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Enhancing biomethanogenic treatment of fresh incineration leachate using single chambered microbial electrolysis cells

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Abstract

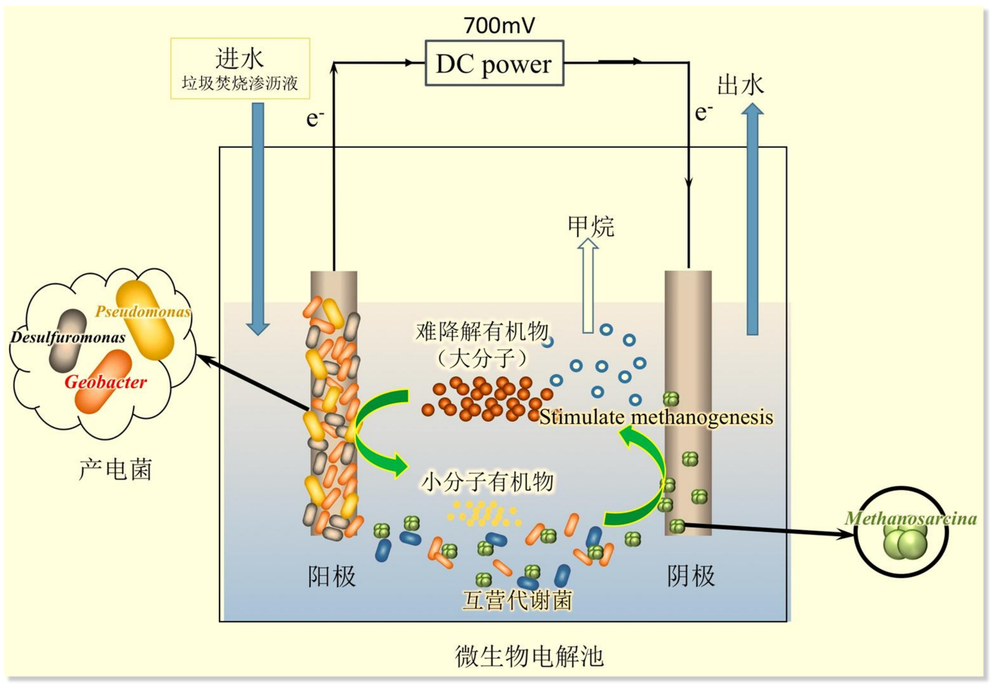
Methanogenic treatment of municipal solid waste (MSW) incineration leachate can be hindered by high concentrations of refractory organic matter and humification of compounds in the leachate. In an attempt to overcome some of these impediments, microbial electrolysis cells (MECs) were incorporated into anaerobic digesters (ADMECs). COD removal efficiencies and methane production were 8.7% and 44.3% higher in ADMECs than in controls, and ADMEC reactors recovered more readily from souring caused by high organic loading rates. The degradation rate of large macromolecules was substantially higher (96% vs 81%) in ADMEC than control effluent, suggesting that MECs stimulated degradation of refractory organic matter and reduced humification. Exoelectrogenic bacteria and microorganisms known to form syntrophic partnerships were enriched in ADMECs. These results show that ADMECs were more effective at treatment of MSW incineration leachate, and should be taken into consideration when designing future treatment facilities.

Research Objectives

The purpose of this study was to investigate whether the incor- poration of a single chambered MEC into an anaerobic digester treating incineration leachate could enhance biomethanogenesis and removal of large refractory molecules such as humic substances. Methane production, COD and volatile fatty acid (VFA) concentrations, dissolved organic matter (DOM) composition, and microbial community structure were monitored throughout this experiment and showed that incorporation of MECs enhanced all of these processes.

Materials and Methods

Three laboratory-scale anaerobic-digester-combined single chambered MECs (ADMECs) containing 500 mL working volume were operated in sequencing batch mode for 58 days. Two graphite rods (Φ0.3 cm×5.0 cm) placed in each digester served as the anode and cathode, respectively. Each reactor had one gas sampling port, one media/sludge sampling port and one gas outlet port connected to a gas sampling collection bag. Triplicate anaerobic digesters without electrodes were set up as controls. All six reactors were operated in sequencing batch mode with a hydraulic retention time (HRT) of 11-12 days and incubated in the dark at 35 C. A constant direct-current (DC) voltage of 0.7 V was applied to the ADMECs with a regulated DC power supply (Dahua, DH1718E-4, Beijing). Current was monitored with a multimeter (UNI-T, UT136A, China) every hour.



Results and Discussion

1. Performance of ADMECs

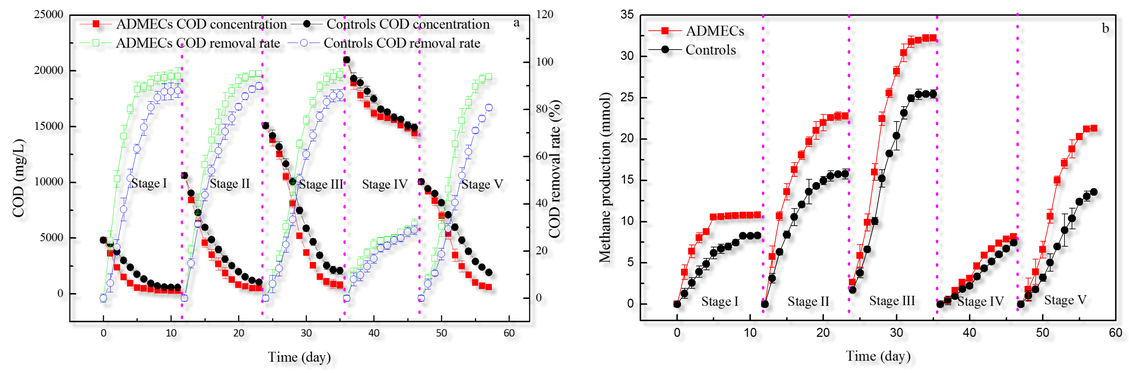


Figure 1. Performance of ADMEC and control reactors fed increasing concentrations of MSW incineration leachate. a) COD removal rates; b) Methane production.

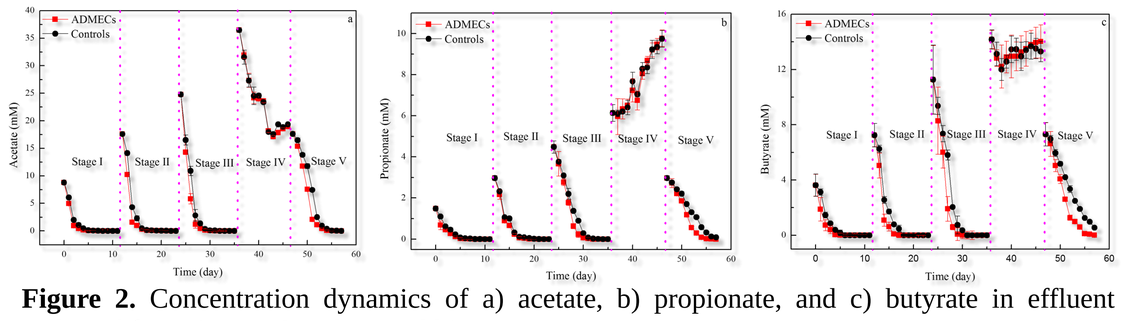


Figure 2. Concentration dynamics of a) acetate, b) propionate, and c) butyrate in effluent collected from ADMEC and control bioreactors.

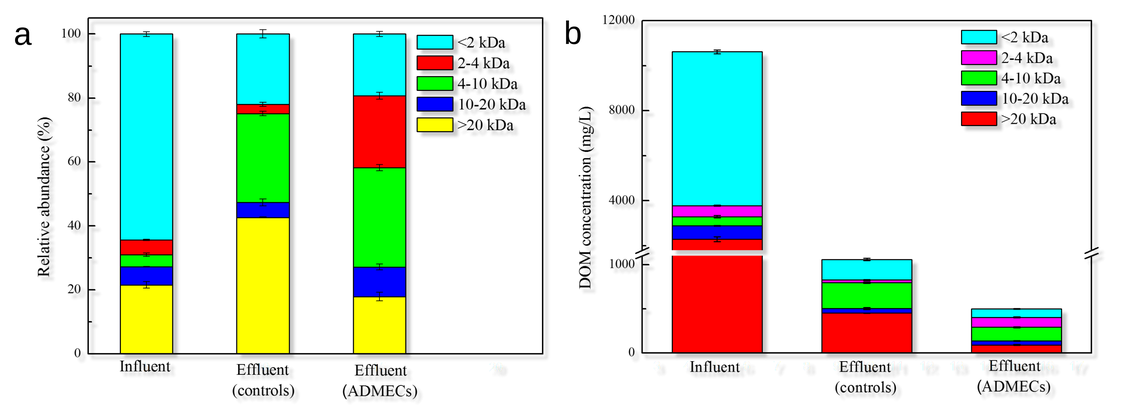


Figure 3. Relative abundance (a) and concentrations (b) of DOM with various molecular weights associated with incineration leachate influent and effluent collected at the end of Stage II from ADMEC and control bioreactors.

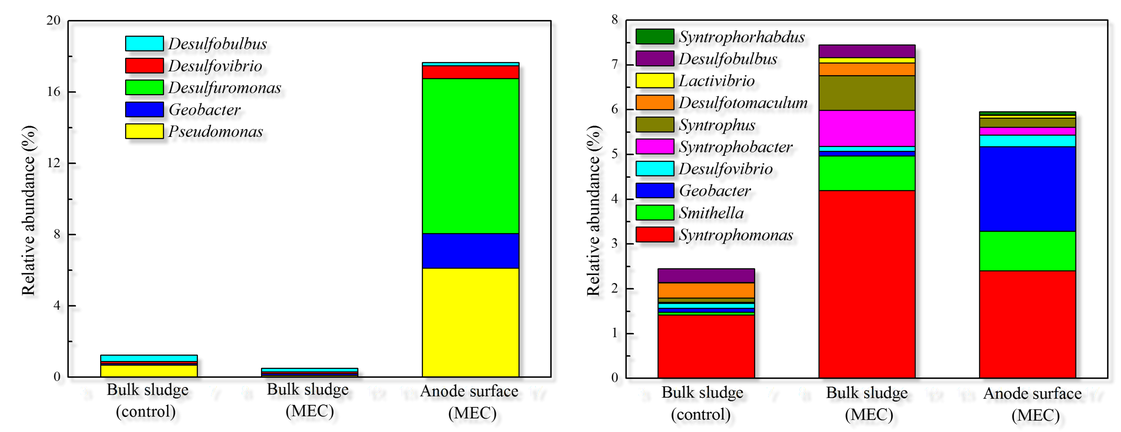


Figure 4. Taxonomic distribution of various bacteria in ADMEC anode biofilms and sludge collected from the ADMEC and control reactors determined by analysis of 16S rRNA gene sequences. (a) Relative abundance of sequences from exoelectrogenic bacteria; (b) Relative abundance of sequences from bacteria known to form syntrophic partnerships with methanogens.

Acknowledgements

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