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Recycling waste CO_2 to valuable resources through microbial electrosynthesis

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Anthropogenic and industrial activities have led to a rapid rise in the atmospheric CO_2 concentrations leading to increased global warming. A new approach that has emerged in recent years is that of Microbial Electrosynthesis (MES), which relies on chemolithoautotrophic bacteria that can uptake electrons directly or indirectly (via H2) from the cathode of an electrochemical cell to catalyze the reduction of CO_2 into fuels or value-added chemicals. Gas-liquid mass transfer is one of the limiting factors in MES, mainly because of the low solubility of gaseous CO_2 in solution. To overcome this limitation, we developed dual-function electro-Catalytic and macro Porous Hollow-Fiber (CCPHF) cathodes that act as an electron donor for chemolithoautotrophs as well as a diffusive material to facilitate direct delivery of CO_2 gas to chemolithoautotrophs through the pores in the hollow fibers. Using the CCPHF cathode we observed a Faradic efficiency of 77% for the production of CH_4 from CO_2 through hydrogenotrophic methanogens when CO_2 was delivered directly through the pores of the CCPHF cathode, compared to 3% when gaseous CO_2 was bubbled into the solution. We also successfully demonstrated that the rates of product formation can be enhanced by using Carbon Nanotubes (CNTs), which increases CO_2 adsorption capability and enhances microbe-electrode interactions. Modification of the CCPHF cathodes with CNTs resulted in 70% increase in acetate production rate from CO_2 in MES using the homo acetogenic bacterium Sporomusa ovata. The use of CCPHF cathodes in MES research is a significant breakthrough. The high specific surface area of the CCPHF cathode maximizes the diffusion of CO_2 gas, and the high surface-area-to-volume ratio of the CCPHF cathode architecture solves the issue of cathode packing density for large-scale applications. Most importantly, using CCPHF cathodes make the MES process highly attractive for on-site carbon capture and utilization.

Biography

Pascal E Saikaly has received his Bachelors in Biology and Masters in Environmental Technology from the American University of Beirut, Lebanon. He has completed his PhD in Environmental Engineering from the University of Cincinnati and pursued his training as a Post-doctorate at North Carolina State University. He is currently working as an Associate Professor at King Abdullah University of Science and Technology. His research interests include microbial electrochemical systems, membrane bioreactors, electro-microbiology and advanced materials for water and energy applications. He has more than 74 refereed journal articles.

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