Bioelectrochemical Chain Elongation: a hypothetical framework of catalysis & electron transfer mechanism

David Strik

Environmental Technology, Wageningen University, The Netherlands

The circular economy requires clean recycling technologies. Chain Elongation is an emerging biotechnology which converts mixed organic and potentially other microbial convertible waste into medium chain fatty acids like n-caproate. Within this process an anaerobic mixed microbial culture is used as biocatalyst. n-caproate is a medium chain carboxylate with relative low solubility and therefore can more easily separated from water broths. n-caproate can used directly or as building block for a wide variety of applications such as solvents, fuels, lubricants, feed/food additives, plastics and dyes. As such it is a high-potential platform chemical. Recent research resulted in a grown-up ethanol based chain elongation technology which is about to be validated in a commercial demo-factory. Within my research group we especially investigate the electro-physiology of Chain Elongation processes. A such I am interested to understand electron fluxes & selection pressure of the involved mixed microbial cultures. This way we aim to initiate new biotechnological applications.

The understanding of mixed cultures and their selection pressure starts for me with the basics of chemical reactions. To sustain their growth and maintenance, biocatalysts perform oxidative and reductive reactions inside their cells. These redox reactions are based on electron flows coming from an electron donor which is stepwise transferred to a terminal electron acceptor. With (mixed culture) Chain Elongation a diversity of electron donors (e.g. CO2, acetate, propionate) and acceptors (e.g. ethanol, methanol, hydrogen) were used to produce the medium chain fatty acids.

In this talk I will give a special attention to bioelectrochemical chain elongation. In this process bacteria use a cathode electrode as source for electron donor. We recently developed a bioelectrochemical chain elongation process which converted CO_2 to n-caproate. A natural based inoculum was enriched into a microbial consortium that was responsible to convert 40% of supplied electrical energy into chemicals up to 14 kA m^{-3} cathode. The performance indicators of the process are promising, though the catalysis and electron transfer mechanisms of the process are fragmented understood. Therefore I present a debatable hypothetical framework of catalysis & electron transfer mechanisms of bioelectrochemical chain elongation. It shows that bioelectrochemical chain elongation is plausible via diverse routes and maybe depending and controllable with electro-catalytic integrations.