A different direction using rheology as a screening tool when reformulating is needed to improve sustainability

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Introduction of research

Consumers demand for sustainable products with high bio-based content is driving the revision of well established formulations. Climate concerns led to the promotion of cold processes in manufacturing. This is the future for industrial production, critical in reducing the carbon footprint coming from the manufacture of high volume products such as body care and hair conditioners. A major challenge facing the formulators: how to update the composition, maintain the stability and be sure the behavior in use meets the consumers expectations? A tool capable of providing quick responses is needed to guide the ingredients selection.

Objective: The aim was to reformulate Oil-in-Water emulsion for body care, packaged in a pump bottle, to improve its sustainability profile. Three targets were selected: reducing the number of ingredients, replacing fossil resources with bio-based ingredients and reducing heating as much as possible during the manufacturing process. Taking advantage of its ability to simulate real-world low to high stress conditions such as conditions during transport, pump distribution and spreading on skin, rheology experiments were carried out to guide the choice of materials and to adjust the composition relative to the Reference profile.

Materials & methods: Reference formulation contained more than 20 ingredients. Among them, waxy components (emulsifier and consistency agents) required a hot manufacturing procedure. Formula composition was simplified by replacing the existing oil phase containing non-biodegradable silicones (linear and volatile) by two plant-based oils chosen for their good spreading properties: C15-19 renewable alkane and triheptanoin. A plant-based cold-processable liquid O/W emulsifier: Lauryl Glucoside (and) Myristyl Glucoside (and) Polyglyceryl-6 Laurate was also chosen for its light skin feel. Two natural gums were evaluated as the main Thickener-Stabilizer: Xanthan Gum coated by Acacia gum (Ag) for easier dispersion and Caesalpinia spinosa Gum (Cg) and an inherently ultimately biodegradable synthetic polymer was maintained as a secondary option due to its strong stabilizing power. The manufacturing process was optimized at room temperature for Ag and water was heated at 40°C prior to addition for Cg, to facilitate polymer deployment and dispersion. Formulation options with liquid and powder stabilizers were compared to the initial hot-processed Reference. Rheology experiments were conducted on the different formulations 7 days after manufacturing, using a rotational Controlled stress/strain hybrid rheometer (DHR2; TA Instruments; cone 40 mm/2°). Oscillatory experiments monitored the influence of ingredients on the structure of the formulation and its resistance, especially to temperature variations related to stability screening (-5/80°C sweep). G' (storage/elastic modulus) and G'/G" ratio were followed as indicators of the formula structure. Flowing experiments at 25°C modeled stresses from pump distribution and spreading on skin (profile from 0 to 1200 s-1, yield stress zooming from 0 to 200Pa steady state ramp with Onset point analysis).

Results & Discussion: Two options improved both the natural content and reduce/avoid heating during production of the body care formula, using one of the natural gums as the main thickener-stabilizer, alone or in combination with the synthetic polymer. The combinations of the two natural gums were discarded because of their uneven texture, very different from that of the Reference. Comparison of the rheological profiles with the initial hot-manufactured emulsion confirmed that stability is the most challenging point and that it remains difficult to obtain a stable cold-processed formulation with 100% bio-based content (Figure 1). The results accurately predicted classical stability in real time after 3 months. Flowing profiles with strongher shear thinning character and lower yield stress highlighted key benefits versus the reference: easier pump dispensing and spreading.

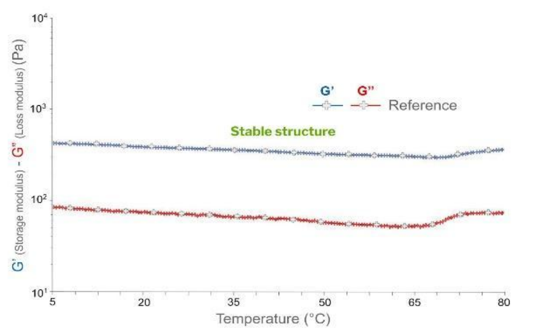

Figure 1a. Reference

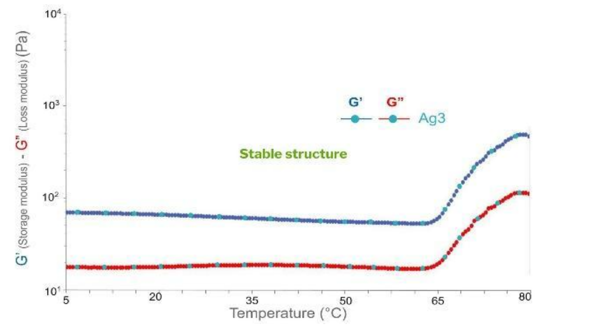

Figure 1b. Ag + synthetic polymer (1.5%; 1%)

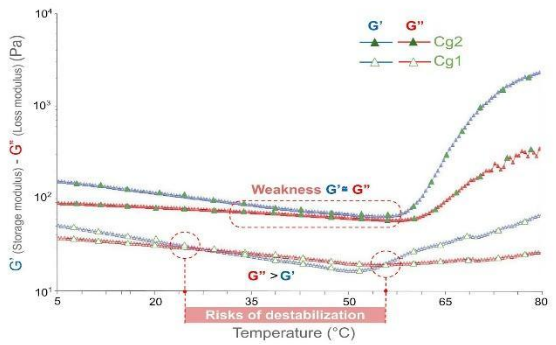

Figure 1c. Cg alone (1=1%; 2=1.5%)

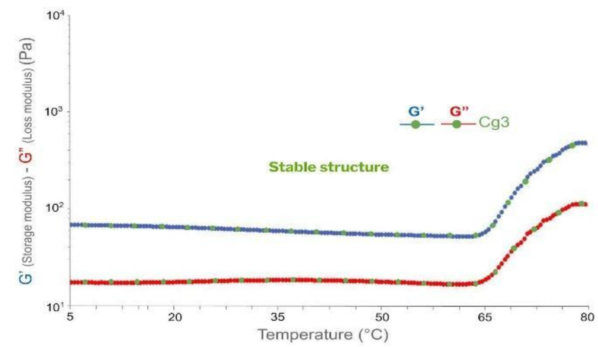

Figure 1d. Cg + synthetic polymer (1.5%; 0.3%)

Figure 1 a. b. c. d. Evolution of the elastic structure with temperature

Conclusion

Rheology provides complementary information to conventional viscosity measurements and stability testing. It helped to better understand the effects of the substitution of the waxy components. Analyzed in a simple manner (without equations), it is another dynamic way to anticipate instability problems under stress and to model flow or spreading situations, facilitating and accelerating the pre-selection in reformulations. It supported the optimization of more sustainable cold-processes with fewer ingredients, that will save time in production. A bio-based liquid emulsifier replaced several waxes. The combination with natural powders help to stabilize a biodegradable alternative to silicones.

About the speaker

Alicia Roso joined Seppic in 1986 and holds a position in the Research and Innovation team as the scientific communication manager. She has worked as a Chemical engineer for twenty years in the cosmetic R&D team. She joined the marketing team in 2006 as product manager and gained a marketing MBA from ESSEC business school in 2012. She was named as Air Liquide International Expert for health care formulation and emulsions in 2010. She is co-author of 23 patents on new ingredients or formulation technologies dedicated to cosmetology and dermopharmacy applications.