Boosting a biocathode by analysis: the invasive effects of cyclic voltammetry on bioelectrochemical chain elongation

Authors

Ms. Sanne de Smit - Wageningen University & Research

Dr. David Strik - Wageningen University

Prof. Cees Buisman - Wageningen University

Prof. Harry Bitter - Wageningen University and Research

Abstract

HIGHLIGHTS:

- Cyclic Voltammatry use for analysis during microbial electrosynthesis disturbed the system operation and resulted in a current increase lasting up to three weeks
- Cyclic Voltammetry resulted in the release of biomass and metal compounds from the biocathode

BACKGROUND: Bioelectrochemical chain elongation is a promising method for the production of valuable chemicals from waste streams, such as CO_2. A microbial electrosynthesis system generally exists of an anode where an oxidation reaction produces electrons, which are supplied to a cathode where a biofilm grows. The bacteria in the biofilm use the electrons for chain elongation conversions. By using an electrode for the electron supply, renewable electricity could be used to upgrade CO_2 to longer chain carboxylates such as acetate, butyrate and caproate. Although offering nice perspectives, the technique still requires a greater understanding of its mechanisms and steering tools. From the field of electrochemistry, various techniques are available for the analysis and characterization of conversions and electrode composition. One such technique is Cyclic Voltammetry (CV). During a CV scan, the potential is subsequently increased and decreased while measuring the resulting current in the system. This potential scan is widely used in bioelectrochemistry to show biological activity. A disadvantage from the technique is that the potential change rate during the scan has to be kept very low to avoid background signals. Using this low scan rate allows for changes at the cathode that

could be irreversible. The aim of our study was to investigate these changes and their effect on the performance of a bioelectrochemical chain elongation reactor.

RESULTS & DISCUSSION: After applying CV on a biocathode in which CO-$_2$ was continuously elongated to acetate at a constant current, the cathodic current increased. This increase lasted for four days up to several weeks. To further elucidate the mechanisms behind this increase, the metal composition and suspended cell concentration of the catholyte were investigated at different moments during and after the scan. The concentrations of Fe, Co, Al, Ba, Mn, Mo and biomass increased in the biotic catholyte predominantly during the oxidation peak of the first CV cycle, indicating these compounds were released from the cathode (Figure 25). The catholyte metal concentrations decreased rapidly within four hours after the CV at the cathodic operation potential of -0.85 V vs SHE suggesting they are re-deposited.

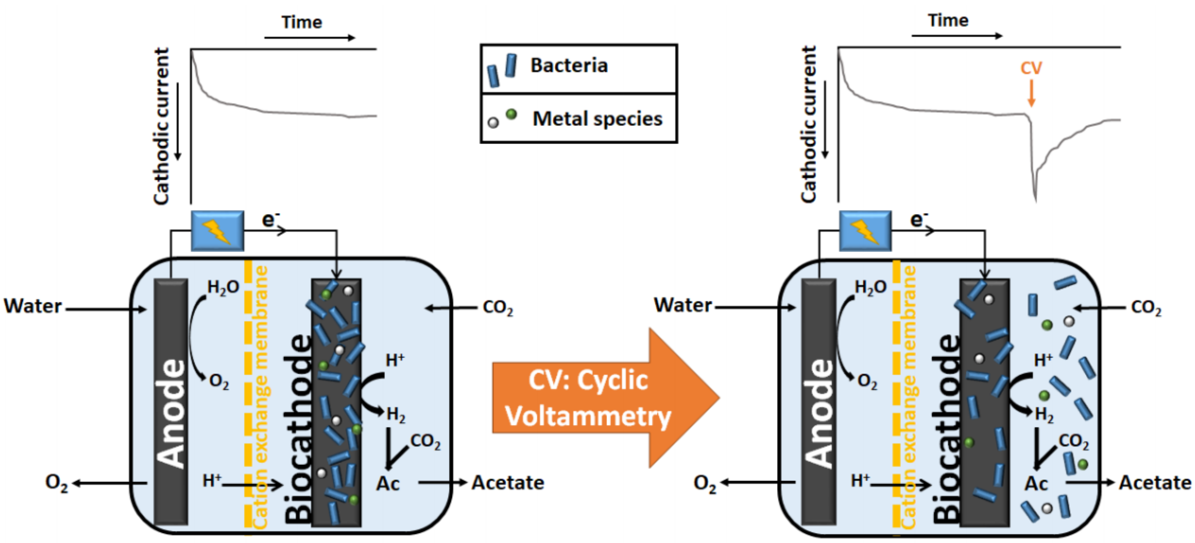

Figure 25. Performing Cyclic Voltammetry on a bioelectrochemical chain elongation system caused a current increase and a release of metal compounds and biomass from the cathode.

CONCLUSION: Our study showed that CV is not an innocent analysis technique, but causes irreversible changes at the cathode. These changes induced a system boost in the form of an increased electron supply to the cathode. Our findings form a starting point for follow up studies investigating the mechanisms behind the catalytic effects of the performed analysis method.