The Human as Hydrogel
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CHEMICAL REACTION **BY STEVE HERMAN**

The Human as Hydrogel

The cosmetic formulator never will be far from polymers either as ingredients, packaging or intended target substrate.

Chemists ... don't split atoms, as the physicists do. They join them together, and a very praiseworthy activity that is. —Anthony Standen

It is common wisdom that the human body is mostly water—you are, in fact, about 60 percent water by weight. Fortunately, the various types of protein in your body tie up most of the water present in the internal organs. Proteins are polymers, and a system where there is an abundance of water bound by polymers is called a hydrogel. Thus, you are a hydrogel draped over a skeleton. To see polymer chemistry in action—look in a mirror!

Polymers are second to aroma oils in dollar volume of cosmetic raw materials purchased by manufacturers, with annual sales nearing the billion-dollar mark, and are increasing at the fastest rate of any class of cosmetic materials into the foreseeable future. Demand is being fueled by the use of natural polymers for skin and hair therapy, the need for substantivity in numerous products and for the nonirritating properties characteristic of the large molecules.

Many polymers have been used for decades, but new ones come along daily, and the applications and possibilities are boundless. Some of the progress in polymers is obvious. Carbomers, which were once very time-consuming to disperse, can now be dumped into solution. Hair resins have evolved with hair styles and VOC regulations. Polymers now act as emulsifiers through steric hindrance, make color cosmetics and sunscreens last longer by forming films, and thicken every sort of personal care product.

When all the repeat units are identical, the compound is a homopolymer. When two or more different monomers are used, the result is called a copolymer. The situation gets complicated quickly even if only two monomers are used. They can be alternating copolymers, block polymers, random polymers or graft copolymers (Figure 1), which have potentially infinite variety. Among the possible components are aliphatic or aromatic hydrocarbons, silicones and ethoxylates. A polymer chain can have many different overall structures, such as linear, branched and crosslinked (Figure 2). Heteropolymers have several different monomer units in an irregular pattern. Many biopolymers, such as proteins and DNA, are heteropolymers.

The number of repeat units in a molecule determines the degree of polymerization (DP) and is related to the molecular weight. Determining the exact size distribution of a polymer is so difficult that averages usually are used. The molecular weight is related closely to the viscosity of the polymer solution, since larger chains slow the flow of solutions. DP also affects mechanical properties such as tensile strength and hardness.

Typical of science, there is a considerable gap between a descriptive approach and rigorous quantitative analysis. With

FIGURE 1. GRAFT COPOLYMER

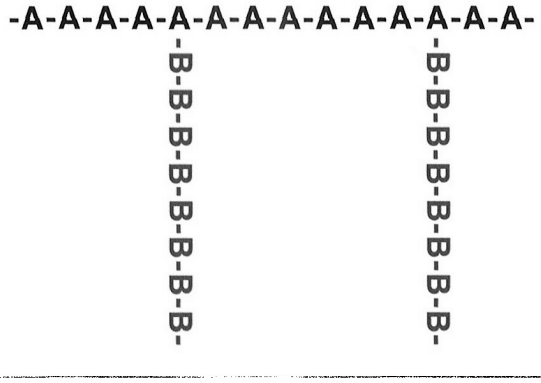
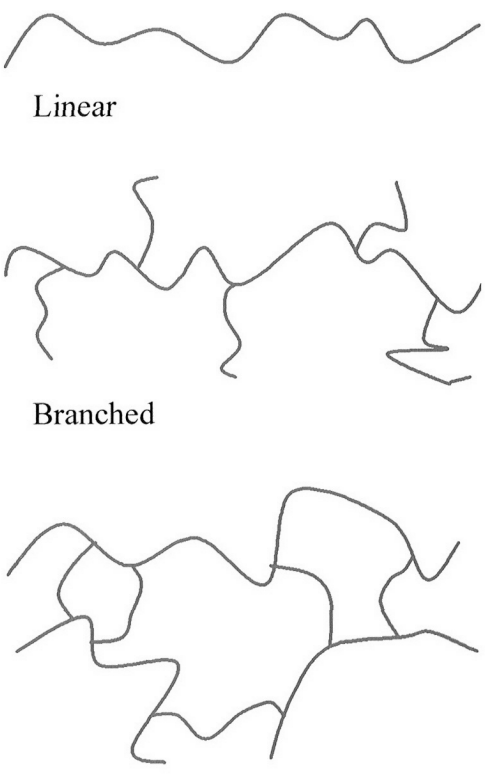


FIGURE 2. POLYMER STRUCTURES



polymers, this gap can be illustrated by the analysis of viscosity. The fact that longer chains typically create higher viscosities is certainly true but does not bring mathematical precision to the phenomena. Part of the deeper approach to the behavior of polymers in solution is the Flory-Huggins Theory. The theory was derived from treating a polymer solution as a lattice in which a solvent molecule can occupy the same lattice position as the polymer segment, with entropy and the Gibbs free energy are thrown into the mix. Flory-Huggins reminds us that polymers are part of colloid science and are only a separate discipline because of their importance.

Gelling polar systems with polymers has been possible for many years, carbomers and xanthan gum being commonly used ingredients. Gelling nonpolar systems is more difficult. Specialized gelled oils have been available, but having polymers to gel a wide variety of oils under common laboratory conditions is a more recent development. The Sylvaclear™, amide terminated polyamide resins, and Uniclear®, ester terminated polyamide resins, available from Arizona Chemical, provide one approach to gelling numerous nonpolar materials. These unusually short polymers allow greater modification of properties by varying the termination. The chains are primarily hydrocarbons with amine groups inserted at wide intervals, so the hydrogen bonding comes from weld points along the molecules.

The human hydrogel, skeleton aside, is not very different in concept from some cosmetic products. One recent innovation in cosmetic hydrogels is the Natragel™ dermal delivery system produced by Gel Concepts. Polysaccharides (mainly carrageenan) gel an aqueous system (primarily water, glycerin and sucrose) into a molded form that can slowly release actives on the skin while providing a cooling effect. In the past, many polysaccharides produced brown, opaque gels, like many older water-based gel air fresheners, but new products can be made crystal clear with the refined raw materials now available.

The cosmetic formulator never will be far from polymers either as ingredients, packaging or intended target substrate, as the skin and hair are chiefly composed of them. Indeed, polymers are so pervasive that we may take them for granted. That would be a mistake, for this never-ending class of materials undoubtedly holds the key to many future innovations. ■ GCI

Polymers undoubtedly hold the key to many future innovations.

Steve Herman is vice president, new technology development, at AFF International. He has more than 30 years of experience in the industry, primarily in fragrance application. He serves as an adjunct professor in the FDU Masters in Cosmetic Science program and has been active in numerous capacities with the SCC. chemreaction@allured.com