Using Silicone Technologies to Deliver Active Ingredients

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Abstract

Silicone technology has recently been evaluated for the delivery or enhancement of active ingredients in final formulations. Studies have highlighted the ability of silicone-based technologies to meet these objectives, while providing a range of desirable features and benefits. Personal care delivery systems range from the simplest concepts such as volatile carriers for actives to increasingly sophisticated technologies such as encapsulation, with the capability of providing controlled or sequential release of the active.

Volatile silicones such as low molecular weight cyclomethicone have often been used as vehicles for delivering antiperspirant actives. In another type of system, silicone can be used to impart a synergistic effect. One example is the beneficial effect on sun protection factor (SPF) value of a sunscreen formulation resulting from the addition of a few percent of an alkylmethylsiloxane copolymer. Encapsulation or entrapment is a delivery form that can be used to release actives simultaneously during application. In one form of entrapment, silicone elastomers can entrap or absorb polar or nonpolar oils prior to their formulation into the end product. Typical examples of actives that can be absorbed into the silicone elastomer network are vitamin E and vitamin A acetate.

In other applications, polyol-in-silicone emulsions offer a stable vehicle for transporting raw materials that are sensitive to hydrolysis. In the personal care marketplace, these emulsions offer a new, reasonably priced and efficient method for encapsulating enzymes, vitamins and antioxidants in conjunction with their incorporation into oil-in-water emulsions.

Introduction

Amid strong competition for highly differentiated products – and fueled by consumer spending on personal care, silicones stand out as high performance ingredients in today's innovative formulations. In recent years, silicone use has expanded to virtually all personal care product segments, including underarm products, skin, sun and hair care. The number of new personal care products containing at least one – and sometimes several – silicone-based materials is significant and growing rapidly. In 1985, approximately 28% of these products contained silicone, and by 2004, the percent of such products had nearly doubled.

The expanding use of silicones is related to a distinct combination of attributes that allow these materials to serve a variety of functions. They can act as emollients, water barriers and emulsifiers. They also provide specific sensory characteristics such as a smooth, silky, nongreasy feel in formulations, an effect that is highly desired by consumers. From a safety perspective, silicones are among the most widely tested materials used in personal care. Polydimethylsiloxanes have a semi-organic molecular structure made up of a highly mobile siloxane backbone that supports a regular and nonpolar arrangement of pendant methyl groups. Because of the mobility and flexibility of the siloxane chain, little energy is required for the polymers to orient when they are in proximity to vicinal entities or surfaces upon which they can be absorbed. The methyl substitution of the silicone polymer is spread out at interfaces, thereby forming a low surface energy shield. This shield develops very low intermolecular interactions and provides unique surface characteristics. As a result of the inherent chemical stability of Si-O and Si-C bonds present in this class of polymers, they exhibit chemical inertness relative to many substances and are thermally stable as well.

As a consequence of these molecular properties, silicones exhibit distinctive properties. In view of their low surface tension, they are able to wet virtually any surface and spread on a wide variety of substrates, making them suitable for lubrication, coating and antifoam applications. They can be formulated to exhibit a broad range of rheological profiles, from viscous fluid to viscoelastic thermoplastic (pressure sensitive adhesive) and rubber-like thermoset (elastomer). The low molecular interactions and the high intramolecular mobility provide outstanding anti-adherent properties (i.e., useful to make release coatings). Furthermore, silicones exhibit a high level of permeability to various substances (including water vapor and drugs).

By substituting organofunctional groups for some methyl groups, significant changes of properties occur. These modified silicones are often referred to as organofunctional silicones.