Título: PROCESOS BIOLÓGICOS PARA EL TRATAMIENTO DE AGUAS RESIDUALES: INTEGRACIÓN DE SISTEMAS BIOELECTROQUÍMICOS Y OTRAS TECNOLOGÍAS

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Resumen: Wastewater streams (such as cheese whey or domestic wastewater) usually require a biological treatment prior to their disposal to the environment. These treatments have traditionally been performed by conventional technologies, particularly anaerobic digestion (AD). Dark fermentation (DF) would be another example, although not so well-established in the real scale. Bioelectrochemical systems (BESs) have recently developed as a promising technology for biological treatments, as the use of BESs for wastewater treatment allows for a reduction in the energy consumption for these processes. Moreover, integration of BESs with conventional bioprocessing technologies (AD or DF), represents an innovative approach that could optimize the amount of energy recovered from the waste streams, making the process more profitable.

In this context, the main objective of this thesis was to evaluate the integration of BESs and more conventional biological processes (such as AD or DF) as a technology for industrial (cheese whey) and domestic wastewater treatment.

The first step was the determination of the operating conditions that optimize the performance of these bioprocesses. In order to do so, the effect of nitrogen and lactose concentration for the batch-mode dark fermentative processing of cheese whey was studied by means of the response surface methodology (RSM), finding that the best operability area for fermentative H2 production was at lower values of nitrogen and lactose. Besides, higher hydrogen yields were found when gradually decreasing N content when working in semi-continuous mode. DF of cheese whey resulted in a maximum H2 production rate of 0.18 L H2 Lr-1 d-1.

The integration, in a two-stage configuration, of biocatalyzed electrolysis as a post-treatment for dark fermentative H2 production from cheese whey was studied afterwards. In the first stage, batch-mode dark fermentation of cheese whey resulted in a H2 production of 0.7 L-H2 Lr-1, obtaining an acidified effluent as well. After being diluted and amended, the effluent was fed into a microbial electrolysis cell (MEC) in continuous-mode. The H2 production rate in the second stage was 0.5 L-H2 Lr-1d-1. As a whole, the combined process resulted in a maximum H2 yield of 94.2 L-H2 kgVS-1, which represents a 20% improvement when compared to cheese whey fermentations yields reported in bibliography.

The integration of electrogens-enriched electrodes and AD in the same reactor was also evaluated. This approach (AD + BES) was used to analyze operation of the system both at overloaded and underloaded (fed with high-strength and low-strength substrates, respectively) conditions, in which AD usually presents inefficiencies.

Given that an excessive acidification by volatile fatty acids (VFA) accumulation is one of the main causes for the collapse of anaerobic digesters, the study was aimed to characterize the behavior of AD + BES integration under acidic conditions. For the case of electrode-containing digesters, it was observed a delay in VFA build-up, as well as an enhancement in CH4 production during the first 100 h of the process. Although this effect relies on biomass proliferation rather than electrochemical activity, these results allow for an optimization of AD process when working in continuous-mode at short hydraulic retention times (HRTs).

The benefits of using MECs to assist methanogenesis while simultaneously treating low-strength domestic wastewater were also investigated. When a MEC electrode was inserted in what could be considered an underloaded anaerobic digester of wastewater in batch-mode, organic matter degradation and CH4 production were increased as a result of an enhancement of hydrogenotrophic methanogenesis, preventing inefficiencies associated to homoacetogens proliferation. In continuous mode, longer HRTs were found to be more favorable for optimizing energy recovery.

Finally, two different strategies for the improvement of exoelectrogenic performance in BESs were tested. One of the approaches consisted in the selective enrichment of exoelectrogenic species from a natural soil substrate by testing different voltages applied. A voltage value of +0.2 V seemed to optimize bioelectrocatalytic response. In the other strategy, a non-targeted mutagenesis induction tool based on the overexpression of DNA polymerase IV could be developed. However, for a proper confirmation of these results, further investigations are required.