

Technology > Industry > Chemical Products

vulcanization

rubber manufacturing

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Table of Contents

vulcanization, chemical process by which the physical properties of natural or [synthetic rubber](#) are improved; finished rubber has higher [tensile strength](#) and resistance to [swelling](#) and abrasion, and is elastic over a greater range of temperatures. In its simplest form, vulcanization is brought about by heating rubber with [sulfur](#).

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Goodyear, Charles Charles Goodyear, undated engraving.

Key People: Charles Goodyear
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The process was discovered in 1839 by the U.S. inventor [Charles Goodyear](#), who also noted the important function of certain additional substances in the process. Such a material, called an [accelerator](#), causes vulcanization to proceed more rapidly or at lower temperatures. The reactions between rubber and sulfur are not fully understood, but in the product, the sulfur is not simply dissolved or dispersed in the rubber; it is chemically combined, mostly in the form of cross-links, or bridges, between the long-chain molecules.

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In modern practice, temperatures of about 140°–180° C are employed, and in addition to sulfur and accelerators, [carbon black](#) or [zinc oxide](#) is usually added, not merely as an extender, but to improve further the qualities of the rubber. Anti-oxidants are also commonly included to retard deterioration caused by oxygen and ozone. Certain [synthetic](#) rubbers are not vulcanized by sulfur but give satisfactory products upon similar treatment with metal oxides or organic peroxides.

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elastomer: Vulcanization

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Science > Chemistry

rubber

chemical compound

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Also known as: caoutchouc
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Table of Contents

rubber, elastic substance obtained from the exudations of certain tropical plants (natural rubber) or derived from petroleum and [natural gas](#) (synthetic rubber). Because of its elasticity, [resilience](#), and toughness, rubber is the basic [constituent](#) of the tires used in automotive vehicles, aircraft, and bicycles. More than half of all rubber produced goes into automobile tires; the rest goes into mechanical parts such as mountings, gaskets, belts, and hoses, as well as consumer products such as shoes, clothing, furniture, and toys.



truck tires being removed from their molds

Key People: Tan Cheng Lock • Paul W. Litchfield • Henry Nicholas Ridley • Giovanni Battista Pirelli • [C...*\(Show more\)*](#)

Related Topics: [polyisoprene](#) • [latex](#) • [vulcanization](#) • [gutta-percha](#) • [foam rubber](#)

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The main chemical [constituents](#) of rubber are [elastomers](#), or “elastic polymers,” large chainlike molecules that can be stretched to great lengths and yet recover their original shape. The first

common [elastomer](#) was [polyisoprene](#), from which natural rubber is made. Formed in a living organism, natural rubber consists of solids suspended in a milky fluid, called [latex](#), that circulates in the inner portions of the bark of many tropical and subtropical trees and shrubs, but predominantly [Hevea brasiliensis](#), a tall softwood tree originating in Brazil. Natural rubber was first scientifically described by [Charles-Marie de La Condamine](#) and François Fresneau of France following an expedition to [South America](#) in 1735. The English chemist [Joseph Priestley](#) gave it the name rubber in 1770 when he found it could be used to rub out pencil marks. Its major commercial success came only after the [vulcanization](#) process was invented by [Charles Goodyear](#) in 1839.



Natural rubber continues to hold an important place in the market today; its resistance to heat buildup makes it valuable for tires used on racing cars, trucks, buses, and airplanes. Nevertheless, it [constitutes](#) less than half of the rubber produced commercially; the rest is rubber produced synthetically by means of chemical processes that were partly known in the 19th century but were not applied commercially until the second half of the 20th century, after [World War II](#). Among the most important [synthetic rubbers](#) are [butadiene rubber](#), [styrene-butadiene rubber](#), [neoprene](#), the [polysulfide](#) rubbers (thiokols), [butyl rubber](#), and the [silicones](#). [Synthetic](#) rubbers, like natural rubbers, can be toughened by vulcanization and improved and modified for special purposes by reinforcement with other materials.



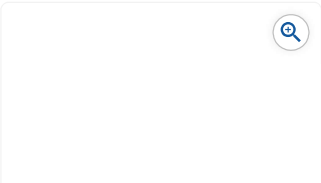
Essential properties of the polymers used to produce the principal commercial rubbers are listed in the table.

Properties and applications of commercially important elastomers						
polymer type	glass transition temperature (°C)	melting temperature (°C)	heat resistance*	oil resistance*	flex resistance*	typical products and applications
polyisoprene (natural rubber, isoprene rubber)	−70	25	P	P	E	tires, springs, shoes, adhesives
styrene-butadiene copolymer (styrene-butadiene rubber)	−60		P	P	G	tire treads, adhesives, belts
polybutadiene (butadiene rubber)	−100	5	P	P	F	tire treads, shoes, conveyor belts
acrylonitrile-butadiene copolymer (nitrile rubber)	−50 to −25		G	G	F	fuel hoses, gaskets, rollers
isobutylene-isoprene copolymer (butyl rubber)	−70	−5	F	P	F	tire liners, window strips
ethylene-propylene monomer (EPM), ethylene-propylene-diene monomer (EPDM)	−55		F	P	F	flexible seals, electrical insulation
polychloroprene (neoprene)	−50	25	G	G	G	hoses, belts, springs, gaskets
polysulfide (Thiokol)	−50		F	E	F	seals, gaskets, rocket propellants
polydimethyl siloxane (silicone)	−125	−50	G	F	F	seals, gaskets, surgical implants
fluoroelastomer	−10		E	E	F	O-rings, seals, gaskets
polyacrylate elastomer	−15 to −40		G	G	F	hoses, belts, seals, coated fabrics
polyethylene (chlorinated, chlorosulfonated)	−70		G	G	F	O-rings, seals, gaskets
styrene-isoprene-styrene (SIS), styrene-butadiene-styrene (SBS) block copolymer	−60		P	P	F	automotive parts, shoes, adhesives
EPDM-polypropylene blend	−50		F	P	F	shoes, flexible covers
*E = excellent, G = good, F = fair, P = poor.						

Natural rubber production

The rubber tree

Commercially, natural rubber is obtained almost exclusively from *Hevea brasiliensis*, a tree indigenous to South America, where it grows wild to a height of 34 metres (120 feet). Cultivated in plantations, however, the tree grows only to about 24 metres (80 feet) because



carbon, necessary for growth, is also an essential constituent of rubber. Since only atmospheric [carbon dioxide](#) can supply carbon to the plant, the element has to be rationed between the two needs when the tree is in active production. Also, with foliage limited to the top of the tree (to [facilitate](#) tapping), the intake of carbon dioxide is less than in a wild tree. Other trees, shrubs, and herbaceous plants produce rubber, but, because none of them compares for [efficiency](#) with *Hevea brasiliensis*, industry botanists have concentrated their efforts exclusively on this species.

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rubber trees Latex being tapped from trees on a rubber plantation near Kuala Lumpur, Malaysia.



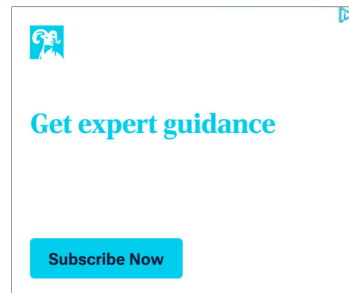
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Building Blocks of Everyday Objects

In the cultivation of *Hevea*, the natural [contours](#) of the land are followed, and the trees are protected from wind. Cover crops planted [adjacent](#) to the rubber trees hold rainwater on sloping ground and help to fertilize the soil by fixing atmospheric nitrogen. Standard horticultural techniques, such as nursery growing of hardy rootstocks and grafting on top of them, hand pollination, and [vegetative propagation](#) (cloning) to produce a genetically uniform product, are also employed.



Hevea grows only within a well-defined area of the tropics and subtropics where frost is never encountered. Heavy annual rainfall of about 2,500 mm (100 inches) is essential, with emphasis on a wet spring. As a consequence of these requirements, growing areas are limited. [Southeast Asia](#) is particularly well situated for rubber culture; so too are parts of [South Asia](#) and [West Africa](#). Cultivation of *Hevea* in Brazil, its native habitat, was virtually destroyed by [blight](#) early in the 20th century.



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Tapping and coagulation

When the bark of the *Hevea* tree is partially cut through (tapped), a milky [liquid](#) exudes from the wound and dries to yield a rubbery film. The biological function of this [latex](#) is still obscure: it may help wound-healing by protecting the inner bark, or it may serve other biochemical functions. The latex consists of an aqueous suspension of small particles, about 0.5 micrometre in diameter, of *cis*-[polyisoprene](#), a linear rubbery [polymer](#) of high [molecular weight](#). The rubber content of the suspension is about 30 percent.



latex dripping into a cup from a tapped rubber tree Latex dripping into a cup from a tapped rubber tree, Krabi, Thailand.

Rubber trees are tapped about once every two days, [yielding](#) a cupful of latex, containing approximately 50 grams (1.7 ounces) of solid rubber, each time. The standard method of tapping is to score the tree with a knife for half the circumference of the trunk, slanting the cut down from left to right at an angle of 30° starting at the highest point convenient to the tapper. Each subsequent cut is made immediately below its predecessor. Trees are often rested for a period after heavy tapping. Production commences when a tree is 5 or 6 years old; with care, the tree's useful life may extend to more than 20 years. With trees [cultivated](#) at a density of 375 per hectare (150 per acre), approximately 2,500 kg of rubber can be produced per hectare per year (that is, approximately one ton per acre per year).



natural rubber Latex being extracted from a rubber tree.

After collection of the tapped latex, rubber is recovered from [emulsion](#) by coagulation with [formic acid](#), creating crumbs that resemble curds of milk. The crumbs are washed, dried between rolls, and compacted into blocks 67 by 33 by 18 cm (26 by 13 by 7.5 inches) in size and weighing 33.3 kg (73 pounds). The blocks are then wrapped in [polyethylene](#) sheets and packed into one-ton crates for shipping.

Other production is as smoked sheet, where the coagulum is pressed into thin sheets that are washed and then dried over a smoky wood fire. The smoke contains natural fungicides that protect against mold growth and [impart](#) a characteristic amber colour. Dried sheets are packed into 110-kg (250-pound) bales for shipping.

About 10 percent of all natural rubber is shipped as latex, concentrated to a rubber content of approximately 60 percent and used for making dipped goods such as surgical gloves, prophylactics, and toys.



sheets of natural rubber coagulated from latex being passed between rollers Sheets of natural rubber coagulated from late...(more)



sheets of natural rubber hanging from racks in a smoke room for final drying Sheets of natural rubber ha...(more)

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