Metal and energy recovery from wastewater using MFC

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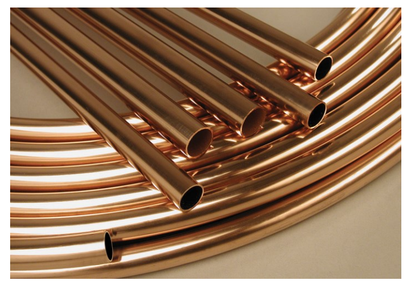
Chemical engineering and advanced materials

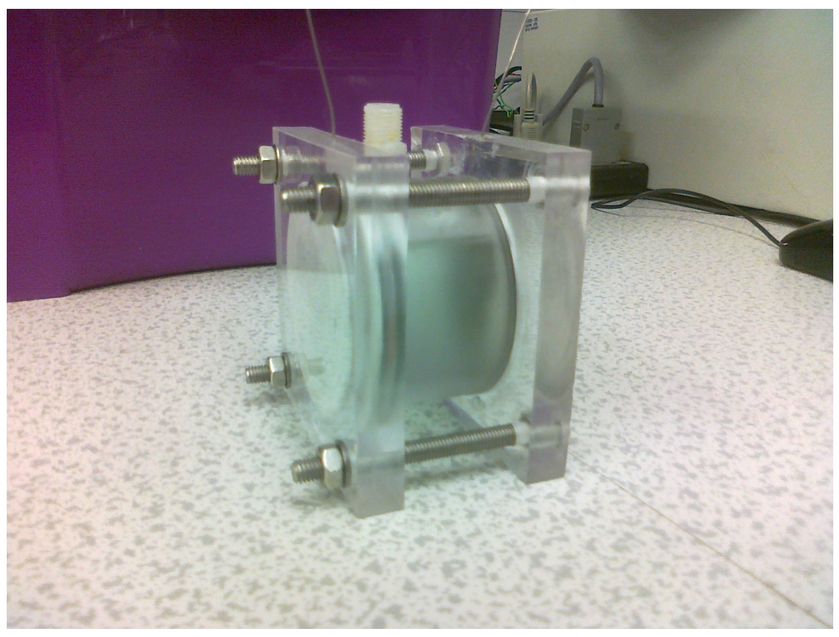


Introduction

Wastewater from electroplating plants and some manufacturing industry, as well as mining, contains various metal ions, and even precious metals. Heavy metal toxicity can affect the whole environmental circle throughout the food chain, and ultimately on human health. The need to remove and recover metal ions from wastewater has both financial and environmental benefits. By recover and reuse metal from wastewater, it is not only cost saving and but also a concept shift in the recovery of resources from waste. Current metal removal strategies are mainly based on physic-chemical techniques, which are high cost, high energy demanding and low metal recovery efficiency. Main aim of this research was to develop an MFC system which can selectively reduce desired metals from various mixtures. For this project nickel, copper and it's mixture where chosen as research subject.

Half cell experiments

For any metal of interest several experiments in half cell must be made. Cyclic Voltammogram (CV) to determine reduction potential and constant potential polarization (CA) to see if desired metal from specified solution can actually be plated out and estimate current, time needed for that processes. CV and CA experiment where made vs Ag/AgCl reference electrode.



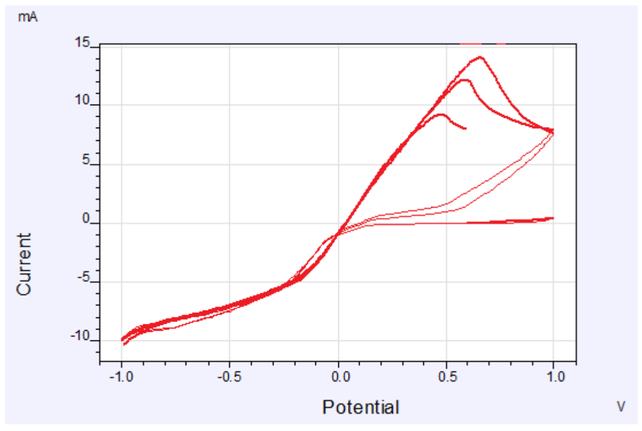
Half cell with $CuSO_4$ and Ni_2SO_4 solution.

Table of CV experiments

Experiment No.	Concentration	Purged with N_2	Working electrode	Counter electrode
1	$CuSO_4$ 12mMol	Yes	Graphite plate	Platinum mesh
2	Ni_2SO_4 12mMol	Yes	Graphite plate	Platinum mesh
3	$CuSO_4$ 12mMol + Ni_2SO_4 12mMol	Yes	Graphite plate	Platinum mesh

CV experiment results

CV of 12mMol $CuSO_4$ + 12mMol Ni_2SO_4 solution

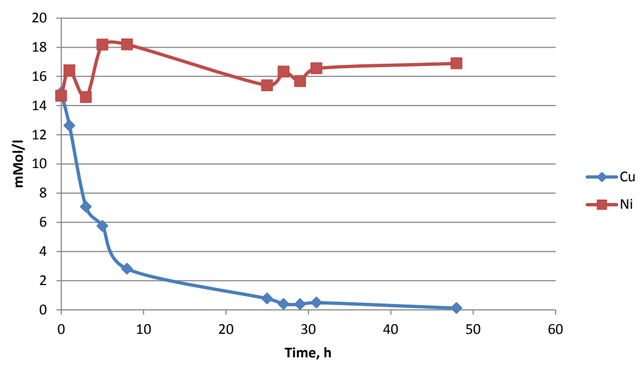


CA experiment

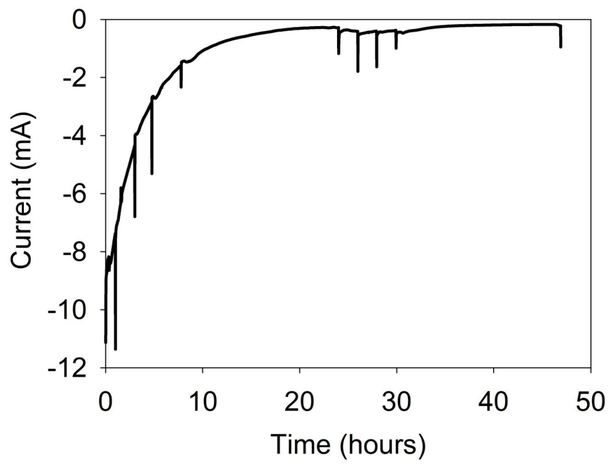
From CV experiments potential of -0.4V where chosen to reduce copper from copper, nickel solution, as it will reduce copper but not nickel. CA experiments have to be ran for relatively long period of time to ensure full recovery of first metal from solution, as it is essential when recovering next metal.

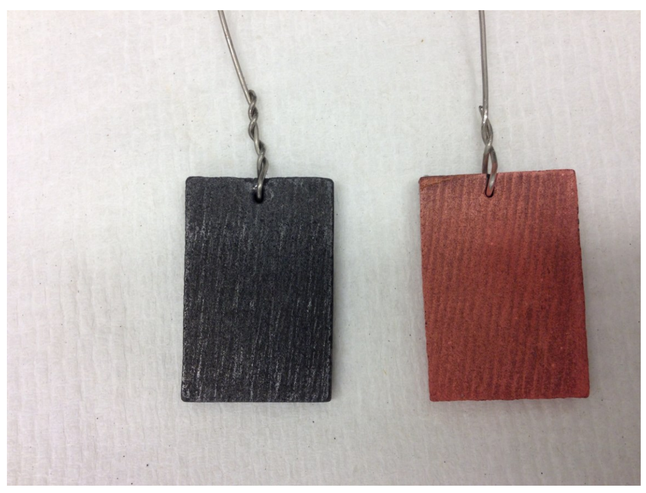
Concentration profile

Cu + Ni Ca -0.4V 48h



Current against time



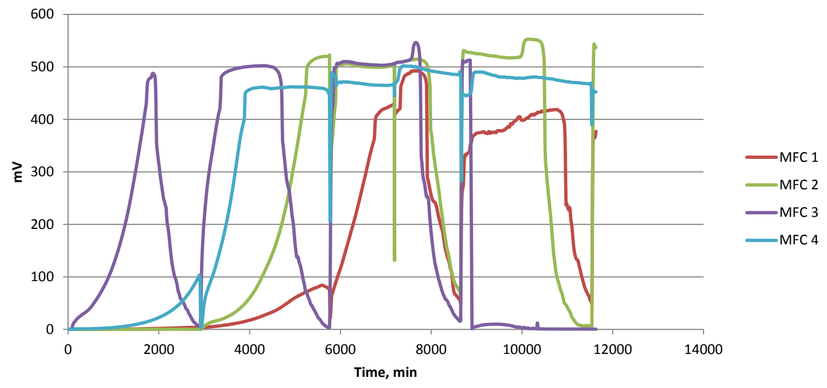


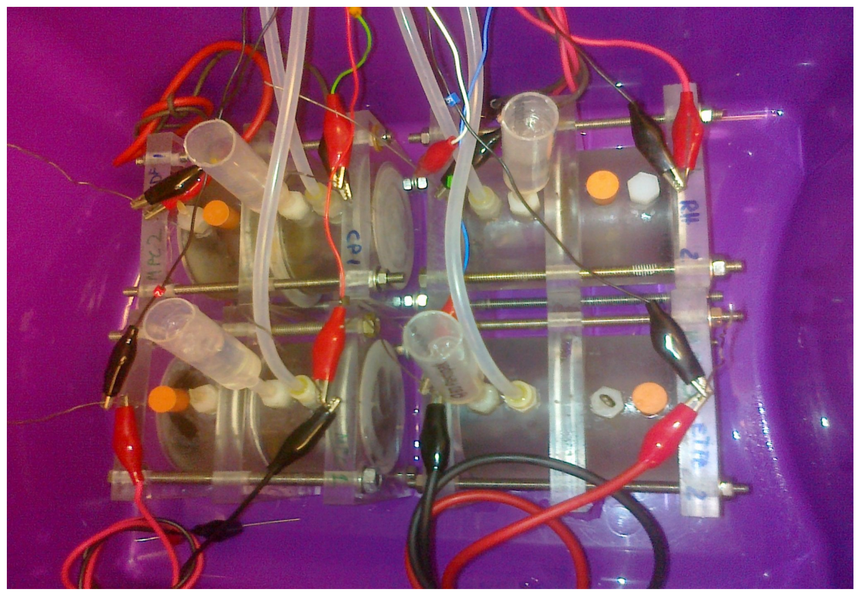
Working electrode at t=0 (left) and t=48h (right)

MFC growing

Dual-chamber MFC where build with an anionic exchange membrane. Because of this specifications it was hypothesized that SO_4^{-2} ions will travel from cathode chamber to anode chamber, and could lead to death of microbes. To test this theory, four cells where set up. MFC 3 and 4 where grown under normal conditions where for MFC 1 and 2 SO_4^{-2} ions where added to cathode chamber to see and effect of it. Results shows us that SO_4^{-2} only slows down metabolism of microbes, but doesn't effect overall performance. During growing all MFC had 1000Ω external resistor.

MFC growing





MFC's system while growing.
From left down corner clockwise MFC 1,2,3,4.

MFC experiments

During these experiments buffer solution where replaced with copper-nickel solution at cathode side. And external resistor changed to reach desired reduction potential at cathode. Summary of experiment are displayed on table below:

	MFC1	MFC3	MFC4
Resistor	Short circuited	10 ohms	10 ohms
Buffer	PBS	PBS	PIPES
Anolyte	50mM PBS 10ml/L Macro elements 1ml/L Micro elements 1ml/L vitamins 1g/L Sodium acetate	50mM PBS 10ml/L Macro elements 1ml/L Micro elements 1ml/L vitamins 1g/L Sodium acetate	50mM PIPES 10ml/L Macro elements 1ml/L Micro elements 1ml/L vitamins 1g/L Sodium acetate
Catholyte	12mM $CuSO_4$ 12mM $NiSO_4$	12mM $CuSO_4$ 12mM $NiSO_4$	12mM $CuSO_4$ 12mM $NiSO_4$
Anode	Carbon felt	Carbon felt	Carbon felt
Cathode	Graphite plate	Graphite plate	Graphite plate
Metals plated	Yes	Yes	unknown
Precipitates	Yes	Yes	Very little

Conclusions and Future work

During MFC experiments it become obvious that wrong buffer was chosen as phosphate travel trough membrane and precipitates with metal ions. Which makes impossible for electrode to plate out metals efficiently. Change of buffer seem to solve this problem, unfortunately due to lack of time results of metal recovery are unknown. Different membranes and salt bridge should be investigated for better efficiency. Optimizing external resistor would decrease time needed for metal reduction. Apply same methodology to mixtures with more then 2 types of metals.