

## SUPPLEMENTARY MATERIAL

**Analysis of the performance of a packed bed reactor to production ethyl esters from crude vegetable oil using lipase immobilized in silica modified with protic ionic liquid**

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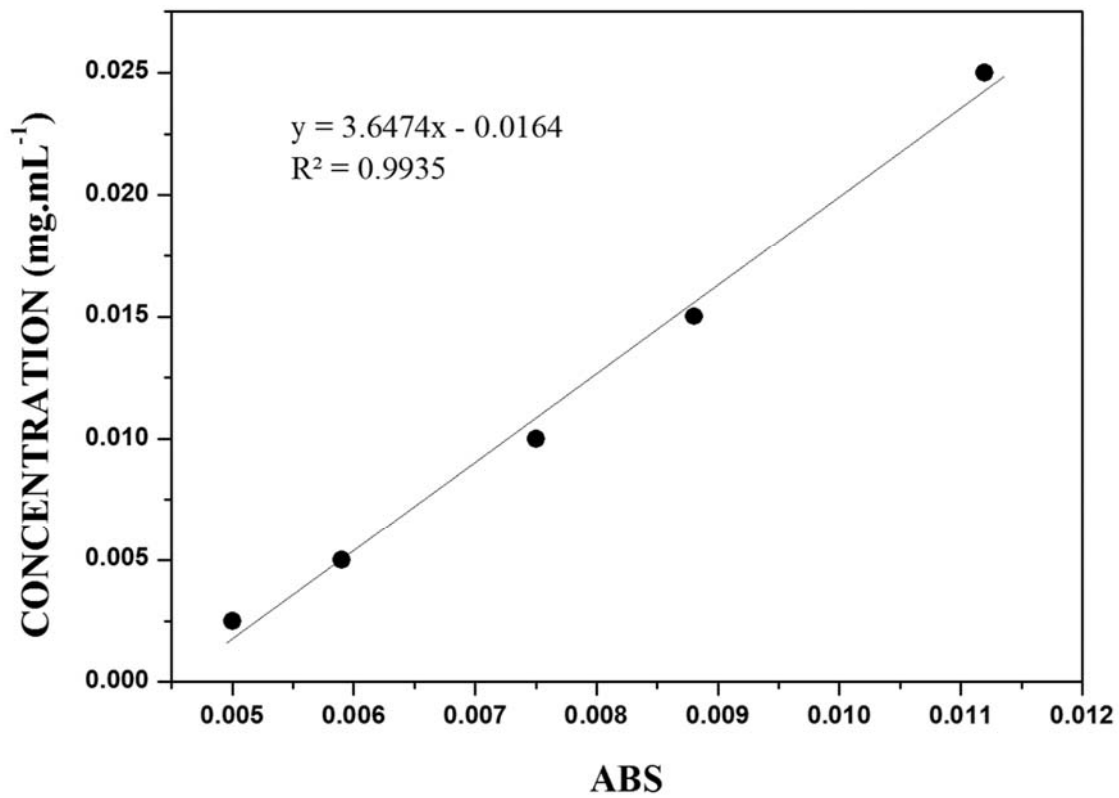
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*Figure 1S. Concentration versus absorbance of the tracer*

**Table 1S.** Dimensionless numbers in function the temperature the reaction, constituted by BCL on control silica (IB control) and BCL on modified silica (IB modified silica), with flow rate and molar ratio constant

Immobilized Biocatalyst	Parameters for equation 13							Re <sub>p</sub>	Parameters for equation 11				D <sub>AB</sub> x10 <sup>-6</sup> (m <sup>2</sup> s <sup>-1</sup> )	Sc	Sh	K <sub>c</sub> x10 <sup>-4</sup> (m s <sup>-1</sup> )
	T (K)	μ <sub>substrate</sub> (kg m <sup>-1</sup> s <sup>-1</sup> )	ρ (g m <sup>-3</sup> )	d <sub>p</sub> x10 <sup>-4</sup> (m)	ε	A x10 <sup>-4</sup> (m <sup>2</sup> )	Q x10 <sup>-9</sup> (m <sup>3</sup> s <sup>-1</sup> )		μ <sub>oil</sub> x10 <sup>-6</sup> (kg m <sup>-1</sup> s <sup>-1</sup> )	φ	M <sub>oil</sub> (kg kmol <sup>-1</sup> )	V <sub>etanol</sub> (m <sup>3</sup> kmol <sup>-1</sup> )				
IB control silica	303	0.0058	845200	9.2	0.3	7.85	2.5	1.44	1.5	698.21	0.058	1.8	0.0039	0.050	0.95	
	313	0.0042	837100					1.95				2.4	2.7	0.0019	0.039	1.14
	323	0.0031	828700					2.68				1.7	4.0	0.0009	0.031	1.33
	333	0.0024	820200					3.43				1.3	5.5	0.0005	0.026	1.53
IB modified silica	303	0.0058	845200	0.16				2.69	1.5	698.21	0.058	1.8	0.0039	0.064	1.22	
	313	0.0042	837100					3.65				2.4	2.7	0.0019	0.050	1.46
	323	0.0031	828700					5.02				1.7	4.0	0.0009	0.040	1.71
	333	0.0024	820200					6.43				1.3	5.5	0.0005	0.033	1.96

**Table 2S.** Dimensionless numbers in function the flow rate the reaction, constituted by BCL control silica (control silica) and BCL on modified silica (IB modified silica), with temperature and molar ratio constant

Immobilized Biocatalyst	Parameters for equation 13						$Re_p$	Parameters for equation 12		Sh	$K_c \times 10^{-4}$ ( $m\ s^{-1}$ )	
	$Q \times 10^{-8}$ ( $m^3\ s^{-1}$ )	$\mu_{substrate}$ ( $kg\ m^{-1}\ s^{-1}$ )	$\rho$ ( $g\ m^{-3}$ )	$d_p \times 10^{-4}$ (m)	$\epsilon$	$A \times 10^{-4}$ ( $m^2$ )		$D_{AB} \times 10^{-6}$ ( $m^2\ s^{-1}$ )	Sc			
IB control silica	0.25	0.0042	837100	9.2	0.3	7.85	0.25	2.7	0.0019	0.039	1.14	
	0.42						0.42			0.048	1.40	
	0.83						0.83			0.062	1.83	
	1.25						1.25			0.073	2.14	
	1.67						1.67			0.082	2.40	
IB modified silica	0.25				0.16		0.16			3.65	0.050	1.46
	0.42									6.13	0.061	1.79
	0.83									12.11	0.080	2.33
	1.25									18.25	0.094	2.74
	1.67									24.38	0.105	3.06

**Table 3S.** Dimensionless numbers in function the molar ratio the reaction, constituted by , constituted by BCL on control silica (IB control) and BCL on modified silica (IB modified silica), with flow rate and temperature constant

Immobilized Biocatalyst	Parameters for equation 13							Re <sub>p</sub>	Parameters for equation 12		Sh	k <sub>c</sub> x10 <sup>-4</sup> (m s <sup>-1</sup> )							
	Razão molar	μ <sub>substrate</sub> (kg m <sup>-1</sup> s <sup>-1</sup> )	ρ (g m <sup>-3</sup> )	d <sub>p</sub> x10 <sup>-4</sup> (m)	ε	A x10 <sup>-4</sup> (m <sup>2</sup> )	Q x10 <sup>-9</sup> (m <sup>3</sup> s <sup>-1</sup> )		D <sub>AB</sub> x10 <sup>-6</sup> (m <sup>2</sup> s <sup>-1</sup> )	Sc									
IB control silica	1:7	0.0042	837100	9.2	0.3	7.85	2.5	2.7	0.0018	0.039	1.14								
	1:9	0.0032	832000									2.53	0.0014	0.038	1.11				
	1:10	0.0030	829900													2.70	0.0013	0.037	1.10
	1:12	0.0028	827800																
IB modified silica	1:7	0.0042	837100	0.16	3.65	0.0018	0.050	1.46											
	1:9	0.0032	832000						4.75	0.0014	0.048	1.42							
	1:10	0.0030	829900										5.06	0.0013	0.048	1.41			
	1:12	0.0028	827800														5.36	0.0012	0.048



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