Candle power
Steve Herman
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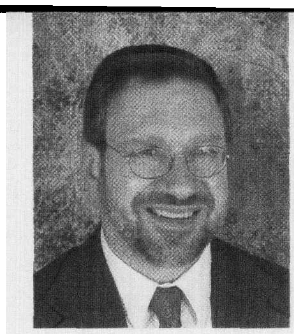


CHEMICAL REACTION **BY STEVE HERMAN**

Candle Power

As magical and hypnotic as the flame of a candle can be, it represents complex technology. Its perfection suggests an ongoing challenge to the steadily growing industry.

> "How far that little candle sheds his beams!
> So shines a good deed in a naughty world."
> —Shakespeare, *The Merchant of Venice*

The prominent display of candles on the cover of September's *GCI* was welcome recognition of the important niche they have carved in the cosmetic marketplace. Candles have been part of the product line of cosmetic companies for years, but have never received serious coverage in the personal care press. Part of the problem is obviously one of usage; candles clearly do not adorn or treat the body. In addition, they do not appear to be technically complex enough to merit extensive attention. However, the seemingly simple candle is a product of surprising challenges for the formulator.

For most of history, candles were used exclusively for illumination. Fragrance delivery did not become a significant function until 1960s. Estée Lauder was an early pioneer with strongly scented candles, symbolized by its Youth Dew line. Despite a few early forays, fragranced candles remained a small market until the explosive growth of the environmental fragrance category in the 1990s. Candles were no longer principally a source of light, but provided color, decoration and room odorizing. The proliferation of candle formulations created an intense need to understand the interrelationships of all the variables of the complete product.

Michael Faraday, an experimental chemist, brought his considerable powers to bear on the subject in his lectures published as *The Chemical History of a Candle*, which should be required reading for everyone involved in candle technology. Surely, the complete understanding of paraffin chemistry, capillary action and combustion requires a firm grounding in fundamental science. To complicate matters, each form of candles—jars, votives, pillars and tapers are the most popular—requires carefully engineered properties. For example, the contraction characteristics vary. Wax in a jar candle should not pull away from the glass, but a votive must shrink to be removed from its metal mold. Figure 1 shows all the components of a typical candle.

The most common candle base for more than a century has been paraffin. Paraffin is a fuel source, but in its solid state it does not burn. Hold a match by a slab of paraffin and nothing happens. Yet, when the wick burns, some wax heats enough to liquefy and moves up the wick by capillary action. The wax then becomes hot enough to vaporize, and the vapor burns when enough oxygen is available. The actual combustion, and hottest part of the flame, is located a slight distance from the wick.

Paraffin is a very complex mixture of hydrocarbons, frequently quantified by melting point (actually a range), and penetration (hardness). Many candle producers assumed that all paraffins with the same melting point and hardness were equal. The tendency was to substitute suppliers, usually based on cost. The results were disastrous, and usually blamed on the fragrance. In fact, paraffins vary widely in key parameters such as oil content, presence or absence of aromatic compounds, and proportion of straight and branched chains. Paraffin for candles typically consists of 85–90 percent

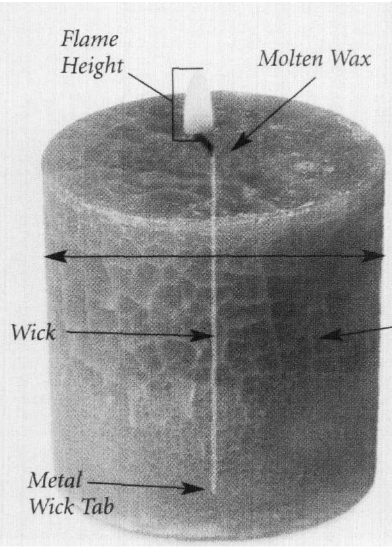


FIGURE 1. DIAGRAM OF A CANDLE
A metal tab at the base supports the wick within the mass of wax, while the molten pool at the top of a candle provides fuel and most of the fragrance throw. Proper burning requires careful matching of the wick, wax base, fragrance and candle diameter.

straight-chain hydrocarbons and 10–15 percent branched chain, with 18–40 carbons per chain, which translates in a molecular weight range of 254–562. Difference in paraffin composition, such as variation in the chain length distribution, affects fragrance solubility and burn properties. Figure 2 shows the basic structure of straight chain, branched chain and aromatic components.

Several structural factors of the wax affect combustion. Branching and the presence of oxygen (such as esters and triglycerides) promote burning, while aromatics do not. Incomplete combustion is the prime contributing factor for soot formation.

The market saturation of the candle industry flamed the quest for new product forms or claims. The two most important directions were clear gel bases and vegetable bases. Clear bases provide stunning visual opportunities, and captured a significant niche market. The leader in this technology is Penreco, although other companies are constantly seeking alternate systems.

The Penreco product is essentially gelled mineral oil, with the key elements being the gelling efficacy of the polymer, tight specifications on the mineral oil and a flashpoint above 170°F.

When the fragrance has slight insolubility—frequently too small to notice—pockets of concentrated fragrance can form. When these pockets ignite,

FIGURE 2. BASIC PARAFFIN STRUCTURES

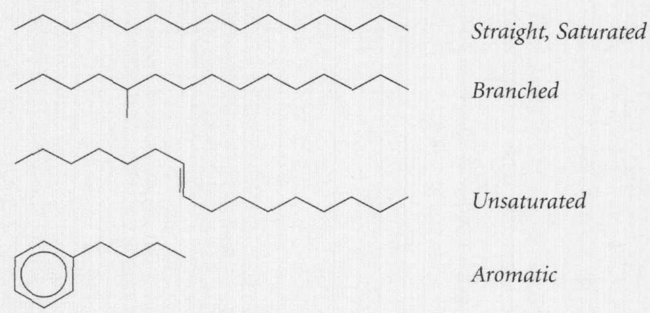
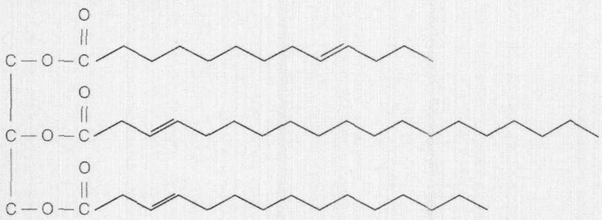
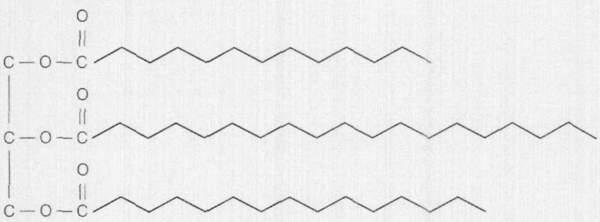


FIGURE 3. SOY WAX COMPONENTS

Soy Oil-Unsaturated



Fully Hydrogenated Soy Oil



Soy alternatives are created by varying the degree of hydrogenation, making blends of hydrogenated material, and adding other materials to adjust hardness and burning.

a flash fire can result. In the interest of safety, it is essential to extinguish the flame when it comes to within a quarter-inch of the bottom. The consumer is alerted to blow the candle out, but separate safeguards can be engineered. One way is to put a separate layer on the bottom of a clear gel containing silica, which will clog the wick. Another approach is to use a wick tab with an extended tube. With the safety factor resolved, gels with colors and suspended decorative materials have become common.

An alternative to paraffin bases, vegetable waxes, particularly those derived from palm or soy, have been attractive as renewable, "green" raw materials. They also claim reduced soot. ADM and Cargill are the major sources of vegetable waxes, which are actually hydrogenated vegetable oils. The structure of natural and hydrogenated vegetable oil is shown in Figure 3.

The National Candle Association (NCA) leads the industry in creating a favorable public image for candles and establishing guidelines for assuring safe products. Fire hazard, lead wicks, the integrity of the glass used for jar candles, and sooting are primary issues. Responsible American producers no longer use lead wicks, but control of imports is more difficult. The NCA works through an ASTM task force to create standards for the member companies. Other issues such as tariffs on Chinese candles are also NCA concerns.

The candle industry has assumed a key role in home décor and environmental fragrancing. While the extraordinary growth of the '90s has leveled, the market remains large and steady. Candles' link to personal care will doubtless continue to expand, and their perfection suggests an ongoing challenge to the industry. GCI

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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.