HAPPY / UNHAPPY BALLS

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DESCRIPTION:

Happy and Unhappy Balls are a pair of black spheres which appear to be almost identical. The 'Unhappy' ball is made from a rubber compound developed and manufactured under the trade name 'Norsorex' and the 'Happy' ball is made from conventional neoprene rubber. Although the two balls appear to be quite similar, they behave very differently because of their physical properties.

PHYSICAL PROPERTIES: Low and High Hysteresis:

Low versus High Hysteresis:

Hysteresis is a measure of the retardation of the natural tendency of a material to return to its original shape after deformation. This retardation is caused by internal frictional forces which are caused by the molecular structure of the material. The dead or 'Unhappy' ball shows the greatest hysteresis.

Rate of Restitution:

The ball with low hysteresis (the 'Happy' ball) shows a more rapid return to its original shape and this results in its greater bounce. That is, it has a high 'coefficient of restitution'. Surprisingly, as the balls are cooled below room temperature, the bounce of the 'Happy' ball is reduced and the bounce of the 'Unhappy' ball increases. Fig.1 below 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 responsible also for differences in the surface friction of the balls. The 'Happy' ball shows a lower surface friction and it rolls more rapidly than the dead ball.

EXPERIMENTS: Encourage your students to perform the following experiments and to present logical explanations for their observations.

ROLLING BALLS: Set up an inclined plane at least one meter in length. A table tilted 15-20 degrees by books under the legs will do. 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, because of its high coefficient of friction, rolls more slowly. It is this friction which makes this type of rubber desirable for racing tyres where high road adhesion is required at high speeds. However, too much friction will cause heat build up and excessive tyre wear, so this property must be balanced by blending high-friction rubber with a more normal vulcanized rubber.

BOUNCING: Drop both balls onto a hard surface from a fixed height and determine the height of their 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 ?

Do you think that the dead property of the rubber is temperature dependent ? Why ? Explain any observed differences in the behavior of the 'Happy' ball.

EFFECTS OF CHILLING: Using a timer to determine the rate at which each ball returns to shape after being flattened by a vise or strong tongs or pliers. Then repeat the experiment after chilling the balls in a freezer or in ice. Are there differences in the rate at which the balls return to shape ?

RESTITUTION: Restitution is the 'desire' of a substance to return to its original shape. It is sort of a 'molecular memory' of its original form.

The dead ball has a very low coefficient of restitution, the other ball has a high coefficient, but each property can have practical benefits. In running shoes, 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 bouncy applications.

Ask your students to think of practical uses for both types of rubber. They might surprise you with their creative answers.

CHEMICAL FORMULATION:

Figure 2 below outlines the primary steps in the formation of ‘Norsorex’.

First, ethylene cyclopentadiene is converted to the monomer (norbormene) via the Diel’s-Alder’s reaction. Then the monomer is 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 performed utilising the double bond.

Fig.1

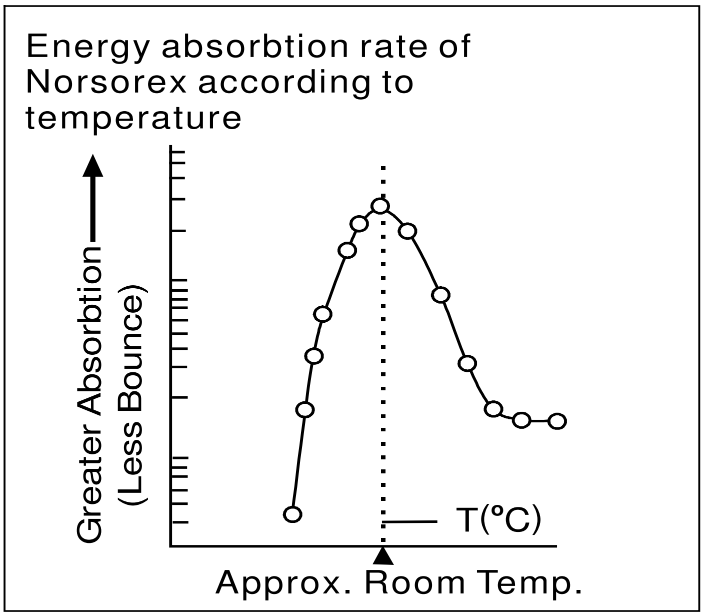

Fig.2