Styleze™ W-20 polymer
A new cationic polymer for a conditioning hold even in high humidity
Styleze™ W-20 polymer

Consumers in all hair care market segments are seeking the power to create a range of hairstyles. They expect hair care styling products to provide long lasting style and hold, hair smoothness, volume, shine, the ability to reactivated and restyle, resilience to high humidity and protection from the damaging effects of mechanical styling.

To achieve variety of style, consumers have increased the use of potentially damaging styling techniques and subsequent hair damage is on the rise in every market category. Whether chemical treatment, coloring, bleaching, perming, relaxing, blow-drying or curling is employed, the result is damage to the hair cuticle and cortex. Consumers not only expect hair styling products to style and hold hair, they require repair and conditioning benefits as well.

Hair care formulators face a sizable challenge: balancing the consumer market need for innovation with the seemingly relentless demands of purchasing and manufacturing for a lower overall product cost and a simplified manufacturing process for new products. An obvious solution to this dilemma is to formulate products with ingredients that provide multiple end use benefits. Unfortunately, achieving multiple benefits from one ingredient in hair formulations has been difficult – until now.

Styleze W-20 polymer, an aqueous, cationic, terpolymer solution, offers unique benefits and superior performance characteristics versus other polymers designed for styling and conditioning. Through its patented technology and breakthrough polymer functionality, Styleze W-20 polymer, meets the critical consumer need for ease of style creation and longevity of style while providing the all-day hold, conditioned feel, and curl memory universally sought by consumers. Lauryl side-chains make the polymer hydrophobic enhancing its styling properties through increased humidity resistance, low tack on exposure to moisture, water resistance, and improved flexibility. Acting as a polysurfactant, the polymer lowers surface tension and stabilizes foam and has enhanced ability for associative binding to surfactants.

**INCI Name:**
Polyquaterium-55


These characteristics coupled with the polymer’s cationic nature produce the styling and conditioning properties of Styleze W-20 polymer.

This quaternized polymer is soluble in water and is supplied as a 20% aqueous solution. However, its films are very hydrophobic yet easily removed from hair by shampooing - there is no resulting build up of polymer on the hair. Figure 1 shows a hair swatch treated with a 1% solids solution of Styleze W-20 polymer, dried as a flat ribbon spike, dipped in water for 5 seconds and then held horizontally to demonstrate resistance to water.

**Figure 1: 5 Second Water Submersion Test**

Water resistance for a measurable time period is a new observed phenomena unique to Styleze W-20 polymer. This new terpolymer is also resistant to high humidity. Figure 2, shows a comparison chart of high humidity curl retention versus some of the most popular styling polymers. The 4-hour curl retention (1% solids solutions, roller set on 6.5” hair, at 90% RH and 80˚F) chart demonstrates the superior curl retention properties of this polymer.

**Figure 2: High Humidity Curl Retention Polymer Comparison Chart**

Excellent High Humidity Curl Retention
Extremely Flexible Films

Water resistance and high humidity resistance are essential factors for creating and maintaining a hairstyle, but there are other consumer perceivable features that are also important to a multifunctional resin, including stiffness, durability, tack and conditioning benefits.

By conducting studies with the Dynamic Hair Spray Analysis (DHSA) on omega loops of hair and the 3 Point Cantilever Bending Method on flat hair tresses, the stiffness, stiffness ratio, flexibility, and durability under 50% and 90% relative humidity of Styleze W-20 polymer has been quantified. When a treated omega loop of hair is depressed and bent 10 times at 50% RH using DHSA, the maximum force needed to depress the curl and the resiliency of the curl is obtained, Figure 3.

The smooth curve at the top of the peaks and the overlapping multiple hysteresis loops indicate the flexibility of the polymer.
film on hair and durability of the hair set. The vertical ‘Y’ axis shows the number of grams of force needed to depress the curl at the depth (in mm) shown on the ‘X’ axis.

**Figure 3: Flexibility Curves of Styleze W-20 polymer from DHSA Demonstrating Strong Hold and Good Flexibility at Low Solids**

Using DHSA, the stiffness of Styleze W-20 polymer was compared to Styleze CC-10 polymer. During this measurement at 50% RH, the resistance to compression of hair set into omega loops was compared. \( F_1 \) is the maximum force attained during the first depression through 4 mm. The stiffness ratio can be calculated from the force needed to depress the set hair to 1 mm (a region that is mostly elastic and reproducible after several depressions if 1 mm isn’t exceeded) divided by the force needed to depress untreated hair 1 mm. Then resilience and durability measurements are calculated by the ratios of the maximum force at the first depression compared to the maximum force at the 10th depression \( (F_1/F_{10}) \), the slope of the 1st depression curve vs. the 10th \( (E_1/E_{10}) \), and the depth of penetration into the hair loop in order to sense plasticity, 1st vs. 10th \( (H_1/H_{10}) \). The data in Figure 4 shows that Styleze W-20 polymer provides similar stiffness and flexibility as compared to Styleze CC-10* polymer.

**Figure 4: Dynamic Hair Spray Analysis Data**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Maximum Force ( F_1 )</th>
<th>Stiffness Ratio ( F_1/F_{10} )</th>
<th>( E_1/E_{10} )</th>
<th>( H_1/H_{10} )</th>
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<tr>
<td>Styleze W-20 polymer (Lot 1)</td>
<td>451</td>
<td>15.9</td>
<td>0.79</td>
<td>0.37</td>
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<tr>
<td>Styleze W-20 polymer (Lot 2)</td>
<td>352</td>
<td>15.6</td>
<td>0.78</td>
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</tr>
<tr>
<td>Styleze W-20 polymer (Lot 3)</td>
<td>344</td>
<td>15.4</td>
<td>0.79</td>
<td>0.35</td>
</tr>
<tr>
<td>Styleze W-20 polymer (Lot 4)</td>
<td>368</td>
<td>15.6</td>
<td>0.77</td>
<td>0.35</td>
</tr>
<tr>
<td>Styleze CC-10 polymer</td>
<td>328</td>
<td>13.5</td>
<td>0.76</td>
<td>0.33</td>
</tr>
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</table>

*(for additional comparison vs. other common polymers: \( F_1 = \sim 350 \text{ g} \) for 1% Styleze W-20 polymer, \( \sim 175 \text{ g} \) for 1% PVP K-30, \( \sim 400 \text{ g} \) for 2% PVP K-30, \( \sim 75 \text{ g} \) for 1% PVP/VA W-735, \( \sim 250 \text{ g} \) for 3% PVP/VA W-735, \( \sim 250 \text{ g} \) for 1% Styleze 2000 polymer).

**Resilient Holding Power**

The 3 Point Cantilever Bending Method utilizes ‘flat’ styled hair, similar in parallel orientation to spiked hair. The dried hair tresses (1% active solutions were applied to hair and dried) were bent repeatedly at 90% RH. As shown in Figure 5, hair treated with Styleze W-20 polymer remains resilient for more than 80 minutes, whereas hair treated with Styleze CC-10 polymer begins to soften at \( \sim 33 \) minutes.

**Figure 5: 3 Point Cantilever Bending Results**

More simply, the stiffness of a treated, flat tress can be felt by bending it between the fingers. The novelty of this product becomes evident when you bend the tress. Even on repeat bending at the same spot, the tress springs back to its original styled form quite quickly.

During blow-drying, Styleze W-20 polymer undergoes a slight tack stage providing a recognizable signal to the consumer that the product has been applied and will function. The tack evaluation is shown in Figure 6. As the tack disappears, the hair is smooth to the touch and easy to brush with a slight resistance and spring-back that denotes body, fullness and volume.

**Figure 6: Tack Evaluation of Styleze W-20 polymer**

Detangling and texturizing properties have been the trademark attributes of mousses since their inception. In addition to the special styling attributes that Styleze W-20 polymer provides, it also delivers additional attributes to the formulation of a mousse. Because Styleze W-20 polymer has a water-soluble backbone with a hydrophobic pendant group, it functions as a polysurfactant and lowers surface tension. This surface activity is excellent for foam stabilization in mousses. Mousses made with Styleze W-20 polymer have very dense, creamy, stable foams that allow the mousse to be distributed throughout hair, even very damaged long hair, before completely collapsing. When the foam collapses, the smoothness of the polymer solution continues to provide a detangling and texturizing medium. Both non-aerosol and aerosol mousses can be made without any added surfactant to produce stable foam balls at 6% - 16% VOC levels.
The hydrophobic lauryl pendant group is attached at a quaternized site. The quat gives the polymer selective orientation and substantivity to keratin (both hair and skin), through the cationic charge, via leave-in and rinse-out products. Styleze W-20 polymer can be formulated at very low solid levels into leave-in detanglers that have the added attribute of maintaining body without adding any stiffness to hair. When used in low viscosity lotions, the wet detangling properties of Styleze W-20 polymer are great for long curly styles, either on wet hair, for detangling, separating, defining curls and preventing the frizzies, or dry hair, defining, scrunching, or reactivating. When included in a rinse-out conditioner emulsion, Styleze W-20 polymer delivers special conditioning at the ends of the cuticle, at split ends and the cracks and crevices at exposed cortex. This functional conditioning attribute can be measured by Diastron combing using Spatially Resolved Combing Analysis (SRCA). Utilizing the 2-Window method of SRCA, the combing curves shown in Figure 7 demonstrate that the hair surface remains smooth after shampooing.

**Figure 7: Spatially Resolved Combing Analysis of Damaged Hair Treated with Styleze W-20 polymer**

The conditioning benefit is not only evident in leave-in or rinse-out conditioners, and during application of a styling product, but also during the rewetting of styled hair. Rewetting causes the hair to become smooth and instantly detangle before shampoo is applied.

**Superb Conditioning Properties**

**Thermal Hair Protectant**

Styleze W-20 polymer inhibits the cumulative damaging effects of curling irons. Curling irons and flattening irons employ temperatures that produce damage on hair while curling or straightening hair. Styleze W-20 polymer was studied under repeated conditions representing 1 month of curling iron use on hair. When hair is treated with Styleze W-20 polymer and dried before application of the curling iron, the hair is protected from surface damage as measured by both Tryptophan degradation and surface roughness measured by combing forces (the consumer touches and combs the surface of the hair and smoothness is important to denote healthy and strong hair). The graph in Figure 8 demonstrates the combing difficulty at various times of exposure to the curling iron. Styleze W-20 polymer inhibits the hair from becoming rough to the touch or to combing.

**Figure 8: Thermal Protection Measured by Combing Force**

Styleze W-20 polymer can be formulated into mousses, gels and styling lotions, to provide style longevity without negative impact on other performance benefits expected by consumers. As a conditioner, Styleze W-20 polymer delivers a luxurious, velvety feel to hair and skin and noticeably improves the combability of dry, damaged hair especially in the wet state.

The complex styling needs of today’s marketplace demand products that provide ease of style creation and style longevity with all-day hold, conditioned feel and curl memory. Through its patented technology and innovative polymer multifunctionality, Styleze W-20 polymer can be formulated into products to meet consumer demands while satisfying supply chain reduction efforts.

**Longevity of Style**

**Summary of Performance Benefits**

- Highly effective styling polymer characterized by firm hold, high humidity resistance and high flexibility
- Excellent conditioning benefits
- Provides thermal protection from curling irons
- Low tack on drying and on exposure to water and high humidity
- Dilutes easily in cold and warm water and can be cold-processed into styling lotions, mousses, gels, leave-in conditioning/styling products, shampoos and conditioners
- Good compatibility with surfactants

**Typical Properties**

- Appearance: Translucent viscous aqueous solution
- % Solids: 19 - 21
- pH: 3.5 - 5.0
- Viscosity: 40,000 - 100,000 cps
- Residual Monomers: <0.01%

**Toxicology**

Material is appropriate for a broad range of both rinse-off and leave-on personal care applications.
Formulations

Intensive Daily Conditioner for Damaged Hair with Styleze W-20 polymer
Formula #: 10748-45

<table>
<thead>
<tr>
<th>Ingredients</th>
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<th>Supplier</th>
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</thead>
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<tr>
<td><strong>Phase A</strong></td>
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<td></td>
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<tr>
<td>Deionized Water</td>
<td>87.05</td>
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<tr>
<td>Disodium EDTA (Versene® Na)*</td>
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<td>Dow Chemical</td>
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<tr>
<td><strong>Phase B</strong></td>
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<td></td>
</tr>
<tr>
<td>Behentrimonium Methosulfate (and) Cetearyl Alcohol (Incroquat™ Behenyl TMS)*</td>
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<td>Croda</td>
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<tr>
<td>Stearamidopropyl Dimethylamine (Adogen ® S-18V)*</td>
<td>1.00</td>
<td>Witco</td>
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<tr>
<td>Cetearyl Alcohol (Lanette® O Wax)*</td>
<td>3.00</td>
<td>BASF Care Creations</td>
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<tr>
<td>Glyceryl Stearate (and) PEG-100 Stearate (Arlacel ™ 165)*</td>
<td>1.50</td>
<td>Croda</td>
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<td><strong>Phase C</strong></td>
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<td></td>
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<tr>
<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<td>Ashland</td>
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<tr>
<td><strong>Phase D</strong></td>
<td></td>
<td></td>
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<tr>
<td>Cyclopentasiloxane (Si-Tec™ CM 040)</td>
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<tr>
<td>Propylene Glycol (and) Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Liquid Germall Plus preservative)</td>
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<tr>
<td>Citric Acid (50% aqueous solution)</td>
<td>0.35</td>
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<td>Total</td>
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*Trademark owned by a third party

**Procedure**
1. Prepare Phase A by adding each ingredient. Mix to 80°C with mixing.
2. Prepare Phase B by adding each ingredient and with mixing.
3. Add Phase B to Phase A, mix for about 30 minutes, cool down to 60°C.
4. Add Phase C, mix well and cool down to 45°C.
5. Add each ingredient in Phase D in order listed with sufficient mixing between each addition.
6. Add citric acid solution to adjust pH to 5.5.

**Physical Properties**
- **Appearance**: White crème
- **pH**: 5.3
- **Viscosity**: 12,800 cps (Brookfield Helipath, Sp# T-B, 20 r

Smooth Ultrahold Surfactantless Non-Aerosol Mousse with Styleze W-20 polymer
Formula #: 10761-109A

<table>
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<tr>
<th>Ingredients</th>
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<tr>
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<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<tr>
<td>Propylene Glycol (and) Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Liquid Germall Plus preservative)</td>
<td>0.50</td>
<td>Ashland</td>
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<tr>
<td>Total</td>
<td>100.00%</td>
<td></td>
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</tbody>
</table>

**Procedure**
1. Weigh water into the vessel. Start mixing.
2. Add Styleze W-20 polymer and mix well.
3. Add Liquid Germall Plus preservative and mix until uniform.

**Physical Properties**
- **Appearance**: Clear, thin liquid
- **pH**: 4.5 - 5.0
- **Viscosity**: 29.4 cps (Brookfield LVT DV-II, UL Adapter, 12 rpm)

**Packaging**
- Pump: Airspray Finger Pump Foamer
Tacky Hair Glue for Styles that Shine with Styleze W-20 polymer and PVP K-90
Formula #: 10852-121

Ingredients | %W/W | Supplier
--- | --- | ---
Phase A  
Deionized Water | 54.50 |  
PVP (PVP K-90) | 6.00 | Ashland  
Polyquaternium-55 (Styleze W-20 polymer) | 10.00 | Ashland  
Glycerin | 5.00 | Dow Chemical
Phase B  
Mineral Oil (Drakeol® 35 Mineral Oil)* | 8.00 | Penreco  
Oleth-5 (Ritooleth® 5)* | 8.00 | Rita Corp.  
Isoceteth-20 (Arlasolve™ 200)* | 8.00 | Croda
Phase C  
Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Germall Plus preservative) | 0.50 | Ashland

Total 100.00%

Ingredients %W/W Supplier
Mineral Oil (Drakeol® 35 Mineral Oil)* | 8.00 | Penreco  
Oleth-5 (Ritooleth® 5)* | 8.00 | Rita Corp.  
Isoceteth-20 (Arlasolve™ 200)* | 8.00 | Croda

Procedure
1. Combine ingredients of Phase A and heat to 70°C with mixing.
2. Combine ingredients of Phase B and heat to 70°C with mixing.
3. Add Phase B to Phase A, and mix slowly to avoid aerating.
4. Cool to 45°C and add Phase C. Mix slowly.
5. Pour or scoop out into containers.

Physical Properties
Appearance | White, opaque crème
pH | 3.87
Viscosity | N/A

Foaming Styling Gel with Styleze W-20 polymer
Formula #: 10748-67

Ingredients | %W/W | Supplier
--- | --- | ---
Deionized Water | 87.00 |  
Hydroxypropyl Guar (Jaguar® HP-60)* | 1.50 | Solvay Novecare  
Polyquaternium-55 (Styleze W-20 polymer) | 10.00 | Ashland  
Propylene Glycol (and) Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Germall Plus preservative) | 0.50 | Ashland  
Glycerin | 1.00 | Dow Chemical

Total 100.00%

Ingredients %W/W Supplier
Deionized Water | 92.30 |  
Oleth-20 (Brij™ 98 VEG)* | 1.00 | Croda  
Polyquaternium-55 (Styleze W-20 polymer) | 5.00 | Ashland  
Panthenol (DL-Panthenol 50L) | 0.20 | Roche  
Methyl Gluceth-20 (Glucam™ E-20 Humectant)* | 0.25 | Lubrizol  
Cocodimonium Hydroxypropyl Hydrolyzed Wheat Protein (Wheat-Quat C™)* | 0.50 | TRi-K Industries, Inc.  
Propylene Glycol (and) Diazolidinyl Urea (and) Methylparaben (and) Propylparaben (Germaben II preservative) | 0.75 | Ashland

Total 100.00%

Procedure
1. Weigh in water and add ingredients one at a time in order listed. Mix well between each addition.
2. Package in finger foamer from airspray.

Physical Properties
Appearance | Clear, pale yellow, thin liquid
pH | 5.2
Viscosity | 13.8 cps (Brookfield DV-II, UL Adaptor, 12 rpm)
6% VOC Ultra Conditioning Styling Mousse with Styleze W-20 polymer and Gafquat™ 755N polymer  
Formula #: 10748-72

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<th>Ingredients</th>
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<tr>
<td>Deionized Water</td>
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<tr>
<td>Polyquaternium-11 (Gafquat 755N polymer)</td>
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<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<td>N-Dodecyl-2-Pyrrolidone (Surfalone™ LP-300 wetting agent)</td>
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<td>Polysorbate 20</td>
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<td>Isobutane (Propellant A-31)</td>
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<tr>
<td>Hydrofluorocarbon 152a (Dymel® 152a)</td>
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<td>DuPont</td>
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<td>Total</td>
<td>100.00%</td>
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Styling Polymer Solids, 2.00%  
*Trademark owned by a third party

**Procedure**
1. Add ingredients in the order listed. Mix well between each addition until clear and homogenous.
2. Fill concentrate into cans, vacuum crimp and charge with isobutane and hydrofluorocarbon 152a.

**Physical Properties**
- **Appearance**: Slightly cloudy
- **pH**: 5.47
- **Viscosity**: 78 cps (Brookfield UL Adaptor, Sp# DV -II, 5 rpm)

**Packaging**
Polyamide Imide aluminum lined cans  
Precision Valve – Stem 024 natural, inverted body with tail piece

Clear Daily Leave-In Conditioner with Styleze W-20 polymer  
Formula #: 10761-125-1

<table>
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<th>Ingredients</th>
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<tr>
<td>Deionized Water</td>
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<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<tr>
<td>Dimethicone PEG-15 Acetate (Si-Tec™ DMC 6032)</td>
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<td>Propylene Glycol</td>
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<tr>
<td>Propylene Glycol (and) Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Liquid Germall Plus preservative)</td>
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<tr>
<td>Cetrimonium Chloride (Varisoft® 300)*</td>
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<td>Evonik</td>
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Styling Polymer Solids, 1.00%  
*Trademark owned by a third party

**Physical Properties**
- **Appearance**: Clear thin liquid
- **pH**: 5.48
- **Viscosity**: 3.6 cps (Brookfield DV-II, UL Adapter, Sp# DV-II, 3 rpm)

Smooth Clear Styling Lotion with Styleze W-20 polymer  
Formula #: 10838-128

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<th>Ingredients</th>
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<td>Oleth-20 (Brj™ 98 VEG)*</td>
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<td>Croda</td>
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<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<td>Ashland</td>
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<tr>
<td>Polysorbate 20 (Tween™ 20)*</td>
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<tr>
<td>Diazolidinyl Urea (and) Iodopropynyl Butylcarbamate (Germall Plus preservative)</td>
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<tr>
<td>Disodium EDTA (Versene® Na₂)*</td>
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<td>Dow Chemical</td>
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<td>Total</td>
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Styling Polymer Solids, 1.00%  
*Trademark owned by a third party

**Procedure**
1. Add water to main tank. Start mixing.
2. Add Oleth-20, mix well.
3. Add natrasol 250 HEC into vortex. Mix until uniform.
4. Heat to 55-60°C, mix until uniform. Cool batch to 35°C.
5. Add Styleze W-20 polymer. Mix well.
6. Add polysorbate 20, Germall Plus preservative, disodium EDTA Na₂. Mix until uniform.

**Physical Properties**
- **Appearance**: Clear, pourable lotion
- **pH**: 5.6
- **Viscosity**: 12,000 cps (Brookfield LV, Sp# 4, 12 rpm)
6% VOC ThermaHold™ Conditioning Mousse with Styleze W-20 polymer and Ceraphyl™ 65 ester
Formula #: 10852-89

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<th>Ingredients</th>
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<tr>
<td>Cocamidopropyl Betaine (Miratane® CB)*</td>
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<td>Polyquaternium-55 (Styleze W-20 polymer)</td>
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<tr>
<td>Propylene Glycol (and) Quaternium-26 (Ceraphyl 65 ester)</td>
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<td>Acetamide MEA (Lipamide® MEAA 100%)*</td>
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<td>Hydrofluorocarbon 152a (Dymel® 152a)*</td>
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<tr>
<td>Isobutane/Propane (Propellant A-46)</td>
<td>6.00</td>
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Total 100.00%

Styling Polymer Solids, 2.00%
*Trademark owned by a third party

Procedure
1. Weigh in water, add ingredients one at a time in order listed. Mix well between each addition.
2. Fill into cans, vacuum crimp valves, and charge with propellant; isobutane/propane first, followed by hydrofluorocarbon 152a.

Physical Properties
- Appearance: Cloudy, hazy
- pH: 5.0
- Viscosity: 26.1 cps (Brookfield DV-II, Sp# LVI, 30 rpm)

Packaging
Can polyamide imide aluminum lined cans
Valve Seaquist Perfect, VX-81 (2x0.20” x 0.343”, Vapor Tap - 0.030”)

References