Catalytic Selective Recovery of Silver from Dilute Aqueous Solutions and Electronic Waste Leachates.

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<u>Introduction</u>

As part of a project course (course numbers- 014301, 014966) that I took in my last semester studying environmental engineering, I researched the recovery of silver (Ag) from dilute aqueous solutions and electronic waste (e-waste) leachates using a technology named *Capacitive Faradaic Fuel Cells (CFFCs).* This technology was developed in the Gendel lab for environmental electrochemistry in the faculty of civil and environmental engineering at the year 2019. The CFFCs are comprised of granular activated carbon loaded with nanosized platinum catalyst which enables two main half cell reaction to occur in ambient temperatures and pressures – hydrogen oxidation and oxygen reduction reactions. By coupling each of these half cell reactions with silver ion hydrogenation or silver metal oxidation, we were able to remove silver ions from lab made solutions and from e-waste leachates (button cell batteries) to be deposited on the CFFCs and recover what was deposited back to a pure solution. The silver in the pure solution can now easily by reused instead of being discarded.

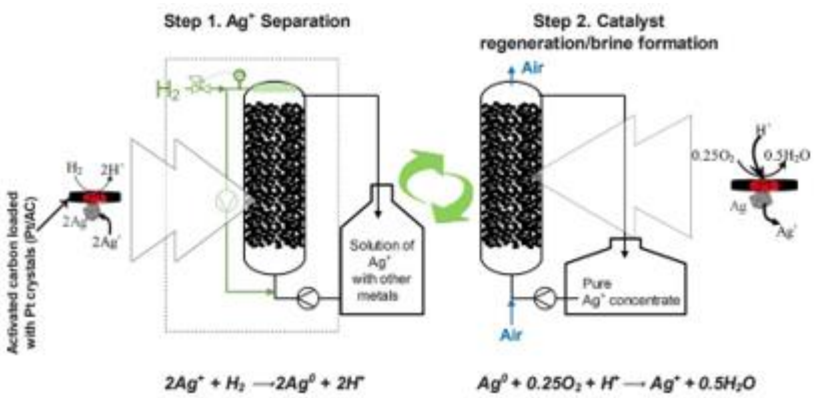

Figure 1: The CFFCs process diagram for silver recovery.

<u>The environmental and economic value of the CFFCs</u>

Using the CFFCs for metal recovery has great environmental and economic value. The increase in demand of electric and electronic equipment by the growing population generates high amounts of e-waste. The global annual e-waste production rates in the years 2016, 2018 and 2019 were 45, 50 and 53 million metric tons, respectively. The typical e-waste contains metals, plastics, and refractory oxides at weight ratios of

40:30:30. Due to a high content of multiple basic and precious metals the e-waste is recognized today as an "urban mine". The estimated global value of raw materials in e-wastes generated in the year 2019 was $57 billion USD.

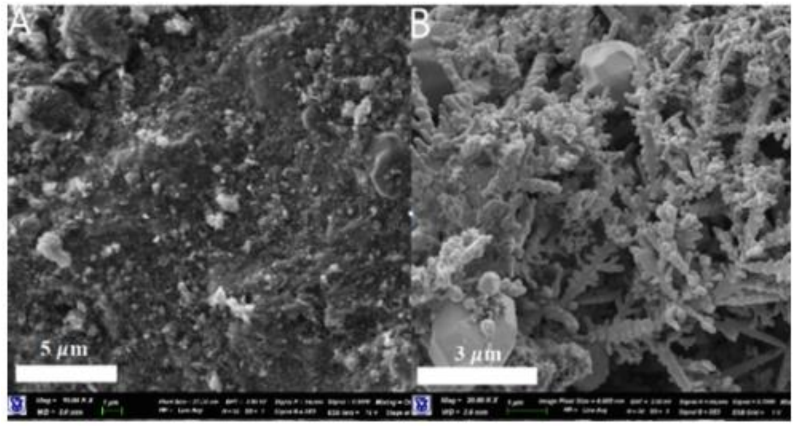

Figure 2: SEM images of CFFCs (A) before Ag deposition and (B) after Ag deposition

Nowadays, the most common process to extract pure metals is the pyrometallurgical method which is cost effective and usually requires only a few pretreatment steps. Unfortunately, the pyrometallurgical e-waste processing generates toxic compounds that can harm humans, animals and the environment. By using the CFFCs technology we reduce drastically the environmental burden of the metal recycling industry. Furthermore, by using the CFFCs for the separation of metals, waste generation can be reduced because of the higher separation efficiency of the CFFCs.

Research Summery

During the research for silver metal recovery, I made different experiments to study the stability of the silver recovery process using the CFFCs, the effect of different platinum loadings on the kinetics of the process and I studied the effect of different pH on the removal and recovery process. Moreover, I studied a few techniques to leach the silver from button cell batteries to an aqueous solution and then separated the silver from other metals using the CFFCs technology (results of separation can be seen in figure 3). Lastly, I showed that both copper and silver can be selectively removed from a mixed metal containing solution using the CFFCs technology to a pure solution. from this pure solution the metals can be reused. After lab experiments were finished, we wrote an article that was published in *Separation and Purification Technology*.

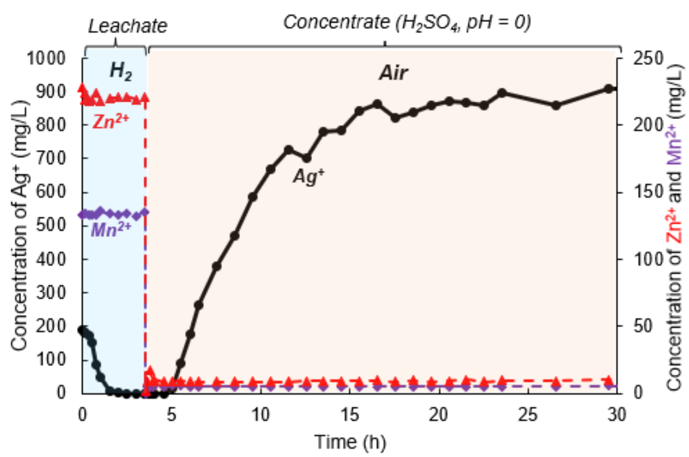

Figure 3: Selective recovery of silver from button cell battery leachate.

Ruck, E. B., Amikam, G., Darom, Y., Manor-Korin, N., & Gendel, Y. (2022). Catalytic selective recovery of silver from dilute aqueous solutions and e-waste leachates. *Separation and Purification Technology*, *285*, 120303.