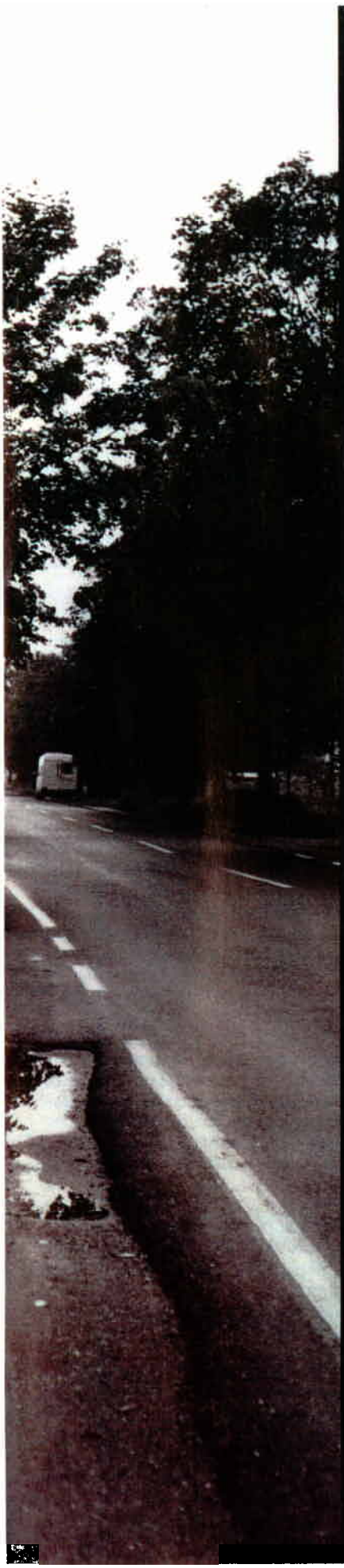


The molding of the world

Once the butt of jokes, plastics have infiltrated every corner of modern life

BY JOANNIE FISCHER

Everybody gets the joke when the tacky party guest in the classic film *The Graduate* makes young Ben promise to consider a career in, of all things, plastics. Since 1967, the scene has endured as a symbol of the dehumanizing superficiality of modern life, and the word "plastic" has morphed into an insult, connoting things fake, meaningless, cheap.

BREAKTHROUGHS

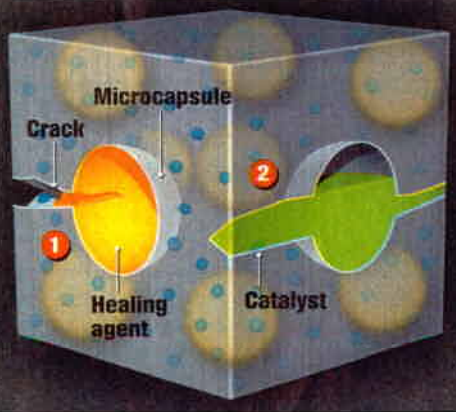
Yet, if Ben *had* ventured into the world of plastics, he would have discovered endeavors worthy of humanity's loftiest ideals. Not only does *The Graduate* itself owe its existence to the plastic film it is recorded on, but by the time the scene was shot, plastics were already reshaping history. Sophisticated new materials would emerge to save lives (artificial hearts, shatterproof glass, bullet-proof vests), conserve energy (home insulation, lightweight cars), and expand human horizons (around the globe via aircraft, across the solar system via spacecraft, and through the World Wide Web via computer). And in the 21st century, a new generation of "super synthetics" promises to again reshape our world and ease many of the planet's most pressing problems.

Medieval alchemists never did brew up gold, but modern chemists tinkering with the elements indeed yield priceless materials. By taking simple building blocks of matter such as carbon, nitrogen, and hydrogen, and putting them through rigors not normally endured on Earth, today's alchemists create substances never seen in nature, with otherworldly qualities. Agents such as chemical catalysts, intense heat or cold, and massive pressure can coax simple, small molecules to break up and rearrange their components into a polymer—a huge, complex "mega molecule" arranged in a long, highly ordered chain. Plastic, from the

Plastic, heal thyself

Researchers at the University of Illinois have created a composite plastic able to repair its own cracks.

1. A crack ruptures microcapsules (about the width of a human hair) filled with a liquid healing agent, which flows into the crack.
2. When the healing agent comes in contact with tiny catalysts, it solidifies and seals the crack.



Source: Nature

RAYMOND DEPARDON—MAGNUM

The stuff of history

1862. A mixture of chloroform and castor oil dubbed Parkesine debuts at London's Great International Exhibition. It is marketed as a replacement for rubber, but the material proves too costly to mass produce.

1870. After an advertisement promises $10,000 for a substitute for elephant ivory, inventor John Wesley Hyatt creates billiard balls from celluloid. Unfortunately, the balls sometimes explode on contact. Still, celluloid launches the photograph and film industry.

1907. New York Chemist Leo Baekeland mixes volatile chemicals under pressure to form Bakelite, which will not burn, boil, melt, or dissolve in acid. It quickly replaces wood and other natural materials in everything from washing machines and jewelry to weapons of war. ◀

1926. Du Pont engineers market cellophane, the first moisture-proof wrapping material. The product causes sales of wrapped goods to skyrocket and gives rise to the modern supermarket.

1940. On May 15, dubbed "N-day," 5 million pairs of nylon stockings become available to American women and sell out in hours. For years, hucksters fraudulently pass silk stockings off as the more popular nylon hosiery because it commands a higher price. ▲

1949. General Electric engineers mix silicone oil with boric acid and produce Silly Putty. The $6 million in sales that year tops any previous toy.

1982. Doctors implant the first artificial heart, the plastic Jarvik-7, which continues to be used for transplants through the turn of the century.

2000. A Dearborn, Mich., company announces development of the first plastic fuel-tank system, which will enable autos to eliminate tailpipe emissions.

2001. Lucent Technologies researchers create the world's first plastic superconductor, paving the way for ultra-high-speed trains and a new era of quantum computing. ▼

Greek root "to form," refers to any of these polymers that can be molded to hold a desired shape. To date, hundreds of different polymers have been created—some feather light but stronger than steel, others impervious to scorching heat or arctic freeze—and new plastics are in the works with even more impossible qualities, such as the ability to "heal" themselves and "remember" to change shape and function in varying conditions.

These sophisticated polymers promise to remold life dramatically. In medicine, researchers say plastics can extend life by 20 years by acting as mini-robots to repair organ damage and clean blood vessels, and as vehicles speeding treatments like chemotherapy to their target. Promethean polymers will allow roads to alter their surfaces in ice or rain and walls to become thicker or more porous to insulate or ventilate. Plastics that mimic natural polymers in the brain will yield nanocomputers thousands of times more powerful than today's machines.

The result is a world where plastics are ubiquitous and essential. Each year, more than 100 million tons of plastics are made; the United States produces more plastic than steel, aluminum, and copper combined. Although purists continue to disparage plastic—Norman Mailer calls it "a malign force loose in the universe that is the social equivalent of cancer"—few would actually want to do without it. True, the mention of plastic can conjure up images of phony pink flamingos, discarded soda bottles, and gaudy souvenir shop tchotchkes, but in fact life as we now enjoy it would be impossible without lab-born polymers.

Just consider plastic by a few of its other names: Teflon, nylon, rayon, polar fleece, Plexiglas, Lucite, Lycra, Formica, Velcro, vinyl, Gore-Tex, saran, Styrofoam, celluloid, cellophane, and polycarbonate. It is a key component of today's computers, cellphones, and jets. It encapsulates our medicines, ensures sterile surgeries, and provides our artificial organs and limbs. It is found in our alarm clocks, shower curtains, contact lenses, and clothing; in our TVs, cookware, and sofas. Even the Statue of Liberty is coated in a polymer that protects it from corrosion.

Replacing nature. The fact that not a single plastic item was found aboard the Titanic, sunk in 1912, gives some idea of how fast the breakthroughs have happened and how massive their repercussions have been. With each new material concocted, stumbled upon, or lucked into, entire industries have been born or transformed. Since the dawn of industrialization, a serious hunt was on for natural resource substitutes: "ivory" that wouldn't require slaughtering elephants, "wood" that wouldn't rot, "metal" that wouldn't corrode. Bizarre odors and the sounds of small explosions came from labs around the world as brave souls mixed recipes including sulfur, gunpowder, acids, petroleum wastes, alcohol, even cream cheese and chicken soup.

The first huge breakthrough was the product of a phenol and formaldehyde mixture, pressurized and heated to over 200 degrees Celsius. Introduced to the United States in 1909 as Bakelite by backyard chemist "Doc" Leo Baekeland from Yonkers, N. Y., the world's first totally synthetic plastic was a durable material that could be molded into everything from ashtrays to airplane propellers. Bakelite became the new "ivory" of billiard balls, formed the classic black dial telephone, and replaced metal agitators in washing machines. By the 1930s more than 90,000 tons of Bakelite were produced yearly.

But it was World War II that placed plastics at the center of necessity. Dire shortages of natural resources made synthetics crucial. A rubber substitute called vinyl supplied Allied troops with waterproof tents and boots. An ultra-light insulation called polyethylene gave the British the ability to install radar on planes and ships—and a critical advantage over the otherwise superior German Air Force and Navy. And a cousin of Plexiglas, a liquid polymer added to Russian fuel, kept tanks and vehicles

running in sub-zero temperatures when Nazi engines broke down.

In peacetime, the military synthetics quickly found new uses. The nylon that had been used for parachutes set off arguably the world's largest fashion craze by becoming more valuable than silk as ladies' leggings. Teflon that lined military fuel tanks made space exploration possible, and spawned dozens of new plastics that would outfit astronauts and their vessels. By 1979, plastic production surpassed that of steel, ushering in what Stephen Fenichell, author of *Plastic: The Making of a Synthetic Century,* calls the Plastic Age, a title as indicative of human progress as the Iron Age or the Bronze Age. Long-lasting superplastics are fast replacing metal in buildings, machines, and vehicles. Virtually all of the data of the Information Age are stored on plastic, from computer components to DVDs.

Backlash. Yet, as plastic has become more dominant, the backlash against it has grown more visceral and vehement. The very endurance for which plastic was celebrated now haunts it. It is "the Rasputin of modern materials," says Fenichell. "You can break it, chop it, dice it, shred it, burn it, and bury it, but it stubbornly refuses to die."

Even the plastics industry admits waste is a big problem, and a sub-industry of "green plastics" is trying to make plastics mortal. McDonald's restaurants in Chicago now serve Big Macs in plastic made from potato and limestone, which can be crushed and dissolved in water. Others are marketing plastic items that break down in moist soil; some are guaranteed to vanish in six weeks.

Only a third of durable plastics now find a second life. The numbers are rising, though, especially as companies such as Reebok, L.L. Bean, and Patagonia are launching large recycling operations that shred plastics, spin them into thread-thin "microfibers," and weave them into fashionable slacks, jackets, fleece vests, and shoes. The newest plastics hold out the promise of never needing to be thrown away, thanks to self-healing microcapsules inside the material itself. When cracked open by injury or age, the materials would release a fresh supply of the polymers to refortify, say, the bumper of a car or the nose of a 747.

Before long, plastic may transform its image from eco-villain to environmental hero, thanks to "smart" plastics now in development. These could allow vehicles to eliminate ozone-depleting emissions and help windows store and make use of the sun's heat. Perhaps by then, the name itself will morph from a pejorative jab into a genuine compliment. ●

A lesson before dying

Med schools tackle end-of-life issues

BY MARIANNE SZEGEDY-MASZAK

The first-year students at the University of Minnesota Medical School start the day studying the motor cortex in neuroscience class. Then they move on to "fluid compartments" in physiology, followed by "enteric viruses" in microbiology. But the toughest lesson is still to come. Back from lunch, they spend two hours witnessing the last months in the life of Vivian Bearing, professor of English literature, who is dying, alone in a hospital, of ovarian cancer, and being treated by highly trained but callous and dismissive doctors.

Vivian Bearing is not an actual patient. She is the central character in *Wit,* the Pulitzer Prize-winning play by Margaret Edson, which has gained a new currency in a teaching effort called the Wit Educational Initiative. At 30 top U.S. medical schools, the play is performed as part of a broader national effort to teach medical students—and their professors—that the heroic saving of life is only half their job. The other half is dealing with the dying when a cure proves impossible.

While the death of a loved one is always a sorrowful event, it often involves suffering that could be avoided. According to a 1995 study of more than 9,000 patients published in the *Journal of the American Medical Association,* death in American hospitals too often involves extreme pain, poor communication between physicians and patients, and misunderstanding about how patients prefer to die. Rather than die in dignity at home, surrounded by loved ones, three quarters of Americans are dying in hospitals and nursing homes, many of them hooked to life-sustaining equipment that is as painful as it is pointless. Last week, a California jury

REVEREND'S STORY

The ministry's last resort

As a Baptist minister, Charles Beaty thought he was ready to help people deal with death. "I thought I was comfortable, but I really wasn't prepared."

He knows that now, because Beaty, 34, has terminal lung cancer. Radiation and chemotherapy have failed to help. In January, the congregation at the First Baptist Church in Kearney, Mo., where Beaty and his wife, Christy, married 12 years ago, helped the couple and their three children move back from Virginia so they could prepare for his death.

Focus on mourners. For Beaty, that preparation includes talking to clergy and to seminary students. "They'll usually ask me, 'How are you dealing with this? Don't you ask why?' They tend to be really dumbfounded." That's because seminary training traditionally emphasizes burying the dead and comforting the bereaved, according to Jo Ellen Wurth, director of Compassion Sabbath in Kansas City, Mo. The Robert Wood Johnson Foundation's pilot program was launched after a survey of clergy found