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PHYSICO-MECHANICAL CHARACTERIZATION OF POLYURETHANES FOR COSMETIC USE: RHEOLOGY AND TEXTURE ANALYSIS

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INTRODUCTION

The chemistry of polyurethanes has aroused considerable interest, because of their versatility, the ability to create engaging textures and their possible biodegradability.

The aim of this work is to characterize the physical-mechanical properties of two polyurethane-based raw materials, used alone or in associations, evaluating their ability to stabilize and thicken cosmetic hydrogels and emulsions.

MATERIALS

Table I: *Raw materials used for the preparation of gels and emulsions.*

	INCI **- TRADE NAME**	GELS (%w/w)	O/W EMULSIONS (%w/w)
X	*Polyurethane-59* (30%), Butylene glycol, Water* **- ADEKA NOL GT-930**	*0.75 - 2	*0.1 - 0.5
Y	*PEG-240/HDI copolymer BIS-decyltetradeceth-20 ether* (30%), Butylene glycol, Water* **- ADEKA NOL GT-730**	*0.75 - 2	*0.1 - 0.5
EMULSIFIER	*Glyceryl stearate, PEG-100 stearate*	-	3
OIL PHASE	*Hydrogenated polydecene, Triethylhexanoin*	-	20

METHODS

Rheological analyses: performed both in continuous and oscillatory flow conditions, with Rheometer Physica MCR-101 (Anton Paar) at 23 ± 0.05 °C, equipped with a PP50/P2 sensor (fixed gap of 1 mm).

Texture analyses: an immersion/de-immersion test was performed with Texture Analyzer TMS-Pro (Food Technology Corporation) equipped with a 10 N load cell and a nylon spherical probe (2 cm diameter).
The probe penetrates the sample at a speed of 1.3 mm/sec to a depth of 10 mm. Software Texture Lab Pro was used to register and display the data. A typical texture analysis (TA) curve and the derived parameters are shown in Fig. 1.

- **Firmness:** the force (N) needed to obtain a deformation;
- **Consistency:** the work (N.mm) the sample opposes against the deformation;
- **Cohesiveness:** the material intramolecular forces (N);
- **Adhesiveness:** the work (N.mm) necessary to overcome the forces between two surfaces;
- **Stringiness:** the distance (mm) the product stretches during the de-immersion phase.

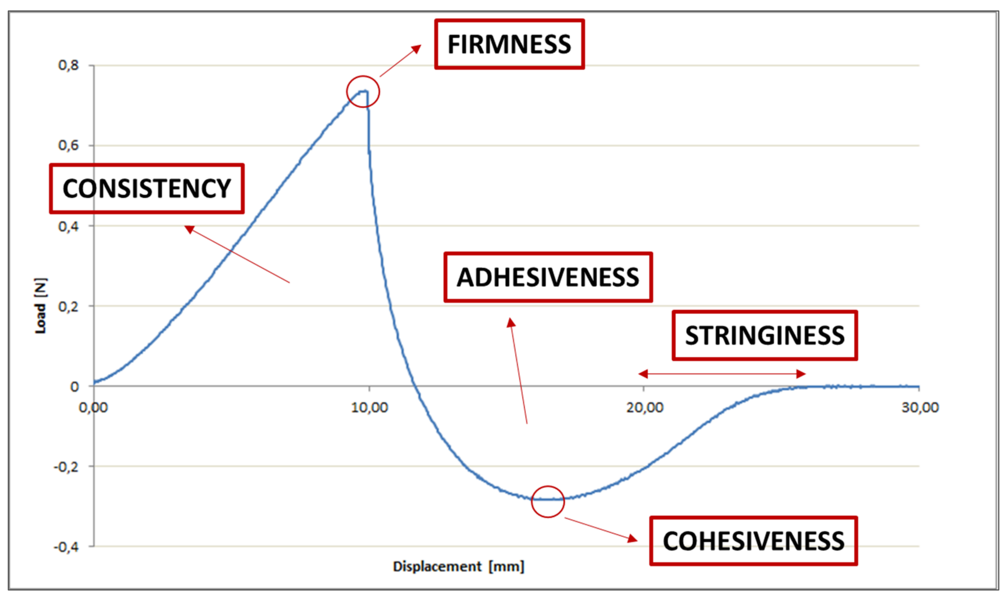

Fig. 1*: Definition of parameters from a TA curve.*

RESULTS

A Principal Component Analysis (PCA), performed using XLSTAT software, was applied to the correlation matrix of the values of the textural and rheological parameters (viscosity **η**, critical strain $\gamma_{G'=G''}$, complex modulus **G*** and damping factor **tanδ**) calculated for **GELS** and **EMULSIONS** (Fig.2).

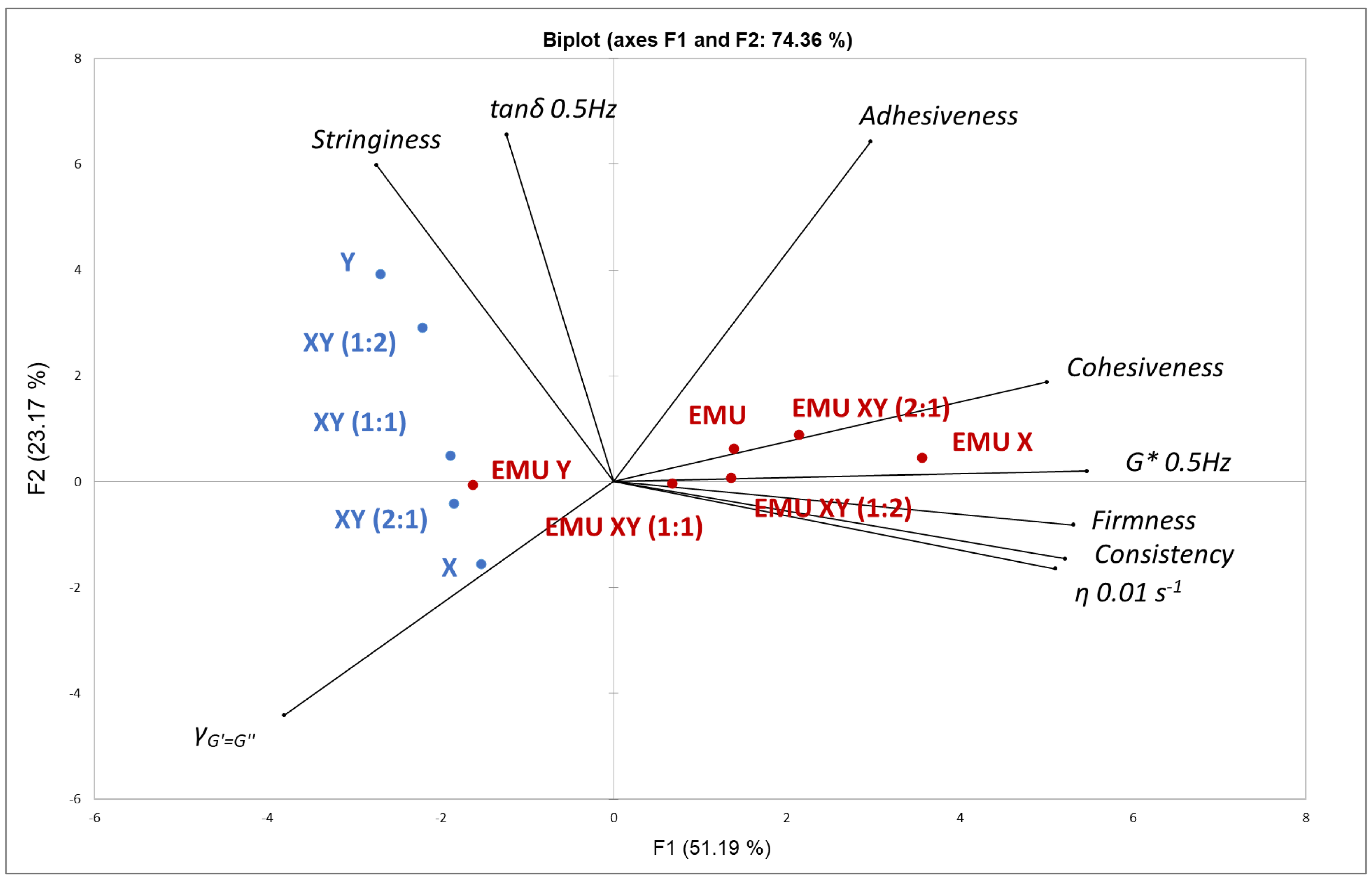

Fig. 2*: PCA loading biplot of gels (in blue) and emulsions (in red) with rheological and textural parameters (variables).*

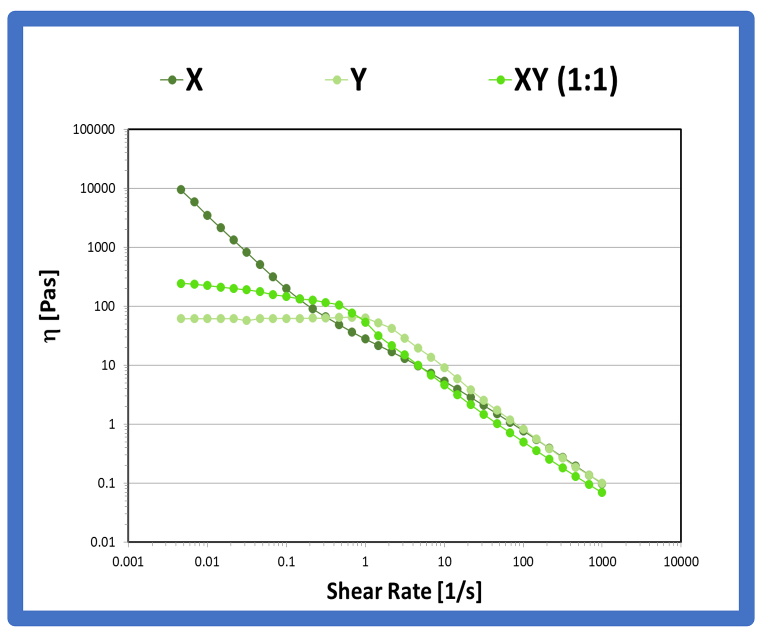

Fig. 3*: viscosity trend in function of shear rate for gels prepared with 1.5% w/w of polymer concentration.*

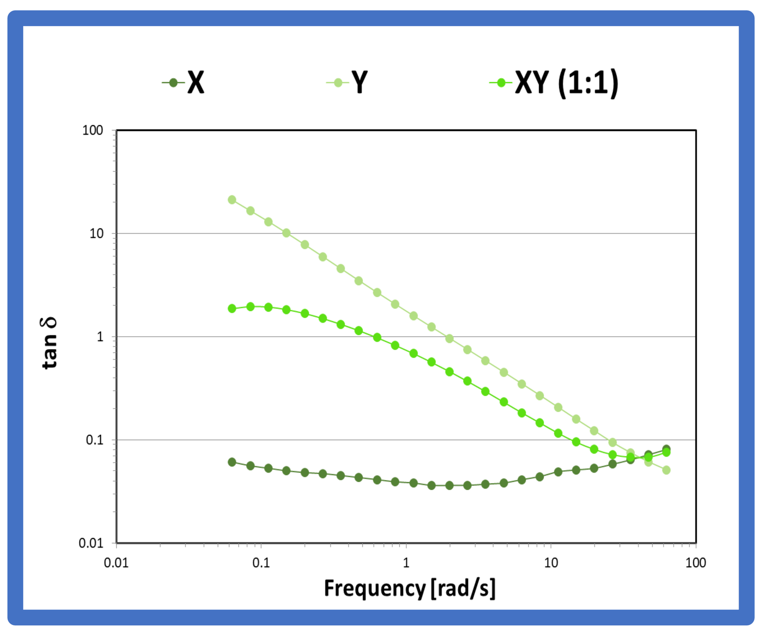

Fig. 4*: tanδ trend in function of the frequency for gels prepared with 1.5% w/w of polymer concentration.*

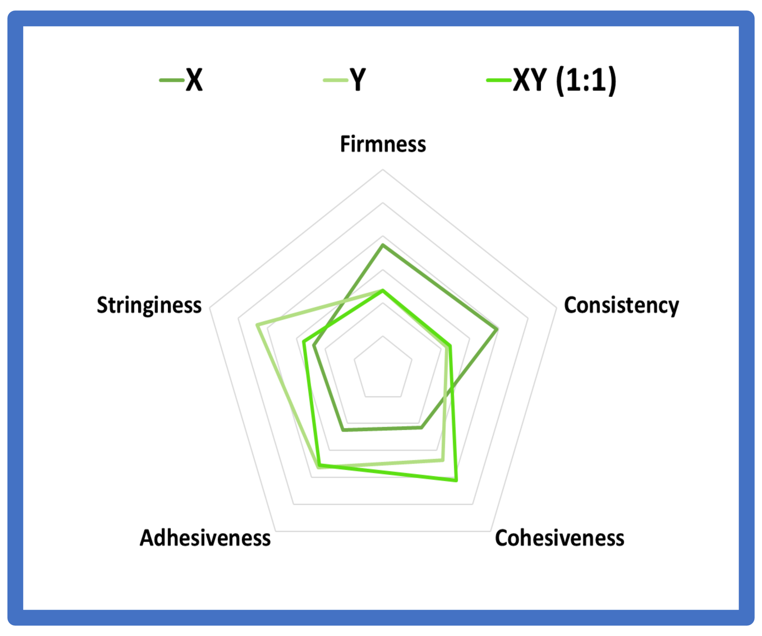

Fig. 5*: radar of texture parameters for gels prepared with 1.5% w/w of polymer concentration.*

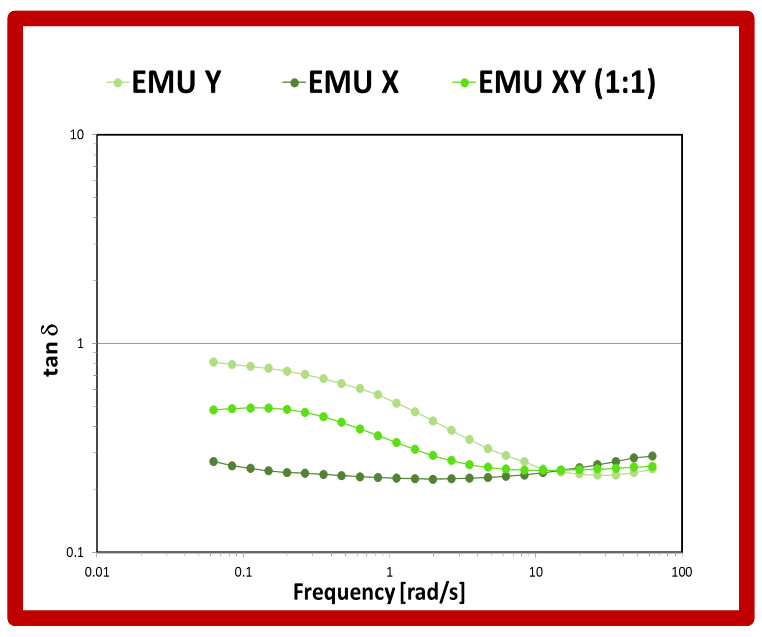

Fig. 6*: tanδ trend in function of the frequency of emulsions prepared with 0.5% w/w of polymer concentration.*

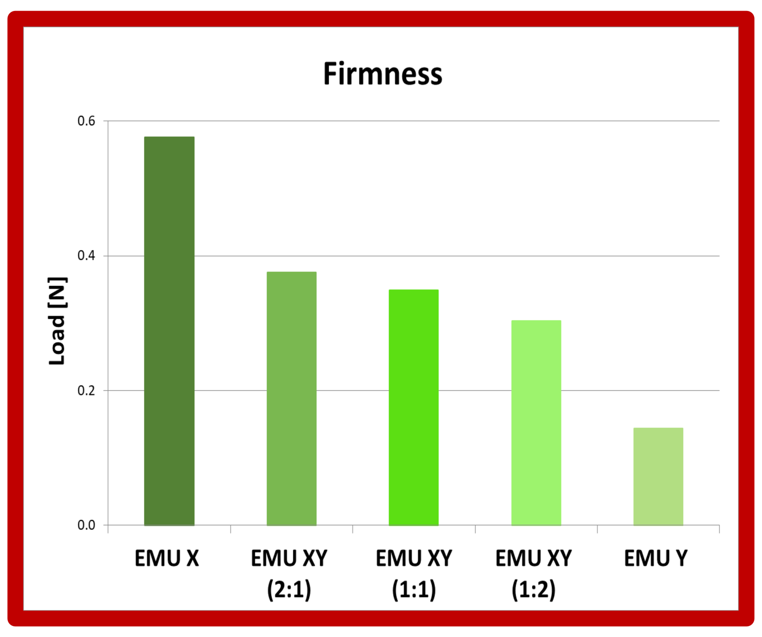

Fig. 7*: firmness values of emulsions prepared with 0.5% w/w of polymer concentration.*

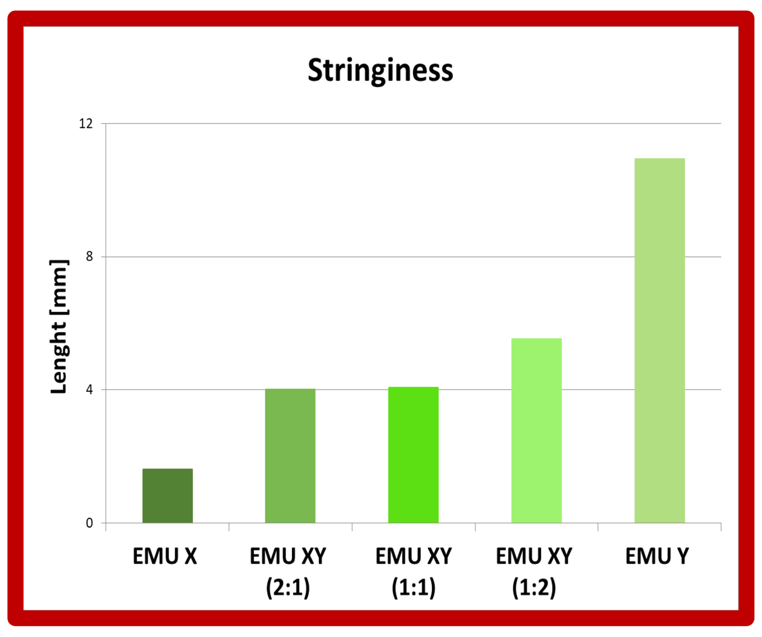

Fig. 8*: stringiness values of emulsions prepared with 0.5% w/w of polymer concentration.*

X showed a **pseudoplastic behavior** when analyzed in continuous flow conditions (Fig. 3) and a **weak gel** rheological pattern of G' and G'' in function of the oscillation frequencies (Fig. 4). It conferred high values of **firmness** and **consistency** but low adhesiveness (Fig. 5).

Y formed **fluid gels** with low firmness and high values of **stringiness** (Fig. 4, 5). The emulsions were characterized by **low viscosity** and good pick-up properties (Fig. 7, 8).

The **associations** of these two polyurethanes allowed modulating the rheological and the textural properties (Fig. 5, 6). The raw materials X and Y combined at a **ratio of 1:1** conferred improved **spreading** and **pick-up properties** to the emulsions (Fig. 7, 8).

CONCLUSIONS

X: elastic properties	**X + Y**	**Y: viscoelastic properties**
co-emulsifying agent	modulation of the properties	rheological modifier

- Rheology and texture parameters are significantly correlated (Table II).
- This approach represent a valid tool to rationalize the use of polymers enhancing the sensory profile of cosmetic products.

Table II: *Pearson's coefficient between rheological and textural values; green boxes for positive correlations and orange boxes for negative correlations (p value < 0.05).*

Variables	$\eta_{0.01\,1/s}$	$\gamma_{G'=G''}$	$G^*_{0.5Hz}$	$G^*_{0.01Hz}$	$\tan\delta_{0.5Hz}$	$\tan\delta_{0.01Hz}$
Firm	0.962	-0.548	0.564	0.898	-0.324	-0.322
Cons	0.970	-0.477	0.529	0.886	-0.367	-0.364
Coh	0.749	-0.726	0.624	0.884	0.001	-0.110
Adh	0.322	-0.697	0.466	0.530	0.380	0.415
Str	-0.476	0.098	-0.325	-0.413	0.492	0.709