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Production of carboxylic acids from organic waste via electro-fermentation: selectivity, recovery and electrochemical upgrading opportunities

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Transforming organic waste into useful recoverable products is a challenging issue, which requires highly efficient and integrated technological solutions to obtain value-added resources. In this work, the organic waste-based production of carboxylic acids (CAs) via electrochemically assisted dark fermentation was studied. Compared to conventional dark fermentation, electro-fermentation applies an external reducing power to achieve 'unbalanced fermentation', resulting mainly in shifts in product selectivity, yields and kinetics. During the treatment of kitchen waste, electro-fermentation proved to be advantageous in terms of improving chain elongation to caproic acid (C6) at higher organic loads. In addition, the lag-phase during electro-fermentation was significantly reduced compared to the conventional dark fermentation. Microbial consortia analysis of the bulk revealed that although higher caproic acid production occurred during electro-fermentation, C6-related bacteria were present with lower relative abundance, indicating remarkable fermentation efficiency improvement, assumably together with lower biomass yield.
The produced CAs – after separation and concentration by e.g. (bipolar) electrodialysis – can be directly used, or further upgraded to higher-value components. Recently, electrochemical methods gained attention, since those fit well to the trends of electrifying biotechnology. This study assessed the potential of electrochemical upgrading via anodic decarboxylation and dimerization. In this process, the decarboxylated CA radicals can form dimers, resulting in alkanes – e.g. decane from caproic acid (C6) -, or could undergo other pathways, forming esters, alcohols, short alkenes, etc. Using model solutions of pure CAs and mixtures, mainly alkanes and esters were obtained, with increased selectivity to alkanes with longer chain CAs.
In summary, it was shown that both the fermentation, separation and upgrading of the CAs can be improved by using electrochemical approaches, thus allowing efficient waste-to-product processes.
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