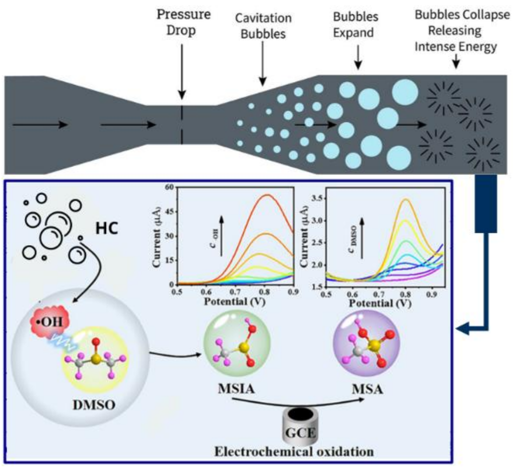
Fakultät Maschinenwesen |Institut für Verfahrenstechnik und Umwelttechnik |
Professur für Chemische Verfahrenstechnik

Student Thesis:

Development of an Electrochemical System for Spatially local and Real-Time Mapping of Hydroxyl Radicals in Hydrodynamic Cavitation Reactors

Hydrodynamic cavitation (HC) reactors, such as Venturi tubes, are widely used in water treatment and chemical processing due to their ability to generate localized high-energy zones that promote hydroxyl radical ·OH formation and molecular breakdown [1]. However, real-time, in situ detection of ·OH in opaque and fast-flowing HC reactors remains a challenge. Traditional dosimetry techniques (e.g., Fricke or salicylic acid) provide only time-averaged, bulk-integrated results, offering no insight into the spatial dynamics of radical formation [2].

This thesis aims to develop a system for **real-time and spatially resolved measurement of ·OH radicals** inside a HC reactor. The core of the project will be implementation of an electrochemical method using dimethyl sulfoxide (DMSO) as an chemical probe, where the resulting reaction with ·OH leads to MSIA, which can be detected electrochemically via its oxidation on an electrode [3].



The student will begin by evaluating the strengths, limitations, and implementation requirements of each technique, and then design and validate a setup tailored for real-time ·OH mapping in a 3D-printed hydrodynamic cavitation reactor.

Thesis Objectives

- Validate DMSO as an electrochemical probe for hydroxyl radicals using the Fenton reaction as a radical generator.
- Implement the selected measurement system with 3D printed cavitation reactors.
- Compare sensor readings across multiple positions in the reactor to map radical generation spatially and correlate with reactor geometry or flow features.

Requirements

- Currently enrolled in a Bachelor/Master's program in Engineering or Chemistry field.
- A solid understanding of fluid mechanics and electrochemistry
- interest in experimental techniques.

Literature

[1] V. V. Ranade, V. M. Bhandari, and S. Nagarajan, Hydrodynamic Cavitation: Devices, Design and Applications, 1st ed. Wiley, 2022. doi: 10.1002/9783527346448.
[2] S. J. De-Nasri, V. P. Sarvothaman, S. Nagarajan, P. Manesiotis, P. K. J. Robertson, and V. V. Ranade, 'Quantifying OH radical generation in hydrodynamic cavitation via coumarin dosimetry: Influence of operating parameters and cavitation devices', Ultrason. Sonochem., vol. 90, p. 106207, Nov. 2022, doi: 10.1016/j.ultsonch.2022.106207.
[3] H. Cui, J. Ma, Y. Liu, C. Wang, and Q. Song, 'Dimethyl Sulfoxide: An Ideal Electrochemical Probe for Hydroxyl Radical Detection', ACS Sens., vol. 9, no. 3, pp. 1508–1514, Mar. 2024, doi: 10.1021/acssensors.3c02644.
[4] D. Podbevšek, D. Colombet, F. Ayela, and G. Ledoux, 'Localization and quantification of radical production in cavitating flows with luminol chemiluminescent reactions', Ultrason. Sonochem., vol. 71, p. 105370, Mar. 2021, doi: 10.1016/j.ultsonch.2020.105370.

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Scope
Thesis

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