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Happy and Unhappy Balls

P6-1000

BACKGROUND:

Happy and Unhappy Balls sometimes known as Happy Sad Balls, are a pair of black spheres which appear to be almost identical. The "unhappy" ball is formed from a proprietary rubber compound developed and manufactured under the trade name "Norsorex," while the "happy" ball is made of conventional neoprene rubber. Although the two balls appear to be quite similar, they exhibit marked difference in their physical properties:

PHYSICAL PROPERTIES:

Low v. High Hysteresis: Hysteresis is a measure of the retardation of the natural tendency of rubber to return to its original shape after deformation. This retardation is caused by internal frictional forces resulting from the molecular structure of the rubber. The dead or "unhappy" ball exhibits the greatest hystersis.

Rate of Restitution: The ball with low hystersis (the "happy" ball) exhibits a more rapid return to its original shape, resulting in its greater bounce (it has a high coefficient of restitution). Paradoxically, as the balls are cooled below room temperature, the bounce of the "happy" ball is diminished somewhat while that of the dead ball increases. Figure 1 shows the changes in the energy absorption rate of Norsorex with changes in temperature.

Coefficient of Friction: The molecular structure of the two types of rubber is also responsible for discrepant qualities in the surface friction of the balls. The "happy" ball exhibits lower surface friction and rolls more rapidly than the dead ball.

SUGGESTED EXPERIMENTS:

Challenge your students to perform the following experiments and some up with logical explanations for the observed events.

1. A Rolling Ball Gathers Momentum: Set up an inclined plane at least one meter in length (a table tilted 15-20 degrees by books propped under the legs will suffice) and roll both balls simultaneously from the same starting point. Note which ball reaches the end of the incline first. Does it do so consistently? What clues does this provide about the friction of the balls relative to the surface and in comparison with each other? The "unhappy" ball, of course, because of its higher coefficient of friction, rolls more slowly. It is this friction which makes rubber of this type very desirable for racing tires where road adhesion is required at high speed. Too much friction, however, will cause heat build up and excessive tire wear, so this property must be balanced by blending high-friction rubber with a more firmly vulcanized rubber.

2. **Sphere of Flying:** Drop both balls onto a hard surface from a fixed height and determine the height of the first bounce (if any). Place both balls in a container of ice or a freezer for about twenty minutes and repeat your measurements. What differences are observed? Why does the dead ball bounce? Would you think that the dead property of the rubber is temperature dependent? Why? Explain any observed differences in the behavior of the “happy” ball.

3. **The Chiller Instinct:** Determine the rate at which each ball returns to shape after being compressed by a vise of heavy tongs. Chill the balls first as before, then repeat. Are there differences in the rate at which the balls return to shape?

EXPLANATION:

Restitution is the “desire” of a substance to return to its original shape, almost a molecular memory of its original form. The dead ball has a very low coefficient of restitution, the other ball a high coefficient; each property can have practical benefits. In running shoes, for example, the superior ability of a “dead” rubber to absorb shocks helps to alleviate the tremendous pounding to which the foot, leg, and ankle are subjected. A rubber with a high coefficient of restitution – that is, one with a lot of bounce – would be ideal for handballs or other applications. Ask your students to think for practical uses for both types of rubber. They might surprise you with their creative answers.

Chemical Formulation: Figure 2 outlines the primary steps in the formation of Norsorex. First, ethylene cyclopentadiene is converted to the monomer norbornene via the Diels-Alder reaction, then the monomer is converted polymerized by a process which opens the norbornene ring, creating alternating bonds between the five-member ring and the newly-exposed double bonds. This polymerization process means that vulcanization can be done utilizing the double bond.converted into electromagnetic radiation.

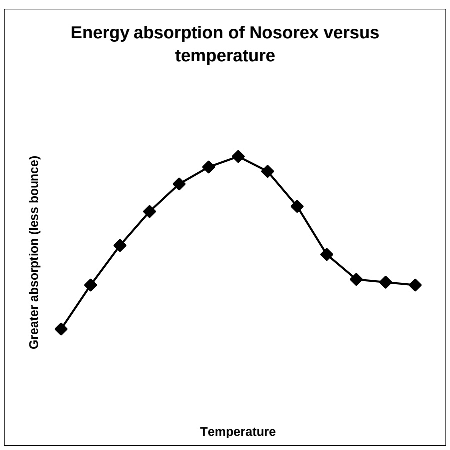
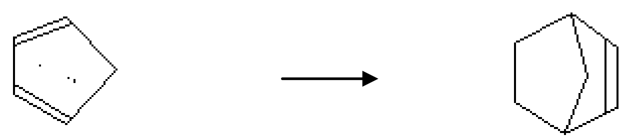


Figure 1

Diels-Alder reaction

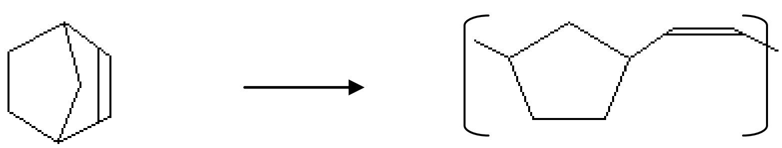
$CH_2 = CH_2$ +



ethylene cyclopentadiene
Norborene

Figure 2

Ring-opening polymerization



Norborene

Poly norborene (Brand name: Norsorex)