Microbial Electrolysis Cell (MEC) for biofuel production from organic waste

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Bioelectrochemical systems make it possible to exploit the ability of some microorganisms to interact with solid-state electrodes. By exploiting microbial metabolisms and controlling the surrounding conditions, it is possible to obtain the desired products while containing the energy cost of the process. Electroactive biofilms are capable of oxidizing organic matter using an electrode as the final electron acceptor. This allows to reduce the content of organic substance inside waste water without the supply of oxygen, moreover, thanks to the help of the electrochemical apparatus and the applied electric potential, various reduction reactions can be coupled to the oxidation of organic substance by adopting specific operating conditions of the cathodic interface. Using a stainless-steel or a graphite electrode and maintaining the anaerobic reaction environment, it is possible to use the reducing power produced by the anode compartment for the reduction of the proton to hydrogen or for the biological reduction of CO_2 into methane. Moreover, the proceeding of the oxidation and reduction reactions, and the consequent ionic transport through ion exchange membranes, involves the progressive unbalancing of the pH between the anodic and cathodic chamber known as "pH split", which involves the progressive acidification of the anodic liquid phase (anolyte) and the alkalization of the cathodic liquid phase (catholyte). This phenomenon is due to the migration through the ion exchange membrane of ions other than proton or hydroxyl (depending on the membrane used). When using a cation exchange membrane, the migration of species other than the proton (such as alkali metal and alkaline earth ions present in higher concentrations than the proton in solutions at physiological pH) leads to the accumulation of protons in the chamber anodic, with consequent acidification while due to the use of protons deriving from the auto-protolysis of water for the reduction of the proton, an accumulation of hydroxyl ions is observed in the cathode chamber with consequent alkalization. While the phenomenon of acidification of the anodic chamber has less impact given by the continuous supply of the buffering power, the progressive alkalization of the catholyte can be exploited to break down the carbon dioxide contained in gaseous mixtures such as biogas by absorption with a chemical reaction with the production of ions carbonate/bicarbonate. Bio-hythane is a mixture in the gaseous phase, composed of hydrogen (from 10% to 30%) and biomethane. This blend can be used as fuel in internal combustion engines for various means of transportation, and has the advantage of faster ignition, since the hydrogen causes acceleration of the flame front, leading to more complete combustion. It is reputed to be able to reduce nitrogen oxide and CO emissions by 50%. In addition to its use in motor vehicles, hydro methane (with a maximum content of 10% hydrogen) can be introduced into the natural gas distribution network, increasing its calorific value, favouring the decarbonisation of the energy sector (in the case of the use of electric current from renewable sources). In the present study the use of a microbial electrolysis cell has been addressed to the production of gaseous biofuels by various cathodic configuration in which biotic and abiotic reduction reactions allows to produce methane hydrogen or a hythane. The different configurations explored were sustained by bioanode fed under continuous flow with a synthetic waste water and polarized by means of a three-electrode configuration at a potential of +0.2 V vs SHE. The different cathodic configuration included a methanogenic biocathode, the abiotic hydrogen production through a stainless-steel electrode and a combination of methanogenic colture and abiotic hydrogen production. In all the configuration explored, more than 50% of the removed organic matter in the anodic chamber was diverted into gaseous biofuels in the cathodic chamber.