Replacing synthetic texturizing polymers with natural raw materials in cosmetic formulations

ID 313

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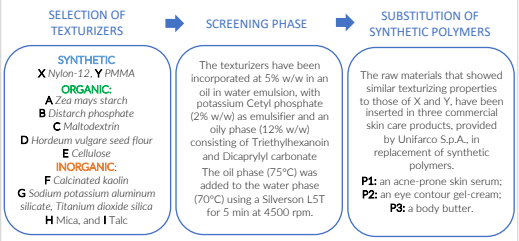
Introduction:

Nylon-12 and **Polymethylmethacrylate** (PMMA) are among the most common synthetic texturizers used in cosmetics for their film-forming, opacifying, and sensorial properties.

Their non-biodegradable polymeric nature makes them fall into the category of **microplastics** which are cause of great concern for the aquatic environment and our ecosystem.[1] The restrictions proposed by ECHA[2] lead to the need to quickly find less impactful alternatives.

The aim of this work was to investigate the possibility of replacing these synthetic texturizers with **natural biodegradable ingredients**,[3] without affecting the products' physico-mechanical characteristics and sensorial performances.

Materials & Methods:



Rheological analysis: viscoelastic properties (**η**: viscosity; **G*** complex modulus; **tanδ**: damping factor) were measured in continuous and oscillatory flow conditions using a Rheometer Physica MCR e302 (Anton Paar) at 23 ± 0.05 °C, equipped with a PP50/P2 sensor (fixed gap 1 mm).

Texture analysis: immersion test was performed with a Texture Analyzer TMS-Pro (Food Technology Corporation) equipped with a nylon spherical probe (Ø = 2 cm), at a speed of 80 mm/min to a depth of 10 mm (Fig. 1a).[4] Adhesive properties of the residual film formed by 0.5 g of the product after application were evaluated by measuring the work needed to unstick a steel spherical probe (Ø = 1 cm) from a silicon surface at a speed of 80 mm/min (Fig. 1b).

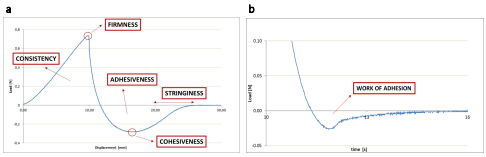


Fig. 1: *Texture parameters obtained from texture analyses: (a) immersion test and (b) adhesion test.*

Sensorial analysis: Thirty-two volunteers were instructed to apply the selected formulations on the skin, answering a questionnaire to evaluate, giving a score from 1 to 7, the appearance (aspect, color), the consistency, the spreadability, the rate of absorption, the after-feel (greasiness, stickiness, glow, softness). The experimental data obtained were submitted to a paired samples t-test.

Results & Discussion:

A Principal Component Analysis (PCA) was performed using XLSTAT software and applied to the correlation matrix of the average values of both texture and rheological parameters (Fig. 2). The graph showed the correlations between these two techniques: η and G* were positively correlated to firmness, consistency, adhesiveness, cohesiveness and negatively correlated to stringiness.

The inorganic polymers F, H, and I formed fluid and viscous emulsions, with high spreadability and stringiness but low adhesiveness. Among the organic polymers, B formed firmer systems with higher elastic G' modulus, while D and E showed higher adhesive properties. **Polymers A, G, and C conferred more balanced parameters, like those conferred by the synthetic polymers X and Y.**

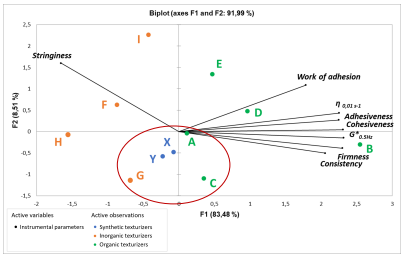


Fig. 2: *PCA loading biplot with rheological and texture parameters measured for the emulsions containing 5% of texturizers.*

P1 XY containing 1% w/w of X and 1.5% w/w of Y has been reformulated replacing them with the selected natural texturizers at the same total amount. The polymer G caused a slight increase of the structure (G*), whereas C determined a decrease (Fig. 3a). Polymer **A** can be considered as a valid alternative to the synthetic polymers in this product.

P2 Y containing 1% w/w of Y has been reformulated with the natural texturizers at the same total amount. The samples did not show quantitative differences. P2 A showed higher values of tanδ, due to the more relevant viscous behavior, whereas P2 **C** had the same trend of both G* and tanδ of the reference P2 Y (Fig. 3b).

P3 Y containing 3% w/w of Y has been reformulated with the natural texturizers at the same total amount. P3 C had lower values of the complex modulus, while polymer **G** conferred similar viscoelastic properties to those of reference (Fig. 3c).

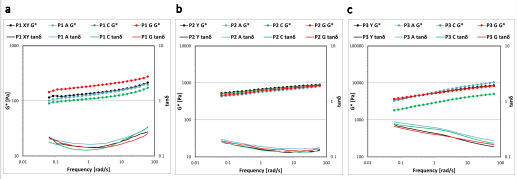


Fig. 3: *trend of G* and tanδ in function of the oscillation frequency for (a) P1, (b) P2 and (c) P3 formulated with synthetic and natural texturizers.*

The results obtained from the double-blind sensory test are summarized in Table I. Each reference product was compared to the samples formulated with the natural texturizers which conferred the most similar mechanical parameters.

- P1 XY was compared to the sample P1 A: no significant difference was detected;
- P2 Y was compared to the sample P2 C: the only difference detected was in the color, since P2 C was perceived as slightly tending to yellow;
- P3 Y was compared to P3 G: the two samples differ not only in color but also for a slight increase of the consistency perceived for P3 G.

Tab. I: *results of the paired samples t-test: green boxes indicate no differences perceived; red boxes indicate significative perceived differences. The average values of differences are reported.*

	ASPECT	COLOUR	CONSISTENCY	SPREADABILITY	ABSORPTION	GREASINESS	STICKINESS	GLOW	SOFTNESS
P1 XY vs P1 A									
P2 Y vs P2 C		1							
P3 Y vs P3 G		-0.8	-0.5						

Conclusions:

The physical and mechanical properties of polymers inevitably have an impact on the applicative and sensorial characteristics of the finished products, affecting consumers' perception and acceptability.

The combined use of **rheology** and **texture analysis** is useful to characterize the applicative properties of cosmetic formulas, evaluating the influence of the vehicle composition and the **replacement of raw materials** on spreading properties and adhesive characteristics. These two complementary techniques could provide a scientific support for cosmetic industries to easily reformulate cosmetic products in a **green and sustainable perspective**.

References:

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