**Introduction**

In this study, three new deodorant formulations were developed and evaluated using high concentration levels of Zemea® propanediol. A clear, natural deodorant stick was developed with a high level of Zemea® propanediol and a unique solubilizer. This formulation solved the key challenges of clarity, aesthetics and durability using naturally-derived ingredients. Two roll-on antiperspirants were also developed—a conventional, opaque formulation and a clear one. Zemea® propanediol functioned as an effective solvent for the aluminum salts and solved some of the challenges with roll-ons such as stability, aesthetics and roller ball mobility issues.

## Formulating Clear, Natural Deodorant Sticks

### Why a Natural Deodorant Stick?
- Propylene glycol sensitivity
- Triclosan aversion
- PEG-free trend
- Natural bias

### Classic Deodorant Sticks
- Clear to translucent
- Based on propylene glycol, water, and sodium stearate
- Triclosan for deodorancy

### Challenges with Deodorant Sticks
- Clarity
- Durability
- Aesthetics

Table 1: Formulation of Clear Deodorant Stick

<table>
<thead>
<tr>
<th>Phase</th>
<th>Ingredients (wt, %)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled Water</td>
<td>54.5%</td>
<td>44.5%</td>
<td>34.5%</td>
<td>22.5%</td>
<td>45.25%</td>
<td>43.25%</td>
<td>35.5%</td>
<td>33.5%</td>
<td>31.5%</td>
<td>31%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Zemea® Propanediol</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide (10% Sol.)</td>
<td>9.5%</td>
<td>9.5%</td>
<td>9.5%</td>
<td>9.5%</td>
<td>3.75%</td>
<td>4.75%</td>
<td>9.5%</td>
<td>9.5%</td>
<td>9.5%</td>
<td>9.5%</td>
<td>9.5%</td>
<td></td>
</tr>
<tr>
<td>Stearic Acid</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>2%</td>
<td>3%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>POLYALDO® 10-1-CCKFG</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Fragrance</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5%</td>
<td>0.5%</td>
<td></td>
</tr>
</tbody>
</table>

**Opaque**  Low  **Clarity**  High

**Procedure:**
- Add phase A in a clean beaker and heat to 85-95°C.
- Add phase B into phase A and continuously mix the mixture at high temperature (85-95°C). A clear solution will be observed.
- Add the water that was evaporated from heating and add phase C into the clear mixture.

## Discussion

- Zemea® propanediol used at 60% provided shorter duration for mixture to solidify and a firmer deodorant stick.
- Combining Zemea® propanediol and a solubilizer provides greater stick clarity at room temperature and the use of higher fragrance loads without the use of triclosan.

## Formulating Conventional and Clear Antiperspirant Roll-Ons

### Why Roll-on Antiperspirants?
- Convenient, effective
- No flaking or whitening
- Ease of production
- Fragrance delivery
- Conventional Opaque Antiperspirant Roll-On Emulsion
- Opaque thin emulsion
- Non-volatile solvent/emollient phase
- High level of aluminum salt

### Classic Roll-on Antiperspirants
- Stability
- Roller ball mobility issues
- Aesthetics

### Challenges with Roll-on Antiperspirants

Table 2: Formulation of a Clear Antiperspirant Roll-on Solution

<table>
<thead>
<tr>
<th>Phase</th>
<th>INCI</th>
<th>Trade name</th>
<th>Supplier</th>
<th>Wt, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cyclopentasiloxane</td>
<td>SF 1202</td>
<td>Momentive</td>
<td>5%</td>
</tr>
<tr>
<td>B</td>
<td>Steareth-2</td>
<td>Bri® S2</td>
<td>Croda</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Steareth-21</td>
<td>Bri® S721</td>
<td>Croda</td>
<td>2%</td>
</tr>
<tr>
<td>C</td>
<td>Propanediol</td>
<td>Zemea® propanediol</td>
<td>DuPont Tate &amp; Lyle</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Silica</td>
<td>Cab-O-Sil® M-5</td>
<td>Cabot</td>
<td>0.2%</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>-</td>
<td>-</td>
<td>68.8%</td>
</tr>
<tr>
<td>D</td>
<td>Aluminum Chlorohydrate</td>
<td>ACH-321</td>
<td>SummitReheis</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Procedure:**
- Add phase A into a clean beaker and heat until the wax is completely melted.
- Prepare phase B in another beaker and heat to 70°C.
- Add phase A into phase B with stirring.
- Remove the mixture from hot plate and continue to stir. Once the emulsion is formed, add phase C slowly into the emulsion and mix until the ACH is completely dissolved.
- Transfer the emulsion to a roll-on container when it cools to room temperature.

### Discussion

- Smooth-feeling, non-sticky, quick-drying opaque and clear roll-on antiperspirant formulations obtained through use of Zemea® propanediol.

**Conclusion**

- Zemea® propanediol works as a replacement for other glycols in deodorant and antiperspirant applications.
- Zemea® propanediol helps formulators solve key challenges of clarity, stability, aesthetics and durability.
- Zemea® propanediol works well with solubilizers, and is an effective solvent for aluminum salts.

- Zemea® propanediol improves skin moisturization and sensory aesthetics without causing skin irritation.
- Zemea® propanediol can reduce water activity and boost preservative efficacy.