Making a Gradient Density Column

(Project CLVE: Chemical Laboratories with Video Enhancement)

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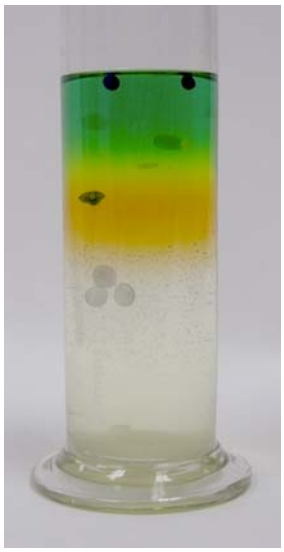


Purpose: to make a gradient density column using the solutions from the *Hands On Plastics 2* (HOP 2) Kit.

Hypothesis: If a density column has three different liquids so that the bottom liquid has a density of 1.1 g/cm^3, the middle layer has a density of 1.0 g/cm^3 and the top layer has a density of 0.9 g/cm^3, then the pellets of the six recycled plastics will be in which positions in the column?

Density Table

Substance	Density (g/mL)
(1) PETE	1.38-1.39
(2) HDPE	0.95-0.96
(3) PVC	1.16-1.35
(4) LDPE	0.92-0.94
(5) PP	0.90-0.91
(6) PS	1.05-1.07

Background: A polyethylene (PE) industry needs to know the density of the newly manufactured PE pellets before the pellets are shipped to its customers. Each batch of pellets is thousands of pounds and customers want to be assured that the shipment is uniform and up to specifications. One quick way to test for density is to drop a few new pellets into a column of liquid. This liquid is a graduated series of densities with the heaviest on the bottom. Industry uses propanol (propyl alcohol) and water solutions for PE and each reference pellet in the column has a known density to 4 significant figures. The gradient density column you will construct today is made from solutions of calcium chloride, water, and isopropyl alcohol. The six recycled plastic pellets will be visible in the column with the densest on the bottom.

Materials: (for a pair or students)

HOP 2 kit of 6 recycled pellets from the American Plastics Council (free)
http://www.teachingplastics.org/
Saturated calcium chloride solution
70% isopropyl alcohol
water
plastic pipets
graduated cylinder- 25 or 50 mL
food coloring
safety goggles

Procedure:

1. Do the activity described in the HOP 2 kit called "Can you find the floaters and sinkers?" It is not necessary to color the alcohol blue at this time. As you identify each pellet by its behavior in the solutions, pause to save the solutions to use in the gradient column later. Label each solution so it will be easy to identify them later.
2. Use a graduated cylinder to make the column of solutions. The first solution is the calcium chloride solution that you make when you separate "Y" pellets. Add this solution to the column so that you have a depth of about 2 cm. Drop in the "Y" pellets.
3. Continue with the flow chart by adding water to separate "W" and "P" pellets. When these are separated, extract a pipet full of this solution (colored with food coloring is optional) and gently add it to the column. CAREFULLY layer the two solutions so that each is about 2 cm in depth. Drop in the "W" and "P" pellets.
4. Optional: Using a plastic pipet, carefully add a layer of water that has been colored with food coloring to the column.
5. Do the other side of the flow chart to separate the other three pellets. The last solution that separates "Z" and "X" is the densest and needs to be added on top of the colored water in the column. You may color this solution before you add it. Drop in pellets "Z" and "X".
6. Add the last solution to the top of the column. This layer may be colored too. Add pellets "M".

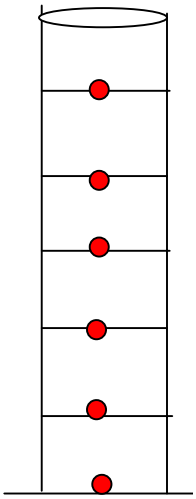
Conclusions:

1. Identify the plastic in each of the pellets by using the density table above.

Letter of Pellet from Flow Chart	Plastic Name or Letters	Plastic Density

2. Do two pellets of the same kind of plastic behave the same? If your answer is no, explain this behavior.

3. Estimate the density of the liquids in the column based on the densities of the pellets.



Density =

Density =

Water = 1.0 g/mL

Density =

Calcium chloride solution - Density =

Extensions: How could you use this column to find the density of a plastic container like a milk jug or butter container? Try it.

Teacher Notes for Making a Gradient Density Column

Overview: Making a gradient density column is a directed laboratory with very explicit instructions. It will take one or two class periods to do the HOP 2 kit laboratory and to make the column. Students might have to store solutions until the next day. Cover them with Saran® wrap to prevent evaporation.

National Science Education Standards Addressed for Grades 9-12:
Content Standard B: Structure and Properties of Matter
Content Standard E: Understanding about Science and Technology

Safety Notes: All the solutions may be poured down the drain. Save the resin pellets!

Procedural suggestions:
Do not color the alcohol blue as suggested in the HOP 2 kit.

It is also possible to change this laboratory into a "problem-based" instead of a "directed" one by having students do the HOP 2 "Floaters and Sinkers" activity and tell the students to save solutions for a density column. This method will make students realize that the densest liquid (concentrated $CaCl_2$) will be on the bottom. Many students may not recognize that the most dense alcohol/water solution is the last one on the flow chart! Best results are obtained if the solutions are carefully added in order from most dense to least, with no bubbles in the pipet stem. Bubbles will tend to mix solutions.

For the Extension suggestion: Cut a small piece of plastic from a container like a HDPE milk jug or PETE soda bottle and drop the piece into the column. Avoid trapping air bubbles under the piece. Each sample should settle at its appropriate location based on its relative density.

Over a period of time, a column like this will lose its layering because of diffusion. A picture of a real column about a day old is on the next page. The orange layer is water and this apparently mixed with calcium chloride solution below it so the PS pellets are floating in the water layer. There are two colorless layers of calcium chloride solutions at the bottom of the column. The QuickTime movie (on www.polymerambassadors.org) shows how to make the gradient density column with the pellets or plastic resins in the correct positions. The four solutions in the movie are colored to make the layering more visible.

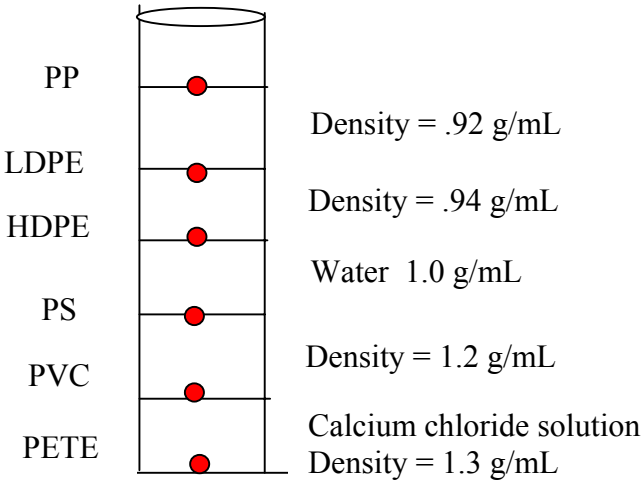
Answers to conclusion questions:

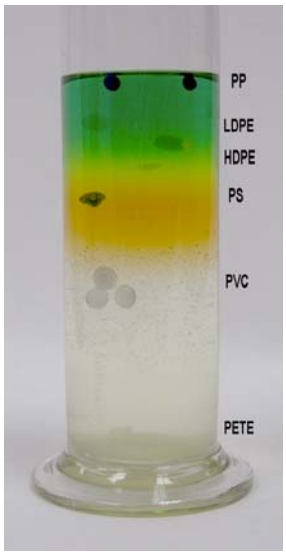
1. Identify the plastic in each of the pellets by using the density table above.

Letter of Pellet from Flow Chart	Plastic Name or Letters	Plastic Density
Y	PETE	1.38-1.39
W	PS	1.05-1.07
P	PVC	1.16-1.35
Z	LDPE	0.92-0.94
X	HDPE	0.95-0.96
M	PP	0.90-0.91

2. Do two pellets of the same kind of plastic behave the same? If your answer is no, explain this behavior. *If two pellets of the same kind don't behave the same, it could be due to adhering bubbles, more coloring agent in a particular pell,t or some other variation in the manufacture of the pellets. These are recycled plastics so the pellets tend to have some variation in their densities.*

3. Estimate the density of the liquids in the column based on the densities of the pellets.





Equipment: Calcium chloride may be purchased from Flinn or Sargent Welch. Bags of deicer for walkways also may contain calcium chloride but read the label before you buy any. Directions for making the solutions are given in the HOP 2 kit. Allow several weeks for delivery.

Visit www.polymerambassadors.org for video enhancement
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