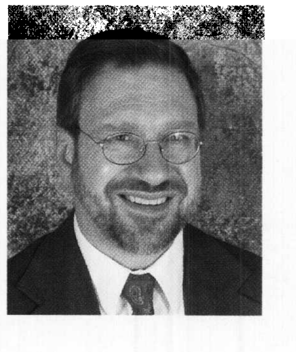
The wing of a butterfly
Steve Herman
Global Cosmetic Industry; Aug 2002; 170, 8; Research Library
pg. 32



CHEMICAL REACTION **BY STEVE HERMAN**

The Wing of a Butterfly

The beautiful insect may not be a practical commercial source for our raw materials, but it does illustrate some important technologies.

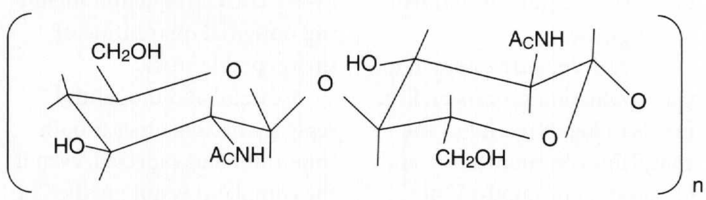
To see the world in a grain of sand,
And a heaven in a wild flower;
Hold infinity in the palm of your hand,
And eternity in an hour.
—William Blake

KEN KLEIN, president of Cosmetech Laboratories and a valued colleague, once said it was easy to find a subject every month for Chemical Reaction. He said, "You can write about anything. You could write about butterflies if you wanted to." Klein knows cosmetics better than most, and he realizes the butterfly example was pushing the envelope—or was it? Let's take up his challenge and see what the butterfly can teach us.

The main attraction of butterflies is surely their colorful wings. The primary structural component of the wings is chitin. Chitin in turn is readily converted to chitosan, a cosmetic ingredient being promoted recently by several suppliers. The color patterns on the wings arise from iridescence, essentially the same phenomena responsible for the colorful surfaces of soap bubbles. The wings of the male butterfly secrete pheromones, a portal to the study of chemical signaling. Clearly, butterflies are a point of entry into many pertinent technologies.

Chitin is a polysaccharide found commonly in nature in organisms such as crustaceans, insects and fungi. The usual source of chitin for personal care is shrimp. Shrimp are harvested for food in massive quantity and the shells are byproducts, an ideal use of resources. The chemistry of chitin from shrimp shells and butterfly wings is the same except for variations in molecular weight, although shells and wings obviously have many components in addition to chitin, which provide further differentiation. Chitin has the catchy chemical name poly(ß-(1,4))-2-acetamido-2-deoxy-D-glucopyranose.

FIGURE 1. CHITIN STRUCTURE



The structure, less formidable than the name, is shown in Figure 1. It is converted to chitosan by deacetylation. Chitosan has a net positive charge that allows it to adhere readily to negatively charged biological surfaces. Lack of consistency and the difficulty of obtaining commercial quantities have limited the use of chitosan in cosmetics until recently.

Several articles on chitosan[1,2,3,4] have suggested its use in skin and hair products. Its film-forming characteristics make it useful for hair styling; on skin, chitosan can reduce transepidermal water loss (TEWL) and skin irritation. In formulations, it has functional uses as a surfactant and viscosity builder, and it has an ideal toxicity profile. Other benefits include moisture absorption, antibacterial effects and enhancement of perfume longevity. The degree of deacetylation and molecular weight influences the product's viscosity, solubility and performance.

A butterfly wing can turn white light into a wonderful spectrum of colors. The colors are caused not by pigment, but by iridescence. Figure 2 shows the iridescence at the scale level of a Morpho rhetenor[5]—the Blue Morpho Butterfly (*Morpho menelaus*) is an iridescent blue butterfly that lives in rainforests of South and Central America, including Brazil, Costa Rica and Venezuela. Butterfly wings are of multilayered thin-film construction, alternating layers of air and scales. The cuticle material itself is a composite of rods of chitin set in a matrix of proteins. Individual chitin scales

The primary structural component of a butterfly's wing is chitin, a cousin to chitosan, which is a common cosmetic ingredient.

are approximately one millionth of an inch thick, nearly the same thickness as the wavelength of light. Each scale is a flattened projection of cuticle from a single epidermal cell within the epithelial layer that makes up the surface of the wing. The arrangement of scales on the wing resembles that of shingles on a roof with two distinct layers of different scales usually present. Additional layers of scales increase the scatter of the reflected light through diffraction, making the butterflies visible from as many positions as possible. The colors are used to attract mates, and for camouflage, mimicry and marking territory.

The light effects of the butterfly wing are utilized most commonly in cosmetics using pearlescent pigments, and the light-modifying characteristics of butterfly wings may soon influence the fabrics we wear. The color of the wings can change from light to dark to aid the regulation of temperature. Other thin films with critical temperature parameters are computer chips during manufacture, and the butterfly is inspiring current research in this high-tech arena.

The study of butterfly wing's optical properties is part of a more general subject: photonics. Photonics considers the study of thin films and interfaces, particularly the optical properties of liquid crystal layers; the interaction of light with waveguides, gratings and surface modes; the fluorescence of molecules near modulated surfaces (photonic surfaces are materials structured on the scale of the wavelength of light); and the electronic properties of molecular layers.

Scent scales are modified wing scales on butterflies and moths that release pheromones. Only males have scent scales, as the pheromones are designed to attract females of that species. Scent scales are also called androconia, which produce a courtship pheromone. The androconia are displayed in front of female antennae during courtship, to induce landing and mating.

The production of the pheromone in some species requires a chemical extracted from milkweed as a precursor, and clear correlation is found between the butterfly's mating and the distribution of this plant. In a charming quirk of nature, a butterfly pheromone is chemically identical to elephant pheromone, shown in Figure 3, although there have been no reports of improper mating caused by signaling confusion.

In humans, the reported pheromones androstenone, androstenal and copulins have not affected our mating behavior significantly, but the power of odors to affect mood and behavior are well known.[6] Aromatherapy and aromascience[7] are major driving forces behind many cosmetic lines. The factors affecting human behavior differ from those of a butterfly, but many of the basic chemoreception principles are the same.

FIGURE 2. AN IRIDESCENT BUTTERFLY WING

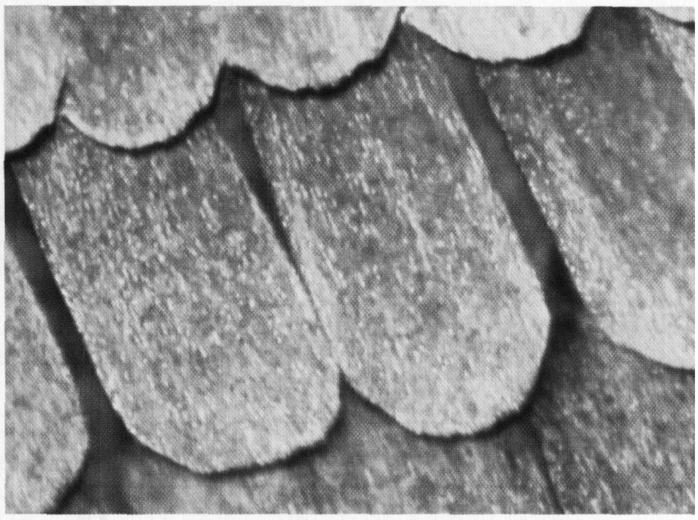


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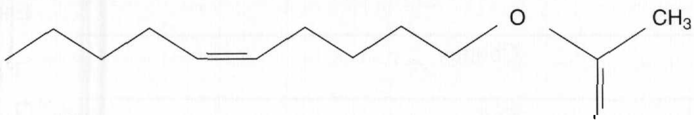
FIGURE 3. BUTTERFLY PHEROMONE

When is an elephant like a butterfly? Cis-7-dodecenyl acetate is a pheromone for both.



Ken Klein did us a great service by suggesting the butterfly as a topic. It may not be a practical commercial source for our raw materials, but it does illustrate some important technologies. A patch on Australian currency based on the structure of butterfly wings makes it almost impossible to counterfeit. According to a spokesman, "The butterflies are pointing out useful techniques rather than giving us absolute blueprints … they offer us a toolkit to work with." The chitin in its wings, the iridescent colors that catch our eye, and the pheromones that attract other butterflies all relate to the domain of personal care. As a final gift, the butterfly will always remind us of the fragile, fleeting beauty many cosmetic companies try to put in a bottle. GCI

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