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Description

This NBC Learn video focuses on the structure and properties of buckminsterfullerene molecules, carbon allotropes, along with diamonds and graphite, usually referred to as buckyballs. Buckyballs have a hollow spherical shape, like the geodesic spheres designed by American inventor and architect R. Buckminster Fuller.

Keywords

Buckyball, Buckminsterfullerene, C60, Carbon, Diamond, Graphite, Pencil, Molecule, Molecular Structure, Allotrope, Fullerene, Sphere, Nanotube, Pentagon, Hexagon, Soccer Ball, Ball Bearing, Cancer, Treatment, Computer Chip, Miniature, Hydrogen, Fuel Cell, Nobel Prize, Chemistry, Richard E. Smalley, Robert F. Curl Jr., Sir Harold Kroto, Buckminster Fuller, Geodesic, Spaceship Earth, Space Elevator, Chemistry Now
Transcript

Diamonds, Pencils and Buckyballs: A Look at Buckminsterfullerene

BETH NISSEN, reporting

How to tell the story of Buckminster-fullerene – and the whole fullerene family?

With a diamond, a pencil, a soccer ball, a shipping container, and the state of Texas.

Let’s start with this: “ice,” “rocks,” “sparklers,” “bling” in popular terms. In chemistry terms, this is what diamonds are: atoms of the sixth element in the Periodic Table – carbon – crystallized at high pressure and high temperature, deep in the Earth, over a billion years. Carbon atoms that bond together in this crystal structure form diamonds, the hardest natural substance known. Now, here’s one of the best proofs in chemistry that a molecule’s properties are determined by the atoms it’s made of and how they’re arranged: Atoms of carbon that bond to each other in this crystal structure form one of the softest natural substances – graphite, the part of the pencil that makes a mark on the page (and is commonly and wrongly called pencil “lead”). Just so you know, molecules made of atoms of the same element in different arrangements are what chemists call “allotropes.” Through the 19th and most of the 20th centuries, chemists thought diamonds and graphite were the only two carbon allotropes forms of solid carbon. But then in 1985, three chemists, two from Rice University in Houston and one from the University of Sussex in the U.K., were shooting a laser at a disk of graphite (long story) which rearranged the carbon atoms in the graphite into a molecule with a structure that looked like this: a hollow sphere, almost perfectly symmetric, the empty insides surrounded by a “cage” of 60 carbon atoms arranged like this, as if at the points of 12 pentagons (5-sided shapes) and 20 hexagons (6-sided shapes) – the pattern on a soccer ball. If you want to amaze, or just baffle, your friends, this shape is called a “truncated icosahedron.” Those 60 carbon atoms explain this molecule’s chemical formula: C
As for its name? The researchers, who, by the way, shared the 1996 Nobel Prize in chemistry for their discovery, were struck by the resemblance between C

“Buckminsterfullerene,” although the molecules were soon more commonly known as “buckyballs.” And were just as soon the focus of intense research interest, because of their remarkable properties. Like diamonds, buckyballs have bonds in three dimensions, making them very strong, yet ultra-tiny: a C

molecules is only about one nanometer in diameter. That’s a billionth of a metre. This might help you visualize how small that is. If a single C

molecule was the size of a soccer ball, a soccer ball on that scale would be the size of Earth. Like graphite spray, buckyballs have great “slip and slide” qualities, because each C

molecule is separate, they behave like ball bearings, move smoothly. All this – plus their hollow insides – mean buckyballs could serve as ideal molecular “shipping containers” or crystal cages, surrounding and smoothly transporting other atoms and molecules that chemists might load into the empty space inside the crystal. Say, cancer-fighting chemicals that would otherwise be destroyed in the body before they could get to a tumor – if they traveled inside buckyballs, these chemical molecules would be protected from being degraded in the cells.

Researchers have already found they can fit large amounts, almost 60 molecules, of hydrogen inside each buckyball. That might lead to development of an entirely new class of atomic-scale hydrogen fuel cells or batteries.

Buckminsterfullerene was only the first of a number of “fullerenes” discovered – molecules made entirely of carbon, in the form of hollow cylinders, spheres, or ellipsoids (they’re like spheres, but with bulgy middles). Fullerenes with structures like cylinders – called carbon nanotubes are especially intriguing. They’re stronger than any other known material, even though most are about 10,000 times thinner than a single human hair. Researchers hope carbon nanotubes will revolutionize 21st century electronics by hyper-miniaturizing components, eventually being crafted into circuits for powerful, but molecule-sized computer chips.

Looking into the more distant future for, Spaceship Earth, a phrase coined by Buckminster Fuller, there may be even more incredible uses for the materials that carry his name. Scientists think the space elevators imagined in science fiction, links from the Earth’s surface to rings in geostationary orbit above it, might run on cables made of buckminsterfullerene or other fullerenes. So now you see the connections: diamond, pencil, soccer ball, shipping container: buckminsterfullerene molecule of the future and, since 1997, the state molecule of Texas. Really! Look it up.