Research Plan

Project ID:

Project Title: Homemade Lemon Battery: Electrochemistry and Energy Conversion

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a. Introduction

Energy conversion is one of the most important concepts in science and technology. Elec- tricity can be generated through chemical reactions in simple electrochemical cells. A lemon battery, using zinc and copper electrodes, is a low-cost demonstration of how chemical energy is converted into electrical energy.

This project will aim to design a homemade lemon battery that can power a small LED, while studying the factors affecting its efficiency such as the number of lemons, electrode materials, and connection method.

b. Selection of Problem and Background Information

In many parts of the world, there is a need for low-cost and renewable sources of electricity for small-scale applications. The lemon battery experiment is a safe, accessible model to understand electrochemistry principles.

It demonstrates oxidation-reduction reactions, electron flow, and voltage generation. Background studies show that zinc (anode) undergoes oxidation while copper (cathode) acts as the reduction site, and citric acid in the lemon acts as the electrolyte.

c. Objective

Research Problem / Question: How effectively can a lemon battery made of zinc and copper electrodes generate electrical energy to power an LED?

What will be found out:

- Voltage and current output of a single lemon cell.
- Effect of connecting multiple lemons in series or parallel.
- Minimum number of lemon cells required to light an LED.

Variables:

- Independent Variables: Number of lemons, type of electrodes (copper, zinc, iron, aluminum).
- Dependent Variables: Voltage (V), current (mA), LED glow (Yes/No).
- Controlled Variables: Size of lemon, type of LED, wire thickness.

Control in the Study: The LED connected to a standard battery (AAA cell) will serve as a control to compare brightness and performance.

d. Hypothesis

If a zinc nail and copper coin are inserted into a lemon, then the chemical reaction between the citric acid and electrodes will generate sufficient voltage to light an LED when multiple lemons are connected in series.

e. Procedure

Design of Study: A series of lemons will be used as electrochemical cells. Electrodes will be connected using wires and tested for voltage, current, and ability to power an LED.

Materials Required:

- Fresh lemons (5–10).
- Copper coins or copper strips.
- Zinc nails or galvanized nails.
- Connecting wires with alligator clips.
- Multimeter (to measure voltage and current).
- Small LED (2V).

Stepwise Procedure:

1. Insert a copper coin and zinc nail into one lemon without touching.
2. Connect wires: zinc (–) to copper (+).
3. Measure voltage and current using a multimeter.
4. Connect multiple lemons in series to increase voltage.
5. Test whether the LED glows and record the number of lemons required.
6. Repeat with parallel connections to measure current change.
7. Record data systematically.

Proposed Data Tables:

Table A: Voltage Output of Single Lemon

Trial No.	Voltage (V)	Current (mA)
1 2 3		

Table B: Series Connection Results

No. of Lemons	Voltage (V)	Current (mA)	LED Glow
1 2 3 4			

f. Risk and Safety

- Project is safe, uses edible lemons and low-voltage LED.
- Metal nails and wires will be handled carefully to prevent injury.
- No hazardous chemicals are involved.

g. Data Analysis

- Average voltage and current of single lemon cell will be calculated.
- Series connection results will be analyzed to find threshold for LED glow.
- Parallel connection results will be studied for current enhancement.
- Graphs will be plotted for Voltage vs Number of Lemons.

h. Bibliography

1. Atkins, P. and De Paula, J. *Physical Chemistry*. Oxford University Press.
2. Zumdahl, S. *Chemistry: An Atoms First Approach*.
3. Science Buddies, "How to Make a Lemon Battery – Electrochemistry Basics."