

Sink, Float, Sort: How a Recycling Plant Tells Plastics Apart

Learning target: I can explain, with evidence from a passage, how a recycling plant uses density and other properties to identify look-alike plastics, and why one property is rarely enough.

Reading with evidence

About 35 min

Individual

MS-PS1-2 · practice

MS-PS1-3 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once without stopping. Read it a second time with a pencil: number the paragraphs 1 to 7 and circle every number that has a unit (g/cm^3 , $^{\circ}\text{C}$, percent). Answer in complete sentences. When a question asks for evidence, quote the passage or paraphrase it closely and write the paragraph number in parentheses.

You will need: This worksheet, Pencil, Scrap paper for the property tracker, Calculator (optional)

Sink, Float, Sort

[1] A bale of mixed plastic arrives at a recycling plant looking like one kind of stuff: a crushed tangle of bottles, tubs, trays and lids. It is not one kind of stuff. The bale holds at least six different substances, each a different plastic, and a factory that melts them together gets a weak, streaky material that nobody wants to buy. Plastics are synthetic materials made from natural resources such as oil and natural gas, and each kind has its own set of properties. The plant's job is to use those properties to pull the tangle apart, substance by substance.

[2] The first clue is printed on the item. Since 1988, a plastics industry group has stamped most containers with a small triangle and a number from 1 to 7. A 1 means PET, the clear plastic of soda bottles. A 2 means high-density polyethylene, the cloudy plastic of milk jugs. A 5 means polypropylene, used for yogurt tubs and caps. The code is helpful but weak. Labels wear off, lids get separated from bottles, and a sorting line moving thousands of pieces a minute cannot stop to read each one. The plant needs properties it can test on every piece automatically.

[3] The oldest and cheapest test uses density. Shredded flakes drop into a tank of water. Polyethylene has a density of about $0.95 \text{ g}/\text{cm}^3$ and polypropylene about $0.90 \text{ g}/\text{cm}^3$, both lower than water's $1.00 \text{ g}/\text{cm}^3$, so their flakes float and are skimmed off the top. PET, at about $1.38 \text{ g}/\text{cm}^3$, sinks and is collected from the bottom. The tank does not care about the shape, color or size of the flake. A tiny chip of PET and a large one sink just the same, because density belongs to the substance, not to the piece.

[4] Density also shows where the method fails. Polyvinyl chloride, PVC, the plastic of blister packs and pipes, has a density of about 1.38 to $1.41 \text{ g}/\text{cm}^3$, nearly the same as PET. In the water tank they sink side by side. This matters because PVC and PET behave very differently when heated: PET melts cleanly at

about 250 °C, while PVC begins to break down near 150 °C and gives off hydrogen chloride gas, which corrodes equipment and spoils the batch. A few PVC flakes in a ton of PET can ruin it. When two substances share a property, a plant has to test a second property to tell them apart.

[5] A second test uses light. A near-infrared sorter shines invisible light, just beyond red, onto the flakes and reads the pattern each flake reflects. Every plastic reflects its own pattern, a kind of fingerprint, so the machine can flag PVC among PET and blow it aside with a puff of air. Even this test has a blind spot. Black plastic, colored with carbon black, swallows nearly all the infrared light and reflects almost nothing, so the sorter cannot read it. Black trays often end up in the trash for that reason.

[6] Chemists in the plant's lab use a third property when the machines disagree: solubility. A flake of PET will not dissolve in water or ordinary alcohol, but it dissolves in certain strong solvents in which polyethylene stays solid. A questionable flake dropped into a small dish of the right solvent settles the argument. Like the water tank, this test gives the same answer for a big flake and a small one, because solubility is also a property of the substance.

[7] Notice what the plant never does. It never sorts by mass, because a heavy flake of polypropylene and a light flake of PET are both ordinary. It never sorts by color, because a blue PET bottle and a blue polyethylene jug are different substances in the same disguise. Every reliable test on the line measures something that stays the same for every piece of a substance no matter its size or shape: density, melting behavior, the infrared fingerprint, solubility. And no single test is trusted alone. The water tank, the light sorter and the lab each catch what the others miss, which is how a careful scientist identifies any unknown: several properties, compared against a table of known substances, until one answer is left.

Questions: cite the passage

1. According to paragraph 1, why can't the plant simply melt the whole bale together? Quote the phrase that describes the result.

2. Paragraph 2 calls the number code 'helpful but weak.' Give two reasons from the paragraph that it is weak.

3. Using the densities in paragraph 3, a flake of PET with a volume of 2.0 cm^3 and a flake of polypropylene with a volume of 2.0 cm^3 are weighed. Calculate the mass of each and the difference between them. Show your work.

4. Paragraph 3 says the tank 'does not care about the shape, color or size of the flake.' Explain in your own words why this is true, using the word *substance*.

5. Paragraph 4 describes a case where the density test fails. Name the two substances, give the evidence (with numbers) that density cannot separate them, and explain why mixing them up is a serious problem.

6. Paragraphs 5 and 6 each describe a test with a limitation. Name each test and its limitation, citing the paragraph.

7. Paragraph 7 lists two things the plant 'never does.' State both and explain, using the idea of identifying properties, why those two methods would fail.

8. The passage ends by comparing the recycling plant to 'a careful scientist.' Using evidence from at least three different paragraphs, explain what the plant and the scientist do the same way, and why doing it that way leads to a reliable identification.

A property tracker

Before answering, make a four-row chart on scrap paper with the headings Property, Which paragraph, What it tells apart, and Where it fails. Fill one row each for density, melting behavior, the infrared fingerprint and solubility. Questions 3 through 8 can all be answered from your chart plus one quotation.

Rescue the black tray

Paragraph 5 says black plastic defeats the light sorter, so black trays are often thrown away. Write a short memo to the plant manager that answers three questions with evidence from the passage: Which of the plant's other tests still work on a black flake, and why does color not affect them? If the black flakes are a mix of PET and polypropylene, which single test would separate them completely? Which pair of black plastics would still be impossible to separate with those tests, and what would you tell the manager to do with that pair?