Hollow carbon fiber arrays for improved electro-chemical and bio-electro-chemical systems

Currently, the over-discharging of CO_2 and excessive depletion of fossil fuels have been threating the sustainable development of society, by causing serious climate change and draining tendency of energy sources. Under this background, to transform the over-discharged CO_2 to valuable carbon species has been well acknowledged as a promising solution [1]. Among the pursued CO_2 derived carbon species, bio-methane is biofuels obtainable in large quantities. Bio-electro-chemical transformation of CO_2 to methane with the help of microorganisms is the essential technology [2]. The involved electron transfer between electrode-support and up-loaded microorganisms has been confirmed to be one of the most limiting factors on energy transformation efficiency [3].

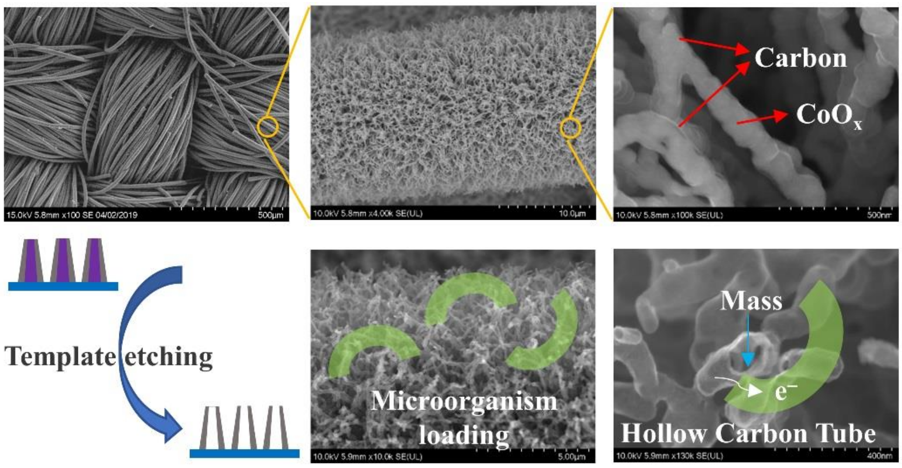

Figure 1. Electrode support design and fabrication for improved electron and mass transfer

To improve the intrinsic low extracellular electron transfer from the electrode-support to electrochemically active biofilms, a three-dimensional (3D) hierarchical porous conductive carbon based electrode-support is designed and fabricated in this study. Figure 1 demonstrates the template directed fabrication and features the structure advantage of this electrode-support. Specifically, Co-compound nanowire arrays are first radially grown on the macroporous carbon cloth substrate, followed by an in-situ chemical vapor deposition (CVD) of conductive carbon shell onto this CoO_x template to form a conformal core/shell nano-structure. Afterwards, a facile acid etching process can etch the CoO_x template away to finally obtain the hollow carbon fiber arrays on carbon cloth. Employed scanning electron microscopy clearly displays the structure evolution and features the 3D hierarchical porous structure, with larger pores ranging from tens to 100 μm stemming from the intertwining units in carbon cloth substrate, and smaller pores ranging from 100 nm to 500 nm stemming from the hollow carbon fibers. The total carbon based electrode-support is capable of ensuring good 1) electronic conductivity, 2) bio-compatibility, 3) mechanical stability, and 4) large surface gain for microorganism colonization. More importantly, the one-dimensional hollow carbon fibers are designed to realize favorable interface interaction with microorganisms for enhanced extracellular electron transfer.

References

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