Green Energy = Safe (Classroom) Environment

Hydrothermal Liquefaction: Waste = Energy

Created by Joelis Velez Diaz

for the STEM Education Center at WPI's Summer 2023 Research Experience for Teachers program

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Subject: Chemistry

Grade Level: High School

United Nations Sustainable Development Goals: The research project precisely associates with the United Nations Sustainable Development Goal (UN SDG) number 7, "ensure access to affordable, reliable, sustainable and modern energy for all"; as well as goal number 12, "ensure sustainable consumption and production". The students will be introduced to it, environmental justice, and sustainable energy; which will be tied directly with separation techniques.

Overview

The bigger issue is climate change, it will be presented with a video of the UN Sustainable goals. For this specific experiment there is a need to separate the components in green waste, to be able to identify what chemicals these leafy vegetables are made of and find what we can do with those chemicals.

Connects to the examples of previous research conducting RET:

- Using green waste and food waste to make bio-oil, we need to do chromatography to identify the chemicals/components of the bio-oil we create, and figure out its applications.
- Breaking down plastic into reusable chemicals.

There is a lot of waste in landfills that comes from food waste and green waste, and we need to be able to remove it. For this reason, your task is to perform a separation technique - chromatography, and you need to find out which are the chemicals in your waste that your pigments show, are there any applications where we can use this. Students will be given a mystery green waste and based on what they know they'll identify these pigments, then with their knowledge about polarity they'll determine the polarity of the components in the mixture. Thereafter students will make further questions they want to research or recommendations on what can be sustainable alternatives to deal with green waste or any other type of waste they want.

Standards & Learning Targets

PS1. Matter and Its Interactions

HS-PS1-11(MA) Design strategies to identify and separate the components of a mixture based on relevant chemical and physical properties.

Clarification Statements: Emphasis is on **compositional and structural features of components of the mixture**. Strategies can include **chromatography**, distillation, centrifuging, and precipitation reactions. Relevant chemical and physical properties can include melting point, boiling point, conductivity, and density.

Vocabulary	**Tier 1 (every day)**	**Tier 2 (school)**	**Tier 3 (science, lab, math)**
	• Identify • Separate • Mixture • Relevant	• Design • Strategies • Components	• Chromatography • Polar • Non-Polar
What do students need to **KNOW**?	1. Students will use the following vocabulary words in context: Polar, non-polar, Chromatography 2. Students will be able to distinguish between polar and nonpolar		
What do students need to **DO**?	1. Be able to identify and separate components of a mixture 2. Be aware of the effects of polarity and use it to their advantage when separating compounds, and identify the polarity of compounds 3. Understand how to perform chromatography by TLC (Thin-layer chromatography) to separate compounds		
What will students **CREATE**?	1. Students will perform an experiment 2. Complete a write-up/lab report 3. Connection to real world problems 4. Create a poster from what they learned and present it *Note: More specifically on the long version students will be able to do authentic research on the classroom following the engineering design process (there are 6 groups, and 2 groups have the same leafy green they are able to compare it - having two different trials now per each leafy green allowing them to have more evidence/data to back up their results while doing collaboration, students get to present their results). Students also carry out 2 different sets of experiments that involve a different procedure, which allows them to compare and contrast them.*		

ELA Standard: Presentation of Knowledge and Ideas
4. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task.

Vocabulary	**Tier 1**	**Tier 2**	**Tier 3**
	• Information	• Evidence	• Findings
What do students need to **KNOW**?	Students will use the following vocabulary words in context: 1. Information/data 2. Evidence/findings		
What do students need to **DO**?	1. Students need to present their information gathered through the lab experiment		

What will students **CREATE**?	1. Student will create relevant data point and use as evidence to support their findings

Prior Knowledge

- Polar vs nonpolar
- How to determine the polarity based on electronegativity
    - Find the difference of electronegativity of the atoms involved
        - If it was between 0.4-1.7 it's polar
        - Below 0.4 is not-polar

Materials/Resources

Presentation: RET lesson 1 - Unit 9 - Intermolecular Forces 5.pptx
Filter paper or coffee filter paper, scissor, cup/beaker, pre-made solutions of different leafy vegetables in isopropyl alcohol, isopropyl alcohol, coins (one per group), lettuce, spinach, and kale

Timeline of Activities

Duration	Activity	Description/Instruction	Product
5 mins	**Hook**	What is research and why do we need it?	Students think about the importance of scientific research, connection with basic research
10 mins	**I Do (demo)**	Teacher shares the engineering design process and the RET project for them to gain insights on the project and research, with an emphasis on the separation techniques that were used in it.	Connection to careers and gain engagement from the students into the subject

30 mins	**We Do** **(guided and group practice)**	Present the problem to students and allow them to perform the experiment (teacher performs a sample experiment),where students get to simulate the chromatography of TLC plates as well as a gas chromatograph (which I used during my research to identify which compounds where in the aqueous mixture and the oil samples) but with isopropyl alcohol as a solvent and filter paper. Students also get to try the chromatography with a different approach in which there is a pre-made mixture of the leafy vegetables and they just put the filter paper on it. This allows for two sets of experiments.	Students are able to carry out the chromatography by two different experiments.
30 mins	**We Do (partner or group practice)**	Creating their own TCL - having 6 groups, and 2 groups having the same leafy green students compare their results with those that had the same leafy vegetable - having two different trials now per each leafy green allowing them to have more evidence/data to back up their results while doing collaboration. Students also discuss with those that had a different leafy vegetable from them and ask about the results. For the premade mixture - students don't know which leafy green they have but they have to figure it out by calculating Rf values or comparing to samples made and labeled by the teacher.	Facilitates collaboration among students in a similar manner to that of the research scientific community.
20 mins	**You Do (individual practice)**	All students formulate future questions that can lead to additional research, or find sustainable applications to reuse the green waste/food waste. Given a sample in Canva, students create and present a poster where they explain in their own words what chromatography is, the pigments they saw, their mystery green, the polarity of the pigments, and the future work or other sustainable applications for waste.	Shows understanding of the engineering design process and understanding of the separation technique - chromatography.
5 mins	**Closing**	Allow students to make a personal connection by letting them choose which type of research they would like to do or find someone that is doing some research they like.	Diversity in STEM role models and careers - Research, could also have them do this at home

			and/or do now for the next day.

Attending to Equity - Teaching Strategies

Strategy	Explain how the strategy contributes/relates to the lesson/activity
Incorporate culturally relevant teaching	Emphasizes social justice (climate change/environmental justice)
Making it a safe place	Students can feel free to share ideas and trial an error (room to fail)
Adjusting to the students learning needs	Get students from where they are to allow them to grow, instead of assuming they are supposed to know certain material already

Career Connections

- By explaining students about research
- Project based learning
- Allow them to experience a hands on activity/perform experiment
- Enhancing teamwork in the classroom
- Giving the space for them to discuss with their classmates and analyze

Assessment

Green Energy = Safe (Classroom) Environment Performance Assessment Rubric

Work samples from the students