4: Sensitive Sunscreen Test

Rheological tests measure linear viscoelasticity to determine how resistant a lotion is to sun and friction.

Source: Coppertone®

One of Coppertone's most memorable advertising campaigns portrayed a 3-year-old girl in pig-tails with her puppy pulling down her bathing suit and, much to her surprise, revealing a beautiful bronze tan. The famous ad marked the early days of children's sun care, when the slogan was "Tan—Don't Burn!" Today, with studies revealing that 80% of sun exposure occurs before age 18 and that just one bad blistering during childhood can double the risk of cancer later in life, the market for children's sun care has grown up and gotten serious about providing stronger and gentler suntan lotions for children's sensitive skin and why Coppertone changed its slogan to "Get Smart About the Sun."

To determine a lotion's overall composition and resistance to friction and sun, formulators perform two tests on lotions—the oscillation stress sweep and the oscillation frequency sweep. One such study involved two commercially available suntan lotions from the same manufacturer; one sun cream for children and the other for adults. While the tests revealed only small differences in the formulas' structures, these differences significantly affected the resulting application in the end products.

Oscillation Stress Sweep

The oscillation stress sweep is performed to determine the linear viscoelastic region of the samples and to see if there is any structural difference between them. The results are presented in diagrams 1 and 2. Diagram 1 presents elastic modulus as a function of applied shear stress. Diagram 2 describes the same parameters as a function of measured strain.

The diagrams reveal that the sample suntan lotion for adults has a higher elastic modulus in the linear region compared to suntan lotion for babies. This indicates that the sample adults lotion is more structured than the sample baby lotion. This can also be seen from the force needed to rearrange this thermodynamically stable structure, which is larger for adult lotion compared to baby lotion. Interesting to note is that the baby lotion has a more sensitive structure indicated by the critical strain, which is lower for this sample compared to adult suntan lotion. This is very positive since a baby's skin is much more sensitive to friction and sun burns. A low critical stress and critical strain makes this sample easy to break and apply to baby skin.

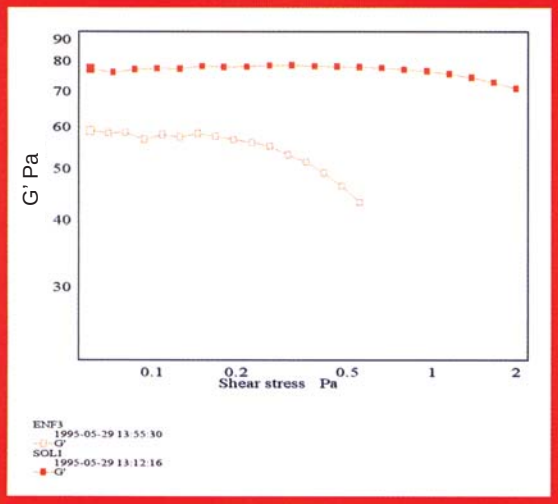
Oscillation Frequency Sweep

The results from the oscillation frequency sweep are presented in diagram 3 and 4. The frequency sweep measures the samples in the structured state, in other words, in the linear viscoelastic region determined in the oscillation stress sweep test.

The figures show that both samples have similar properties at high frequencies (5 Hz) by a comparison of elastic modulus, viscous modulus, phase angle and the complex viscosity. This indicates that there are different types of structures in the two samples and a suggestion can be made that the samples have a different kind of stabilization.

For the baby lotion, we see that at low frequencies G'=G", which is important since a higher degree of liquidity is important for the smoothness to the skin. A comparison shows that the baby lotion has a higher G" than the adult lotion. The baby lotion also has a more frequency dependent G', but at higher frequencies both samples have identical values as mentioned above. This gives the baby lotion the same resistance toward abrasive removal of the lotion from the skin.

From the right diagram, we see that the phase angle for the baby lotion is considerably higher, indicating a larger proportion of liquid-like properties. The viscosity is also lower for the baby lotion in the full frequency range. These factors contribute to the overall higher smoothness and softness of the baby lotion.



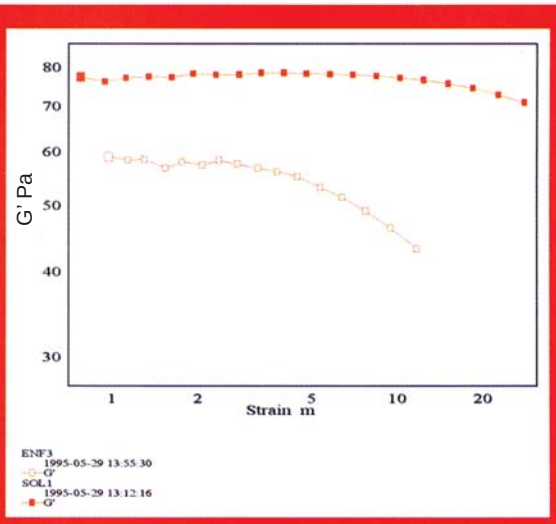
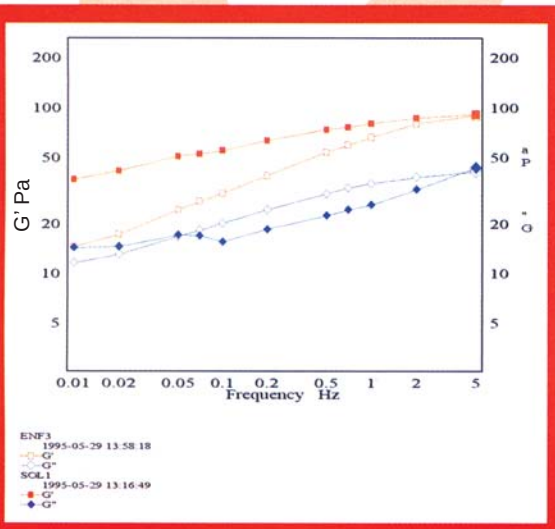


Diagram 1 and 2. G', G" and δ as a function of σ (left) and γ (right) for two suntan lotions.



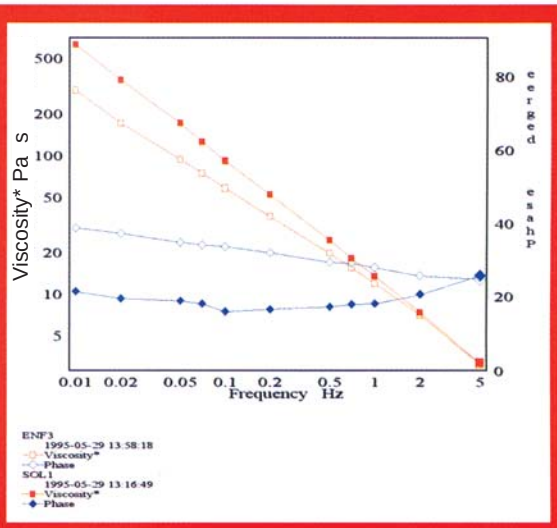


Diagram 3 and 4. Left diagram presents G'(red) and G" (blue) for the two different suntan lotions. Right diagram represents viscosity (red) and phase angle (blue) for the same lotions. Filled symbols represent the adult lotion and unfilled symbols represent the baby lotion.

A study of the graphs in diagrams 3 and 4, as well as the oscillation stress sweep, give a deeper understanding of the differences in formulation between the samples. The adult lotion has a more frequency independent structure that is basically a particle emulsion structure, and the adult lotion contains a polymer with a high molecular weight which doesn't contribute to any interactions between the droplets, but stabilizes the overall particle structure.

Baby lotion is more frequency dependent and shows some polymeric features, as it is a mixed structure. This complements a low molecular weight polymer added as an emulsion stabilizer. This polymer acts in the interface between the two phases. The hydrophilic part of the polymer chain acts outside the emulsion droplet. Since these polymers have a larger affinity for each other than the water phase, they tend to build a weak agglomerated structure. The tails and polymers acting as micelles in the solution create the larger frequency dependency and a resulting higher elastic resistance.

By identifying the subtle differences between children's and adult suntan lotion, manufacturers are distinguishing the needs of each product on a grand scale, and demonstrating that the children's sun care market is no longer in its infancy. ■ **GCI**

Source: These studies are courtesy of Reologica Instruments, Inc. For further information on rheological testing, please contact Fred J. Klein, Western Region Manager, Reologica Instruments, Inc. at fjk@reologicainstruments.com.