Microbial Electrolysis Cells and Copper Anodes: High current, low cost, high risk

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Research Questions

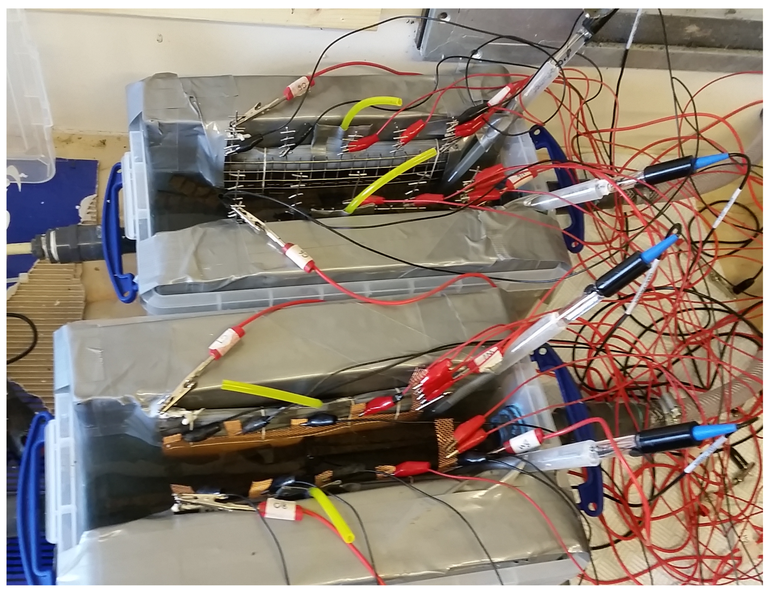
Do copper anodes increase current density in Microbial Electrolysis Cells?

Can copper anodes operate safely in 'real' conditions?

Introduction

Wastewater treatment plants have **high energy costs**. Microbial Electrolysis Cells [MEC] pose a potential solution. In MECs, energy is retrieved from wastewater by electrogenic organisms. These microbes consume substrate and 'shuttle' electrons to solid surfaces, and to one other. MECs take advantage of this process but require a material surface (the anode) and an applied (or set) electric potential (voltage).

Fig 1: MEC set-up (lower cells: copper).



MECs incur **high investment costs**, but **low operating costs**, and **valuable** products can be produced at the cathode, such as Hydrogen gas. Using **copper anodes,** electrical resistance and costs are reduced. But copper greatly increases the risk of corrosion (table 1, fig2). Four MECs were made: two with **carbon felt anodes** and two with **copper anodes** (fig 1).

Table 1: Properties and costs for potential electrode materials

Metal	Resistivity (nohm.m)	Price (£/kg)	Half potentials
Carbon (Graphite)	36,000	£ 0.77	High
Gold	24.4	£ 32,584.00	+1
Silver	16	£ 475.90	+0.8
Copper	17	£ 3.64	+0.153

Methods

Copper anodes have been operated successfully in the lab[2] but have not, to our knowledge, been operated in 'real wastewater'. Corrosion risk varies depending on environmental conditions (fig 2). Domestic wastewater comprises a complex, changing chemical environment, which increases risk of corrosion. A four-channel potentiostat was used to control voltage and measure current density. The MECs were set at -0.18V v.s. SHE* [a known reference potential] to facilitate microbial attachment (fig 2).

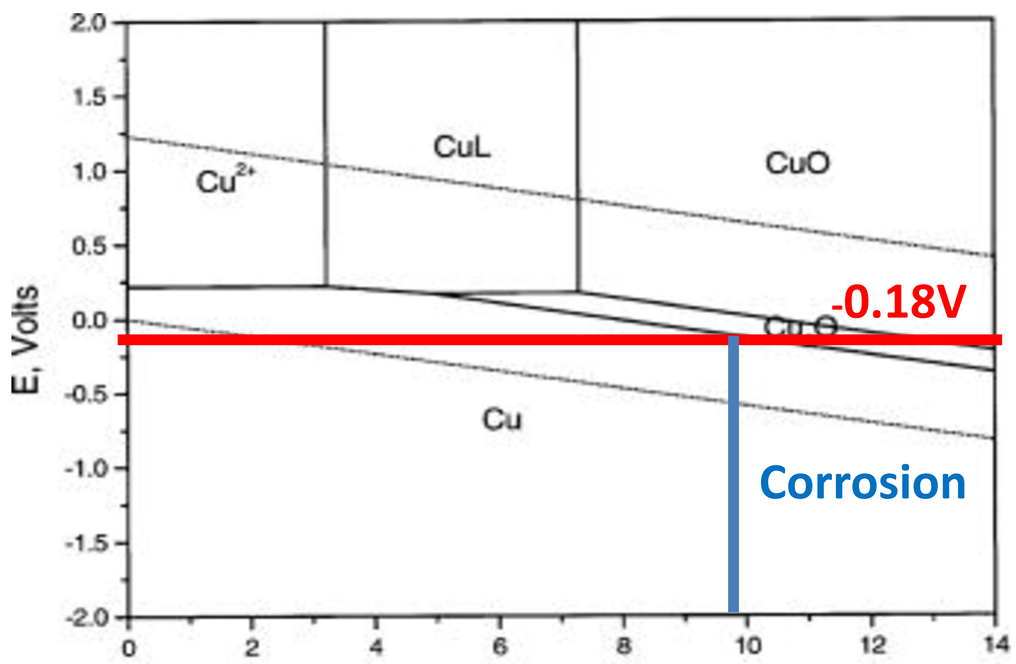
*SHE = standard Hydrogen electrode potential

Results

Table 2: Analysis of current densities

	Carbon Felt	Copper
Average current density	0.012	0.079
StDev	0.04	0.066
Samples	15374	15372
Sample StDev	0.0003	0.0005
Z		125.8
p-value		0.05
Z > 3, therefore:		
Copper anodes increase current density		

Fig 2: pH-potential diagram Copper-Water [1]



Copper anodes **worked successfully for two weeks** (table 2) **before corroding** (fig 3). Biocidal ions released during oxidation is of **high risk** to microbes and treatment processes. XPS analysis showed that the copper reacted with sulphur, oxygen, carbon and sodium.

Fig 3: Corrosion of copper anode

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Ref: 1:Electrochem. Soc. 2002 vol. 149 no. 12 G638-G642 **2:** Baudler, Schmidt, Langner, Greiner and Schroder, Energy Environ. Sci., 2015, 8,2048.

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