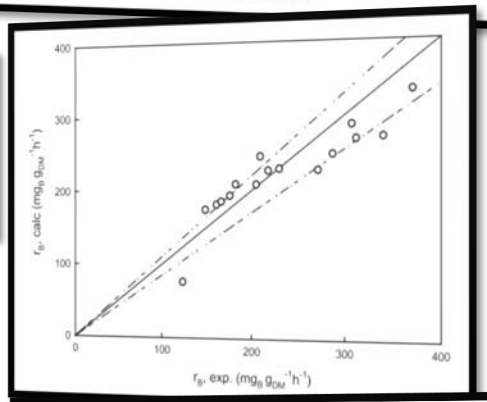
$$\mu = \mu_{max} \cdot \frac{L}{L+K_L} \cdot \left(1-\frac{AA}{AA_{max}}\right)^{n_{AA}} \cdot \left(1-\frac{BA}{BA_{max}}\right)^{n_{BA}} \cdot \left(1-\frac{Ac}{Ac_{max}}\right)^{n_{Ac}} \cdot \left(1-\frac{Et}{Et_{max}}\right)^{n_{Et}} \cdot \left(1-\frac{B}{B_{max}}\right)^{n_B}$$

$\mu_{max} = 0.95\ h^{-1}$ $K_L = 1.34$ g/L
$AA_{max} = 1.56$ g/L $n_{AA} = 0.98$
$BA_{max} = 3.00$ g/L $n_{BA} = 0.96$

$Ac_{max} = 64.5$ g/L and $Et_{max} = 35.0$ g/L

Solventogenesis Kinetics

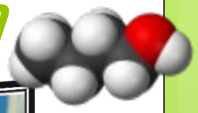




$$r_B = r_{B,max}\left(\frac{C_L}{K_{L,B}+C_L}\right)\left(\frac{AA}{K_{AA}+AA}\right)\left(\frac{BA}{K_{BA}+BA}\right)\left(\frac{K_B}{K_B+B}\right)$$

[5] Napoli et al. (2012). Enzyme and Microbial Technology. 50:165-172.
[6] Napoli et al. (2011). Bioresource Technology. 102:1608-1614.

ABE production by *Clostridium acetobutylicum*

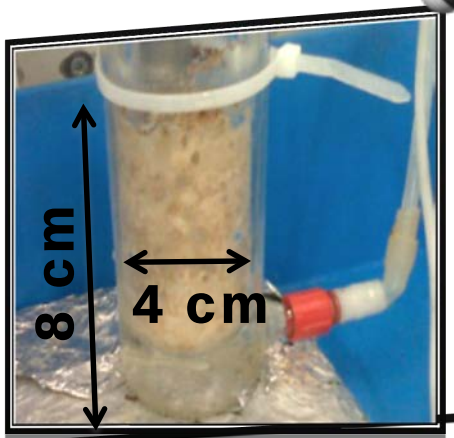


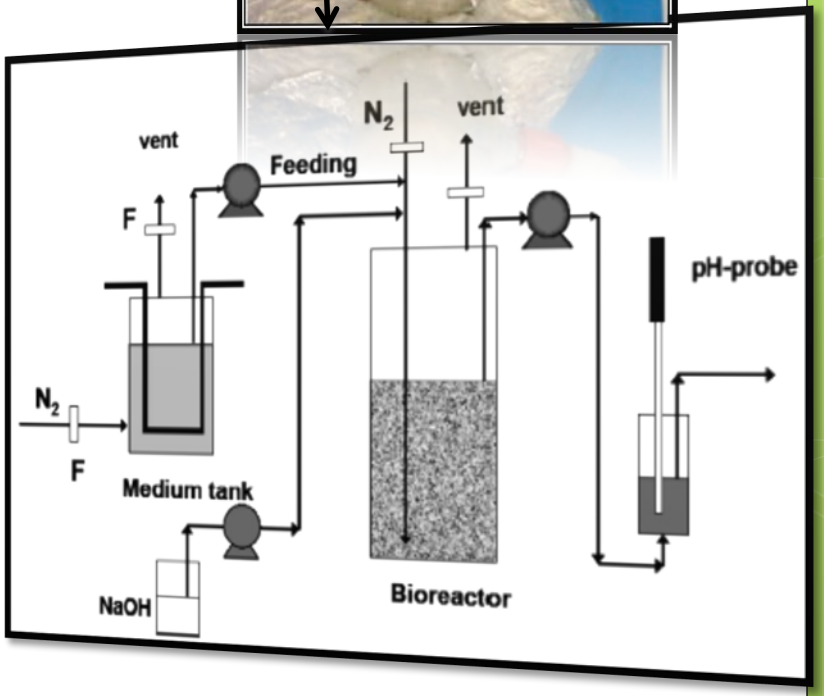
2010

Biofilm Packed Bed Reactor fed with Lactose/cheese whey

Steady-state cultures of *C. acetobutylicum* (up-phase).

Operating conditions	
D [h^{-1}]	0.54
pH	
Lactose in the feeding [g/L]	
Results	
Lactose [g/L]	9.1
Lactose conversion degree, ξ_L [%]	68
Acetone [g/L]	0.58
Butanol [g/L]	4.93
Ethanol [g/L]	0.50
Acetic acid [g/L]	1.23
Butyric acid [g/L]	1.32
Butanol productivity, W_B [g/Lh]	2.66
ABE productivity, W_{ABE} [g/Lh]	3.24
Butanol yield, $Y_{B/L}$ [g/g]	0.26
ABE yield, $Y_{ABE/L}$ [g/g]	0.32
Acids yield, $Y_{Acids/L}$ [g/g]	0.14
Butanol selectivity, Φ [g/g]	0.82



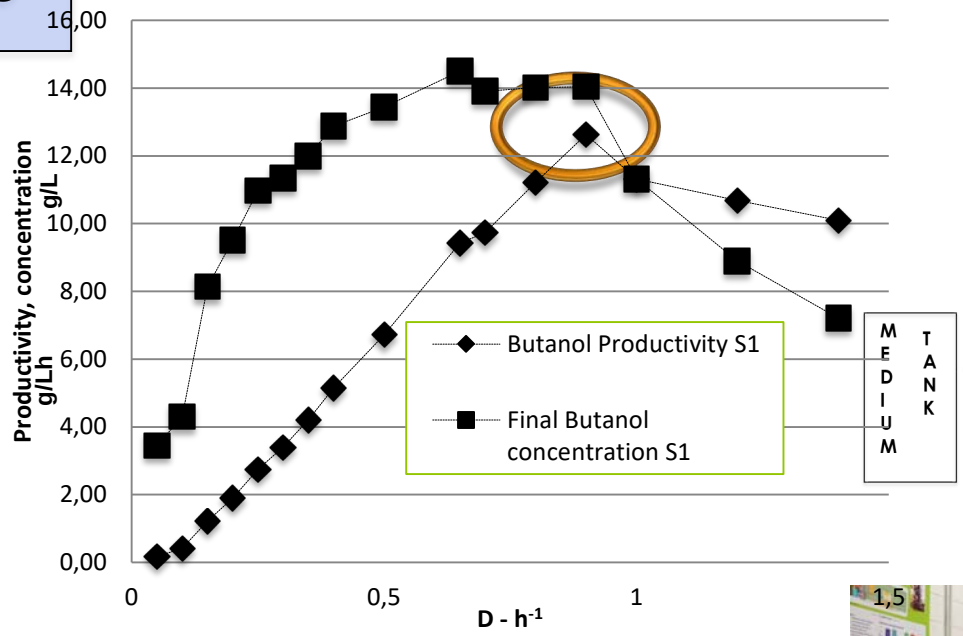


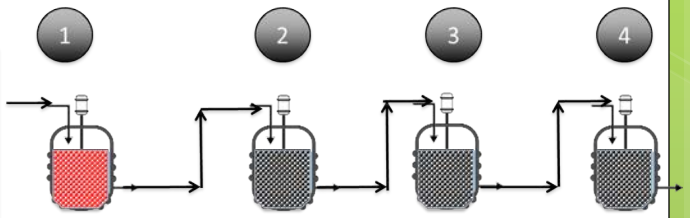
2012

[7] Raganati et al. (2013). Bioresource Technology. 138:259-265.

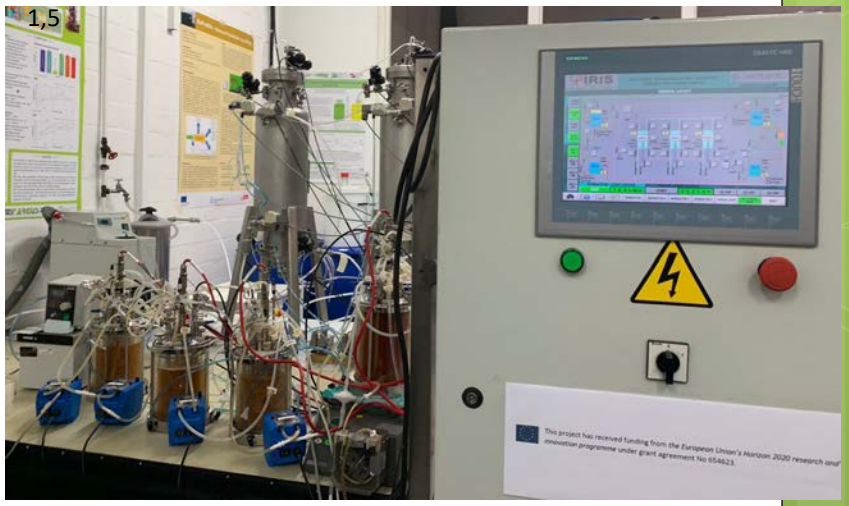
ABE production in a series of 4 biofilm reactors

2013





Sustainable production of next generation biofuels from waste streams-
Grant Agreement 654623 H2020 – LCE-11-2015

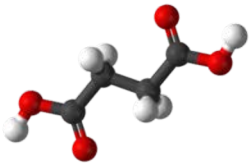


2018

[8] Raganati et al., patent RM2015A000185 (2015)
[9] Raganti et al. (2016). Chem Eng Sci. 152: 678-688.

2015

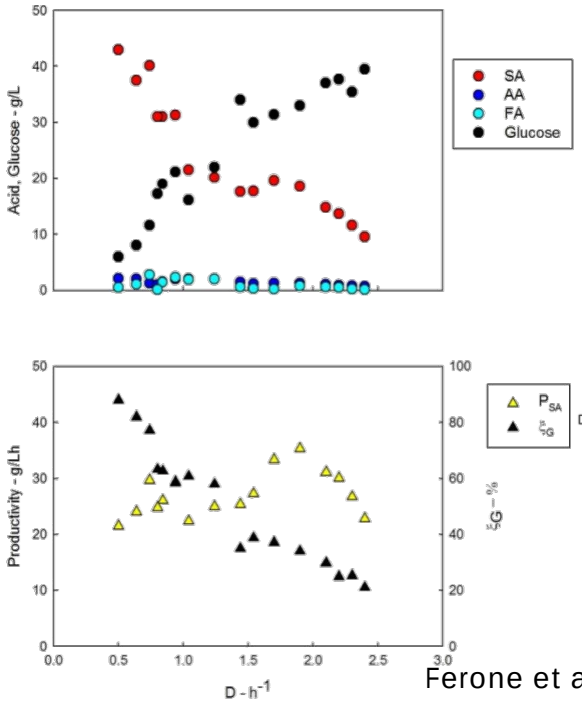
SUCCINIC ACID PRODUCTION by *Actinobacillus succinogenes*



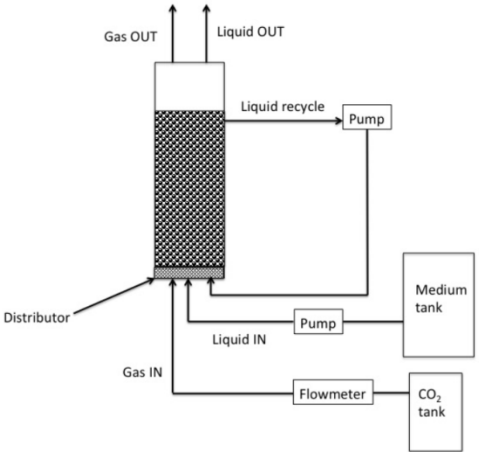
Growth Kinetics

Characterization of the Conversion Process

Packed bed biofilm reactor (PBBR)



Fluidized bed biofilm reactor (FBBR)



Ferone et al. (2018). Biotechnol. Biofuels 1–11.

2018

Ferone et al. (2018). Appl. Biochem. Biotechnol. https://doi.org/10.1007/s12010-018-2846-8
Ferone et al., (2017). Appl. Biochem. Biotechnol. doi:10.1007/s12010-017-2514-4

Prospettive future

- **Syngas fermentation** for the production of bio-fuels (butanol) and bio-commodities (bio-polymers)
- Application of BIOFILM REACTORS to bioconversion processes: sharing expertize in modelling, design, lab-scale set up and operation for interdisciplinary projects.

Prospettive future

Naples Summer school:

‘Biofilm fundamentals and application’??

Summer 2020??

Lecture sessions??

Practice sessions??