Westlake Chemical Corporation

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# Epolene® Polymers as Candle Additives

The toughness, opacity, and gloss in high-quality candles have traditionally been determined by the quality of wax used. The high-melting-point petroleum waxes that provide these desirable features have become scarce as the market for high-quality candles has grown. This has generated a need for additives for low-melting-point waxes that will impart the desirable features normally associated with the more expensive, higher-melting-point products. Westlake Chemical Corporation offers polyethylene that can fill this need, including *Epolene*® N-34, *Epolene* N-10, *Epolene* N-11, *Epolene* C-15, and *Epolene* C-10.

# General Technology

### Shrinkage

Shrinkage and mold release characteristics are important factors in the manufacture of high-quality candles, and these properties will vary from one type of raw material to another. While excessive shrinkage is to be avoided, some shrinkage is desirable to facilitate mold release.

Petroleum-derived paraffin, for example, consists principally of normal alkanes. On the other hand, polyethylene is an alkene, and its molecular weight and melting point exceed those normally found in paraffin waxes. Thus, these two materials exhibit different degrees of shrinkage when cooled. Another factor affecting shrinkage is the method used to cool the molded candle. For example, a paraffin/polyethylene blend that has been quenched in a chill bath will shrink more than the same blend cooled at room temperature. *Epolene* N-34, N-10, N-11, C-10, and C-15 polymers offer a good balance between shrinkage and mold release characteristics.

### Scentings

Scented candles are quite popular and are available in many fragrances. Since *Epolene* Polymers are practically odorless, they should not interfere with any scents a manufacturer might select for use. Several factors will affect candle fragrance, and trial formulations should be evaluated to achieve acceptable results. These factors include:

- Size and shape of candle
- Type and condition of wick
- Concentration of perfume compound
- Room space and air circulation surrounding the candle
- Loss of scent during shelf life

## Formulating

Two methods may be used to add *Epolene* Polymers to candle formulations. One method involves heating all components to a temperature of 107° to 121°C (225° to 250°F) with mild agitation.

The second method involves the preparation of a concentrate of 25% to 50% *Epolene* Polymer in paraffin. The concentrate is heated to a temperature of 107° to 121°C (225° to 250°F). A small portion of the concentrate is then added to the final candle formulation. The second method permits preparation of the candle formulation at a lower temperature.

Once the base wax, candle size, and end-use properties have been established, bench-scale evaluations, followed by production trials, should be made to determine optimum additive levels. Table 1 is a guide to assist in developing suitable formulations.

**Table 1**

**Suggested Levels of *Epolene* Polymer Additives**

| | |
|---|---|
| *Epolene* C-10 | 1% to 3% |
| *Epolene* C-15 | 1% to 4% |
| *Epolene* N-10 | 1% to 4% |
| *Epolene* N-11 | 1% to 4% |
| *Epolene* N-34 | 1% to 4% |

## Physical Properties

The physical properties of *Epolene* Polymers commonly used in candles are given in Table 2. Table 3 summarizes the effects on the physical properties of both 52°–54°C (125°–130°F) and 60°–63°C (140°–145°F) paraffin waxes modified with *Epolene* C-15 polymer. Some definitions and test methods used are:

- **Density** (ASTM D 1505)
- **Viscosity** (ASTM D 3236): Determined using a *Brookfield* Thermosel Viscometer, Model LVTV-II; and measured at 121°C (250°F). The RPM of viscometer was set to obtain viscosity reading on the high end of the scale.
- **Ring and Ball Softening Point** (ASTM E 28): Determined on a B/R International Automatic Apparatus for softening point measurement, using a glycerine bath. The reported values are an average of two tests.
- **Cloud Point** (ASTM D 2500): Each formulation was heated to 121°C (250°F) and poured into a hot 100-mm test tube. The wax blend was agitated with a thermometer, while viewing under a bright spotlight with a black background. The temperature at which the first signs of haziness or a cloud appeared was recorded. The values reported are an average of three tests.
- **Congealing Point** (ASTM D 938): Each formulation was heated to 121°C (250°F). A thermometer was stirred in the wax blend until the temperature was about 102°C (215°F). The thermometer was taken out of the wax blend leaving a drop of molten

wax on the bulb. It was then rotated at a constant rate until the material ceased to flow as the thermometer was rotated, and this temperature was recorded. The values reported are an average of three tests.

- **Penetration Hardness** (ASTM D 1321): Each formulation was heated to 121°C (250°F) and poured into an aluminum weighing dish. Hardness was determined on the smooth bottom side after conditioning 24 hours at 22°C (72°F) and 50% relative humidity. Values reported are an average of five tests.
- **Tensile Strength and % Elongation** (ASTM D 412): The formulations were heated to 121°C (250°F) and poured into a mold to make the "dumbbell-shaped" specimens for testing. The specimens were clamped in the grips of a tensile-testing machine and stretched at a rate of 5.08 mm/min (0.2 in./min). The data, as automatically recorded on a load-extension curve, was used to calculate the tensile-property values. The values reported are an average of five tests.
- **Optical Microscopy:** Each formulation was poured into an aluminum weighing dish at about 1/8 inch thick. The Microscopy & Morphology Research Laboratory then cut cross-sectional samples, observed them under polarized illumination, and took microphotographs.

**Table 2**

**Typical Physical Properties of *Epolene* Polymers**[a]

| Component | Density g/cc | Ring & Ball Softening Point °C (°F) | *Brookfield* Viscosity °C (°F), cP | Cloud Point °C (°F)[b] | Congealing Point °C (°F)[b] |
|---|---|---|---|---|---|
| *Epolene* C-15 | 0.906 | 102 (215) | 150 (300), 3,900 | 75 (167) | 58 (136) |
| *Epolene* C-10 | 0.906 | 104 (219) | 150 (300), 7,800 | 77 (171) | 59 (138) |
| *Epolene* N-34 | 0.910 | 103 (217) | 125 (257), 450 | 76 (169) | 57 (135) |
| *Epolene* N-11 | 0.921 | 108 (227) | 125 (257), 350 | 80 (176) | 57 (135) |
| *Epolene* N-10 | 0.925 | 111 (232) | 125 (257), 1,500 | 82 (180) | 57 (135) |

[a]*Reported for information only. Westlake Chemical Corporation makes no representation that the material in any particular shipment of* Epolene *Polymer will conform to the values listed.*
[b]*2% Wax in 54°C (130°F) paraffin.*

**Table 3**

**Properties of Paraffin Wax (Modified With *Epolene* C-15 Polymer)**

| **Formulations** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Paraffin 52°–54°C (125°–130°F) | 100 | 99.5 | 99 | 97 | — | — | — | — |
| Paraffin 60°–63°C (140°–145°F) | — | — | — | — | 100 | 99.5 | 99 | 97 |
| *Epolene* C-15 | — | 0.5 | 1 | 3 | — | 0.5 | 1 | 3 |
| **Properties** | | | | | | | | |
| Viscosity @ 121°C (250°F), cP | 2.8 | 2.8 | 3.3 | 3.8 | 3.5 | 3.7 | 3.7 | 4.8 |
| RBSP, °C (°F) | 65 (149) | 68 (154) | 68 (154) | 68 (154) | 74 (165) | 74 (165) | 74 (165) | 75 (167) |
| Cloud Point, °C (°F) | — | 63 (145) | 66 (151) | 71 (160) | — | 64 (147) | 65 (149) | 70 (158) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Congealing Point, °C (°F) | 129 | 129 | 130 | 131 | 142 | 142 | 143 | 145 |
| Penetration Hardness, dmm | 11 | 9 | 8 | 7 | 11 | 10 | 9 | 7 |
| Tensile Strength, max psi | 200 | 200 | 200 | 270 | 150 | 150 | 180 | 280 |
| % Elongation | 0.8 | 0.8 | 0.8 | 1.6 | 0.6 | 0.6 | 0.6 | 1.1 |

**Experimental Results**

As the addition of any of the polyethylene waxes was increased, all physical properties improved to produce a harder, tougher candle wax. The physical properties of the wax blends containing *Epolene* polyethylene were similar with the exception of cloud point. The blends modified with *Epolene* C-15 polymer have much lower cloud point temperatures than any of the other blends. *Epolene* C-15 polymer is the preferred wax of the ones evaluated because of its lower cloud point temperatures. The advantages of modifying paraffin with *Epolene* polyethylene are higher ring and ball softening points, increased hardness, and greater tensile strength and percent elongation.

To further explain the reason the physical properties of the paraffin wax improve with the addition of polyethylene, microphotographs of the wax blend samples were prepared. The microphotographs (see Figures 1–4) show the effect polyethylene has on the crystallinity of paraffin. For example, the unmodified paraffin (Figure 1) contains large pieces of crystalline material (white areas) and large pieces of amorphous material (black areas). At 0.5%, 1%, and 3% addition levels of polyethylene, a significant change is observed in that the large crystalline and amorphous areas become smaller and more uniform. This uniformity explains why the physical properties such as hardness, tensile strength, and percent elongation improve as the addition of polyethylene are increased.

**Figure 1**
**Cross Section of Paraffin Wax—No PE Added**

**Figure 2**
**Cross Section of Paraffin Wax Modified With 0.5% *Epolene* Polymer**

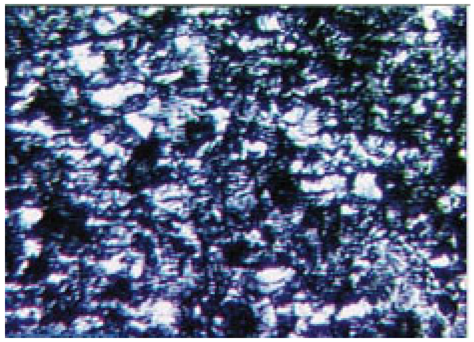
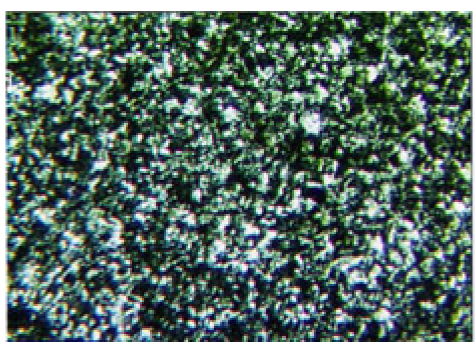


**Figure 3**
**Cross Section of Paraffin Wax Modified With 1% *Epolene* Polymer**

**Figure 4**
**Cross Section of Paraffin Wax Modified With 3% *Epolene* Polymer**



## Conclusions

All the *Epolene* polyethylene polymers evaluated effectively upgrade the performance of paraffin in candle formulations. The benefits of using *Epolene* polyethylene include the following:

- Longer burning
- Easily blended
- Nontoxic

- Desirable candle opacity, gloss, and sheen
- Smooth, blemish-free finish without the use of a water-chill quench
- Increased hardness of the wax
- Higher tensile strength and flexibility
- Increased temperature resistance
- Essentially odorless (particularly interesting to scented-candle manufacturers)
- Virtually smokeless when the correct wick size, candle shape, and additive concentration are used
- Brighter and more reproducible colors. (*Epolene* polymer molecules contain no acid groups that might affect certain dyes. Some *Epolene* polymers are being used as color dispersing agents.)
- Excellent melt and color stability in concentrations of 1% to 5%

While *Epolene* C-15 is the preferred polymer for candle wax modification, the other *Epolene* Polymers may be preferred when certain properties are required:

- *Epolene* N-10, *Epolene* N-11, and *Epolene* N-34 polymers when very low melt viscosities are required
- *Epolene* C-10 polymer to upgrade very low-melting candle wax [50° to 55°C (120° to 130°F)]. *Epolene* C-10 is also suggested as a replacement for ethylene-vinyl acetate copolymers.