Suitable System for Investigation of CO_2 Fine Bubbles in Biotransformation

TECHNISCHE BIOKATALYSE TUHH

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Introduction

- Fine bubbles have diameters of less than 100 micrometer
- Fine bubbles show a slow rising velocity, less foaming and tend to repel each other as they show a negatively charged surface[1]
- Based on small size and high interfacial area, fine bubbles have the potential for efficient mass transfer in multiphase systems
- Optimization of a biotransformation regarding mass transport and biocatalyst activity is important

Aim

- Determination of the potential of fine bubbles in biocatalysis
- Utilization of the greenhouse gas **carbon dioxide as substrate**
- Development of a **highly efficient aeration with low CO_2 emissions**
- Characterization of enzyme activity and stability for different bubble sizes and respective interfacial areas

Carboxylation of Resorcinol in TEA

- Several dihydroxybenzoic acids are used in cosmetics as they show antioxidant and antimicrobial activities[2,3]
- Decarboxylases are carbon-carbon lyases that add and remove carboxyl groups in organic compounds
- Investigation of the reversible decarboxylation of resorcinol in triethanolamine (TEA) solutions to supply carbonates by CO_2 aeration
- TEA binds CO_2 in water to produce molar concentrations of carbonates, which can be used by decarboxylases[4]

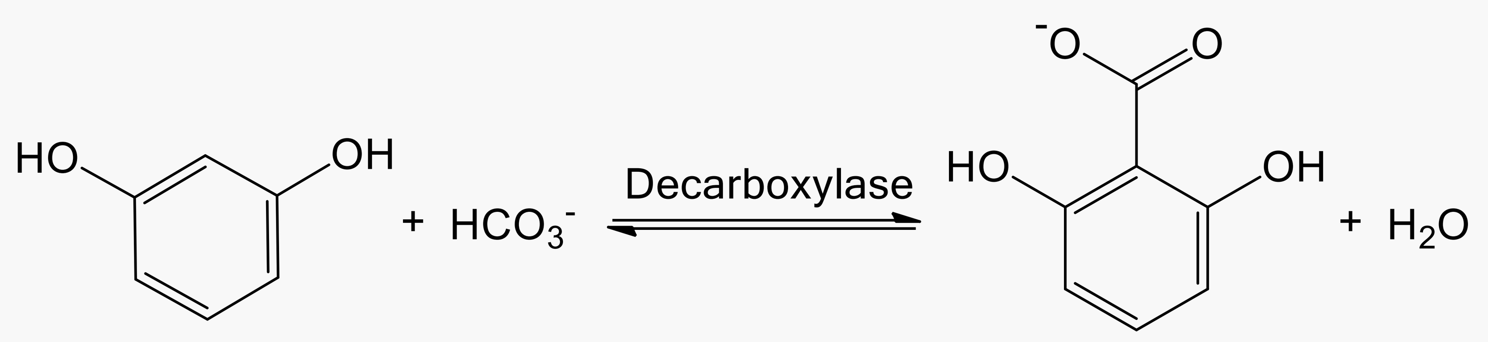

Fig. 1: Carboxylation of resorcinol to 2,6-dihydroxybenzoic acid by decarboxylase

Reaction Kinetics

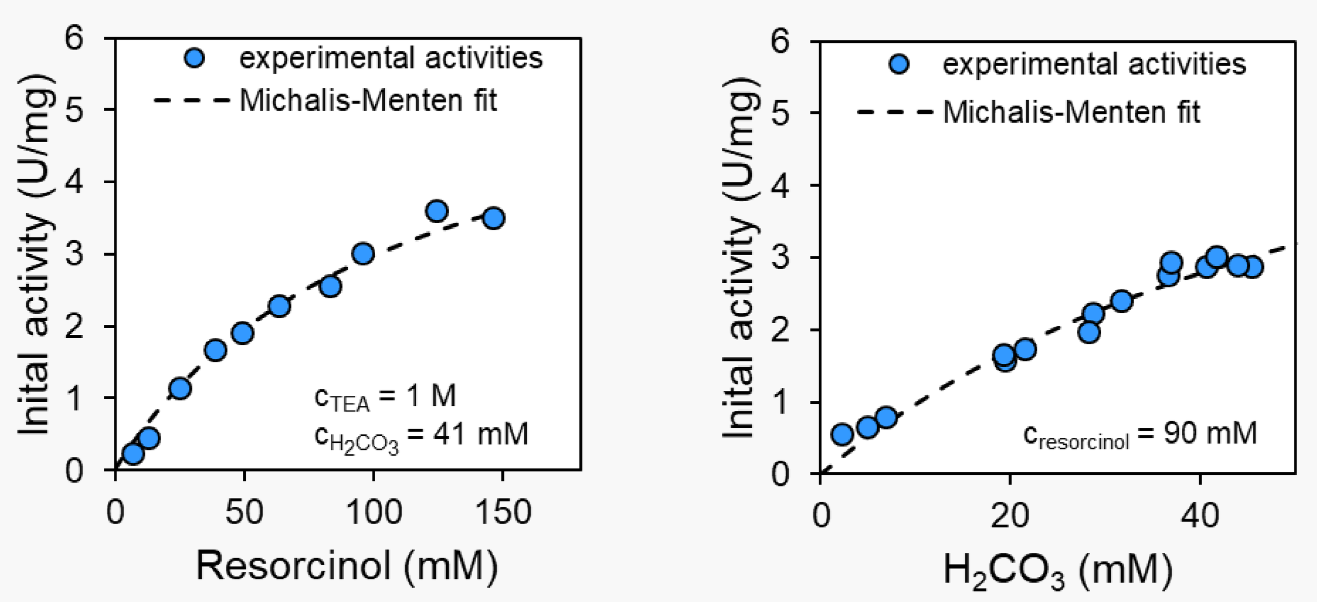

Fig. 2: Reaction velocity measurements for the carboxylation of resorcinol by 92.8 µg/mL decarboxylase dependent on resorcinol and TEA, more specifically carbonic acid, concentration at 30 °C.

Tab. 1: Determined kinetic parameters for the carboxylation of resorcinol at 30 °C.

	K_M (H_2CO_3)	K_M (resorcinol)	v_{max}	k_{cat}
Exp. Result	65.7 mM	110 mM	16.4 U/mg	10.2 s^{-1}
Error	± 40.5 mM	± 49 mM	± 7.46 U/mg	

Enhanced Mass Transfer

- Effect of sparger pores:
  - Smaller pores resulted in better k_La at lower gassing rates
  - 0.5 µm sparger achieved higher maximal k_La
- Effect of fine bubbles:
  - Increased residence time
  - Rapid shrinking
- Gas hold-up:
  - Linearly increased for spargers below 200 mL/min
  - Larger slopes for spargers with smaller pores

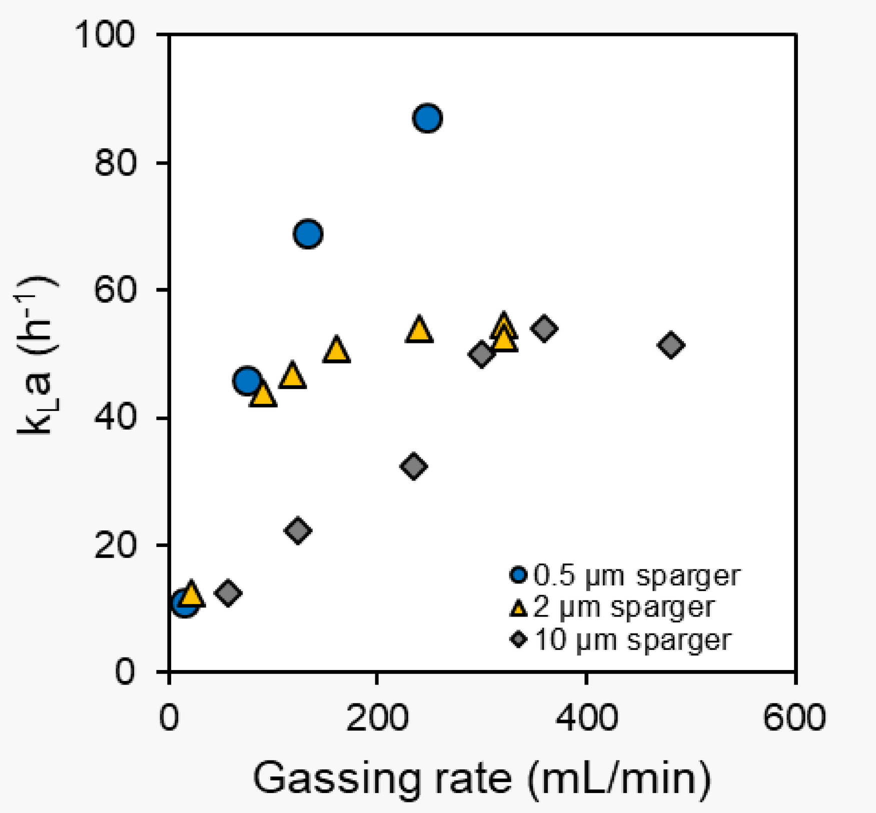

Fig. 3: Comparison of k_La values measured in bubble column by dynamic method in 1 M triethanolamine.

Bubble Size Distributions

- **Broadening and shift** of bubble size distribution
- **Production of mainly fine bubbles with 0.5 µm sparger**

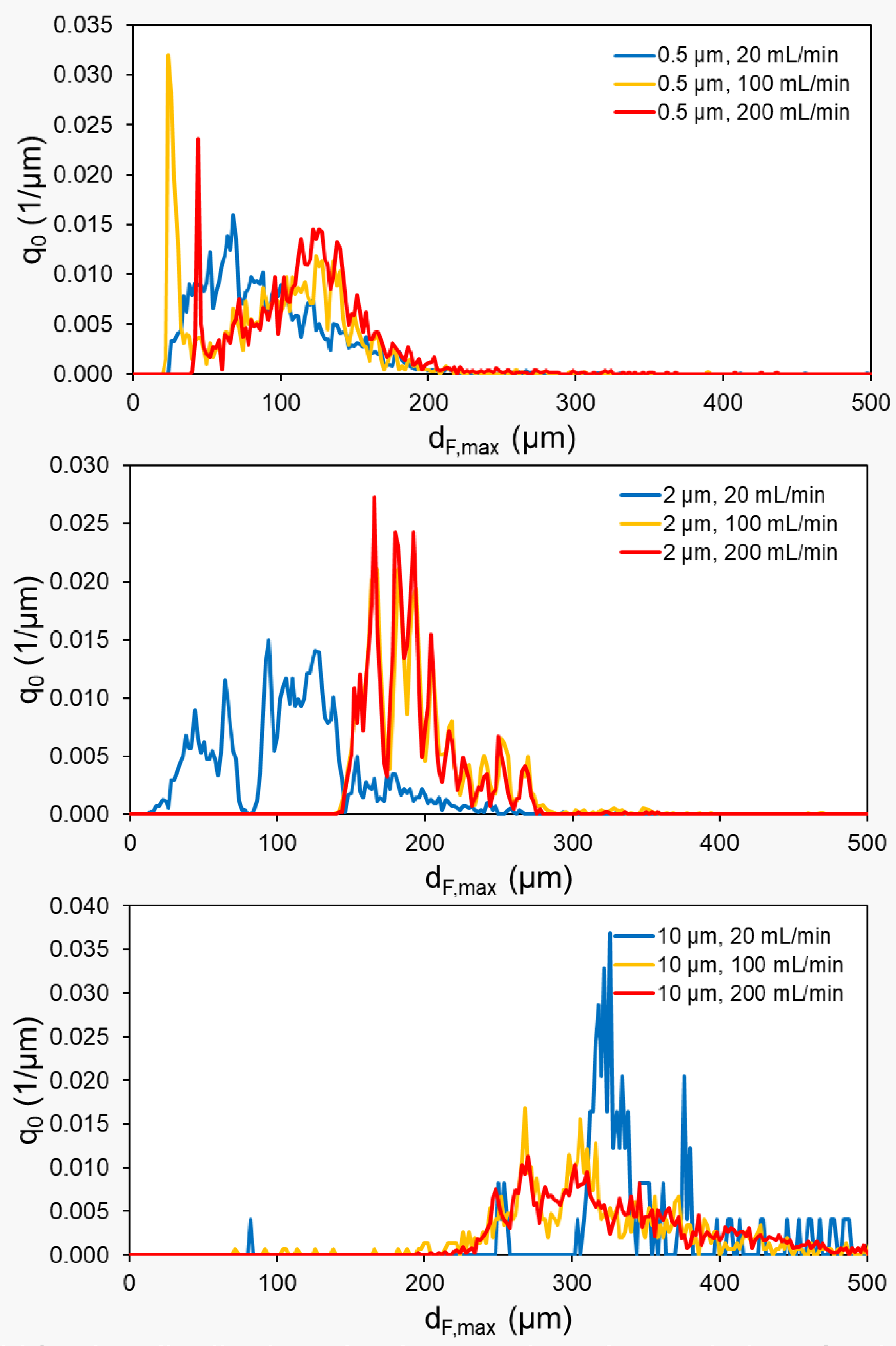

Fig. 4: Bubble size distributions for the aeration of 1 M triethanolamine at CO_2 saturation with varying CO_2 gassing rates and sparger pore sizes.

Conclusion

- Investigation of decarboxylase kinetics revealed **H_2CO_3** as **active substrate**
- **Importance of CO_2 aeration** for maintaining low pH and high H_2CO_3 concentration for higher productivity
- Demonstration of **highly efficient fine bubble aeration** for reduction of CO_2 emissions

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Acknowledgement:
We are grateful to the Deutsche Forschungs-gemeinschaft (DFG) for financial support (LI 899/7-1).

DFG Deutsche Forschungsgemeinschaft

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