Measuring Microplastics in Oceans via Impedance Spectroscopy

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Introduction

Microplastic (MP) pollution of Earth's oceans is a pressing concern for all. MPs are defined as small pieces of plastic less than 5 mm [1]. Their impact on human and animal life is not fully understood, but continuous sampling demonstrates that microplastics are found in all environments. Existing MP detection technology is typically *ex situ,* expensive, and time-consuming [2]. Examples include Raman spectroscopy and pyrolysis gas-chromatography mass spectroscopy. Equipment needed for these methods cannot be used *in situ* and cannot take rapid measurements. To facilitate sampling around the world by scientists and communities with all levels of funding, a more affordable and efficient method must be produced.

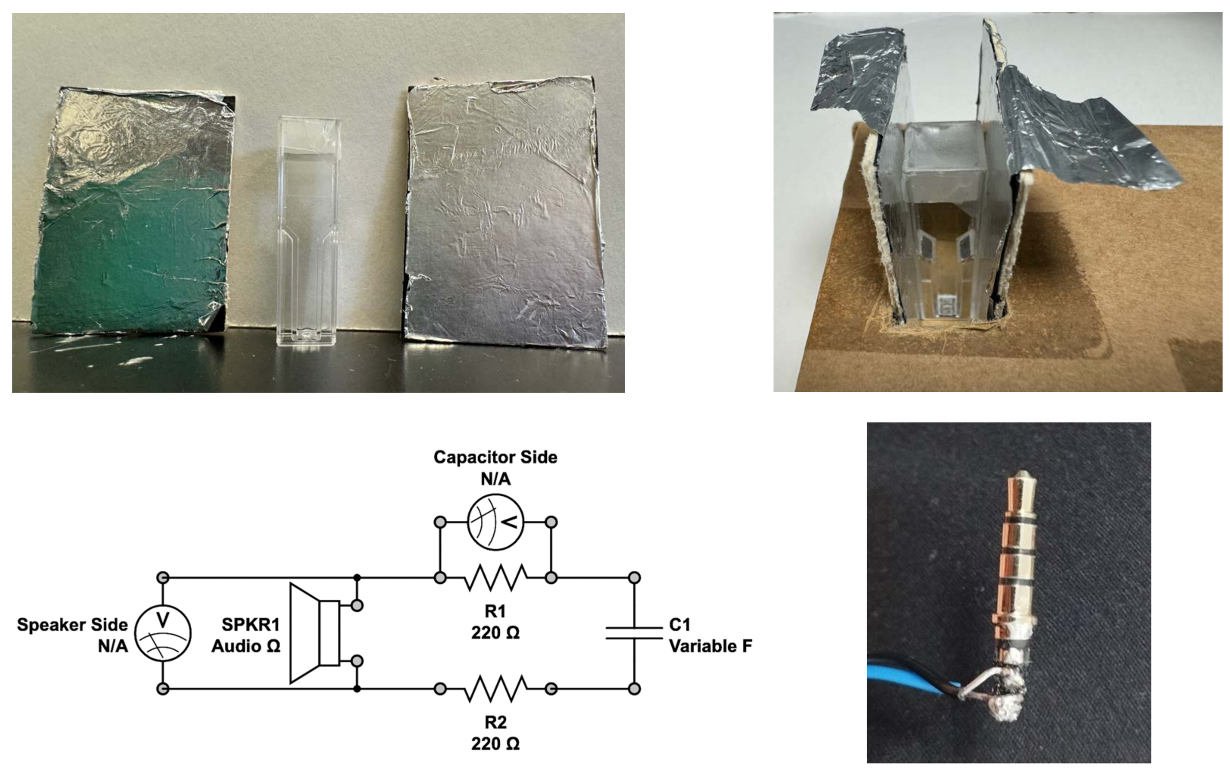

Fig. 1. Top left to bottom right: Aluminum foil was adhered with glue to cardstock, with sample cuvette. A cardboard box was cut into to create a support structure. Circuit diagram. A stripped TRRS audio jack is shown on the right, with two wires soldered on.

Objective

This research aims to use readily available materials to design a mass-producible method of detecting microplastics in Earth's oceans that can be validated by existing methods.

Existing Solutions

Fig. 2. RFT-6000 FT-RAMAN [3]

Fig 3. Agilent Solutions 7000E Triple Quadrupole GC/MS [4]

Circuit Design

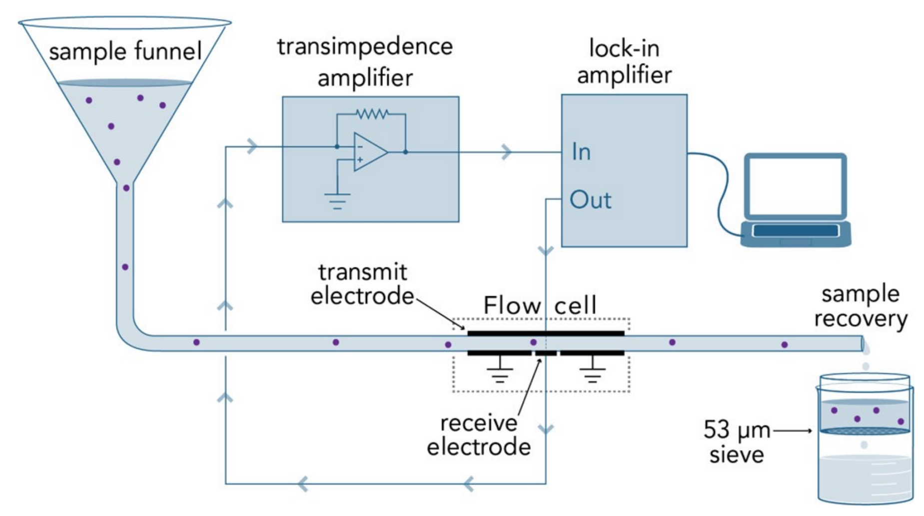

Fig. 4. Impedance Spectrometer Design [2]

Methodology

Impedance Spectroscopy: When a frequency is passed through a capacitor, the dielectric material can affect the phase change of the output frequency. To calibrate findings, the phase change caused by cuvettes filled with air and water was measured, providing a baseline for measuring the phase change caused by microplastics or other substances in a water sample.

Capacitor Construction: Aluminum foil adhered to cardboard acted as capacitor plates, and a cardboard box cutout was used to support the plates around a cuvette.

Frequency Generation: In the absence of a function generator or 555 timer, it was determined the best method to pass a fixed frequency signal through the capacitor was audio signals. A computer with audio output was connected to the circuit.

Results

Upon testing, the first observation was larger resistors reduced the signal noise. However, there was unfortunately no significant phase shift observed, regardless of the dielectric medium. It was also observed that waveforms were not consistent across all devices used. The Dell PC used produced clear sine waves, while MacBooks generated a modified digital audio signal, which increases the difficulty of measuring of phase shift.

Medium	Phase Change (°)
Air	0
Water	0
Water & MP	0

Tab 1. Phase change assoc. with each dielectric medium

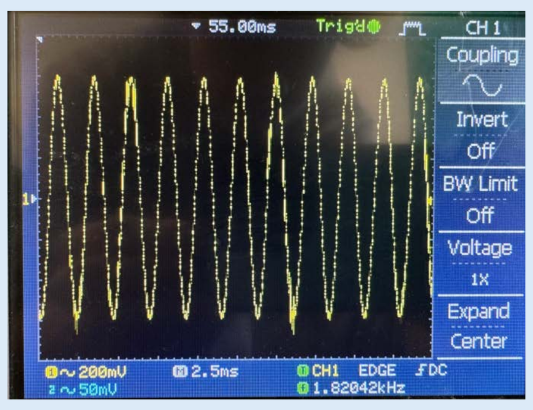

Fig. 5. Frequency produced by PC. 400 Hz input.

Fig. 6. Frequency produced by MacBook. 400 Hz input.

Discussion

There are several possible reasons for the lack of results from this initial research. One is the focus on using readily available materials may have been too much of a hinderance, but further experimentation may solve these issues. Another is poor signal generation. Further work with small integrated circuits, such as 555 timers, may be ideal. The capacitor did appear effective when measured with a multimeter, indicating that the low-budget solution is still feasible. Impedance spectroscopy has been shown to be effective, which indicates that low-cost MP detection is worth pursuing [2].

Acknowledgements

I would like to thank Dr. Mark Pickering for his supervision, Niamh Burke for her assistance, and Dr. Kevin Nolan for his direction of this program.

Bibliography

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