Master-Thesis

Integration of microbial and electrochemical processes for conversion of CO_2 to valuable products

CO_2 can be converted to different products through microbial or electrochemical methods. However, combination of these two technologies offers a promising method for conversion of CO_2 to the products with high commercial values such as dicarboxylic acid of itaconic acid, by using the advantages of each technology. Fast kinetic of CO_2 reduction through electrochemical reactions and vast diversity of the products from microbial activities could lead to not only CO_2 reduction but also a broad portfolio of valuable products (e.g. *ChemSusChem* 13 (19), 5295 - 5300, *ChemElectroChem* 6 (14), 3731 - 3735 and *Appl. Catal. B-Environ.* 238, 546 – 556 including the perspective paper of *Joule* 6 (5), 935-940). Hence, the first step is electrochemical reduction of CO_2. C_1-compounds such as formate are the common products of electrochemical CO_2 reduction reaction, which can be later fed to the microbial cells as substrates for further biosynthesis. Catalysts such as indium are known for selectively producing formate through electrochemical CO_2 reduction reaction.

In our group, we have developed an efficient and reproducible method for electrochemical reduction of CO_2 to formate using the indium-based electrode, with more than 80% coulombic efficiency (*ChemSusChem* 10 (5), 958 - 967). However, indium has a high supply risk and is included in the EU`s list of Critical Raw Materials (CRMs) since 2010. Therefore, there is a need to transfer the method using other catalysts. In this Master thesis, tin will be used as a catalyst for electrochemical reduction of CO_2 to formate. Tin is accessible, cheap and has been widely used in previous studies, displaying high selectivity for formate production with high efficiency. The method transfer from indium to tin, from electrode preparation until product detection, will be performed in small-scale reactors (50 mL) developed within the lab. After a successful method transfer, the processes will be evaluated in a 1 L bioreactor, which was designed, engineered and operated in our lab to provide optimal technical conditions not only for electrochemical processes but also further biosynthesis through microbial pathways. To assess the performance of the system in both scales, pH and formate concentration will be measured regularly, and formate production rate and coulombic efficiency over time will be calculated. The results will assist the further investigation on production of value-added compounds via microbes using the formate produced in the electrochemical reactors. Thereby, the focus of the proposed work will be on analytical and electrochemical techniques as well as microbial cultivation procedures in aerobic as well as anaerobic conditions and may include methods for surface characterisation.

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