Leaf-Based Electrolytic Photovoltaics

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Terminology

**Photovoltaic (PV) System/Cell:** a power system designed to supply usable solar power by means of photovoltaics, a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons.

**Dielectric Capacitor:** a cell in which terminals are connected to two metal plates separated by a non-conducting substance, referred to as the dielectric.

**Deep Eutectic Solvent:** a homogeneous mixture of substances that melts at a single temperature that is lower than the melting point of either of the constituents.

**Asymmetric electrodes:** Two dissimilar metals that are used as the metal plates of a capacitor.
Research Question

What is the effect of increasing the concentration of a leaf-based electrolyte on the current generated by a photovoltaic light sensitive dielectric capacitor?
Hypothesis

If the concentration of the leaf extract electrolyte increases, the current generated by the photovoltaic cell will increase as well.

Research mainly from the University of Manchester

According to research, the chlorophyll in leaves can be utilized in a photovoltaic cell, harnessing the Sun’s energy and converting it to usable energy.
Most commercial PV cells consist of crystalline silicon (semiconductor) put between two conductive layers.

Key components of PV cells:

- N-type silicon: has extra electrons.
- P-type silicon: has extra spaces for electrons, called holes.

If a high energy photon strikes the silicon cell it can knock out an electron.

The free electrons will flow through the circuit to the holes in the P-type.

The flowing of electron creates current which can be used to power household items, such as light bulbs.
Processes: Leaf Extract Rationale

- Chlorophyll takes the radiation energy from the Sun and converts it to energy that is usable for the plant.
- However, this chlorophyll can also be used to generate energy in the same manner if used in a “supercapacitor” type setup.

![Diagram of conductive plates and dielectric](image-url)
Processes: Sun’s Energy

- Sun and Earth’s effect on voltage generation:
  - The earth absorbs roughly $10^{17}$ photons per second per square centimeter from the sun
  - Sun produces much more than this, much of it is lost because:
    - Absorbed by Earth’s atmosphere
    - Reflected from clouds
    - Reflected from Earth’s surface
    - Photons that reach the Earth are absorbed
    - Reradiates them back to space as “cold photons”
Background Information

**Independent Variable:**
- Electrolytic leaf extract concentration

**Dependent Variable:**
- Current drawn through cell
- Measured by multimeter

**Control Group:**
- Commercial photovoltaic cell

**Controlled Variables:**
- Environmental conditions when giving light exposure and collecting data
- Surface area of aluminum plates, amount of electrolyte used
Materials

- Birch leaves
- Blender
- Distilled water
- Vacuum filter
- Ethylene glycol ($\text{C}_2\text{H}_0\text{O}_2$)
- Choline chloride ($\text{C}_5\text{H}_{14}\text{ClNO}$)
- Hot plate
- Aluminum plate/Copper plate
- Multimeter

Additional materials:
- Safety gloves, goggles, scissors
- Soldering iron and solder
Procedure

1. Blend 75 grams with 250 mL of water together.
2. Next, filter the mixture with filter paper to get a chlorophyll solution.
3. Mix the solution with 50 grams of ethylene glycol and 50 grams of choline chloride.
4. Put the solution in a beaker and heat it to 100°C.
5. Use an aluminum plate and a copper plate and put between them a paper towel soaked in the chlorophyll solution. Seal the cell.
6. Repeat this process three times with each different concentration (control group, 100 grams, and 125 grams) of birch leaves in the solution.
Experimentation

1. Connect the photovoltaic cell with a multimeter set to milliamps.

2. Expose the photovoltaic cell to a synthetic LED light to simulate the light of the Sun in a laboratory setting.

3. Record current data for 10 trials for each photovoltaic cell made, for a total of 40 trials.

4. In addition, extend the data to collect the data from each one of these trials over a 60 minute period.
Data Charts

### Current Produced from Control Group Over Time (mA)

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### Current Produced from 75g-PV Cell Over Time (mA)

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## Data Charts

### Current Produced from 100g-PV Cell Over Time (mA)

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This graph shows the average current flowing through the PV cell circuit over time.
This bar graph shows the average initial current flowing through the each cell’s circuit.
Data Analysis

- The peak current produced from the sun’s energy was when data was first recorded (t=0) for the PV cell with a 125g concentration of extracted electrolyte.
  - Average of 94 milliamps.
- The original current generated by the 100g and 75g PV cells, respectively, had an average of 78 and 76 mA.
- The current of all three PV cells seemed to decrease parabolically.
- On average, the PV cell with 125g electrolyte produced the most current from the Sun’s energy, while the 75g concentration produced the least current.

**The control group did not produce any current throughout any trials as reflected in the graph**
Original Hypothesis: If the concentration of the leaf extract electrolyte increases, the current generated by the photovoltaic cell will increase as well.

The hypothesis was supported by the experiment because the current produced had a strong positive correlation with an increase in the concentration of the leaf extract solution.

• Explanation: Due to the larger amount of chlorophyll present in the solution, more of the solar energy was able to be converted to usable energy.
Possible Errors in Data/Experimental Design and Improvements:
• Tested the photovoltaic cell under laboratory simulated conditions, using a high wattage light bulb to mimic the role of the sun

Challenges:
• Acquiring choline chlorine and ethylene glycol

Why researcher chose this topic:
• Wants to use this energy source to its fullest potential to be as efficient as possible

Benefits to society:
• Maximizing “green” energy produced
Why Does This Matter?

- **Resemblance to a supercapacitor**
  - Despite similarity in structure, the cell functions as means for energy production, rather than an electrochemical cell.

- **Cost effectivity**
  - Comparison to commercial solar cells

- **Potential for widespread use**
  - Paint
  - 3D variant
In Addition

- **Questions that arose during the experiment**
  - How is it possible for us to mass produce these photovoltaic cells in the most environmentally friendly way, while limiting our use of earth’s natural resources?

- **Future Research**
  - Producing a gel using this leaf based electrolytic extract and polyvinyl alcohol for increased energy output cost efficiency.
Bibliography


Thank you for your attention! Are there any questions?