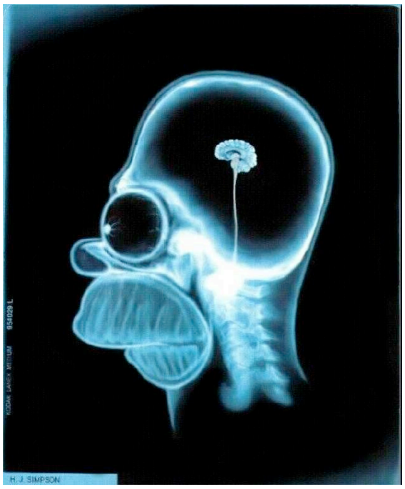
Quantitative Real-World Inquiry Topics:

Fireworks, Pickles and X-Ray Guns





Kate Dickinson
Rio del Valle Middle School
Oxnard, CA

University of California, Santa Barbara
Materials Research Laboratory
Research Experiences for Teachers II

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Abstract

This portfolio includes three inquiry-based lab modules focusing on atomic structure, solution conductivity and astronomical spectroscopy. These modules allow students to identify and test their own hypotheses, collect and analyze quantitative results and explore real-world applications associated with each topic. Additionally, each module is closely tied to middle and high school chemistry standards, as well as topics in astronomy, earth science, and physics. Overall, the modules strive to go beyond traditional middle school activities and provide opportunities for students to collaborate with peers, incorporate informational texts and familiarize students with technical writing, while still providing hands-on exploration, engaging questioning, and exposure to science in everyday life.

Project Overview

Introduction to RET I Research:

My RET I project focused fabrication techniques and morphology studies of organic photovoltaics (OPVs), which rely on a thin polymer:fullerene (P3HT:PCBM) matrix to transport charges through the cell and generate energy. In order to achieve optimal cell efficiency, the active layer thickness and transport channels must be fabricated in an uniform fashion. While easier said than done, traditional thin film fabrication uses high rotational speed to spread a solution across a glass slide, called spin coating. However, this method is difficult to control and does not produce consistent results. Alternatively, blade coating techniques use a thin blade to spread a solution across a glass slide and offer greater parameter control including substrate temperature, blade speed and blade angle.

For my RET I project, I studied how solution concentration, blade speed, substrate temperature and quenching/cooling rate effected blade coated film fabrication and film morphology. Film roughness and domain characterization were then studied using atomic force microscopy (AFM). These studies produced promising results, showing more defined domain separation as compared to spin coating techniques. My research was continued following my RET I internship and remains a promising alternative.

Rationale:

Middle school physical science is designed to introduce students to the most basic topics of physics, chemistry and astronomy. These introductory topics also happen to be mostly qualitative and abstract, which make them somewhat difficult for students to understand. With this in mind, these lab modules were designed to integrate hands-on lab opportunities as well as quantitative data collection, analysis and real-world applications.

In addition to 8th grade physical science standards, each activity can be adapted to fit high school chemistry topics, as well as high school physics and earth science standards and reading/writing common core literacy standards. Students will also be changed to think critically and clearly articulate scientific concepts.

Learning Objective:

Each lab module includes its own learning objectives, but overall each strives to go beyond the basic middle school curriculum and provide comprehensive, hands-on experiments. In addition, the modules incorporate experimental design, engineering, peer collaboration and analysis of middle school topic in an nontraditional way. Students will also complete formal lab reports to practice technical writing and presenting their data and findings.

Overview of Standards

Middle School Physical Science

3. Structure of Matter
    a. Structure of the atom and know it is composed of protons, neutrons and electrons
    c. Compounds are formed by combining two or more different elements and that compounds have properties that are different from their constituent elements
    f. Use the periodic table to identify elements in simple compounds
7. Periodic Table
    a. Identify regions corresponding to metals, nonmetals, and inert gases
    c. Substances can be classified by their properties
5. Earth in the Solar System
    a. Sun is one of many starts in the Milky way galaxy and stars differ in size, temperature and color
    c. Stars are the source of light in space, the Moon and planets shine by reflected sunlight
    d. Appearance, general composition, relative position and size, and motion of objects in the solar system
9. Investigation and Experimentation
    e. Construct appropriate graphs from data and develop quantitative statements about the relationship between variables.
    f. Apply simple mathematical relationships to determine a missing variables
    g. Distinguish between linear and nonlinear relationships on a graph of data

High School Chemistry:

1. Atomic and Molecular Structure
    b. Use the periodic table to identify metals, semimetals, non-metals and halogens
    d. Use the periodic table to determine the number of electrons available for bonding.
    g. Relate the position of an element in the periodic table to its electron configuration
    i. Quantum theory of atomic structure
    j. Spectral lines are the result of transitions of electrons between energy levels that correspond to photons with a frequency and energy ($E = hv$)
2. Chemical Bonds
    a. Atoms form molecules by sharing electrons or by exchanging electrons to form ionic bonds
6. Solutions
    a. Definitions of solute and solvent
    b. Describe the dissolving process at the molecular level
    c. Calculate the concentration of a solute in terms of molarity and molality
    d. Relationship between the molality and depressed freezing point/elevated boiling point
1. Investigation and Experimentation
    a. Select and use appropriate tools and technology to perform tests, collect data, analyze relationships and display data

High School Physics:

10. Waves
    a. Waves carry energy from one place to another.
    c. Solve problems involving wavelength, frequency and wave speed.
    e. Spectrum of electromagnetic that can travel through a vacuum at approximately 3×10^8 m/s

High School Earth Science:

1. Earth's Place in the Universe I
    a. Differences and similarities among the sun, the terrestrial planets and the gas planets
2. Earth's Place in the Universe II
    d. Visual, radio and x-ray telescopes are used to collect data that reveal differences in stars
8. Structure and Composition of the Atmosphere
    a. Thermal and chemical composition of the atmosphere
    c. Location of the ozone layer and its role in absorbing UV radiation