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DISSERTATION

Development of Carbon Materials for Microbial Fuel Cells

Musa Bishir

Band 9

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UNIVERSITÄT HOHENHEIM

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SUMMARY

Thesis Title: Development of Carbon Materials for Microbial Fuel Cells

There are growing interests in microbial fuel cells (MFCs) for anaerobic bioenergy generation. MFC uses electrodes and organic wastewater as substrate for electrogenic bacteria, to catabolize and generate power. Researchers in this discipline continue to be most interested in finding suitably affordable electrode materials. However, despite the large varieties of commercially available electrodes, only few are suitable for electro-active bacterial colonization, during biofilm formation in microbial fuel cells (MFCs), and most of these electrodes are cost prohibitive. Hence there is need to search for low-cost alternative electrodes for MFCs. The focus of this study was to develop electrodes locally from corncob biomass for application in microbial fuel cells. Pyrochars were produced by pyrolysis (600 °C and a continuous flow rate of 3 NL/min of nitrogen gas for 30 min) and subsequently steam or potassium hydroxide (KOH) activation of the pyrochar at 600 °C were carried out accordingly. Physicochemical, structural, and electrochemical properties of the activated and non-activated pyrochars were determined according to standardized analytical methods. A comparative bioelectricity generation from process water of hydrothermal carbonization (HTC) of spent bear grains (pH = 5.99) and treated–biogas digestate (pH = 7.97), was carried out in dual-chambered MFCs, using graphite rod (non-porous and very low surface area) and the locally developed potassium hydroxide (KOH)–activated corncob pyrochar (KAC) and steam- activated corncob pyrochar (SAC) electrodes. In all the MFC systems of this study, a standard strain of actively dividing cells of the electroactive bacterium *Shewanella oneidensis* MR-1, which were at logarithmic phase of growth (24 h) was used as inoculum for bioelectricity generation. According to BET measurements, 1626 m^2 g^{-1} surface area and 14.74 Å pore diameter were obtained from the KOH-activated pyrochar, which was also the most conductive (0.26 S m^{-1}) carbon material used here. The highest power outputs achieved were 323.8 µW and 316.8 µW from HTC process water with SAC and biogas digestate with KAC electrodes, respectively, at an external load of 47 Ω. The initial Chemical Oxygen Demand (48780 mg / L), Dissolved Organic Carbon (4000 mg / L), and Total bounded Nitrogen (5600 mg / L) of the biogas digestate decreased significantly to 36405, 3610 and 4300 mg / L, respectively, in the MFC with KAC electrodes. A Coulombic efficiency of 75 % was recorded from the MFC operated with treated biogas digestate and KAC electrode in a significantly shorter residence time, making it more efficient than its counterpart with SAC electrode, which had a lower Coulombic efficiency of 64 %. In conclusion, chemical activation of pyrochar with KOH resulted in increased electrical conductivity (EC), pore diameter, and most importantly the material's surface area according to the findings. Therefore, KOH-activated corncob pyrochar holds potentials for producing electrode materials with desirable characteristics for successful application in MFC compared to the non-activated and steam-activated pyrochars of the same biomass.