

Accepted Manuscript

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PII: S0021-9797(18)30946-9
DOI: <https://doi.org/10.1016/j.jcis.2018.08.031>
Reference: YJCIS 23964

To appear in: *Journal of Colloid and Interface Science*

Received Date: 22 May 2018
Revised Date: 8 August 2018
Accepted Date: 9 August 2018

Please cite this article as: L. Ditscherlein, S. Jolan Gulden, S. Müller, R-P. Baumann, U.A. Peuker, H. Nirschl, Measuring interactions between yeast cells and a micro-sized air bubble via atomic force microscopy, *Journal of Colloid and Interface Science* (2018), doi: <https://doi.org/10.1016/j.jcis.2018.08.031>

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Measuring interactions between yeast cells and a micro-sized air bubble via atomic force microscopy

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Abstract

A method for the determination of interactions between yeast cells and air bubbles using the atomic force microscope was developed, in which a bubble acts as probe on immobilised living cells. The experimental setup and influencing parameters like bubble size, dwell time and maximum contact force on force-distance curves and maximum adhesion forces are explained. Also, interactions between bubble and yeast cells under variation of pH, ethanol concentration, salt concentration, ionic strength and influence of storage time in Yeast Malt Broth and phosphate buffered saline are investigated and discussed.

Key words:

yeast cells, atomic force microscopy, bubble probe spectroscopy, interactions

1. Introduction

Measurement of interactions between particles or cells and bubbles in a liquid media is of vital interest in chemical engineering applications, especially for optimization of flotation, fermentation, extraction or recycling operations. In general, a particle or cell has to pass through three zones to make contact with a bubble: In the first zone, the distance between particle and bubble is large and only hydrodynamic interactions occur. When the distance gets smaller, a second, diffusio-phoretic zone is reached, where the equilibrium distribution of adsorbed ions is disturbed by the liquid flow around the bubble. If the separation distance is reduced further to approximately 50 nm, surface forces will dominate all other forces [1] in the third zone. In here, a film rupture might occur, bringing particle/cell and bubble into contact. This paper focuses on this third zone.

In 1991, DUCKER [2] and BUTT [3] developed a new method to determine surface forces by way of the atomic force microscope and called it colloidal probe technique. With the help of this technique many research groups have investigated particle-bubble interactions under various conditions, changing scanning as well as system parameters [4-6]. The earliest particle-bubble measurements were those of BUTT [7] and DUCKER et al. [8], subsequently refined by FIELDEN et al. [9], who gives an introduction in acting interfacial forces like VAN DER WAALS, electrostatic and even hydrophobic forces. With coated and uncoated particles it was shown that repulsive forces can be reduced by adding a certain amount of salt [10], surfactant [11, 12] or variation of pH [13]. Furthermore, the relative position and motion of particle and bubble is crucial when determining the range of the repulsive potential, because a position-dependent variation of the applied force occurs [14]. If a high force is applied, the particle will overcome the repulsive regime and snap into the bubble. In the case of hydrophobic

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