Thanks to Chemistry

By Lois Fruen

The way you style your hair can make a bold statement about who you are. There are lots of different styling products that can give you the look you want, and those products are all formulated by chemists. Many of these products also help repair potential damage caused by blow-drying, coloring, and straightening your hair.

Below is an overview of hair products that you can find in your favorite store. You will discover some of the chemicals they contain and how some of them interact with your hair.

Conditioners

To add moisture to hair and smooth the cells on its surface—collectively called the hair cuticle—most people use hair conditioners, which help untangle and improve hair appearance, prevents hair from getting dry and brittle, and makes locks easy to brush.

“Stripped of its natural oils, hair feels dry and raspy,” says Anita Grahn, a cosmetic chemist at Aveda Corporation. “This is because strands of negatively charged hair repel each other, causing so-called ‘flyaway hair.’”

Hair conditioners usually contain positively charged molecules called quaternary ammonium compounds, such as stearalkonium chloride (Fig. 1), which bind strongly to the hair surface and then act as the new hair surface. Conditioners usually also contain molecules called amino silicones that fill in the splits, cracks, and chips present on the surface of damaged strands.

Both ingredients work together to add weight to the hair, make it easier to comb, and restore the essential oils needed to make hair healthy. A hair strand that was exposed to a conditioner is shown in Fig. 2.

Antihumectants

If your hair frizzes in humid weather, you can use an antihumectant pomade, which contains chemicals free of water.

Substances that repel water often feel oily or greasy, which is unappealing. But most antihumectants are not greasy, yet they repel water. The reason is that most atoms in greasy substances have nonpolar bonds with their neighboring atoms, that is, they share electrons equally. Instead, antihumectants contain a molecule called isopropyl palmitate (Fig. 3), in which some atoms have nonpolar bonds with their neighbors, while other atoms have polar bonds, in which electrons are unequally shared with neighboring atoms. This doesn’t make the antihumectant greasy, yet it repels water.

In addition to isopropyl palmitate, antihumectants also contain phenyl trimethicone, which acts like a lubricant to add shine and makes hair easier to brush. These ingredients are dissolved in a solvent, such as cyclopentasiloxane, which evaporates readily and prevents the ingredients from feeling heavy or oily.

Styling products

Once your hair is conditioned and defrizzed, you can use one of many styling products. For example, styling gels prevent fine hair from falling flat and make it shine...
with a substance called a film former that forms a coating around the strands of hair as the gel dries.

In these gels, molecules called polymers, which contain a chain of identical units, make a film that steps between hair strands, drawing them together. When the gel dries, it forms a firm connection between the hair strands which can be immediately undone by brushing or washing.

Styling gels are usually used to make hair stand out. This way, you can try to make a Mohawk spike—like the British punk-rock band G.B.H. or American Idol finalist Sanjaya Malakar—or a fauxhawk—like the British soccer player David Beckham.

“Some of these styling products are really sticky to start, but they dry down to a nice film,” Grahn says.

The chemicals at work in these products have exotic names, such as polyvinylpyrrolidone (PVP) and a molecule called a copolymer made of a chain of smaller molecules called methyl methacrylate, octyl acrylamide, propylene glycol monomethacrylate, butylaminoethylmethacrylate, and acrylic acid (Fig. 4). In the copolymer, some of these molecules are positively charged, while others are negatively charged, making the copolymer soluble in water, so that it can be removed with a shampoo.

You may also want to give your hair a gritty, messy look. You can try a product that uses grit wax, which works by coating the hair with powdered starch for separation. But if you prefer lacquered spikes, you can try polyurethane products.

Styling products for dreadlocks can make extremely thick gels in water, helping to wash hair and keep a twisted rope styling. Such products contain a dye called D&C Yellow 11 and a thick oily liquid called 1,2-propylene glycol (Fig. 5).

Frizzy and springy hair benefits from moisturizing products that soften the curls while fighting frizz. Such products contain polyquaternium-11, a molecule that reduces frizz while softening the curls.

**Hair dyes**

You can also change the color of your hair. You can do it in one of three ways: temporarily, semipermanently, and permanently. Dyes used for temporary hair color contain pigment molecules that are large and, therefore, don’t penetrate the cuticle layer. Instead, they coat the cuticle and may be removed by shampooing.

Semipermanent hair dyes deposit color on the hair shaft but don’t remove the hair pigments. These dyes contain small molecules that penetrate the hair shaft.

The third type of dyes first removes the hair pigments with a chemical called hydrogen peroxide (H₂O₂). This process is called lightening, since it gives hair a lighter color. Then other chemicals such as p-aminophenol (Fig. 6) penetrate the hair and give it a new color.

You can also do highlights, which consist of selecting small or thick strands of hair and giving them a color that is at least two

**What Does**

**Anita Grahn** is a cosmetic chemist who works for Aveda Corporation. She uses her degrees in chemistry and biology to formulate new products and to monitor her formulations for quality and safety.

Grahn likes to use for herself the products that she and her team have developed. She likes to give body to her hair, so she uses Pure Abundance, which gives some volume to her hair.

“I designed Pure Abundance to rough up my hair cuticles, which are the cells located on the surface of each hair,” she says. “Most hair products are designed to keep cuticles lying flat, but Pure Abundance makes cuticles flare out without damaging them, which gives hair a fuller look.”
shades lighter than the rest of your hair. Hair creams that contain acetic acid, cet- earyl alcohol, and a dye called D&C red 33 can give you funky burnt-orange and pink streaks.

**Straightening your hair**

Maybe you are looking for straighter hair. You can temporarily straighten your hair with a hot ceramic flat iron that works at temperatures between 170°C and 230°C. The flat iron realigns bonds between proteins inside each hair strand.

Each strand of hair is made up of millions of long chains of proteins cross-linked with each other by three different types of bonds called hydrogen, salt, and disulfide bonds (Fig. 7). When you apply heat to your hair, these bonds are the first to break, but they can easily reform by drying or cooling your hair. But heat from the iron can also frizz your hair, so be sure to use a defrizzing product. Such products use a variety of silicones, such as phenyl trimethicone, along with cyclopentasiloxane for lightness. All of these chemicals handle the heat of the iron to make hair shiny and leave it soft after straightening.

To permanently straighten your hair, you can use a lotion or cream that relaxes hair curls called a relaxer. This product permeates the protein structure of the hair and weakens its internal bonds, causing the natural curls to loosen out. Some relaxers use potassium hydroxide (KOH), lithium hydroxide (LiOH), or a combination of calcium hydroxide (Ca(OH)₂) and a solution of guanidine carbonate.

**What Does a Cosmetic Chemist Do?**

Anita Grahn, Director of Hair Care Research at Aveda Corporation.

During her 16 years at Aveda, Grahn has prepared a number of the company’s most popular hair products, such as Custom Control and Rosemary Mint Shampoo. Her team of eight chemists also has prepared many of the hair products that are sold in Aveda shops, including Be Curly, Brilliant Anti-humectants Pomade, and Hang Straight.

Grahn’s team is now working on a new shampoo plus conditioner that will be launched soon. The scientists are also working to find alternatives to petrochemicals that are still used to prepare some products. “My team is currently experimenting with plant waxes that hold hair in place using viscosity,” she says.

Grahn also works with many other scientists, including microbiologists who ensure that products are free from bacteria; formulators who find ways to use raw materials in new and innovative ways; perfumers who formulate aromas; color chemists who make products appealing to consumers; and chemical engineers and technicians who test products on hair.

—Lois Fruen

**SELECTED REFERENCES**


Lois Fruen teaches chemistry at Breck School in Minneapolis, Minn. Her most recent ChemMatters article, “Real of Fake? The James Ossuary Case,” appeared in the February 2006 issue.