Investigation of Carbon Dioxide Fine Bubbles in Biocatalysis

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Introduction

- Fine bubbles have diameters of less than 100 µm
- Due to their small size, fine bubbles show a slow rising velocity, less foaming and tend to repel each other as they show a negatively charged surface[1]
- As the interfacial area is proportional to the mass transfer rate, fine bubbles have the potential for efficient mass transfer in multiphase systems
- Optimization of a biotransformation regarding mass transport and biocatalyst activity is important as biocatalysts are susceptible to a wide range of process parameters

Aim

- Determination of the potential of fine bubbles in biocatalysis
- Utilization of the greenhouse gas carbon dioxide for aeration
- Characterization of enzyme activity and stability for different bubble sizes and respective interfacial areas

Carboxylation of Resorcinol

- Decarboxylases are carbon-carbon lyases that add or remove carboxyl groups from organic compounds
- The employed decarboxylase can catalyze the reversible decarboxylation of 2,6-dihydroxybenzoate (2,6-DHBA) to resorcinol
- Resorcinol has medical applications as antiseptic and disinfectant as well as industrial applications as intermediate for pharmaceuticals and other organic compounds
- Several dihydroxybenzoic acids show antioxidant and antimicrobial activities[2,3]

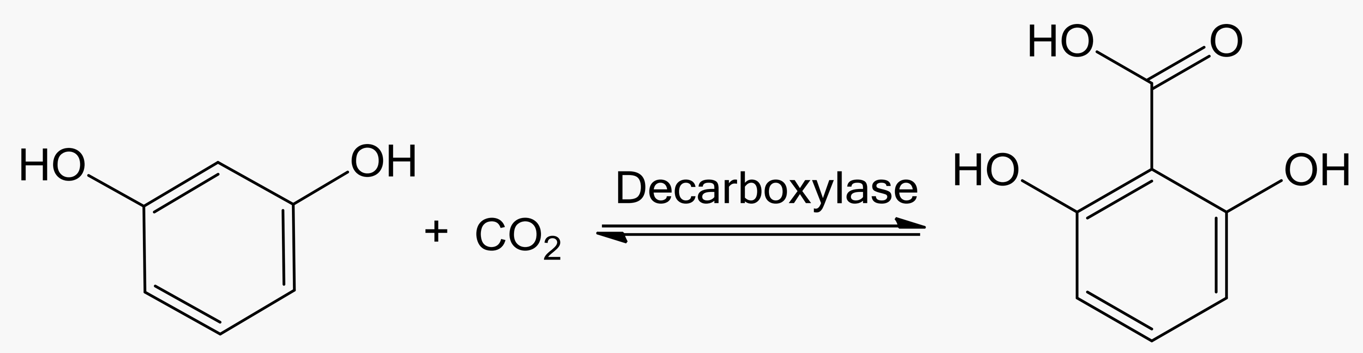

Fig. 1: Carboxylation of resorcinol to 2,6-DHBA by decarboxylase

Reaction Conditions

- Carboxylation of 50 mM resorcinol to 2,6-dihydroxybenzoic acid by 12,5 µg/mL (1,49 U/mg) decarboxylase in 100 mM potassium phosphate buffer and 1 M of a tertiary amine
- Continuous aeration with CO_2 by spargers of different pore sizes
- On-line measurement of pH and temperature
- HPLC analysis of substrate and product concentrations for determination of conversion and yield
- The reaction parameters were optimized to the effect that no mass transfer limitation occurred during the biotransformation by using low enzyme amounts which sufficiently slowed the reaction

Bubble Aeration

- Mean bubble diameters of 0,4 mm and 0,2 mm were produced by spargers with 10 µm and 2 µm pores at a constant aeration of 100 mL CO_2/min, respectively

Fig. 2: Bubble aeration with 2 µm sparger

Fig. 3: Bubble aeration with 10 µm sparger

Effect on Conversion Rate

- Identical reaction conditions were tested, which only varied by the employment of different sparger pore sizes resulting in varying bubbly sizes
- Smaller bubbles resulted in elevated foam formation and slower conversion of resorcinol

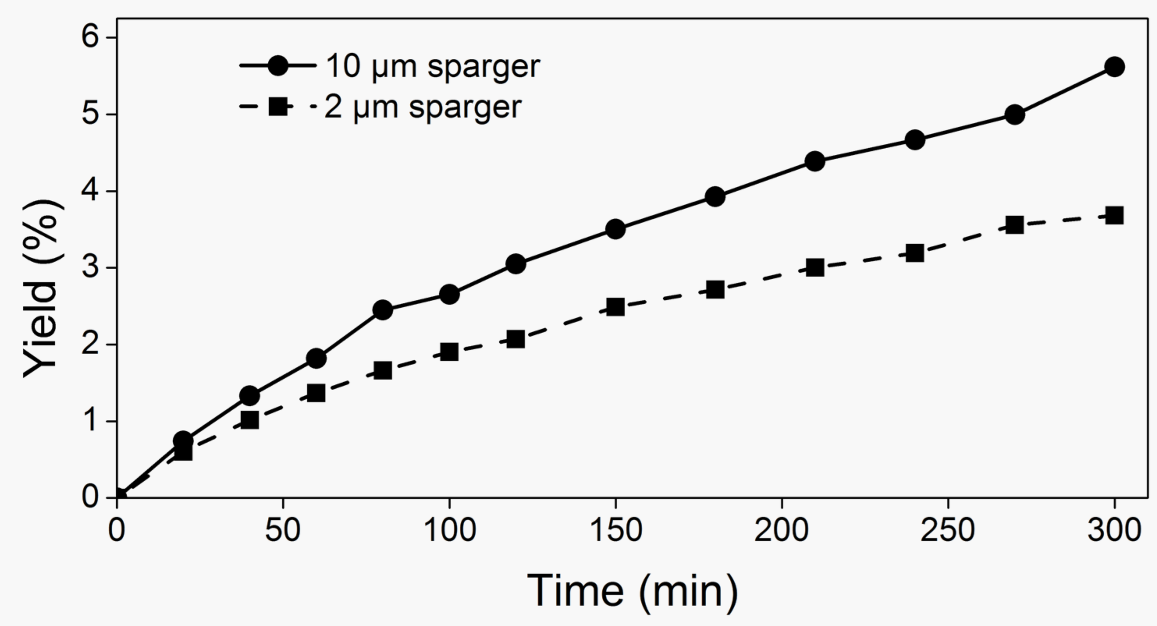

Fig. 4: Conversion of resorcinol to 2,6-DHBA by decarboxylase during CO_2 aeration. The reactions were performed at 100 mL CO_2/min with different sparger pore sizes and otherwise identical reaction conditions.

Summary

- Varying the CO_2 bubble sizes by otherwise identical reaction conditions resulted in slower resorcinol conversion rates when 0,2 mm instead of 0,4 mm bubbles were used
- The increased foam formation by decreasing bubble sizes could be a reason for the slower biotransformation
- Fine bubbles could not be produced with the tested sparger

Outlook

- Fine bubble aeration will be investigated with a 0,5 µm sparger
- Further characterization of enzyme deactivation due to interfacial area and foam formation
- Determination of bubble size distributions

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