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Organic Synthesis of Rubber

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ABSTRACT: There are many rubber products which we come across in our daily life. Some common rubber-based objects that we encounter in our day-to-day lives include rubber gloves, rubber bands, and rubber footwear. Rubber items have the ability to recover their shapes after being stretched or distorted, which is the reason why rubber can be classified as an elastomer. Rubber is an elastic substance which can be obtained both naturally (natural rubber) or artificially (they can also be synthesized chemically in laboratories; synthetic rubber-like butyl rubber, neoprene, etc.) There are two primary types of rubber, namely natural rubber and synthetic rubber.A synthetic rubber is an artificial elastomer. They are polymers synthesized from petroleum byproducts. About 32-million metric tons of rubbers are produced annually in the United States, and of that amount two thirds are synthetic. Synthetic rubber, just like natural rubber, has many uses in the automotive industry for tires, door and window profiles, seals such as O-rings and gaskets, hoses, belts, matting, and flooring. They offer a different range of physical and chemical properties, so can improve the reliability of a given product or application. Synthetic rubbers are superior to natural rubbers in two major respects, thermal stability and resistance to oils and related compounds.[1] They are more resistant to oxidizing agents, such as oxygen and ozone which can reduce the life of products like tires.

KEYWORDS: SYNTHETIC RUBBER, POLYMERS, RELIABILITY, COMPOUNDS, OXIDIZING AGENTS, TIRES, RESISTANT, THERMAL STABILITY

I. INTRODUCTION

The expanded use of bicycles, and particularly their pneumatic tires, starting in the 1890s, created increased demand for rubber. In 1909, a team headed by Fritz Hofmann, working at the Bayer laboratory in Elberfeld, Germany, succeeded in polymerizing isoprene, the first synthetic rubber.[2][3]

Studies published in 1930 written independently by Lebedev, the American Wallace Carothers and the German scientist Hermann Staudinger led in 1931 to one of the first successful synthetic rubbers, known as neoprene, which was developed at DuPont under the direction of E. K. Bolton. Neoprene is highly resistant to heat and chemicals such as oil and gasoline, and is used in fuel hoses and as an insulating material in machinery. The company Thiokol applied their name to a competing type of rubber based on ethylene dichloride.[4]

In 1935, German chemists synthesized the first of a series of synthetic rubbers known as Buna rubbers. These were copolymers, meaning the polymers were made up from two monomers in alternating sequence. Other brands included Koroseal, which Waldo Semon developed in 1935, and Sovprene, which Russian researchers created in 1940.[5]

Production of synthetic rubber in the United States expanded greatly during World War II since the Axis powers controlled nearly all the world's limited supplies of natural rubber by mid-1942, following the Japanese conquest of most of Asia (from where much of the global supply of natural rubber was sourced).[6]

Operation Pointblank bombing targets of Nazi Germany included the Schkopau (50,000 tons/yr) plant and the Hüls synthetic rubber plant near Recklinghausen (30,000, 17%),[7] and the Kölnische Gummifäden Fabrik tire and tube plant at Deutz on the east bank of the Rhine.[8] The Ferrara, Italy, synthetic rubber factory (near a river bridge) was bombed August 23, 1944.[9] Three other synthetic rubber facilities were at Ludwigshafen/Oppau (15,000), Hanover/Limmer (reclamation, 20,000), and Leverkusen (5,000). A synthetic rubber plant at Oświęcim, in Nazi-occupied Poland, was under construction on March 5, 1944[10] operated by IG Farben and supplied with slave labor, by the SS, from the associated camp Auschwitz III (Monowitz).[11][12]

The most prevalent synthetic rubber is styrene-butadiene rubbers (SBR) derived from the copolymerization of styrene and 1,3-butadiene. Other synthetic rubbers include:

- polyisoprene, prepared by polymerization of isoprene

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- chloroprene, prepared by polymerization of 2-chlorobutadiene
- nitrile rubber made from cyanobutadiene or 2-propenenitrile and butadiene

Many variations of these can be prepared with mixtures of monomers and with various catalysts that allow for control of stereochemistry.[13]

Polyisobutylene or butyl rubber is commonly used in tyre inner tubes or linings owing to its resistance to diffusion of air through the lining. It is however, a much less resilient material than cis-polybutadiene which is frequently used in tyre sidewalls to minimize energy losses and hence heat build-up. Indeed, it is so resilient that it is used in super balls. An elastomer widely used for external sheet such as roof coverings is Hypalon or chlorosulphonated polyethylene. Synthetic rubbers like EPR can also be used for electrical insulation.

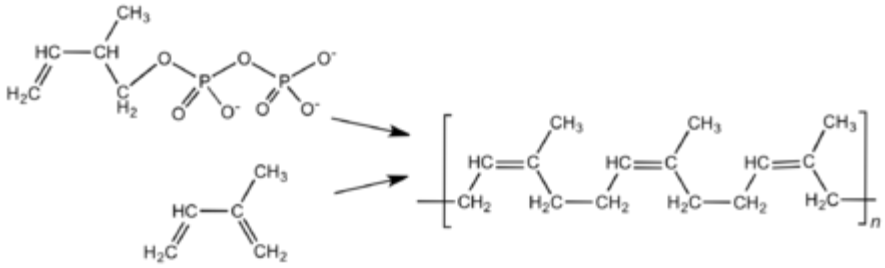
Silicone rubber is also a synthetic elastomer composed of silicone polymers. Silicone rubbers are widely used in industry, and there are multiple formulations. Silicone rubbers are often one- or two-part polymers, and may contain fillers to improve properties or reduce cost. Silicone rubber is generally non-reactive, stable, and resistant to extreme environments and temperatures.[1]

Natural rubber, coming from latex of Hevea brasiliensis, is mainly poly-cis-isoprene.

Synthetic rubber, like other polymers, is made from various petroleum-based monomers.

Some synthetic rubbers are less sensitive to ozone cracking than NR. Natural rubber is sensitive owing to the double bonds in its chain structure, but some synthetic rubbers do not possess these bonds and so are more resistant to ozone cracking. Examples include Viton rubber, EPDM and butyl rubber.[2]

A new class of synthetic rubber is the thermoplastic elastomers which can be moulded easily unlike conventional NR vulcanized rubber. Their structure is stabilized by cross-linking by crystallites in the case of polyurethanes or by amorphous domains in the case of SBS block copolymers.



Chemical structure of cis-polyisoprene, the main constituent of natural rubber. Synthetic cis-polyisoprene and natural cis-polyisoprene are derived from different precursors by different chemical pathways.[3]

II. DISCUSSION

These are the elastomers which are obtained naturally. Natural rubber is made up of solid particles suspended in a milky white liquid (called latex) that drips from the bark of certain tropical and subtropical trees. This latex rubber is mainly found in countries like Brazil, India, Indonesia, Malaysia, and Sri Lanka. It is made by the polymerization of isoprene (2 methyl-1, 3-butadiene) which has a chemical formula $(C_5H_8)_n$ and it is known as cis- 1, 4- polyisoprene. In simple words, we can say that they are made by loosely joining the monomers of isoprene (C_5H_8) in the form of a long tangled chain.[4]

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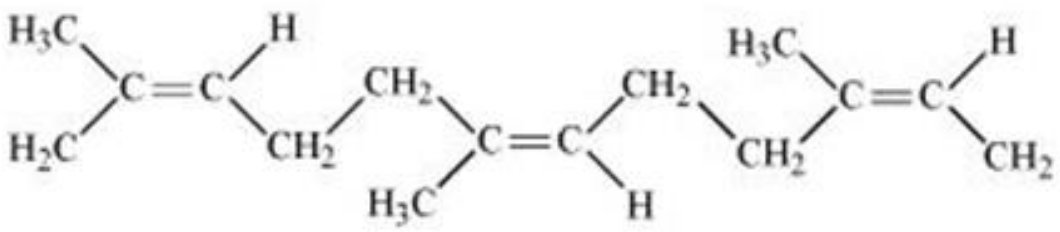

Natural rubber

Preparation of Natural Rubber:

- Rubber tapping – The milky white liquid latex is collected from the rubber trees in a cup by making a slight V-cut on the tree bark. The collected latex is washed, filtered and reacted with acids to congeal the rubber particles.

- Mastication – The rubber obtained from the tapping process is still not ready to be used. When it is cold it is very brittle in nature and when warmed up it becomes very gluey. To remove the brittle nature and strong odour of the rubber, it is allowed to pass through the rollers and is pressed to make it softer and flexible to work. This process is repeated based on the properties that are required for the rubber. In this process, extra chemical ingredients are also added to enhance the properties of rubber.

- Calendering is a process which is mainly performed to provide shape to the rubber using rollers (after proper mixing of the chemical ingredients).

- The final product obtained is then extruded to make hollow tubes by passing them through specially designed holes in an extrusion machine.

- Vulcanization – Performing all the steps listed above will not yield rubber that is strong or hard enough to be used in items like car tires and machinery. To enhance all these properties, sulphur is added to the rubber and it is heated at a temperature ranging from 373 K to 415 K. This process is known as vulcanization. The sulphur acts as a cross-linking agent and after vulcanization, rubber gets cross-linked and becomes hard.[5]

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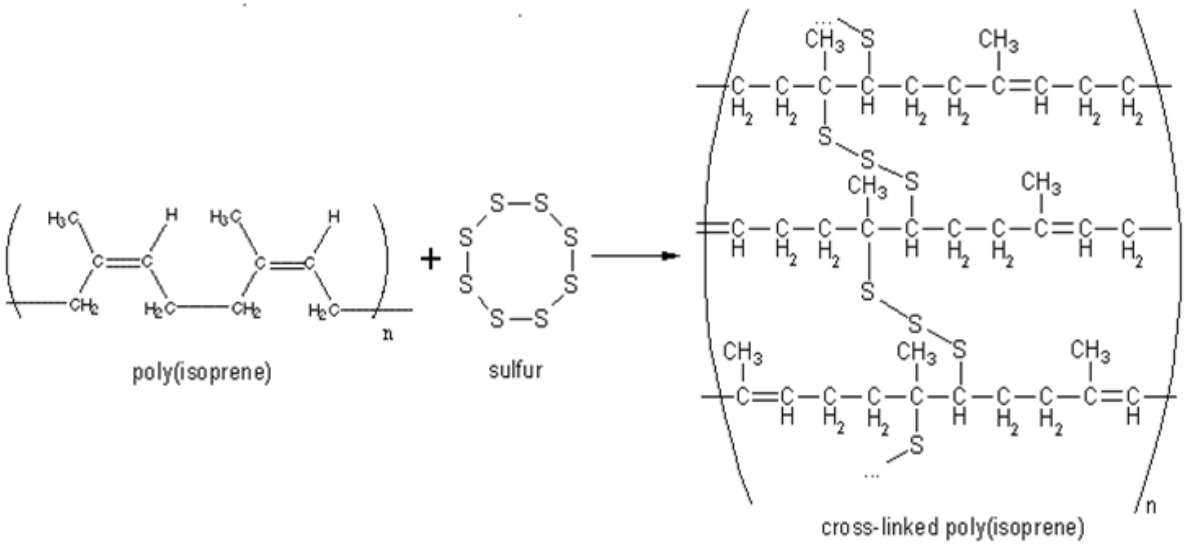


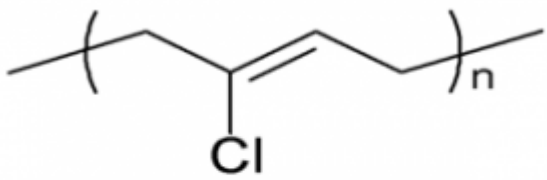
Vulcanisation

Synthetic rubbers are produced from petroleum and natural gas. It is obtained by polymerization of 1, 3 – butadiene derivatives or by copolymerization of 1, 3 – butadiene along with an unsaturated monomer.

Preparation of synthetic rubbers:

Neoprene (Polychloroprene): –

The monomer of Neoprene is 2-chloro-1,3-butadiene, it is commonly known as chloroprene. Neoprene is a polymer of chloroprene, which is formed by joining together the monomers of chloroprene.[6]



Neoprene

Buna- N:-

It is a copolymer of 1, 3 – butadiene and acrylonitrile, it is formed in the presence of a peroxide catalyst.

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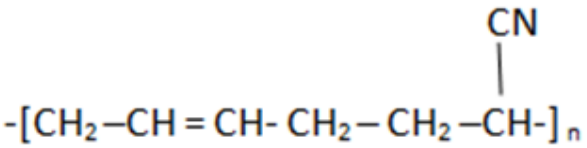

Buna-N

III. RESULTS

Synthetic rubber differs from natural rubber in that it doesn't occur naturally, even though it shares many of its defining characteristics with processed latex.The synthetic rubber manufacturing industry as a whole is part of a global effort to make rubber production more sustainable overall, as the base compounds in synthetic rubber are predominantly polymers synthesised from petroleum byproducts.Aquaseal Rubber Ltd is always looking for ways to further increase our sustainability levels by reducing the amount of non-renewable resources used in our production process

Even though synthetic rubber is man-made, it is just as reliable as its natural counterpart. At Aquaseal Rubber, we process and manufacture a number of different synthetic rubbers, each for different purposes.[7]

- Neoprene
  Neoprene rubbers are based on polychloroprene; a polymer composed of chloroprene, acetylene, and hydrochloric acid. Aquaseal formulate high quality neoprene by modifying the chemical structure of polychloroprene and adding additional elements to ensure the end product features a broad range of chemical properties.
- Ethylene Propylene Diene Monomer (EPDM)
  EPDM rubber is based on ethylene and propylene. Aquaseal add a small amount of diene to these compounds so we can cure the rubber with sulphur. This changes their chemical structure to that of an unsaturated polymer, resulting in EPDM.
- Styrene Butadiene Rubber (SBR)
  SBR is a polymeride which we create using styrene and butadiene. Those compounds are derived from petroleum at an oil refinery, before we combine the two with a ratio of 25/75 for styrene/butadiene.
- Butyl Rubber
  Butyl rubber is a copolymer created using isobutylene and isoprene – isobutylene is a compound made of methyl and propylene, and isoprene makes the rubber unsaturated and capable of vulcanisation. [8]
- Fluoroelastomers
  Fluoroelastomers are a family of copolymers originally composed of hexafluoropropylene and vinylidene. Aquaseal modify the consistency of our fluoroelastomers depending on the needs of our client – we can offer premium, long-lasting reliability even in some of the harshest environments. [13]
- Silicone
  Silicone rubber is an inorganic polymer comprising of silicone and oxygen, which Aquaseal can modify by adding various chemicals to improve performance. Adding fluorine to silicone rubber compounds will make it solvent-resistant; phenyl will improve low temperature flexibility and resists gamma radiation; and vinyl makes vulcanisation more effective.
- Buna N Rubber
  Buna N rubber (also known as standard Nitrile rubber) is a synthetic rubber compound comprising acrylonitrile and butadiene – two copolymers. Because acrylonitrile is a volatile organic liquid, when it mixes with butadiene (a synthetic chemical compound) a reaction occurs, producing Buna N rubber.[9]

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IV. CONCLUSIONS

Uses of Rubber

- One of the largest consumers of rubber is the tire and tube industry. To make natural rubber more durable, it is combined with synthetic rubber over time.
- Rubber is also employed in other areas of the vehicle industry. Seals and various types of cushioning for different car parts are made from natural rubber. For example, it's used to make brake pads and window and windshield seals in automobiles.
- Rubber is used to produce airbags in automobiles, which protect passengers from damage caused by accidents.[10]
- Clothing: Because natural rubber is elastic in its fibrous form, it is utilized to make clothing that is tight-fitting and expandable, such as swimwear and cycling shorts.
- Rubber is utilized to make flooring in a variety of business establishments, kitchens, and even playgrounds. It creates a cushioned surface that is also slip-resistant and waterproof. It's simple to keep up with and lasts a long time.
- Gaskets: Gaskets are used to prevent leakage or fill uneven spaces between two or more mechanical parts.[11]
- Erasers: This rubber device could "rub" away pencil marks on paper, earning it the name "eraser."
- Natural rubber was used by ancient Mesoamerican civilizations to build waterproof shoes and bottles. Not only that but it was also utilized to make a sports ball for a game called football, which is comparable to modern-day basketball.[12]
- Rubber is utilized as an adhesive and a protective layer for a variety of surfaces in its latex state.
- Rubber gloves are a well-known rubber product since they are frequently used to keep our hands safe and clean.
- Rubber is used to make soundproofing materials and a variety of children's rubber toys.[14]

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