Property Differences in Polymers: Happy/Sad Balls

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Abstract
This demonstration shows that differences in composition can drastically affect the properties of the balls that look identical. Here, balls with different resiliencies and densities are bounced to demonstrate these differences. While balls may appear to be the same, their composition differences lead to their different properties. Students become aware also that differences in ways of making the balls also can affect properties. Students can continue the experiments with balls from home.

Objectives: The student will be able to
- Explain that materials with similar appearance do not necessarily have the same properties
- Explain how different compositions of balls leads to different properties
- Experiment with their own balls and explain differences

MatEd core competencies addressed (most important in bold)
- 4B Determine and develop effective project interactions
- 7B Explain the general nature of polymers and plastics
- **16A Explain Effects of Processing and Manufacturing Variations on Material Properties**

Key Words: polymer, structure, processing, properties

Type of Module: Demonstration or full class laboratory

Time Required

As a simple bouncing demonstration:
10 minutes with discussion

Full experiment:
For introductory classes: 90 minutes
For advanced classes: 60 minutes

Grade Level: Middle school through college

Equipment and supplies needed:
Happy/Sad balls (see references for sources)
An assortment of other balls, as available
(e.g., racket balls, golf balls, superballs, misc. toy balls)

For cooling, use ice, dry ice or liquid nitrogen, as available
For heating, boil water in a Pyrex beaker on a hot plate
Note the safety precautions in reference 1

Instructor background and notes:

Polymer structure differs from metals in that polymers are long chain molecules. Structural differences come from the degree of stiffness of the chain itself, the presence of molecules attached to the chain, and cross-links between chains. A microstructural model of simple polymer chains in a product would look something like a pot of boiling spaghetti. Commercial plastics consist of polymer molecules with specific properties and specific additives needed to provide the properties of the product.

In addition to changing the structure and adding other polymers to a plastic, changes in properties can also be related to changes in processing or production of the product. By experimenting with different types of balls, students can get an understanding of the influence of both structure and processing on a plastic product.

Procedure: Demonstration
Bounce the "happy" ball on a table and note how high it bounces. Invite a student to do the same. Then substitute the "sad" ball that does not bounce. Discuss with the class what the differences may be and how they could find out.

Procedure: Full Experiment

After the demonstration above, conduct the Happy/Sad ball experiments as outlined on the Polymer Ambassador web site, reference 1. Include the experiments of comparing densities, cooling and heating, as described. Refer to the discussion in ref. 1 to lead the class to answer these questions:

1. What makes the happy ball bounce so well? What are its important components? What would happen if one or more of these components were omitted when the ball is made? What if an incorrect amount of one of these components were omitted?
2. Help the students understand the reasons for the differences they found in densities and after cooling and heating.
3. Compare the components of the sad ball to the happy ball. Why are their properties so different even when they look alike?
4. Discuss the applications of plastics with the components of the Happy ball. The Sad ball.

Optional additional activities
Experiment with the bounce of several other types of balls. Investigate whether there are differences of properties with changes in temperature.
Discuss with the class the differences and have them speculate why they are different.
Have the class do Internet research on the composition and processes used to make several different types of balls.

References

1. An extended set of experiments with Happy/Sad Balls is available at http://www.polymerambassadors.org/happyandsad.pdf
2. The recommended source for larger balls is http://www.teachersource.com/Energy/EnergyConversion/ChoositzDecisionBalls.aspx
3. Other sources are available on the Internet by looking for "Happy Sad Balls," including a number of sources for the balls themselves. Two inexpensive sources for smaller balls are http://www.enasco.com/product/SB33947M and http://www.arborsci.com/prod-Happy_Unhappy_Balls___Happy_Sad_Balls-362.aspx
4. A general discussion on polymers and their structure is available on Wikipedia, http://en.wikipedia.org/wiki/Polymer

Evaluation

Student evaluation questions (discussion or quiz):

1. Why do the balls bounce differently even though they look the same?
2. Does density play a role in the differences between happy and sad balls?
3. Why does heating help the sad ball bounce better?
4. What happens to the happy ball when it is cooled?
5. How would you use the material from the happy ball in your bicycle? The sad ball?

Instructor evaluation questions:

1. At what grade level was this module used?
2. Was the level and rigor of the module what you expected? If not, how can it be improved?
3. Did the activity work as presented? Did they add to student learning? Please note any problems or suggestions.
4. Was the background material sufficient for your background? Sufficient for your discussion with the students? Comments?
5. Did the activity generate interest among the students? Explain.
6. Please provide your input on how this module can be improved, including comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Course evaluation questions (for the students)

1. Was the activity clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. Was the importance of materials testing made clear?
6. What was the most interesting thing that you learned?