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Upcycling E-Waste to E-Skin

Ann Badia
Binghamton University--SUNY

Pauline Macapinlac
Binghamton University--SUNY

Upcycling Compact Discs for Bioelectronic Applications

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK

Ann Badia, Pauline Macapinlac, Matthew Brown, Ahyeon Koh

Department of Biomedical Engineering, Binghamton University

Introduction

Electronic waste (e-waste) is a pressing global issue due to its unsustainable use, toxic materials, and short life cycle, with only 15% of e-waste being recycled. Repurposing electronic waste can be a potential solution to mitigate its impact. Notably, compact discs (CDs) can be upcycled to create biosensors for biopotential measurement and metabolite monitoring. By harvesting the metal layers of CDs, biosensors can be developed to monitor electrical activity in the human body, including the heart and muscles, as well as lactose, glucose, pH, and oxygen levels. This approach is energy-efficient, reduces hazardous waste, and enhances the accessibility and affordability of biosensors. To facilitate the production of these biosensors, it is crucial to identify the most effective method of extracting recyclable metals from CDs. Research on solvents and extraction methods can improve the efficiency of further studies and potentially industrial-scale extraction in the future. Additionally, engineering strategies can be employed to evaluate the potential of silver CDs for bioelectronic applications, leveraging the properties of the metal layer extracted from the polycarbonate substrate.

Methods

- To determine the most effective strategy for extracting the metal layer, compact discs were subjected to testing using various solvents.
- Acetone, dimethylformamide (DMF), and tetrahydrofuran (THF) were used to soak the compact discs for different durations in order to break down the polycarbonate substrate.
- The metal from the CDs was then harvested by adhering the polyimide tape to the water-soluble tape.The amount of salvageable silver from the CDs was quantified by calculating the area of the metal layer that was removed.
- Patterns for the biosensors were created from the extracted metals using a Cricut fabric cutter.
- The effectiveness of using gold and silver CDs as electrodes was assessed by observing the P and T waves on the electrocardiogram. Biopotential measurements were conducted and processed with a PowerLab data acquisition unit, and the data was analyzed using LabChart software.

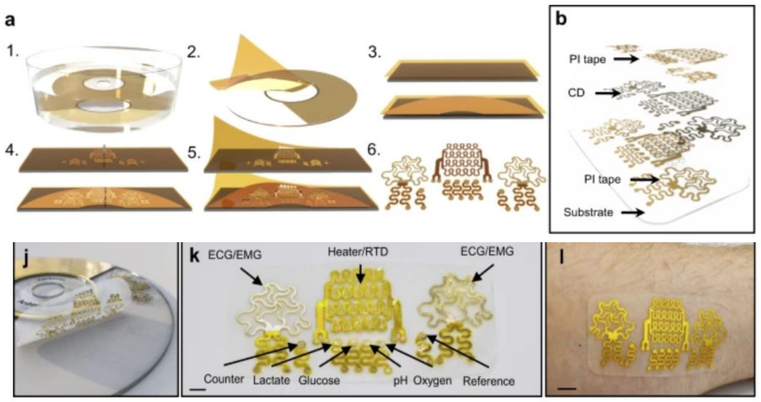

Figure 1: Procedure to Upcycle CDs into Stretchable Biosensors

Results

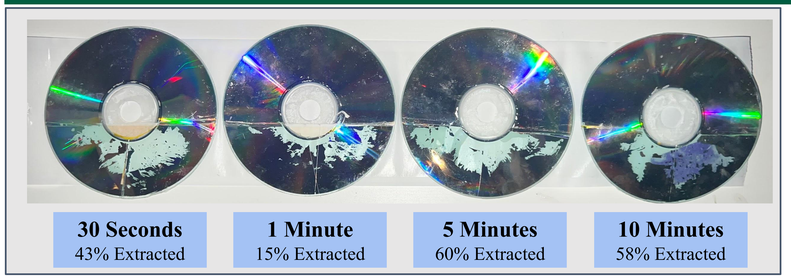

Figure 2: CDs Were Soaked in Tetrahydrofuran (THF) for Varying Time Intervals

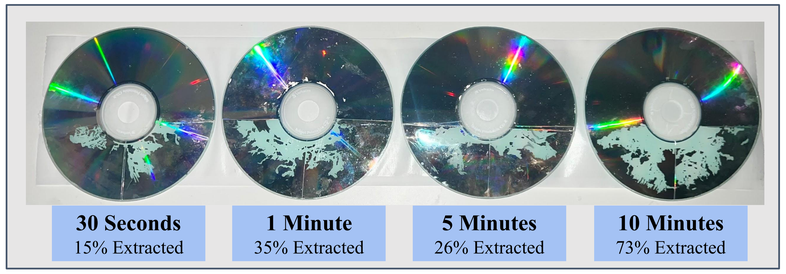

Figure 3: CDs Were Soaked in Acetone for Varying Time Intervals

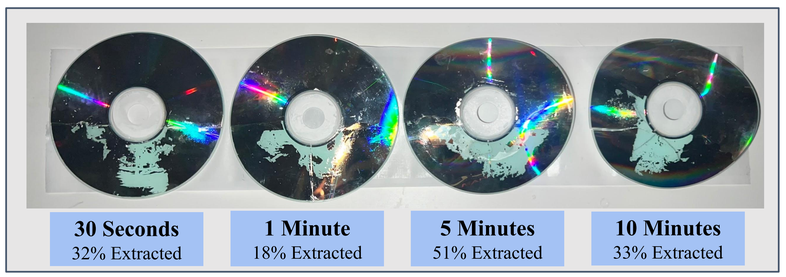

Figure 4: CDs Were Soaked in Dimethylformamide (DMF)

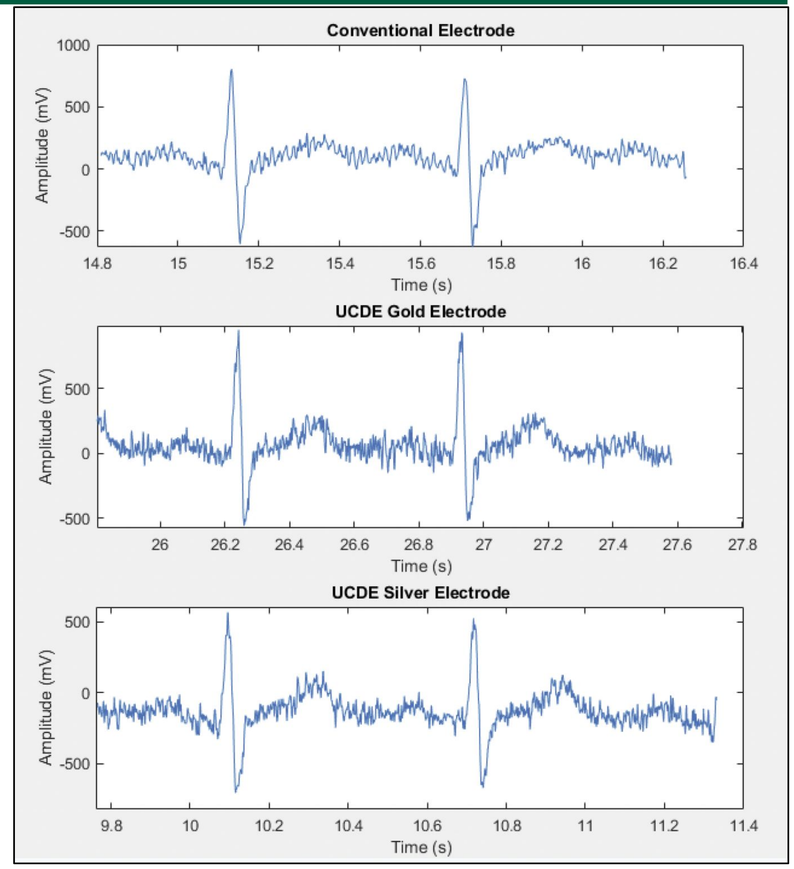

Figure 5: ECG Comparison Results of Conventional Electrode, UCDE Gold Electrode, and UCDE Silverde Electrode

Conclusion & Future Work

- Based on the findings presented in *Figures 2, 3, and 4,* acetone was identified as the most effective solvent for breaking down the polycarbonate substrate and releasing the metal layer, as it removed the largest amount of metal compared to the other two solvents.
- Both gold and silver upcycled compact disc electrodes (UCDEs) exhibited mechanical properties that resulted in electrocardiograms comparable to those produced by standardized electrodes. As demonstrated in *Figure 5*, the P and T waves observed in the electrocardiogram generated by the gold and silver UCDEs were more distinct and recognizable compared to those produced by commercially available sensors.
- In future research, different forms of patterning can be explored to reduce the chances of error. Additionally, investigating the main causes of e-waste, such as small IT devices, and developing more efficient industrial methods for metal extraction could unveil additional opportunities for upcycling.

References

[1] Brown, M.S., Somma, L., Mendoza, M. et al. Upcycling Compact Discs for Flexible and Stretchable Bioelectronic Applications. Nat Commun 13, 3727 (2022). https://doi.org/10.1038/s41467-022-31338-9

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Contact Information

Ann Badia
Email: abadia2@binghamton.edu