

## **Latex Chemistry and Vulcanization** **(An Understanding of the Natural Rubber Gloves Manufacturing Process)**

**Vulcanization** is a process of improving the characteristics or properties of natural or synthetic rubber by heating it with sulfur. It was discovered by Charles Goodyear that when raw rubber and sulfur were heated together the rubber hardened to an elastic state that is no longer sticky but rather acquired physical properties that makes the rubber useful as a material to be fabricated into many items that we are now very familiar today, such as tires, mats, tubing and gloves.

Over the years vulcanization chemistry developed for various applications. But the fundamental concept remained unchanged although sulfur is sometimes excluded or replaced as a linkage material. In the case of the production of latex gloves, sulfur remains the key substance, aided by several other chemicals known for their functions. They are accelerators, activators, stabilizers, anti-foaming agents, anti-webbing agents, anti-oxidants, pigments, etc.

### **Nature of Latex**

Natural rubber latex (from the *Hevea Brasiliensis* tree that originated from Brazil) is made up of an ultra-fine emulsion of rubber particles suspended in aqueous (watery) phase. The aqueous phase, called serum, contains several non-rubber matters such as carbohydrates, proteins, lipids, minerals, microorganisms and of course, water. The rubber phase is made up of billions of rubber globules or particles. Each of these particles contains pure rubber surrounded by a layer of soapy-like substances that keep the particles apart. The manner how this takes place is through the negative electric charge on the surface of the particles, so that the particles repel each other and remain separate. These soapy-like substances are made up of proteins and phospholipids.

### **Making Natural Latex Useable**

The natural latex direct from the trees, besides being too watery for use, also contains a significant amount of non-rubber and is not a commercially useable raw material. Raw latex must be processed by centrifugation that also purifies it further. Centrifugation makes the latex more concentrated besides removing much of the non-rubber matters such as sludge and dissolved solids in the serum. To compensate for the loss of the natural soap present in the latex, as well as to prevent premature coagulation and preserve the latex from deterioration during storage, ammonia and some artificial soap are added.

Centrifuged latex is the basic material for the manufacture of latex gloves. However, without the necessary vulcanizing chemicals, the latex will not have the elasticity and strength of making the gloves stretch and not tear.

### **Mixing Latex with Chemicals**

To produce the effect of vulcanization in latex, various vulcanizing chemicals and other processing aids must be added as a liquid emulsion. Since almost all of them are denser than rubber (which by itself is a little lighter than water) they must be ground up into very fine pastes or dispersions. Most importantly, the particle size of these chemicals must be smaller than those of the rubber particles. If they are bigger they settled out and are wasted. A formulated quantity of each of the chemicals in a paste or dispersion state is added into the latex and the mixture, called compound, stirred at slow speed for several hours. In a variation, these mixtures with latex are heated up gradually to yield a pre-vulcanized or PV latex. PV latex when used for making gloves need not undergo a thorough vulcanization process since this has already taken place during the mixing and heating up of the chemical mixtures with the latex.

### **What Happens During Compounding**

It is most interesting to understand what happens within the latex compound mixture. During stirring, the chemical particles bump against each other and with the rubber particles. The collisions result in agglomeration of the chemicals with the rubber particles. Over the period of stirring the chemicals became fused with the rubber inside the rubber particles. Even at ambient temperatures, vulcanization starts but progresses slowly with time. However, without heating vulcanization will be incomplete and will take several days to reach a significant extent to make the product useable.

### **Understanding Vulcanization**

To begin to understand vulcanization, remember that rubber molecule is a very long thread polymer made up of millions of monomer units called isoprene. The chemical name of natural rubber is therefore poly-isoprene, or more accurately, cis 1,4 poly-isoprene. Some of these polymers are longer than others but they are all thread-like and together, still does not have any 'network' strength. Imagine these molecules as cut pieces of cotton threads and when they are pulled they just fall apart. This is the situation with dry film of un-vulcanized latex.

### Vulcanization Process

With the vulcanizing chemicals inside the rubber particles, the sulfur atoms form linkages or cross-links between the rubber molecules and sometimes within the molecules. These sulfur atoms act as connectors and the other chemicals called activators and accelerators help speed the reaction. When heated up the cross-linking of sulfur with the rubber molecules speeds up and become more intense and complete. The greater the cross-linking is, the stronger the network and hence the tougher the vulcanized rubber. A well-vulcanized rubber is much like a fishing net or basketball net.

### The Making of Latex Gloves

In the making of gloves it is important that full vulcanization only takes place after the latex has taken the shape of the hand. To cause this to happen, the hand molds need to be dipped into a coagulant solution first. The coagulant serves as a pick-up by 'freezing' the rubber particles over the molds so that they take on the shape of hands. Coagulation takes place when the negative electric charges on the rubber particles are neutralized by the positively charged calcium ions (from the calcium nitrate). This forces the rubber particles to collapse into each other and coagulate. The reaction is instantaneous. These freshly born gloves, called wet gel, have to undergo leaching to flush out as much of the water-soluble non-rubber as possible. These would include the latex proteins that can sensitize some users and cause allergic reactions.

The cuffs need to be beaded before they dry up. Beading is optional but they are popularly requested as they add strength to the gloves during the process of donning.

The wet gel moves into the oven for drying and vulcanizing. When they leave the oven they are in a state that is for all purposes and intent, a protective device. Subject to several stages of quality inspection, they are classified, graded and packed.

### Chemicals Used

The common chemicals used and their functions are as follows:

Sulfur – cross-linking agent

Zinc Oxide - activator

Zinc Dibutyldithiocarbamate – accelerator

Zinc Diethyldithiocarbamate – accelerator

Zinc Mercaptobenzothiazole – accelerator

Titanium Dioxide - whitening pigment

Calcium Carbonate - anti-tack agent

Calcium Nitrate - coagulant

Corn Starch - donning agent

Potassium Hydroxide - pH stabilizer

Anti-oxidants, anti-foaming agents, anti-webbing agents, surfactants, color pigments, flavoring compounds, fragrance and other additives used are mixtures of compounds that are proprietary knowledge and rights of the various brand owners and may not be disclosed here.

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