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Impact of energy supply and oxygen transfer on selective lipopeptide production by *Bacillus subtilis* BBG21

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HIGHLIGHTS

- ▶ Demonstration that k_La is the key parameter controlling lipopeptide production.
- ▶ Determination of k_La ranges favorable for surfactin mono-production.
- ▶ Determination of k_La ranges favorable for mixed production of surfactin and fengycin.
- ▶ Demonstration that power dissipation influences indirectly lipopeptide production via k_La.
- ▶ Establishment of correlations between k_La and lipopeptide production and selectivity.

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ABSTRACT

The influence of power dissipation and volumetric oxygen transfer coefficient k_La on *Bacillus subtilis* productivity of lipopeptides surfactin and fengycin was studied in shake flasks in view of scaling-up of this fermentation process. The experiments performed with different flask sizes, relative filling volumes, and shaking frequencies confirmed clearly that lipopeptide production changed in function of power dissipation, via interfacial gas–liquid contact surface and oxygen supply. It was demonstrated that k_La is the key parameter controlling the productivity and the selectivity of the bioreaction. Varying the oxygen transfer conditions, the synthesis could be oriented to mixed production or to surfactin mono-production. The fraction of surfactin towards total lipopeptides produced and the maximal surfactin production both increased with k_La increase (surfactin concentration about 2 g L^{-1} at k_La = 0.04–0.08 s^{-1}), while the maximal fengycin production (fengycin concentration about 0.3 g L^{-1}) was obtained at moderate oxygen supply (k_La = 0.01 s^{-1}).

1. Introduction

Bacillus subtilis produces three different families of lipopeptides: surfactin, iturin and fengycin. Surfactin is considered as one of the most potent biosurfactant and shows antiviral properties. Iturin and fengycin are strong antifungal compounds (Jacques, 2011). In addition, surfactin and fengycin are able to induce systemic resistance in plants and could be used in a next future as biocontrol agent of plant diseases (Ongena and Jacques, 2008). The actual level of knowledge of the biosynthesis of these lipopeptides and its regulation mechanism allows developing different techniques to overproduce the main active compounds and to reach yields that are compatible with industrial development of such compounds (Jacques, 2011). A lot of studies have pointed out different environmental factors for their effect on lipopeptide production using planktonic and immobilized cells. Several studies demonstrated that the production of lipopeptides is strongly influenced by oxygen transfer conditions. In these studies the authors analyzed this effect by different ways. Phae and Shoda (1991) and Ohno et al. (1993) have demonstrated that in flasks and in fermenters, deficiency in dissolved oxygen has no adverse effect on iturin production by *B. subtilis* NB22 strain. Hbid et al. (1996) have shown the negative influence of the addition of an oxygen vector, the *n*-dodecane, on the production of surfactin and iturin A in bioreactor. Results of Sen and Swaminathan (1997) indicated that a low agitation and a high aeration rate favored, in bioreactor, the biosynthesis of surfactin by *B. subtilis* 3256 while Jacques et al. (1999) have demonstrated, in flasks, that a high shaking rate is beneficial for a good production of the total amount of lipopeptides by *B. subtilis* S499. Yeh et al. (2006) have proposed for surfactin production an innovative bioreactor equipped with a foam collector and a cell recycling system. In the used modified jar fermentor, they have observed a clear positive effect of the volumetric oxygen transfer

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