

Lab: Photovoltaic Cells (with the Photoelectric Effect lab)

I. Equipment

- ⇒ White light source
- ⇒ Precision filters (± 10 nm)
- ⇒ Light blocking box in which to place photovoltaic cells
- ⇒ 1 each photov. cell:
 - raspberry/purple juice (anthocyanin) & TiO₂
 - plant/green juice (chlorophyll) & TiO₂
 - Silicon
- ⇒ Digital Multimeter (DMM) set to read volts (V)
- ⇒ 2 lead wires

II. Introduction

You may already know that you want to go into nano- and/or green-technology fields. You may be curious about them. Then again, you may not know anything about them. In our ENGIN-230 (Circuits) and ENGIN-240 (Materials) classes, you will get to look at photovoltaic cells from different perspectives and in a more structured way. If you have taken one of those classes already, you will get to contribute your knowledge to your team. If you have not taken those classes, this might excite you about taking them—they are very useful and way cool!

Physics 231 approaches these **pigment (“dye”) photovoltaic cells** from a different angle. In undergraduate labs, we are typically given the experiment design, equipment and procedures that have us attempt to reproduce a foregone conclusion or result. In graduate level research and beyond, be it in industry or academia, we are expected to create, test, and modify the experiments as we obtain and interpret preliminary results. This is more challenging, more rewarding and, for those that really like doing science, more fun. This part of your lab is designed to give you a taste of real-world experimental science. It will be up to you to **organize, present and try to make sense of your data**. Most importantly and as best you can, you are to come up with (and present) questions that would guide further research. You are also to suggest experimental designs to explore those questions. If you were applying for grant money, what experiments would you want to run? Outline them. You should research anything you need or want to learn about. Additionally, be sure to directly address the questions below and to make a clear list of the resources you use.

III. General Questions

1. What is the basic physics of light? Briefly discuss energy, intensity, absorption and reflection.
2. Compare and contrast the photoelectric effect and the photovoltaic effect. Keep it short and simple.
3. What are some technical applications that use the photoelectric effect?
4. What are some technical applications that use photovoltaic cells?
5. What natural processes use these effects?
6. What is “nano-technology”?
7. Briefly compare nuclear scale, atomic scale, visible light wavelengths, nano scale and micro scale. What is the scale of molecules and biological cells?
8. What is “green-technology”?
9. In simple terms, how do semiconductors work? Consider p-n junctions and try to gain a clear picture of what goes on without being too concerned about *why* certain atoms work better than others.

IV. Experiment Design and Data

10. In general, how do we advance knowledge? Be succinct, but substantive.
11. How do we advance technology?
12. What do you notice about the design of the set-up given to you?
13. Hypothesize! Looking at your data, what might be going on?
14. What other tests would you design and run to test what is going on and to design better photovoltaic cells?

V. Research Papers—Reading and Writing Them

15. Go to the class portal and download the article “Dye-sensitized solar cells.” What is the order of the sections in the paper? What purpose does the abstract serve?
16. Do not expect to be able to read and understand the article on the first pass. As usual, skim through first and then go back through and get what you can. Pick out at least five key terms that you don’t understand, look them up, and explain them. For example, you might use “IPCE” or “sintered.”
17. In the article, find and report why titanium dioxide (TiO_2) has become the chosen semiconductor.

VI. Economics and Engineering

18. How much solar energy is available?
19. What should/could be explored about efficiency issues?
20. What should/could be explored about manufacturing?
21. In what way are these pigment photovoltaic cells related to nano-technology? (Hint: How does the titanium dioxide help?)
22. In what way are these cells related to green-technology?
23. How might this benefit society?

VII. Connections–Relating to Other Fields

24. BIO: Consider the rain forest. What color are the plants in the higher regions and what color are the plants near the shaded bottom? Why is this so?
25. ASTRO: People wonder what forms life might take on other worlds (planets and moons). If a world went around a “red giant” star, would plants likely be different colors?

Be sure you have followed the instructions in the introduction section. /Do NOT plagiarize! Read lots of sources and gather information relevant to the points you want to make. Cite your sources and present your synthesis of ideas.