Improving the Efficacy of Dye-Sensitized Solar Cells with the use of Organic Dyes

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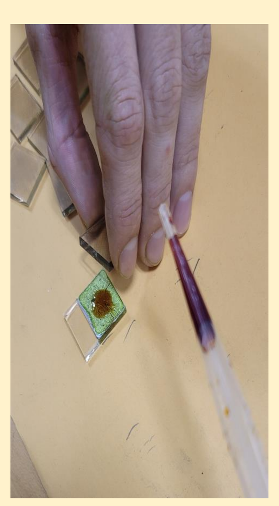
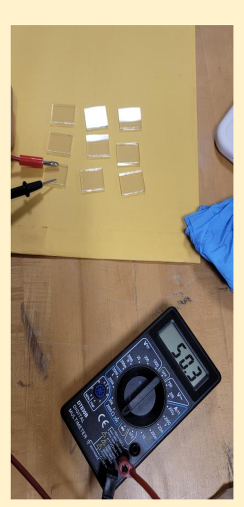
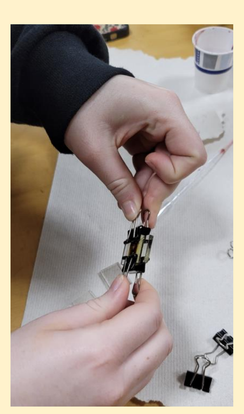
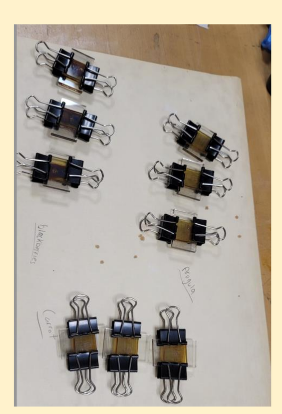
Abstract

Due to advancements in technology over the past three decades coupled with the increasing demand for sustainable energy practices, more types of solar cells have been constructed and utilized in recent years. One example of these solar cells is the Dye-sensitized Solar cells (DSSCs), which utilize organic dyes for greater photon absorption. The organic composition of dyes within the dye-sensitized solar cells is less efficient than synthetic solar cells, however, they are cheaper and easier to construct on a small scale. Different dyes used can influence the efficiency of DSSCs because their chemical structures differ (carbazole, coumarin, cyanine, and hemicyanine). Therefore, the purpose of this study is to investigate the efficacy of different organic substances on photon absorption within DSSCs. We hypothesize that the best-performing organic substance will be the juice of raspberries because they contain the chemical anthocyanin which has been shown to increase photon absorption in past studies. We will also be testing dyes with chlorophyll and beta-carotene to make a comparison between the three chemical compositions. If this hypothesis holds, more DSSCs will be constructed with anthocyanin to increase energy conversion efficiency.



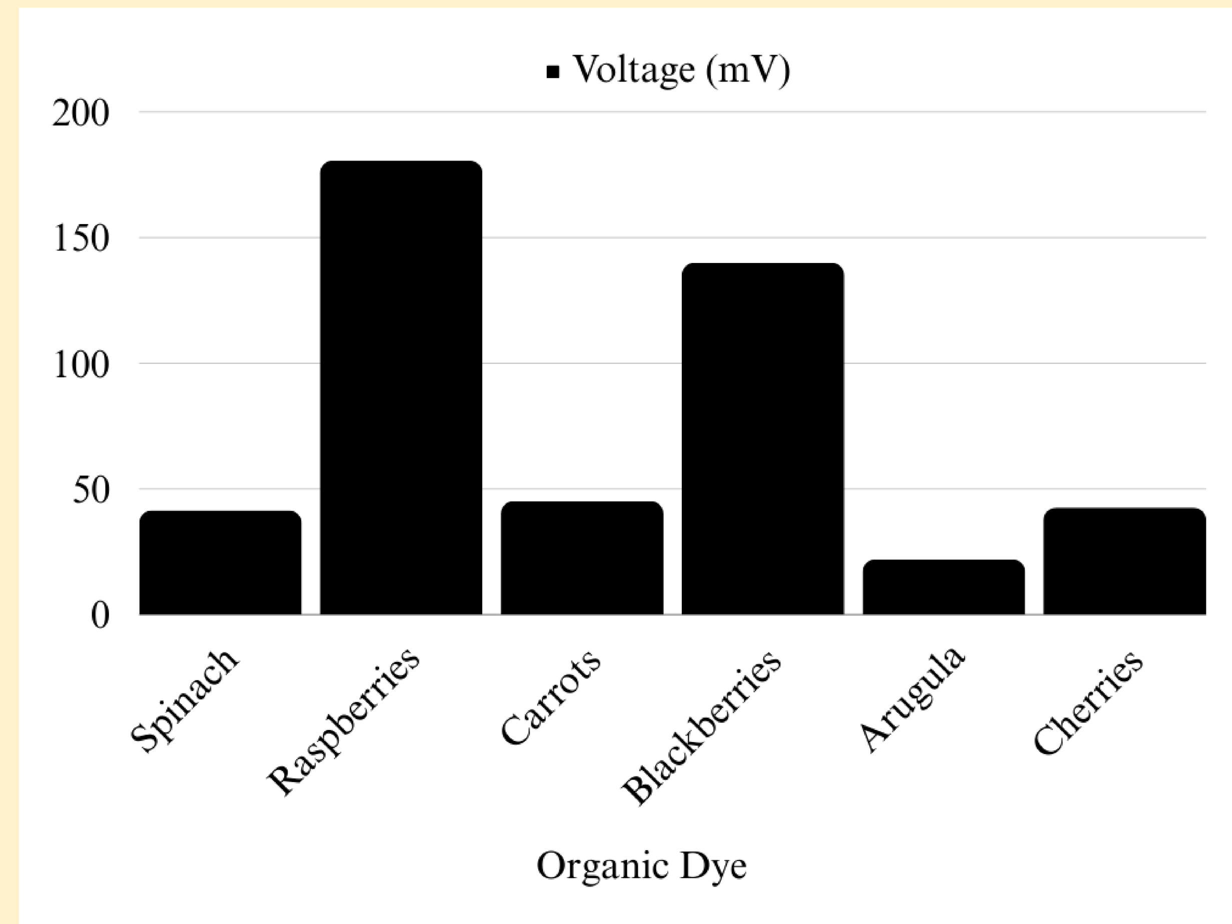


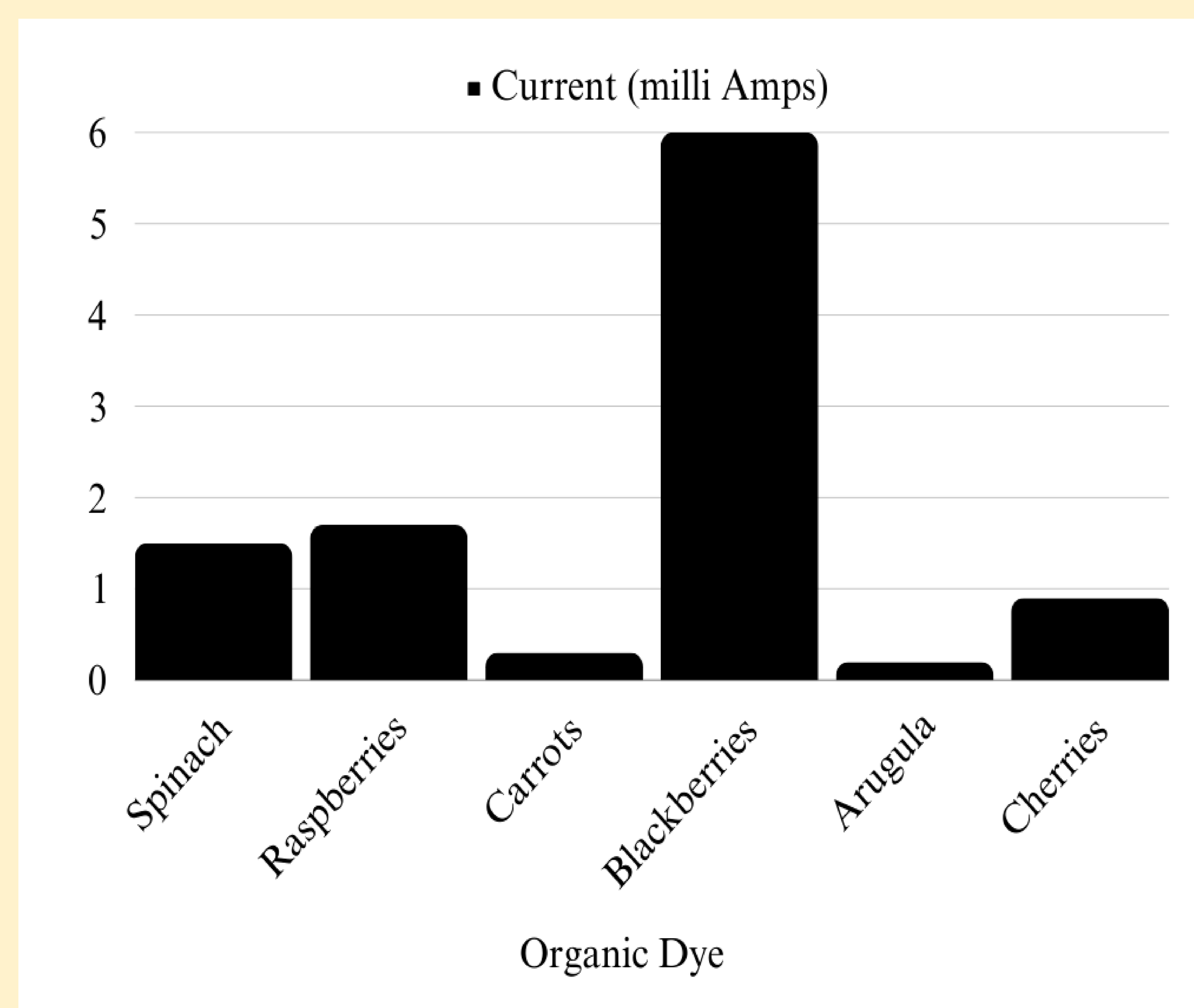




Introduction

Our research on DSCCs aims to improve efficiency in solar cells using organic dyes. The goal of our research is to identify a cost-effective, sustainable, and impactful resource that can be used for DSCC production in the future, as an alternative to silicon-based solar cells, or other light sources. By testing a variety of organic materials, we can identify success rates in consistency and effectiveness for DSCCs. Dye solar cells were first invented in 1988, made up of conducting glass, a conductive oxide film, a layer of Titanium Dioxide to act as a semiconductor, and the dye material to act as a photosensitizer. The dye is typically a ruthenium complex dye do to its high absorption rates. Our research seeks to test anthocyanin and chlorophyll based dyes, as a natural alternative. The objective of this research is to demonstrate sufficient effectiveness in organic materials to prove DSSCs with organic dyes as a sustainable alternative.





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Methods

To analyze the effectiveness of DSCCs, we compared the effectiveness of different types of dyes in the solar cells. Our methodology was as follows

- Using all organic dyes, and keeping all other testing factors constant, including amount of dye, size of solar cell, time allotted for TiO2 paste to dry, amount of TiO2 paste applied, and overall cell structure
- Placing each cell under a halogen lamp in order to simulate how the cells would react in sunlight absorption
- Conducting the first trial runs consisting of test runs, each with 3 different dyes (cherries, spinach, and raspberries)
- Conducting the second trial run with multiple dyes (blackberries, arugula, and carrots)
- Collecting data points for current and voltage for each due tested. By including a diverse collection of different compounds, we can acquire a broadened scope of information on the success rates of different dyes.

Conclusion

Overall, the most efficient dyes utilized in the solar cells were the raspberries and blackberries. The maximum output in millivolts (mV) was 180.6 for the raspberries, and 140 mV for the blackberries. This marks a substantial difference between three types of dyes used in dye sensitized solar cells. We conclude that the presence of anthocyanin in the blackberries and raspberries proved to be effective in having a higher electrical output than the rest of the dyes tested; spinach, cherries, carrots and arugula. The current measured throughout the different materials also was highest in the blackberries and raspberries reaching a maximum current of 1.2 and 1.7 microAmps, respectively. More testing is needed to determine the real efficacy of these different dyes for sensitized solar cells, including research regarding the waiting time before measuring the current and voltage after assemblance. In a few of our trials we had noticed that the longer we waited to test the cells after adding the dye, the lower the voltage was despite previous testing being higher. Of our less effective trials, the highest achieved output for cherries was 42 mV, for carrots was 45.2 mV and for arugula was 22 mV. Testing each dye was essential in order to determine the most effective, as the different compounds contain different qualities that could allow one to surmise they might be most efficient. The arugula and spinach both had photosynthetic material that would have made them optimal for the storage of solar photons. The raspberries cherries and blackberries all had ethanol cyanine which was proven to be effective in the absorption of photons and previously made solar cells. And the carrots had beta carotene which was also found to be effective in previous studies. However, our data displays that cells containing anthocyanin would likely be most impactful for future use.