

CHEMISTRY IN THE TOY STORE

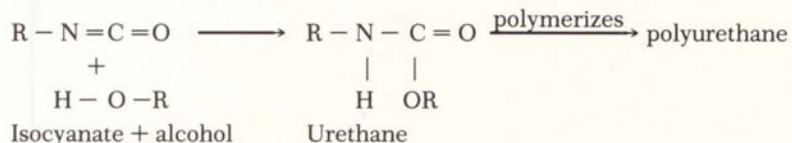
Part 2: Polymers:

Craft Cast, Silly Putty, Slime, Super Ball, Wall Walkers, and Magic Eggs (Grow Creatures)

Craft Cast

Craft Cast® is a two-part liquid material that, when mixed in equal amounts, produces a rigid polyurethane foam that can be used for insulating and soundproofing and to make castings of objects. Part A consists of a polymer containing either two or three hydroxyl groups, a blowing agent, a silicone surfactant, and a catalyst. Part B contains a polyisocyanate.

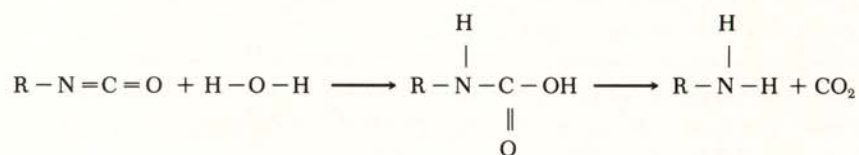
When the two parts are mixed, a polymerization reaction occurs that results in the formation of a large molecule that is rigidly held into a three-dimensional structure. At the same time, the small amount of water present causes a decomposition of some of the isocyanate and the evolution of carbon dioxide that results in foaming. The carbon dioxide bubbles create pores in the viscous mixture as the foam sets into a rigid mass. The cell size and structure of the foam are controlled by the silicone surfactant. A generalized reaction scheme is:



A magician demonstrates the needle-through-the-balloon trick. At the far left he inserts, slowly and with a twisting motion, a large needle into a balloon of good-quality rubber. The balloon should be inflated to its maximum extent and a small amount of air released from it; the end should be tied into a knot. The needle, pointed toward the knotted end, should be wiped with a cloth containing a small amount of oil. If the needle is sufficiently sharp and smooth, it will not tear the rubber but will slide between the rubber's polymer chains and emerge at the opposite side (middle). With the proper equipment even a string attached to the needle can go through the balloon (above).

Magic effect by Ralph Beck; photos, Bill Arsenault

The reaction forming the carbon dioxide is:



Part B may contain toluene diisocyanate (toluene-2, 4-diisocyanate), a substance that is toxic as well as an irritant to the skin and eyes. It may also cause an allergic response. This material should be used only with good ventilation.

A variation of the polyurethane foam is a product called String Con-fetti. Manufactured in France, it is an aerosol spray producing instant streamers of colored foam that become hardened when they are exposed to air.

Silly Putty and Slime

Silly Putty, under low stress as when being slowly pulled apart (below), flows and forms thin strands. When under high stress, such as a sharp pull, it breaks (below right). Transfer of pictures from a newspaper to Silly Putty (bottom right) is accomplished by a reaction between the silicone oil in the putty and the newspaper ink.

Silly Putty® is a silicone polymer that is marketed by Binney & Smith Inc. and sold under other names by other companies. It is packaged in small egg-shaped containers and is usually pink in color. Some forms of Silly Putty contain phosphorescent material that will allow it to glow in the dark.

Silly Putty tends to dilate (or expand) when sheared, resulting in an increased viscosity under stress. For this reason it has some unique properties: (1) under low stress, such as being slowly pulled apart, the



Reproduced by permission of Binney & Smith, Inc.; photos, Cameramann International, Ltd.



© Mattel, Inc., 1987, photo, left, Charles Cegielski



Silly Putty flows, forming thin strands; (2) under high stress, such as a sharp pull, the putty breaks; (3) if rolled into a ball and dropped, the putty will bounce; (4) if a ball of putty is placed on a tabletop and hit with the hand, the ball will hardly be deformed; if hit with a hammer, it will shatter; yet if it is squeezed gently, the ball will flatten; (5) if the putty is stuffed through a tube, it will swell as it emerges from the open end; this is known as die swell. (This works best with freshly prepared putty because the putty tends to harden with age.)

When Silly Putty is prepared in the laboratory, it is initially clear and either colorless or slightly yellow. It will cure within one week to an opaque white solid with properties closer to the commercial Silly Putty, which contains fillers to make it stiff. As it is used, it will pick up foreign matter and become gray in color and slowly improve its properties so that they become similar to those of the commercial product.

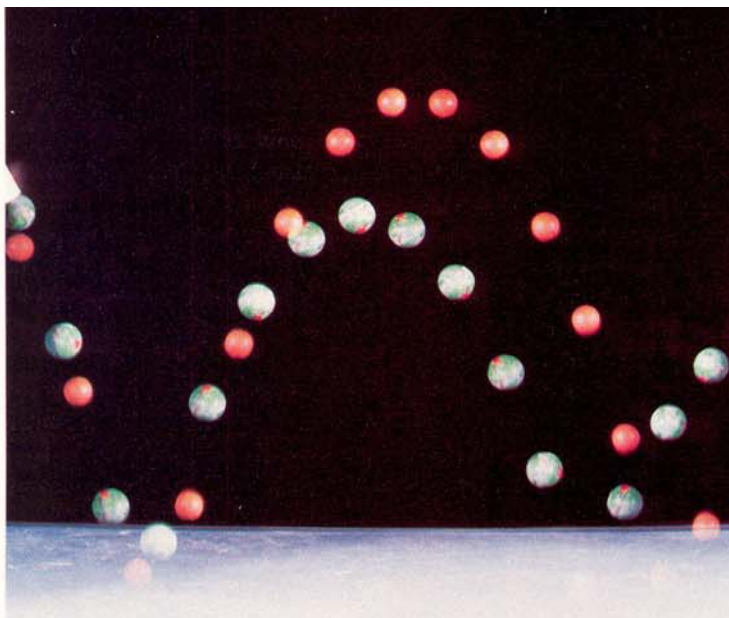
One of the interesting properties of Silly Putty is that it picks up pictures from newspapers or the comic sections. This is a function of the ink that is used in newspapers. The ink is composed of mineral oil and carbon black or colored pigments. These inks do not dry readily, as is demonstrated when a finger is rubbed over them. When Silly Putty is placed on the newsprint, the pigment is transferred to the excess silicone oil in the putty.

Slime® is a cross-linked gel made from natural gum. Like Silly Putty, Slime is a fluid that is dilatant. Its properties are also similar: (1) if Slime is pulled slowly, it will flow and stretch; if one is careful, a thin film will form; (2) if Slime is pulled sharply, it breaks; (3) if Slime is poured from

Slime is poured out of a container and oozes through a child's hand (above left). If Slime is pulled sharply, however, it breaks. In the popular toy Slime Pit (above), Slime is poured into the head of the monster after which it flows from the monster's mouth onto the figure below.

The Super Ball, colored orange, bounces higher than its ordinary counterpart. Consisting of about 100 parts polybutadiene, 0.5 to 15 parts sulfur vulcanizing agent, and 5 to 15 parts of a filler such as hydrated silica or carbon black, a Super Ball has a very high resilience factor and a high coefficient of friction. The relatively large amount of sulfur vulcanizing agent produces the high resiliency.

Wham-O a Kransco Group Company; photo, Cameramann International, Ltd.



its container and the container is then tipped upward slightly, the gel will self-siphon; (4) if a small piece of Slime is placed on a tabletop and hit with the hand, there is no splashing or spattering; if a small piece is thrown onto a hard surface, it will bounce slightly; (5) if Slime is stuffed through a tube, die swell occurs as it emerges.

The natural gum in Slime has a molecular weight of about 220,000. It is used for a wide variety of purposes, including a protective colloid, stabilizer, thickening, and film-forming agent for cheese, salad dressing, ice cream, and soups; as a binding and disintegrating agent in tablet formulations; and in lotions, creams, and toothpastes.

Super Ball

A Super Ball® is a highly resilient ball that was originally made by the Wham-O Manufacturing Co. Similar products are marketed under other names by other manufacturers; *e.g.*, Bounce Ball. A Super Ball is a ball or sphere having an extremely high resilience factor—in excess of 90%—and a high coefficient of friction. These two qualities cause the ball to react in an extraordinary and unpredictable manner when bounced or struck. Thus, any spin applied to the ball will be accentuated when the ball rebounds from a hard surface.

The Super Ball is composed of about 100 parts polybutadiene, 0.5 to 15 parts sulfur vulcanizing agent, and 5 to 15 parts of filler such as hydrated silica, carbon black, or lithium oxide. There is a higher percentage of sulfur vulcanizing agent in a Super Ball than in products such as automobile tires in order to produce cross-linking between polybutadiene chains; this cross-linking produces the ball's high resiliency. The ball is molded at a pressure of between 500 and 3,000 pounds per square inch for 10 to 30 minutes at a temperature of 140–171° C (285–340° F). Besides the properties described above, a Super Ball exhibits an ability to conserve energy. That is, when bounced, the ball dissipates in the form of heat very little of the energy imparted to it.

A Bad Case of Worms and other wall walkers

A Bad Case of Worms®, once made by Mattel, Inc., is a small plastic case, resembling a suitcase, containing two yellow plastic “worms.” The Worms are made of a soft, limp, tackified plastic that is tough enough that a child cannot easily bite off a piece. The plastic, an isoprene polymer, is also washable so that the surface can be restored without losing the tackifier.

To use a Worm, one throws it against a smooth, clean surface, such as a wall, to which it will stick. After a while the Worm will slowly release from the wall and “crawl” down its surface. The rate of motion will depend on the cleanliness of both the wall and the Worm’s surface. When the Worm no longer adheres to a surface, it is washed with soap and water to restore its tackiness.

Similar to A Bad Case of Worms are toys in the shape of an octopus, a spider, an insect, a bat, and a skeleton. As one example, the Magic Octopus is made of a soft, limp plastic, probably a styrene or vinyl-



butadiene block copolymer (long segments of polybutadiene separated by segments of styrene or vinyl polymers) that has been tackified so that it sticks to a smooth surface on contact and then slowly releases and “crawls” down the surface. The octopus is stickier than the Worms, and it has better adhesion to surfaces. It does contain excess plasticizer, however, and thus leaves an “oily” residue on the surface that may be difficult to remove. When the octopus ceases to adhere to a surface, its stickiness can be restored by washing it with soap and water.

Variations of the Magic Octopus are the Frog and the Snapper Hand. These are highly tackified and stretchy soft rubber bands shaped as a frog’s tongue attached to a frog-shaped handle and a band with a hand-shaped end. They are cast out like a fishing line toward a small object, which will stick to the tacky band and be retrieved when the band snaps back.

Magic Eggs

Magic Eggs, also called Water Wonder Creatures and Grow Creatures, are named for egg-shaped plastic containers each of which contains a small plastic creature that swells up to 200 times its original size when placed in water. These creatures are composed of a polymer of hy-

Magic Eggs are egg-shaped plastic containers which hold small plastic creatures. When the creatures are placed in water, they swell to more than 200 times their original size. This is a result of the material from which the creatures are made, a polymer of hydrolyzed starch-polyacrylonitrile mixed with glycerine or ethylene glycol. On drying, the creatures resume their original size.

drolyzed starch-polyacrylonitrile (polyacrylonitrile is commonly known as Acrilan, Orlon, or Creslan) mixed with glycerine or ethylene glycol. This material is commonly called "Super Slurper," and it is capable of absorbing up to 2,000 times its weight of distilled water. The process is reversible, and the Magic Egg creature will shrink almost to its original size on drying.

A recent application of "Super Slurper" is in Pampers disposable diapers. The polymer gel in such diapers can absorb 80 times its weight in liquid.