8th Grade Science – Uddo Name: ____
Polymers and Teflon

Discovering Teflon

Teflon is so slippery it is one of the only surfaces geckos cannot stick to.

Teflon, listed by Guinness Book of World Records, as the slipperiest substance on Earth, is one of the only surfaces that geckos can't stick to. The material is used in cooking pans to make them non-stick. Teflon was first discovered by accident in 1930 by a scientist named Roy Plunkett.

On April 6, 1938, Plunkett was trying to come up with a chemical to use in refrigerators that had improved cooling properties. He decided to use a gas, which he stored in metal cans with a valve release (similar to hair spray cans today). On the morning he tried to release the gas from the can, Plunkett, realized he couldn't get the gas out of the can. However, the can weighed the same as it had when the gas was added. Plunkett was curious as to what was going on. He cut open the metal can, and discovered that the gas had turned into a waxy, white powder that was impervious to many corrosive chemicals.

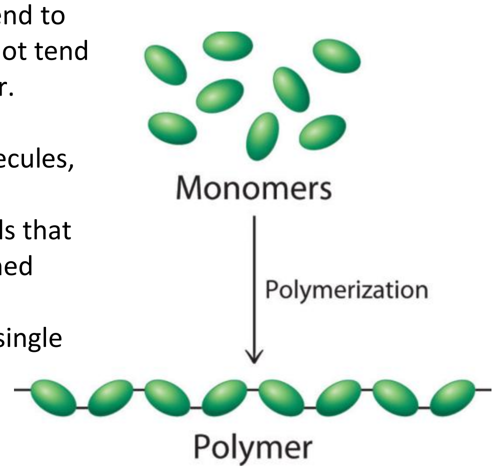
Plunkett was intrigued. He tested the unknown white powder for its properties. He discovered that the white powder was heat resistant and had a low surface friction. This means that most other substances wouldn't stick to it. The white powder was tetrafluoroethylene (PTFE), a solid version of those dreaded fluorocarbons, like Freon. Tetrafluoroethylene is not a super catchy name, so Plunkett came up with an abbreviated name, Teflon. Full-scale commercial production of Teflon did not begin for another 10 years, but was pretty much limited to industrial applications.

In the early 1950's, a man in Paris, Marc Gregoire, learned of Teflon and devised a way to apply the plastic to his fishing tackle to minimize tangling. His wife conceived of the idea to apply it to pots and pans.
Gregoire applied the Teflon to one of her frying plans with great success. Within several years, he was selling more than a million Tefal (his trade name for Teflon) coated pans a year. Yet no one in America had ever seen one of these pans.

It wasn't until 1960 when the Food and Drug Administration approved PTFE for food processing equipment.
Without meaning to, Plunkett had produced a synthetic polymer. **Polymers** are large molecules that are made up of many smaller molecules of the same type, **monomers**, bonded together in a repeating chainlike pattern. Polymers are all around us. DNA, spider silk, natural rubber, and protein are all examples of naturally occurring polymers. Plastics, nylon, acrylic, and Teflon are all examples of **synthetic** polymers.

All polymers, including silk, Teflon and nylon share certain properties. They are all huge molecules, with hundreds and sometimes thousands of atoms per molecule. Their structure gives them unique properties. For example, polymers are so large that they become entangled with each other. Think of one polymer molecule as a piece of cooked spaghetti. In a bowl of spaghetti, that one piece of cooked spaghetti gets tangled up with all of the other pieces of pasta. It is very difficult to separate one piece of spaghetti from the remaining pieces because the strands of spaghetti are tangled together.

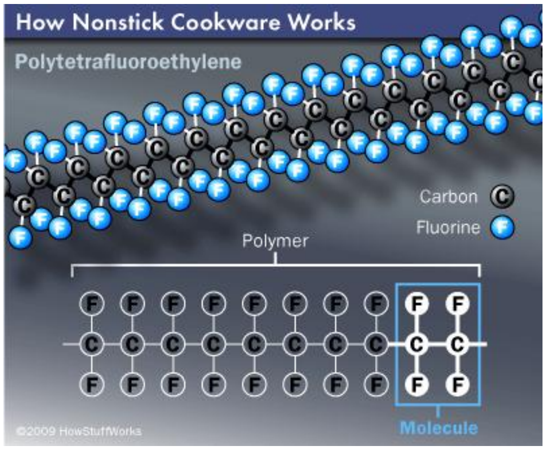
Polymer molecules are arranged in a similar way. Because of this structure, polymers tend to be light, strong, and resistant to chemicals. In contrast, small molecules, like water do not tend to get tangled with each other because each water molecule is separate from the other.



Polymerization is the method of creating synthetic polymers by combining smaller molecules, called monomers, into a chain held together by covalent bonds. Various chemical reactions — those caused by heat and pressure, for example — alter the chemical bonds that hold monomers together. The process causes the molecules to bond in a linear, branched or network structure, resulting in polymers. These chains of monomers are also called macromolecules. Most polymer chains have a string of carbon atoms as a backbone. A single macromolecule can consist of hundreds of thousands of monomers

Another way of thinking about the structure of polymers is to picture a box filled with steel chains. Each chain is made up of hundreds of individual links, but the chains themselves are not connected to any other chain. In this example, each steel chain represents one polymer molecule, made up of hundreds or thousands of atoms (individual links).

If you were to reach into a box and grab a chain, you could pull out an individual chain. But now imagine that you add a lot of tiny magnets into the box. Those magnets would attract the steel chains, connecting the individual chains into one large mass of chains. If you were to reach into the box and grab a chain now, you would pull out the entire mass of chains.



PTFE is a type of fluoropolymer. Fluoropolymers are polymers that include the fluorine atom, which is the key to many unique characteristics of PTFE. Fluorine's electron structure is very stable—it doesn't share its electrons with other atoms easily. The chemical composition of PTFE is based on two carbon atoms and four fluorine atoms, which are repeated throughout the molecules structure. The molecular structure has an outer shell filled with fluorine atoms, which shield the carbon atoms from reacting.

Along with their resistance to reacting with other chemicals, fluorine atoms also play a role in giving PTFE a low coefficient of friction. The coefficient of friction is a measure of how easy it is for two substances to slide by each other – the harder it is to slide, the higher the coefficient of friction. PTFE doesn't put up a lot of resistance when sliding by another substance giving it a low coefficient of friction. The low coefficient of friction gives PTFE that signature slippery quality.

The rest is Teflon pot and pan history.

Which leads to the question: If nothing sticks to Teflon, how do they get it to stick to the pan?

Originally it didn't stick well - you had to use special utensils or the Teflon would chip off.

Today, they roughen the pan's surface by sandblasting it. A primer is applied to the surface and then the Teflon is embedded in the primer.

The idea is quite simple - the Teflon won't *chemically* bond to anything else, but you can *mechanically* get it stuck in small cracks and crevasses.

Think of it this way: if you get stuck in a house without doors or windows, you cannot get out through a mouse hole. You're mechanically stuck in there (no matter how slippery you may be).