Microbial anodes for CO_2 recovery in regenerative life support systems

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Extraterrestrial human exploration will require recovery of organic resources through closed loop systems, such as the micro-ecological life support system alternative (MELiSSA) currently being developed by the European Space Agency (ESA). Recovery of carbon as CO_2 from organic waste with minimal oxygen consumption is a critical challenge at the moment. We assessed a microbial electrolysis cell as a fitting technology for this purpose. Plate-and-frame fixed anode potential (-0.1 V vs. Ag/AgCl) reactors with 0.008 m^2 carbon felt anodes were fed either filtrate from a fermenter treating a mixture of vegetables and human feces, or a mineral salts medium containing acetic and butyric acid. Multiple batch tests with defined medium established that CO_2 recovery of 82 % could be reached with coulombic efficiencies between 73 and 97 %. Similar performance was reached in continuous mode with an organic load of 23 g COD m^{-2} d^{-1}. Coulombic efficiencies were lower for the filtrate fed reactor (79 %), with 72 % carbon conversion to CO_2. Coulombic efficiency dropped to 56 ± 3 % during continuous tests due to a drop in the anode pH which stabilized at 5.3 ± 0.5 over one month. Some pH control or optimization of loading is likely necessary to improve performance. This technology looks promising for regenerative life support and is undergoing further development with the support of ESA, to include optimization of continuous long-term operation, and implementation of a 10 times scaled up anode with improved hardware and sophisticated system design and control.