Poly(Styrene-Butadiene-Styrene) Introduction

Poly(styrene-butadiene-styrene) (pol-ee-STYE-reen-byoo-tah-DYE-een-STYE-reen) is a thermoplastic block copolymer of styrene and butadiene. The compound is often called simply SBS or SBS rubber. A thermoplastic polymer is one that can be converted back and forth between liquid and solid states by alternate heating and cooling. A copolymer is a polymer made from two monomers, in this case, styrene (C6H5CH=CH2) and 1,3-butadiene (CH2=CHCH=CH2). The term block copolymer means that one section of the polymer chain consists of polystyrene (-[CH2CHC6H5-]n to which is connected another section consisting of polybutadiene (-[-CH2CH=CHCH2-]n), which, in turn, is connected to another section of polystyrene (-[CH2CHC6H5-]n), and so on.

KEY FACTS

OTHER NAMES:

SBS

FORMULA:

$-[CH_2CHC_6H_5-]_n-[-CH_2CH=CHCH_2-]_n-[CH_2CHC_6H_5-]_n$

ELEMENTS:

Carbon, hydrogen

COMPOUND TYPE:

Organic polymer

STATE:

Solid

MOLECULAR WEIGHT:

Varies

MELTING POINT:

160°C to 200°C (320°F to 400°F)

BOILING POINT:

Not applicable

SOLUBILITY:

Insoluble in water

A copolymer like SBS has properties of both polymers of which it is composed. In the case of SBS, the polystyrene segments give the product strength and durability, while the polybutadiene segments provide flexibility. The substance acts like natural rubber at room temperature, but becomes soft and plastic when heated. The latter property means that products made of SBS can be formed into a variety of shapes.

SBS is resistant to abrasion and does not readily break down when exposed to heat, light, and chemicals. It may dissolve or break down when exposed to fats and oils and various types of hydrocarbon compounds and mixtures. It maintains its structure and performance well over a wide temperature range from −60°C to 150°C (−75°F to 300°F).

SBS was first developed in the early 1930s by two German chemists, Walter Bock and Eduard Tschunkur. Their research was part of Germany's Four Year Plan for self-sufficiency. Under that plan, the nation worked toward eliminating, so far as possible, the import of essential materials that might be needed in case of a war. Germans already had one type of synthetic rubber, known as Buna, but it had a number of disadvantages. SBS was far superior to Buna, and was soon being produced in very large amounts in German factories.

HOW IT IS MADE

Molecules of both styrene and 1,3-butadiene contain double bonds. Any compound with double bonds has the ability to form polymers. Polymerization occurs when the double bond in one monomer molecule (such as styrene) breaks apart. A hydrogen atom from a second molecule of the monomer then adds on to one end of the broken double bond. The rest of the second molecule adds to the other end of the broken double bond. A "double-molecule," consisting of two monomers joined to each other, forms. The "double-molecule" also contains a double bond. So the process can be repeated to form a "triple-molecule" consisting of three monomer molecules. The process is repeated hundreds or thousands of times producing a long chain of monomers.

In the production of a block copolymer, one extra step is added. First, a long chain of styrene monomers is produced. Then a long chain of butadiene monomers is made. Next, the two chains are joined to each other. Finally, additional chains of polystyrene and polybutadiene are added, making a very long chain consisting of alternating blocks of polystyrene and polybutadiene.

This method is used for the production of many different kinds of polymers. The most difficult problems may be how to get the first few double bonds to break apart, and how to stop the polymerization reaction at just the right point. The method used to make most SBS today involves the use of a butyl lithium (C_4H_9Li) catalyst, which is very effective in getting the reaction started. The reaction is terminated at some given point by the addition of dichlorodimethylsilane ($SiCl_2(CH_3)_2$). The dichlorodimethylsilane reacts with the last monomer at the end of the SBS chain, blocking the addition of any additional styrene or butadiene monomers.

COMMON USES AND POTENTIAL HAZARDS

The process by which SBS is made can be modified to produce products with somewhat different physical and chemical properties. For example, some forms of SBS are especially strong, making them suitable for the manufacture of tires, shoe soles, conveyer belts, and the tracks on caterpillar trucks. Other types of SBS are engineered to be more flexible, for use as rubber tubing, flexible toys, sporting goods, and refrigerator gaskets. SBS products can also be made in a variety of colors and shapes for use as seals, rubber mats, floor coverings, tire treads, and shoe components.

SBS production fluctuates or changes according to a number of factors, including market demand, the price of petroleum, and the price of natural rubber. For example, when natural rubber is readily available

and inexpensive, the demand for synthetic types of rubber, such as SBS, decreases. Also, when the price of petroleum increases, SBS becomes more expensive to make and production decreases.

Words to Know

COPOLYMER

A polymer made with two different monomers.

MONOMER

A small molecular unit that joins with others to form a polymer.

POLYMER

A compound consisting of very large molecules made of one or two small repeated units called monomers.

THERMOPLASTIC

A material that becomes soft and moldable when heated, then hardens when it is cooled.