HYDRODYNAMIC CHARACTERISATION OF AN AIRLIFT WITH AN ENLARGED DEGASSING ZONE

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ABSTRACT

The hydrodynamics of a 60 L airlift bioreactor with an enlarged degassing zone are studied.

Mixing and circulation times are determined for different airflow rates (up to 1.1E-03 m^3/s) and for different solids loading (up to 40% v/v). It is shown that, regardless of solids concentration, circulation time decreases with an increase in airflow rate, for solids loading bellow 30%. Above this value, circulation time drastically increases.

A similar decrease with airflow rate is also observed for mixing time. However, in this case, solids loading is also an important factor. For all tested airflow rates, a maximum in mixing time is observed for a solids concentration of 20%.

KEYWORDS Airlift; Three-phase bioreactor; Hydrodynamics.

INTRODUCTION

Biotechnological processes are complex in hydrodynamic and mass and heat transfer terms. This complexity results from the number of phases in the bioreactor, often 3 or 4, being one of them a solid phase, usually a biocatalyst.

The airlift bioreactors have been used in a variety of applications, such as cell protein production, waste water biological treatment and antibiotics, animal and vegetable cell production [1], [2], [3]. The principal advantage of this kind of systems is due to the low shear that it generates, its simpler design and its easy operation. The absence of mechanical agitation leads, however, to a lower oxygen mass transfer.

Till now, most of the studies were made with two-phase bioreactors. The effect of the volume of solid phase on hydrodynamic behaviour and on mass transfer of airlift bioreactors has not been extensibly investigated. Solids loading is a very important parameter in operation of high density cellular systems [4], [5]

The aim of the present work is to study the influence of aeration (airflow values less then 1.1E-3 m^3/s) and solids loading (5, 10, 15, 20%, 30% and 40% (v/v)) in mixing and circulation times and liquid velocity, for a 60 L internal loop airlift bioreactor with an enlarged degassing zone.

MATERIALS AND METHODS

The experiments have been carried out in a 60 L airlift bioreactor of the concentric draught tube type, with a cylindrical conical top section. The circulation and mixing times were determined using the pH pulse technique. Ca-alginate beads were used as the solid phase.

RESULTS AND DISCUSSION

It was found that, for solids loading less than 30%, the decrease of circulation time (tc) with riser gas velocity (Ugr), shown in Figs. 1 and 2, can be described by:

$$tc\ (s) = 4.878 * Ugr^{-0.344}\ (m/s)$$

with a correlation coefficient of 0.98. For solids loading higher than 30%, circulation time increases.

Mixing time decreases with riser gas velocity (Fig. 3) and, as shown in fig. 4, reaches a maximum for 20% of solids.

Solids loading does not affect downcomer liquid velocity; for the range 0%-40% of solids, the increase of downcomer liquid velocity (Vld) with riser gas velocity (Fig.5) is represented by the equation:

$$Vld\ (m/s) = 0.292 * Ugr^{0.378}\ (m/s) \qquad c.c.=0.95.$$

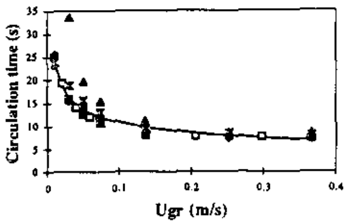

Fig. 1. Circulation time vs. riser superficial gas velocity, for different solids loading (□-0%; ◆-5%; O-10%; ■-15%;✧-20%;✱-30%;▲-40%).

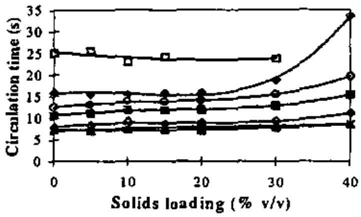

Fig. 2. Circulation time vs. solids loading, for different airflow rates (□-3.2E-5 m^3/s;◆-9.2E-5 m^3/s;O-1.5E-4 m^3/s;■-2.3E-4 m^3/s;✧-4.1E-4 m^3/s;✱-7.6E-4 m^3/s;▲-1.1E-3 m^3/s).

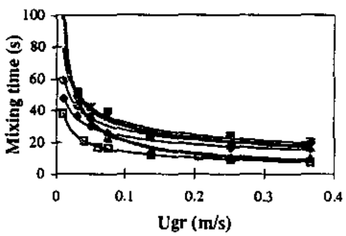

Fig. 3. Mixing time vs. riser superficial gas velocity, for different solids loading (□-0%; ◆-5%; O-10%; ■-15%;✧-20%;✱-30%;▲-40%).

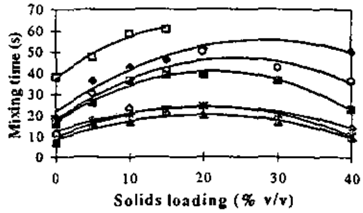

Fig. 4. Mixing time vs. solids loading, for different airflow rates (□-3.2E-5 m^3/s; ◆-9.2E-5 m^3/s; O-1.5E-4 m^3/s; ■-2.3E-4 m^3/s;✧-4.1E-4 m^3/s;✱-7.6E-4 m^3/s;▲-1.1E-3 m^3/s).

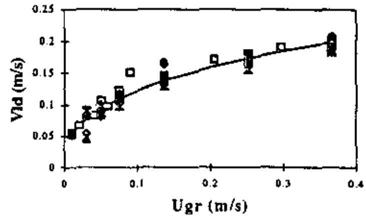

Fig. 5. Downcomer liquid velocity vs. riser superficial gas velocity, for different solids loading (□-0%; ◆-5%; O-10%; ■-15%;✧-20%;✱-30%;▲-40%).

CONCLUSIONS

Circulation and mixing times decrease with the increase of air flow rate.

The increase of solids loading only affects significantly circulation time for solids loading up to 30%.

With an increase in solids loading, mixing time increases till a maximum, for 20% of solids.

For higher amounts of solids, mixing time decreases.

Downcomer liquid velocity increases with air flow rate and is independent of solids loading.

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