Effect of the operating parameters on Oxygen Transfer Rate in shaking flasks

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Introduction. Shaking flasks are widely used to study kinetics. Parameters such as pH, substrate and biomass concentrations among others are study to optimize the culture of microorganisms. Buchs et al[(1)]., pointed out problems related to oxygen limitation during biodegradation, such as metabolic slowing down and production of undesired toxic intermediary products. The aim of this work is to study the effect of operating parameters to improve the Oxygen Transfer Rate (OTR) during shaking flasks studies.

Methods. OTR in shaking flasks were determined at several nominal volumes (0.50 L and 1 L), agitation speeds (200 rpm and 250 rpm) and filling volumes (0.05 L and 0.10 L). The results were analyzed by statistical software (Statgraphics Centurion XVI, StatPoint Technologies, USA). OTR in the shaking flasks was measured according to a sulfite oxidation method modified from Quijano et al[(2)]. The power input (P/V) was calculated by using the correlation previously suggested by Buchs et al[(1)] for shaking flasks (Eq. 1).

$$\frac{P}{V} = C \cdot \rho \cdot \mathrm{Re}^{-0.2} \cdot \frac{n^3 \cdot d^4}{V_L^{2/3}} \qquad (1)$$

Results. The maximum OTR was obtained at 250 rpm and 50 mL of filling volume in the 1L flask (0.538 ± 0.042 g $O_2 \bullet L^{-1}$ h^{-1}) and the minimum OTR was obtained in the 0.5 L flask at 200 rpm filled with 100 mL (0.094 ± 0.011 g $O_2 \bullet L^{-1} \bullet h^{-1}$). Figure 1 shows that a linear correlation was observed between OTR and P/V (r2 = 0.975).

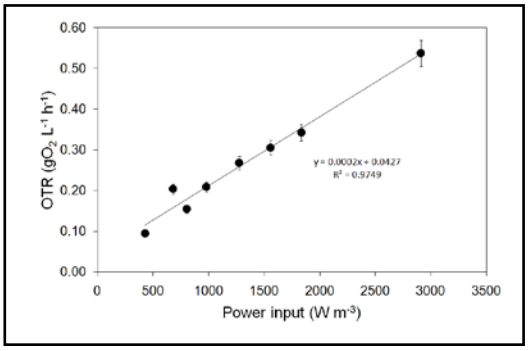

Fig.1 OTR observed at different power input calculated with Eq. 1

Table 1 shows the results for the ANOVA, it shows both the effect of each one of the main factors alone and the interactions of the factors on the OTR. From the F-Value obtained, the nominal volume is the factor that has more effect on the OTR, however as the three main factors are very inside in the critic region of F-Value (5.32), it can be said that all have a great effect on the OTR. On the other hand the interactions of agitation speed and nominal volume has an effect on the OTR and in less proportion the interactions of the tree factors. Table 1 also shows the P-value for each one of the factors and interactions. Since the 3 P-values of the main factors are less than 0.05, these factors have a statistically significant effect on the OTR at the 95 % confidence level. The P-Value of the interactions shows that agitation speed and nominal volume have a great impact on OTR. The values of P and F indicate that the interaction between agitation speed and filling volume and the interaction between nominal volume and filling volume have no significant effect to the experiment.

Table 1. Results of the ANOVA for the experimental design during the OTR experiments Fcrit = 5.32.

Parameter	F-Value	P-Value
Agitation speed (A)	147.36	2.0 E-06
Nominal Volume (B)	185.12	8.2 E-07
Filling Volume (C)	120.56	4.2 E-06
AB	38.41	2.6 E-04
AC	5.11	0.054
BC	0.73	0.418
ABC	7.45	0.026

Conclusions. The OTR can be increased by increasing the nominal volume and the agitation speed and reducing the filling volume. The increase in these parameters led to an increase in the power input, while the contrary effect was observed when the filling volume is increased.

References.

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2. Quijano, G., Revah, S., Gutiérrez-Rojas, M., Flores-Cotera, L.B., Thalasso, F. (2009) *Process Biochem.*, 44, 619-624.