HYDRODYNAMIC AND OXYGEN MASS TRANSFER STUDIES IN A THREE-PHASE (AIR-WATER-ORANGE OIL) STIRRED TANK BIOREACTOR

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Introduction. Two-phase partitioning bioreactors have demonstrated significant potential for enhancing the productivity of many bioprocesses by overcoming issues of poor substrate solubility and toxicity (1, 2).
The aim of this work is to study the hydrodynamic and oxygen mass transfer characteristics of a three-phase gas-medium-orange oil dispersion, for bioconversion of (+)-valencene to (+)-nootkatone.

Methods. A central composite experimental design was used to investigate the interaction of three operational factors, agitation (300, 400, 500 rpm) and aeration rates (0.5, 0.75, 1.0 vvm), and orange oil volume fraction (0.2, 0.35, and 0.50), on two response variables, the *Sauter* mean droplet diameter (d_{32}) and the volumetric oxygen transfer coefficient (k_La). Aerated power consumption (P_g/V) was also measured.

Results. The relationship between the measured d_{32} values as a function of agitation and aeration rate are shown in Figure 1.

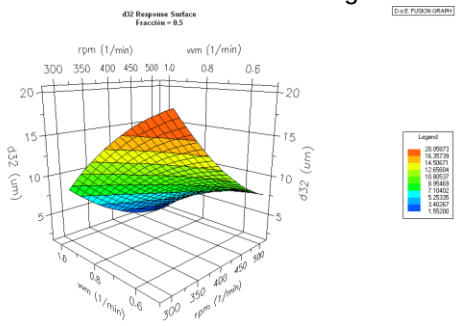

Fig.1 Effect of aeration and agitation rates on measured d_{32} values at an orange oil volume fraction of 0.5.

The effect of bioreactor operating conditions on experimentally determined k_La is shown in Figure 2. For orange oil k_La values generally increased as agitation and aeration rates increased as would be expected from more conventional biphasic gas-liquid system studies. The maximum k_La values (around 116 h^{-1}) were obtained at a dispersed phase volume fraction of 0.5. The high value obtained may be related to the significantly small droplets formed with the orange oil and the impact that the droplets have on gas-liquid dispersion.

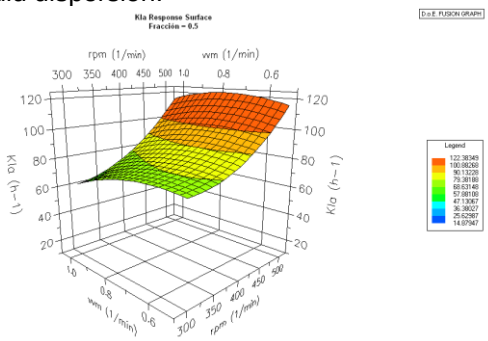

Fig.2 Effect of aeration and agitation rates and orange oil volume fraction (50%) on measured k_La values.

All results obtained for the hydrodynamic experiments are shown in Table 1. Measured k_La values increased as orange oil volume fraction increased and d_{32} values decreased. It is observed that P_g/V values decreased as aeration rates increased as would be expected for a single liquid phase.

Table 1. Operational variables and experimental results obtained for orange oil dispersion.

ϕ	rpm (min^{-1})	vvm (min^{-1})	P_g/V (W m^{-3})	d_{32} (μm)	k_La (h^{-1})
0.2	300	0.50	1784	13.05	47.27
	400	1.00	2429	13.49	53.04
	500	0.75	3225	14.10	59.83
0.35	300	0.75	1828	18.93	24.65
	400	0.50	2431	14.75	16.63
		0.75	2490	14.25	27.45
		0.75	2437	15.49	24.65
	500	1.00	3055	12.35	47.92
0.5	300	1.00	1829	8.27	62.21
	400	0.75	2540	9.26	88.51
	500	0.50	3433	7.98	116.44

Conclusions. These correlations will be useful for ongoing studies on the design and operation of partitioning bioreactors for oxidative bioconversions.

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