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Linear Polyethylenes and Long-Chain Alcohols in Underarm Sticks and Soft Solids

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Key words

antiperspirant, C20-40 alcohols, cyclomethicone, gellant, polyethylene, stearyl alcohol

Abstract

Linear polyethylenes and long-chain alcohols are alternatives to stearyl alcohol for gelling systems based on cyclomethicone. These materials have particular utility in formulations for antiperspirant or deodorant sticks and soft solids.

In today's increasingly competitive personal care market, formulators of underarm products need technologies that can help them deliver novel and aesthetically pleasing product forms to consumers – while at the same time satisfying manufacturing needs for easy formulating and cost efficiency.

Stearyl alcohol is a common gelling agent for antiperspirant sticks and gels. However, new technological developments allow formulators to use lower quantities of totally linear polyethylenes and linear, long-chain alcohols (in the range of C20 to C50, compared to C18 for stearyl alcohol) as gellants.

Although other long-chained materials exist, the completely linear form of the polyethylenes and alcohols is distinctive and makes these polymers more crystalline than branched polymers or shorter-chain polymers. Using these materials allows more flexibility in formulation because less gellant is required, and the ultimate structure is characterized by a latticework of smaller crystals than those associated with other gellants. This structure can improve formulation aesthetics as well as enhance the distinctive sensory properties of cyclomethicone to give soft, dry and smooth application without drag. In addition, the smaller crystal size improves stability of the final formulation.

This article describes these linear polyethylenes and their corresponding long-chain alcohols, compares their gelling efficiency and stability with that of stearyl alcohol and uses microscope photographs to illustrate their crystalline characteristics. In addition, a prototype formulation demonstrates use of the materials in a soft solid product form.

New Options with Polyethylenes and Alcohols

These materials are linear ethylene homopolymers having the structure:

CH_3-CH_2-$(CH_2$-$CH_2)_n$-X

where

X = CH_3 for polyethylenes or OH for alcohols,

n = 9-106 and

MW = 400-3000.

For the polyethylenes, typical materials have melting points in the range of 84-128°C. Those with the lower melting points (i.e., approximately 84-88°C) have viscosities in the range of 4-7 cP at 99°C, while materials with higher melting points (approximately 100-128°C) have viscosities in the range of 5-130 cP or more at 149°C. The polyethylenes are hydrophobic film formers and can be used as viscosity modifiers or emulsion stabilizers. They are compatible in a variety of common organic materials and silicones.

In the case of the C20-40 alcohols, typical materials have melting points in the range of 79-105°C. These ingredients can be used as replacements for natural waxes to modify rheology. They can act as secondary emulsifiers and dispersants, or serve as conditioning agents or film formers. Like their polyethylene counterparts, they are compatible in a number of common organic materials and silicones.

When formulating systems with cyclomethicone, it is advisable to use the polyethylenes and C20-40 alcohols with lower melting points, due to the volatility of the silicone.

Gelling Efficiency

Studies were conducted to determine the gelling efficiencies of the polyethylenes and long-chain alcohols in cyclomethicone. Blends of these ingredients at 10% and 20% concentration were prepared in the silicone. Several polymers were evaluated: C20-40 alcohols

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(MW 375)[a], C20-40 alcohols (MW 460)[b], C30-50 alcohols (MW 550)[c], polyethylene (MW 450, C20-40)[d] and polyethylene (MW 500, C30-50)[e]. For simplicity, in this article we will refer to those five polymers as LCA1, LCA2 and LCA3 (for the long-chain alcohols) and PE1 and PE2 (for the polyethylenes), respectively. We also evaluated a blend of PE1 and LCA2 at a ratio of 1:4. These materials were compared with stearyl alcohol. Table 1 shows the INCI names, the carbon counts and the molecular weights of the linear polyethylenes and long-chain alcohols used in this study.

The test materials were cooled overnight in covered metal

[a] *Performacol 350 Alcohol, New Phase Technologies, Sugar Land, Texas, USA. Performacol is a registered trade name of New Phase Technologies.*
[b] *Performacol 425 Alcohol*
[c] *Performacol 550 Alcohol*
[d] *Performalene 400 Polyethylene. Performalene is a registered trade name of New Phase Technologies.*
[e] *Performalene PL Polyethylene*

Table 1. Gelling agents used in this study

Code	INCI name	Trade name*	Carbon Count	Molecular Weight
LCA1	C20-40 alcohols	Performacol 350 Alcohol	20-40	375
LCA2	C20-40 alcohols	Performacol 425 Alcohol	20-40	460
LCA3	C30-50 alcohols	Performacol 550 Alcohol	30-50	550
PE1	Polyethylene	Performalene 400 Polyethylene	20-40	450
PE2	Polyethylene	Performalene PL Polyethylene	30-50	500

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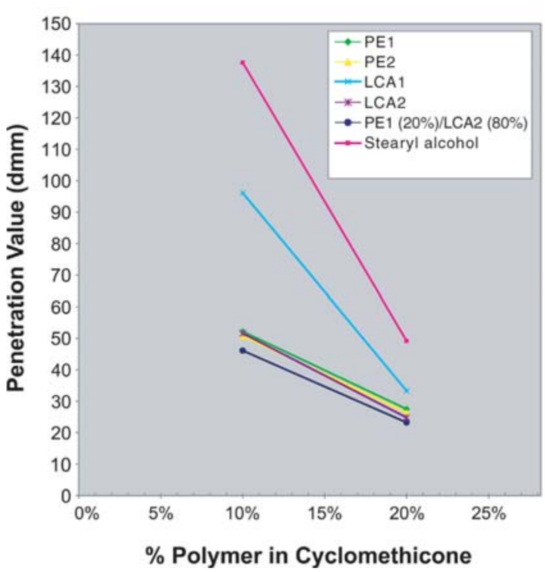

Figure 1. Comparison of gelling among linear polyethylenes and long-chain alcohols

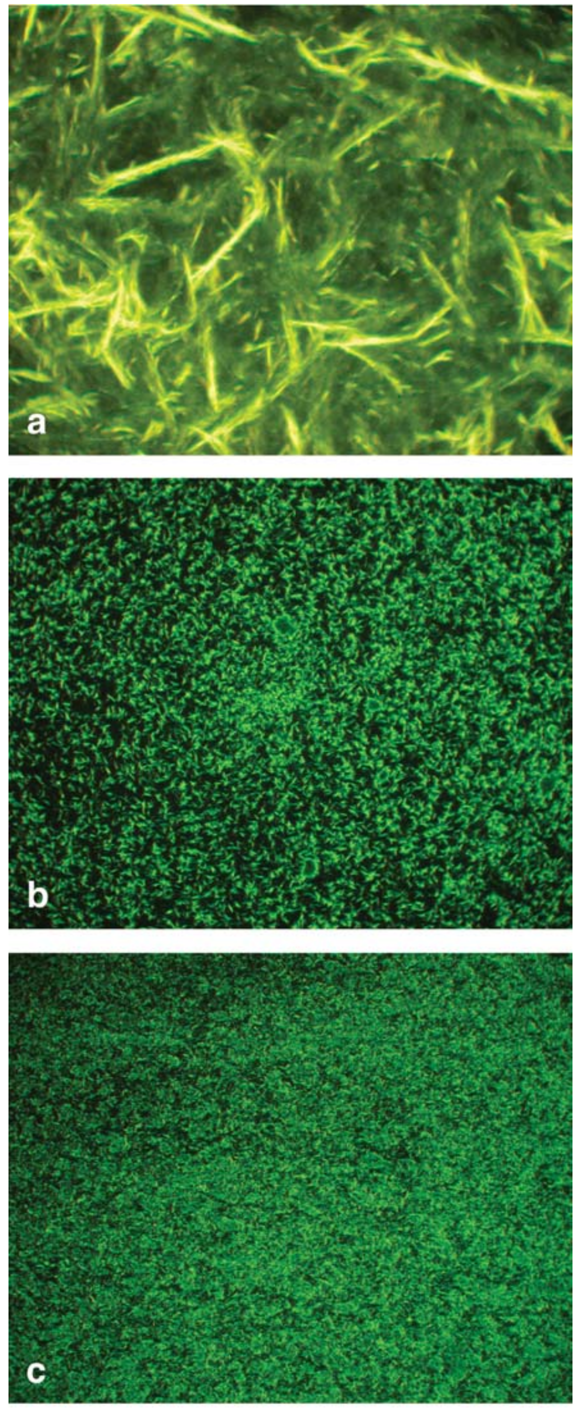

Figure 2. Comparison of crystal size in cyclomethicone systems gelled with selected gelling agents (Magnification = 100X)
a = Stearyl alcohol
b = C30-50 Polyethylene (MW 500) (PE2)
c = C20-40 Alcohols (MW 460) (LCA2)

tin cans, after which penetration values were recorded using a 35 g cone needle and a penetrometer[f]. Five measurements of gel firmness were recorded by measuring the needle penetration at five different points within the sample. ASTM D-1321 was used as a guide. Measurements in decimillimeters were averaged and standard deviations were calculated.

Figure 1 compares the gelling ability of various linear polyethylenes and long-chain alcohols. For each of the materials, a linear relationship was assumed between 10% and 20% polymer in cyclomethicone. However, the equations should not be used to extrapolate points outside this range.

Penetration data show that these polymers are more efficient than stearyl alcohol at gelling cyclomethicone. Efficiency depends on the level of polymer used and the desired penetration value. In this study, the higher the molecular weight of the polymer, the harder the resulting gel, with the 500 MW polyethylene having the highest gelling efficiency of a single polymer. However, with the combination of PE1 and LCA2, there is a slight synergistic effect, and the resulting gel is firmer than with either material when used alone.

Better Stability for Sticks and Soft Solids

Linear polyethylenes and their long-chain alcohols have the distinct ability to form a tight network of small, regular crystals. Figures 2a through 2c compare the crystal structures of stearyl alcohol, PE2 and LCA2. It is this crystal structure that gives enhanced stability and aesthetics to the polyethylene and its alcohol.

Soft solid antiperspirants based on cyclomethicone illustrate how these polymers improve formulation stability. Formulations of this type present a challenge to formulators because the pressure required to extrude the soft solid through the holes of the package can cause syneresis, or bleeding, of the silicone. Although specialized packaging has been developed to alleviate the pressure problem, it adds cost to the finished product.

In contrast, formulations based on the long-chain alcohols form more stable systems because the compact, uniform crystal structure effectively entraps the silicone. In addition to being efficacious, this solution is also economical because specialized packaging is not required.

Figure 3 illustrates the stability of a

[f] *Model K19500 Penetrometer, Koehler Instrument Company, Bohemia, New York USA*

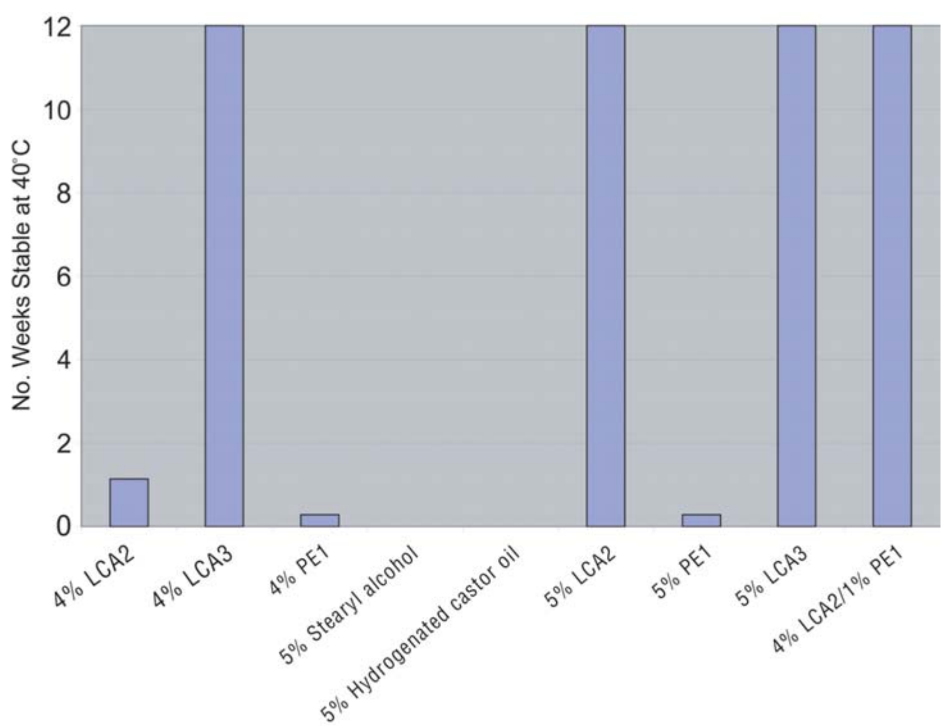

Figure 3. Stability of soft solid antiperspirant (cyclomethicone/dimethicone system) incorporating linear polyethylene or long-chain alcohol gellants

Formula 1. Soft solid antiperspirant

A.	C20-40 alcohols (MW 460) (Performacol 425 Alcohol, New Phase Technologies)	4.0% wt
	Polyethylene (MW 450) (Performalene 400 Polyethylene, New Phase Technologies)	1.0
	Cyclopentasiloxane (SF 1202, General Electric)	60.0
	Dimethicone (SF 96-100, General Electric)	10.0
B.	Aluminum zirconium tetrachlorohydrex GLY (Reach AZP-908, Reheis)	25.0
		100.0

Procedure: Heat A to 92-95°C with mixing until dispersed and uniform, covering to retain cyclopentasiloxane. Maintain temperature while adding B with high shear mixing. After fully dispersed, remove from heat and fill containers.

soft solid antiperspirant system based on cyclomethicone that is gelled with various long-chain alcohols and polyethylene. Notice that at levels of 4-5%, the long-chain alcohols form stable soft solid formulations for at least 12 weeks. Also, the addition of 1% PE1 to a formulation containing 4% LCA2 increased stability from approximately one week to at least 12 weeks.

Formula 1 illustrates the use of LCA2 and PE1 in a soft solid antiperspirant formulation. The two polymers thicken and stabilize the volatile cyclomethicone and low molecular weight dimethicone. The formulation has excellent stability, a soft and creamy texture, and it feels light and comfortable on the skin.

Conclusions

Linear polyethylenes and their corresponding long-chain alcohols (C20-C40) are more efficient at gelling cyclomethicone than traditional gellants such as stearyl alcohol, and they present new formulating options for stick and soft solid antiperspirant applications. In the case of soft solid formulations, those gelled with 5% long-chain alcohol (or a combination of 4% 460 MW alcohol and 1% 450 MW polyethylene) show better long-term stability with no syneresis.

These materials allow formulators to use less gellant, with greater formulation flexibility and better aesthetics—ultimately providing opportunity for innovative new product forms in the underarm market.

References

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