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Anaerobic Biodegradation of Pyridine in a Stationary Basket Bioreactor with Immobilized *Bacillus spp.* Cells

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Pyridine is one of the most encountered and, implicitly, important pollutant from the N-heterocyclic compounds class. Although the heterocyclic structure of pyridine does not make it a proper substrate for microbial consumption, the biological methods of pyridine removal from wastewaters became the most attractive alternative, because several species of microorganisms proved efficient affinity and activity for this compound or its derivatives through biodegradation under anaerobic or aerobic conditions.

OBJECTIVE

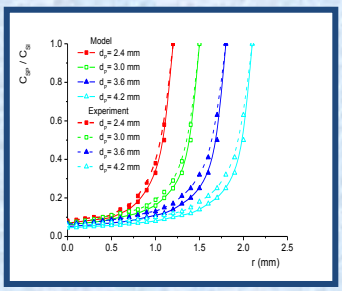
This work is focused on the investigation of the **pyridine biodegradation** by immobilized *Bacillus spp*. cells in a **stationary basket bioreactor**. Considering that the bacterial process occurs under substrate inhibition restriction, and using Haldane kinetic model, the roles of external and internal diffusions of pyridine on its concentration profile, as well as on its biodegradation rate have been analyzed.

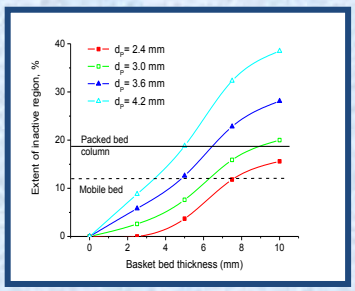
METHOD

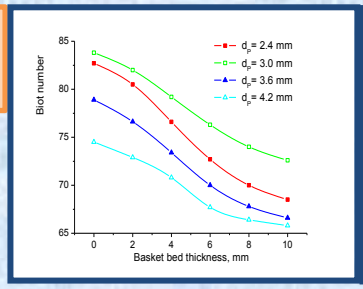
- bioreactor type Fermac 360 Electrolab, UK
- cylindrical bed of basket type having the inner diameter of 100 mm, height of 100 mm and the bed thickness of 10 mm
- impeller rotation speed: 300 rpm
- immobilized cells of *Bacillus subtilis, Bacillus megaterium, Bacillus licheniformis* and *Bacillus ortoliquefaciens* (particle diameters: 2.4, 3.0, 3.6 and 4.2 mm)
- culture media containing 0.5 g/l pyridine

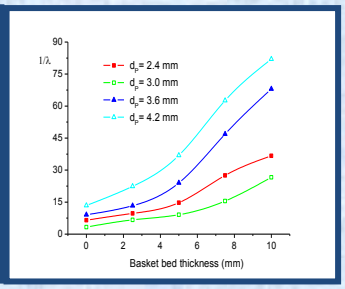
RESULTS

The extent of the inactive region varies between 0 and 38.5% from the overall volume of each studied size of the biocatalysts, increasing with the biocatalyst particles and basket bed width.









The pyridine biodegradation rate decreased radially inside the basket bed from 5.6 to 7.5 times, the magnitude of this variation being amplified for larger particles of biocatalysts.

$$C_{SP} = \frac{R_p.\sinh(3\varphi\cdot r)}{r\cdot\cosh(3\varphi\cdot R_p)}\cdot\frac{(C_{SL}-C_{Si})\cdot B_i\cdot k_L\cdot V\cdot C_C}{3\varphi\cdot B_i\cdot D_{Se}-k_L\cdot\tanh(3\varphi\cdot R_p)+K_I} \qquad Bi = \frac{k_L\cdot R_P}{D_{Se}}$$

$$C_{Si} = \frac{\tanh(3\varphi\cdot R_p)\cdot C_{SL}\cdot B_i\cdot k_L\cdot V\cdot C_C}{3\varphi\cdot B_i\cdot D_{Se}+k_L\cdot\tanh(3\varphi\cdot R_p)\cdot[B_i\cdot k_L\cdot V\cdot C_C-1]+K_I} \qquad \varphi = \frac{R_P}{3}\cdot\sqrt{\frac{V}{K_M'\cdot D_{Se}}}$$

$$\lambda = \frac{3D_{Se}\cdot(C_{SL}-C_{Si})\cdot\left(K_M'+C_{Si}+\frac{C_{Si}^2}{K_I}\right)\cdot B_i\cdot k_L\cdot\left[R_P\cdot\varphi\cdot\cosh(3\varphi\cdot R_p)-\sinh(3\varphi\cdot R_p)\right]}{R_P{}^2\cdot C_{Si}\cdot\cosh(3\varphi\cdot R_p)\cdot\left[3\varphi\cdot B_i\cdot D_{Se}-k_L\cdot\tanh(3\varphi\cdot R_p)+K_I\right]}$$

Bi	- Biot number
λ	- effectiveness factor
ϕ	- Thiele modulus
C_C	- cells concentration, kg/m³ d.w.
C_S	- pyridine concentration, mol/m³
C_{Si}	- pyridine concentration at the biocatalyst particle surface, mol/m³
C_{SL}	- pyridine concentration in the liquid bulk, mol/m³
C_{SP}	- pyridine concentration inside the biocatalyst particle, mol/m³
d_p	- biocatalyst particle diameter, m
D_{Se}	- pyridine effective diffusivity, m²/s
D_{SL}	- pyridine liquid phase diffusivity, m/s
k_L	- liquid phase mass transfer coefficient, m/s
K_{iP}	- pyridine inhibition constant, kg /m³
K_{iS}	- pyridine inhibition constant, kg /m³
R_p	- biocatalyst particle radius, m
v_s	- liquid superficial velocity, m/s

CONCLUSION

➢ **The studies on the biodegradation of pyridine with immobilized *Bacillus spp.* cells showed that the optimum diameter of immobilized *Bacillus spp.* cells particles is 3 mm, similar to the mobile bed of the same biocatalysts, due to the less important influence of external and internal diffusion of pyridine on its biodegradation rate.**

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