

# I Got Sole !



*The world's oldest running shoe*  
<http://duckhenge.uoregon.edu/io/article?id=370>



[www.myvoucherCodes.co.uk](http://www.myvoucherCodes.co.uk)

## The Chemistry of Polyurethanes

Many years ago I participated in track and field events. Thanks to polyurethane I was able to use all my energy for performing my best. Life before polyurethane and other performance materials must have been difficult and wearing for athletes. Before the late 1970s, running shoes were not high-tech items. With rare exceptions, until the middle of the 19th century, shoes were made on a single straight cast and there was no differentiation between left and right shoes. During those years, not many international competitions were held, the modern Olympics did not occur until 1896. Keds had their beginning as a product of US Rubber in 1917. Keds was chosen as a name because the desired name, "Peds," was already trademarked by another company. Keds were the first sneakers, so-called because of the stealth and quiet manner in which you could creep up on someone when you wore them. Keds, and later Converse, captured much of the US "Sneaker Market." Keds was purchased by the Stride Rite Corporation in 1979. ([http://www.drpribut.com/sports/sneaker\\_odyssey.html](http://www.drpribut.com/sports/sneaker_odyssey.html)) Have you ever tried running a few miles in a pair of Keds? Ouch! Since then, polyurethanes have become the major component in athletic shoes. Otto Bayer and co-workers discovered and patented the chemistry of polyurethanes in 1937.

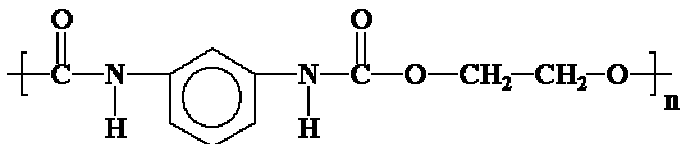
(<http://inventors.about.com/library/inventors/blpolyurethane.htm>) This would change the shoe world forever!

According to Ecco Shoe Company, polyurethanes are very useful for making the soles of shoes. They give several reasons why;

- It is one of the longest lasting sole composites that can be used in shoe making.
- It has what is known as “direct energy return”. In essence the polyurethane absorbs the shock of taking a step and turns it into energy. Therefore causing a trampoline effect with the shoe.
- Polyurethanes hold their shape

<http://www.zappos.com/n/br/b/54/faq/1.html>

Polyurethanes are polymers that have a urethane group in the backbone of the polymer chain. A polyurethane looks like this.



Picture taken from: <http://www.pslc.ws/macrog/level1.htm>

Polyurethane is made from **reacting diisocyanates with di-alcohols**. In today lab we are going to make two types of polyurethanes, soft foam and rigid foam.

#### Demonstration

##### Part I -Making soft polyurethane foam

#### Experiment

##### Part II- Making rigid polyurethane foam

<http://www.elmhurst.edu/~chm/demos/PolyurethaneFoam.html>

#### Science Concept:

Two monomers react producing a three-dimensional polymer by cross-linking many rows of linear polymers.

#### Materials:

- Solution A (trichloroflouromethane and polymer alcohol)
- Solution B (poly functional isocyanate)
- styrofoam cup
- wooden stick for stirring

#### Directions:

- \* Place a mark on the cup about 1/3 of the way up from the bottom. Place a second mark of equal distance up from the first.
- \* Pour solution A up to the first mark and pour B up to the second mark on the styrofoam cup.
- \* Begin stirring the thick solution with wooden stirring stick for about 30 seconds.
- \* The reaction might take 1-2 minutes, so be patient.

### **Explanation:**

A polymer is a long chain of molecule made of many repeating monomer units. In this experiment, the monomers units we call molecule A and molecule B. A adds to B and A adds to B many, many times to form the polymer. A-B-A-B-A-B-A-B are linear chains formed by monomers.

In addition these molecules have a third place for the reaction to take place. The individual polymer chains are cross linked together. The cross-linking of the two monomers A and B is what caused the reaction. Many alternating units of A-B-A-B are cross-linked. The main cause of it to be rigid and foam out is the cross-links along with the formation of bubbles. Carbon dioxide bubbles are released which also contributes to the production of the foam. The three dimensional polymer is called polyurethane foam. The reaction gives off heat. If you were to place your hand above the reaction, you can feel the heat rising. In a few minutes, the reaction is complete and we will be able to touch it.

### Questions for further discussion

1. What other applications might require the same properties as polyurethanes?
2. Why do you think so?
3. Find a website and list five other applications of polyurethanes. Make sure at least one is an application of rigid foam!

4. Which polyurethane (soft or rigid) would have the highest degree of cross-linking? Why?