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Did Spock make tires?

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Did Spock make tires?

Both Spock and tires are "vulcanized," but for tires, the connection is to the Roman blacksmith-god, Vulcan. It is heat, together with some very interesting chemistry, that makes rubber the incredibly useful engineered material we use in tires.

The first recorded commercial use of rubber was in 1770, when small cubes of it were sold in London for erasing, or "rubbing" away pencil marks.

The name "rubber" has lasted to this day, but we would scarcely have progressed beyond pencil erasers had it not been for vulcanization, as we'll see.

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Why is vulcanizing so important?

As it comes from the tree, rubber is not very useful. It's a liquid, called "latex," and a bit like milk or egg whites. Expose latex to alcohol or salt water or smoke and it coagulates, somewhat like cheese. It's rubbery, and you could compress it into erasers, but it doesn't have much other use.

Rubber latex looks and acts a bit like milk.

Why is that?

Uncured rubber consists of many very long, stringy molecules, mixed together like a plate of spaghetti.

These molecules consist of carbon and hydrogen, with the carbon atoms linked to each other, like the links of a chain.

And, like spaghetti, if you could reach in and grab a single strand, then pull on it, you could eventually remove it.

Is that a problem?

The result of these spaghetti-like properties is that when rubber (or spaghetti) is hot, it won't hold a shape. It's sticky, has no strength, and isn't resilient – that is, it has little ability to "bounce back."

Worse still, early workers found the material could actually rot, and many early rubber goods disintegrated into a smelly mess over time.

And if it isn't hot?

Again, like spaghetti, when cold, uncured rubber became a sort of congealed glob. It would hold a shape, but if you tried to squeeze it or stretch it, it was brittle. Try to grab a single strand of cold spaghetti and pull on it, and it breaks immediately.

So, rubber wasn't very useful in that state either. Vulcanization was the answer.

Cold uncured rubber, like this chilled spaghetti, holds its shape, but is brittle and has very little strength.

Uncured rubber, when hot, is a bit like this plate of spaghetti. Long strands of molecules are loosely mixed together and can easily slide past each other. It won't hold a shape and can easily be pulled apart.

How was vulcanization discovered?

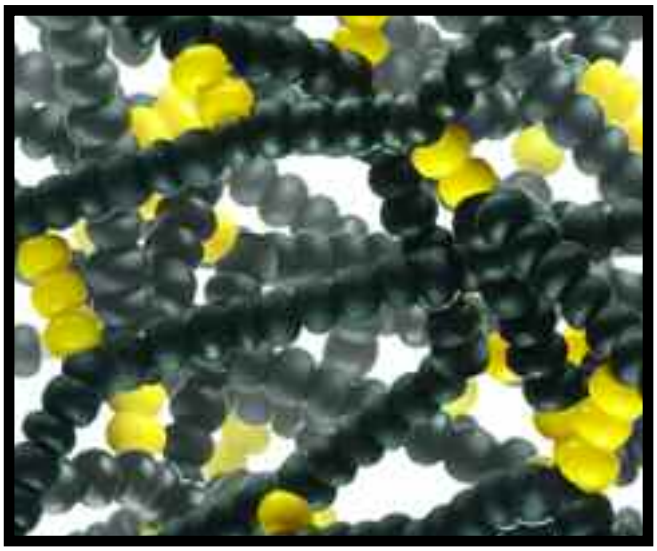
Probably pretty much by accident, by a fellow named Charles Goodyear, in 1839. He mixed sulfur with rubber, and apparently dropped some of the mixture on a hot stove.

When he scraped it off, he discovered that the rubber no longer melted with heat, nor did it get brittle with cold. It stayed "rubbery."

So sulfur was the answer?

Sulfur and heat. When you heat the mix, the sulfur atoms form links that attach to the rubber molecules.

Instead of being like a plate of spaghetti, it becomes something much more like a fishing net – or a tangled-up mess of fishing nets.



When sulfur and rubber are mixed, then heat applied, sulfur atoms (indicated here by yellow beads) can link the long strands of rubber molecules together. The result is a bit like a tangle of fishing nets.

How much sulfur and heat?

It depends on the properties you want. The more sulfur you use, the stiffer the rubber gets. In our example about five percent of the rubber compound is sulfur.

High-pressure steam, hot water or electricity is used to heat the molds in which tires are cured. The heat softens the rubber so it can fill the mold and take its shape, then causes curing to take place, locking that shape into place.

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Is there any way to undo the process?

Not really. Once a tire is vulcanized, there's really no easy way to "devulcanize" it. Much as there's no easy way to "uncook" an egg or a cake.

Unfortunately, though, too much heat can cause problems.

What kind of problems?

If you heat a piece of cured rubber too much, you can actually break down the chemical bonds that were holding its atoms together.

The big network of linked molecules that you tried to create with vulcanization starts to come apart, but not the way it went together.

Some of the sulfur links between chains break, but many of the chains themselves break. The result is a bit like uncured rubber – only worse.

Worse?

Because it's almost impossible to repair these broken links. An overheated tire can literally come apart.

Too much heat (caused by excessive flex resulting from underinflation) can break the chemical bonds that hold rubber molecules together. The tire literally "comes apart."

Where does the heat come from?

Generally, from mechanical flexing – too much of it – resulting from tires that are underinflated, overloaded, or both.

Temperatures inside tires, especially near belt edges, can easily exceed 250 degrees – if a tire is underinflated. That can be enough to cause the cured rubber to "revert" or "devulcanize."

Treads and belts can detach from the body of the tire with disastrous results. It's just another negative result of insufficient inflation pressure.

So heat can make – or break – a tire?

Absolutely. Without the chemical reactions the heat of vulcanization causes, we couldn't make a useful tire. And yet, get that same tire too hot, and it can turn into junk.

As with so many things – with tires and in life – moderation is the key.