Intermolecular Bonds: Polymer Density Separation Analysis

Background:

All plastics do not share the same chemical structure and therefore have unique physical properties. Plastic materials collected for recycling must be separated before being melted down, in order to preserve the integrity of the material and its value. Quite often, the plastic materials need to be cut into smaller pieces or “flakes,” in order to undergo separation treatments. Float tanks are the most common wet method, separating material based on density and whether it sinks or floats. The smaller pieces also allow further processing and to provide easier packaging, transportation, and distribution of recycled stock.

A critical component of a float tank system is the liquid medium used to separate the plastics by density. The application of chemistry can be used to design fluid mixtures that are “tuned” to achieve specific densities that will enable the separation of a particular mixture of plastics.

The ASTM International Resin Identification Coding System, often referred to as Recycling Codes, is a set of symbols appearing on plastic products that identify the plastic resin out of which the product is made. An example table of these codes is included below.

Your task:

In this lab, you will be directed to create a mixture that can be used as a separation medium for specific plastics. Your objective is to observe how this separation process works; and most importantly, explain the chemistry that occurs to make the separation process effective.

The guiding question of this investigation is: “What occurs at the molecular level, that makes the addition of sodium chloride critical for this separation process to be effective?”

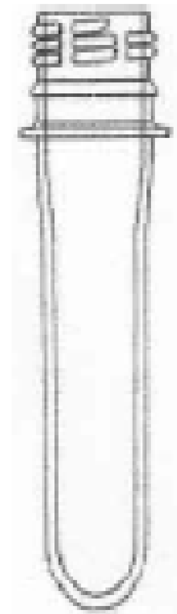
Getting Started Within Your Groups:

Your “float tank” (tube) already has two kinds of plastic pellets inserted into it: polyethylene terephthalate (PETE, recycle code #1) and high density polyethylene (HDPE, recycle code #2). These may be separated using fluids that have different densities from each other as well as the plastics.

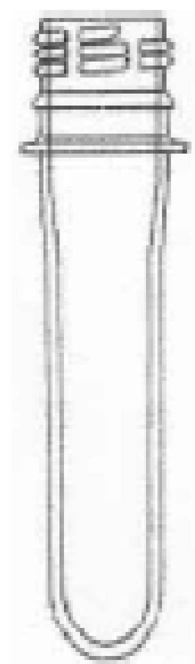
Prepare your “float tank” (tube) as follows:

1. Add 20 ml isopropyl alcohol (C_3H_7OH), cap and shake.
2. Record your observations.
3. Add 10 ml of water (H_2O), cap and shake.
4. Record your observations.
5. Go to your instructor to have dyes placed into your tube (1 drop yellow, 2 drops blue). The blue dye is an alcohol based dye and is therefore miscible only in alcohols. The yellow dye is a water-based dye and is therefore miscible only in water.

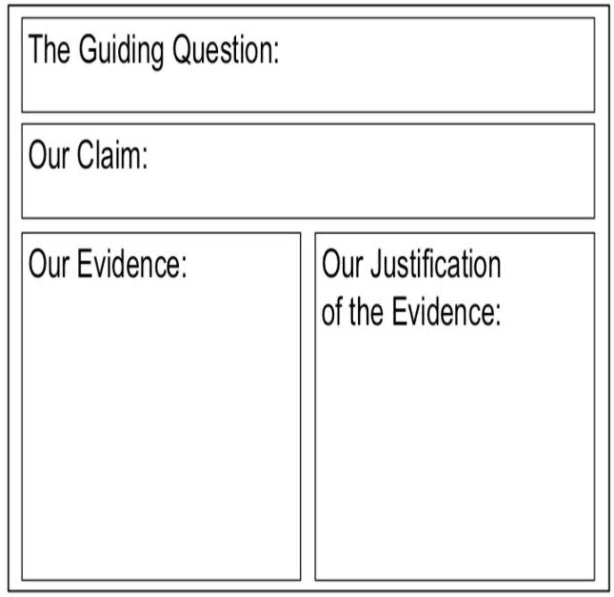
6. Secure the cap to the tube, shake for 30 seconds and then let rest.
7. Record your observations, using the figure of the tube to aid your description.



8. Now remove the cap and add 4 grams of sodium chloride. Secure the cap to the tube, shake for 90 seconds (or until salt dissolves) and then let rest.
9. Record your observations, using the figure of the tube to aid your description.



10. **Initial Argument**
Develop an initial argument to explain the chemistry behind your observations. Your argument must include a ***claim***, which is your answer to the guiding question. Your argument must also include ***evidence*** in support of your claim. The evidence is your analysis of the data and your interpretation of what the analysis means. Finally, you must include a ***justification*** of the evidence in your argument. You will therefore need to use a scientific concept or principle to explain why the evidence that you decided to use is relevant and important. You will create your initial argument on a whiteboard. Your whiteboard must include all the information shown to the right.



11. **Argumentation Session**
The argumentation session allows all of the groups to share their arguments. One member of each group stays at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the initial arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see.

To critique an argument, you might need more information than what is included on the whiteboard. You might therefore need to ask the presenter one or more follow-up questions, such as:

- What did your group do to analyze the observations, and why did you decide to do it that way?
- Is there another way to interpret the observations of your group? How do you know that your interpretation of the analysis is appropriate?
- Were there possible observations that were overlooked?
- What other claims did your group discuss before deciding on that one? Why did you abandon those alternative ideas?
- How confident are you that your group's claim is valid? What could you do to increase your confidence?

12. **Post Argument Session**
Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

13. **Report**
Once you have completed your research, you will need to prepare an *Investigation Report* that consists of three sections that provide answers to the following questions:

a. What question were you trying to answer and why?
b. How did you use Lewis Structure Diagrams during your investigation and why did you conduct your investigation in this way?
c. What is your argument (claim, evidence and justification)?

Your report should answer these questions in two pages or less. The report must be typed (double-spaced, using a 12 point font) and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

Reference Documents

Electronegativity Values (Pauling Scale)

H 2.20																	He n.a.
Li 0.98	Be 1.57											B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne n.a.
Na 0.93	Mg 1.31											Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar n.a.
K 0.82	Ca 1.00	Sc 1.36	Ti 1.54	V 1.63	Cr 1.66	Mn 1.55	Fe 1.83	Co 1.88	Ni 1.91	Cu 1.90	Zn 1.65	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	Kr 3.00
Rb 0.82	Sr 0.95	Y 1.22	Zr 1.33	Nb 1.60	Mo 2.16	Tc 1.90	Ru 2.20	Rh 2.28	Pd 2.20	Ag 1.93	Cd 1.69	In 1.78	Sn 1.96	Sb 2.05	Te 2.10	I 2.66	Xe 2.60
Cs 0.79	Ba 0.89	La 1.10	Hf 1.30	Ta 1.50	W 2.36	Re 1.90	Os 2.20	Ir 2.20	Pt 2.28	Au 2.54	Hg 2.00	Tl 1.62	Pb 2.33	Bi 2.02	Po 2.00	At 2.20	Rn n.a.
Fr 0.70	Ra 0.89	Ac 1.10	Rf n.a.	Db n.a.	Sg n.a.	Bh n.a.	Hs n.a.	Mt n.a.	Ds n.a.	Rg n.a.	Uub n.a.	—	Uuq n.a.	—	—	—	—

Difference in Electronegativity Between Two Atoms	Type Of Bond
0	Non-Polar Covalent
0 > 0.5	Weak Polar Covalent
0.5 > 2.1	Strong Polar Covalent
> 2.1	Ionic

Household plastics, from least dense to most dense:

Recycle code	Density in g/mL	Symbol	Name
isopropyl alcohol	0.86	C_3H_7OH	2-propanol
rubbing alcohol	0.88	water in alcohol	70% isopropyl alcohol
5	0.90-0.91	PP	polypropylene
corn oil	0.92-0.93		Not a plastic
4	0.92-0.94	LDPE	low density polyethylene
2	0.95-0.97	HDPE	high density polyethylene
water	1.00	H_2O	Not a plastic
6	1.05-1.07	PS	polystyrene
salt water	~1.2	NaCl(aq)	saturated salt solution
3	1.16-1.35	PVC	polyvinyl chloride [in film form]
1	[illegible]	[illegible]	[illegible]

Plastic Identification Codes

Plastic Identification Code	Name of plastic	Description	Some uses for virgin plastic	Some uses for plastic made from recycled waste plastic
1 PETE	Polyethylene terephthalate PET	Clear, tough plastic, may be used as a fibre.	Soft drink and water bottles.	Soft drink bottles, detergent bottles, clear film for packaging, carpet fibres, fleecy jackets.
2 HDPE	High density polyethylene HDPE	Very common plastic, usually white or coloured.	Milk and cream bottles, bottles for shampoo and cleaners.	Compost bins, detergent bottles, crates, mobile rubbish bins, agricultural pipes, pallets, kerbside recycling crates.
3 V	Un-plasticised polyvinyl chloride UPVC	Hard, rigid plastic, may be clear.	Clear cordial and juice bottles, blister packaging	Detergent bottles, tiles, plumbing pipe fittings.
4 LDPE	Low density polyethylene LDPE	Flexible plastic.	Ice-cream containers lids, garbage bins.	Film for builders, industry, packaging and plant nurseries, bags.
5 PP	Polypropylene PP	Hard, but flexible plastic - many uses.	Ice-cream containers, hinged lunch boxes.	Compost bins, kerbside recycling crates, worm factories.
6 PS	Polystyrene PS	Rigid, brittle plastic. May be clear, glassy.	Yoghurt tubs, margarine containers.	Clothes pegs, coat hangers, office accessories, spools, rulers, video/CD boxes.
7 OTHER	Other	Includes all other plastics, including acrylic and nylon. These plastics – if they take the form of plastic containers - are also able to be recycled in your yellow-lid bin.		

Grading Rubric
Intermolecular Bonds: Polymer Density Separation Analysis

Objective	Points
Intro: Provide background of experiment; Guiding question is clearly stated and related to the background.	/ 6
Method: Describe and defend the procedure for collecting selected data.	/ 6
Method: Describe how data was analyzed and explain why the analysis helped answer the Guiding Question.	/ 6
Argument: Claim is clearly stated so that it explicitly and correctly answers the Guiding Question.	/ 6
Argument: Evidence presented in properly labeled diagrams, graphs and/or tables.	/ 6
Argument: Valid analysis of quality evidence is made; evidence is referenced and consistent with claim.	/ 6
Argument: Justification of evidence is provided using specific science concept(s) and principles.	/ 6
Error Analysis: Logically explain two potential causes of error and their effect on the experimental results. Clearly identify how the direction of the error would impact the experimental results to become overstated or understated.	/ 6
Mechanics: Double-spaced, passive voice, proper grammar, correct terms used, persuasive style used.	/ 6
Total	/ 54