B.Sc. Semester-VI
Organic Chemistry
Paper-XIV

2. Synthetic Polymers

Coverage:

15. Vulcanization of Rubber

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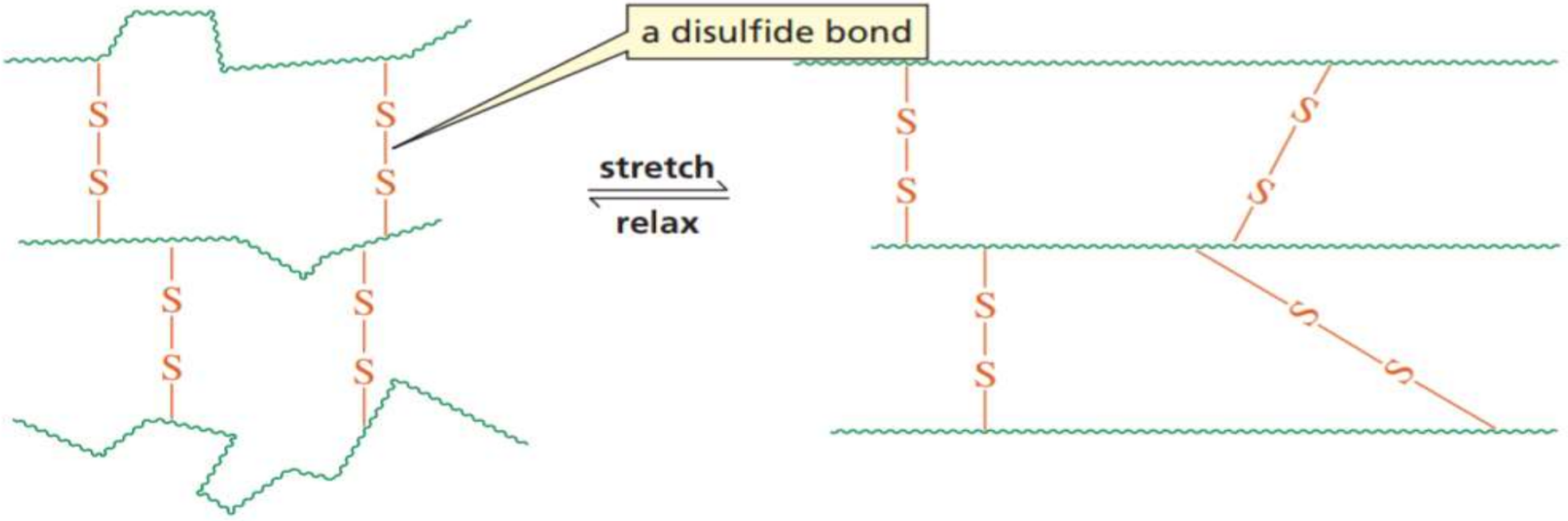
15. Vulcanization of Rubber

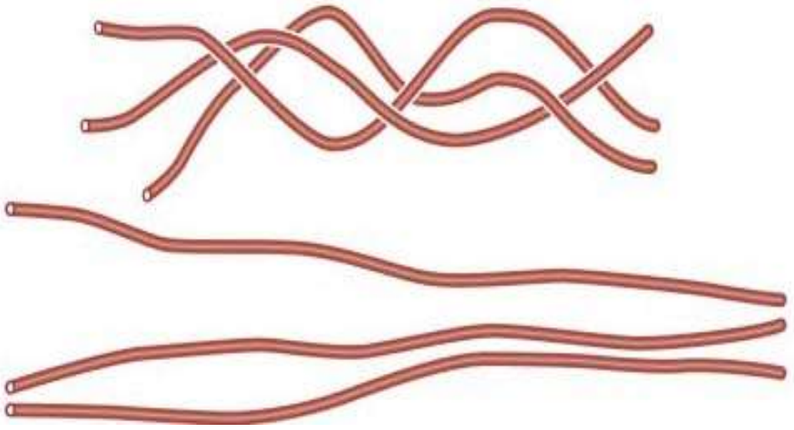
A problem common to both natural and most synthetic rubbers is that the polymers are very soft and sticky. They can be hardened by a process known as *vulcanization*. Charles Goodyear discovered this process while trying to improve the properties of rubber. He accidentally spilled a mixture of rubber and sulfur on a hot stove. To his surprise, the mixture became hard but flexible. He called the heating of rubber with sulfur **vulcanization**, after Vulcan, the Roman god of fire.

Heating rubber with sulfur causes **cross-linking** of separate polymer chains through disulfide bonds . Instead of the individual chains just being entangled together, the vulcanized chains are covalently bonded together in one giant molecule. Because the polymer has double bonds, the chains have bends and kinks that prevent them from forming a tightly packed crystalline polymer. When rubber is stretched, the chains straighten out along the direction of the pull. Cross-linking prevents the polymer from being torn when it is stretched, and the cross-links provide a reference framework for the material to return to when the stretching force is removed.

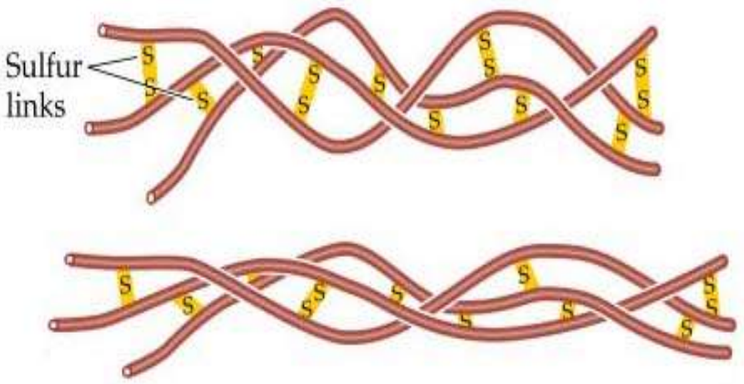


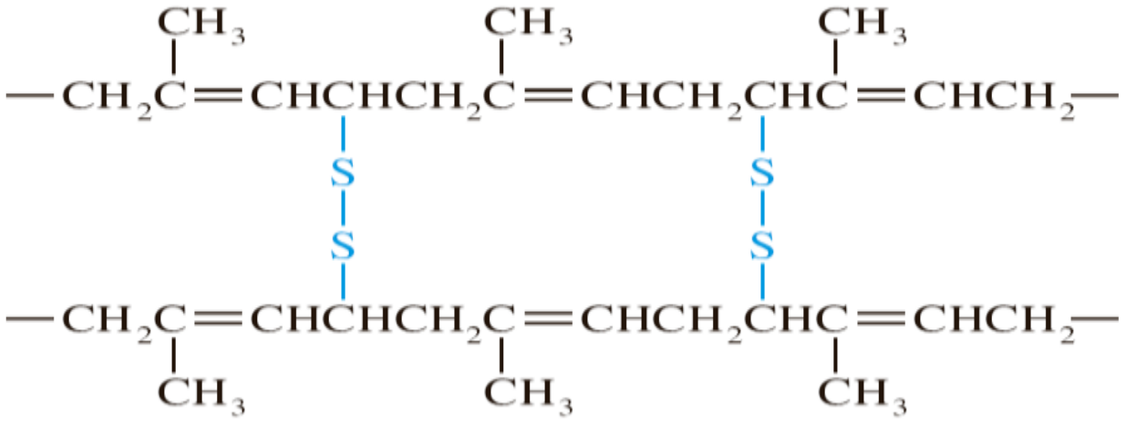
The physical properties of rubber can be controlled by regulating the amount of sulfur used in the vulcanization process. Rubber made with 1–3% sulfur is soft and stretchy and is used to make rubber bands. Rubber made with 3–10% sulfur is more rigid and is used in the manufacture of tires. Goodyear's name can be found on many tires sold today. The story of rubber is an example of a scientist taking a natural material and finding ways to improve its useful properties.

Polymeric strands of unvulcanized rubber slip past each other when the rubber is heated and stretched.



Vulcanization connects the strands through links of sulfur so that the interconnected polyisoprene molecules retain their orientation when heated and stretched.





In the segment of vulcanized rubber shown below, the chains of polymerized isoprene are cross-linked by sulfur–sulfur bonds, giving the polymer more strength and elasticity.

The rigidity of rubber is increased by cross-linking the polymer chains with disulfide bonds. When rubber is stretched, the randomly coiled chains straighten out and orient themselves along the direction of the stretch.

Charles Goodyear (1800–1860), *the son of an inventor of farm implements, was born in Connecticut. He patented the process of vulcanization in 1844. The process was so simple, however, that it could be easily copied, so he spent many years contesting infringements on his patent. In 1852, with Daniel Webster as his lawyer, he obtained the right to the patent.*