How to mimic acrylate-based thickener benefits with greener value according to ISO 16128?

NT_147

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INTRODUCTION

The market shares of natural cosmetics are continuously growing. One of the main concerns of formulators is thus to develop appealing textures with skin feels similar to those appreciated in conventional cosmetics. To achieve this goal, they have access to a more reduced number of raw materials. In addition, the performances of natural ingredients are often more limited than those of synthetic ingredients. This is particularly the case for thickening and sensorial properties of the acrylates-based polymers. Those ingredients are well-known for their ability to provide light and thick gels with a quick break effect upon application which is to date quite impossible to duplicate with natural ingredients.

The aim of the present work was to evaluate a combination of two thickeners, one based on an acrylate copolymer and the other based on polysaccharides, to achieve a high level of naturality as per ISO 16128 norm – while obtaining the texture performance expected with all acrylate systems. Firstly, a synergistic effect on viscosity was demonstrated by means of two Design Of Experiments (DOE) studies. Then, the synergy was further proven on application formulae which were also evaluated sensorially.

MATERIALS & METHODS

Materials

- Acrylate-based thickener → Acry = A + lecithin*
- Natural thickener → Nat = B + C + D + lecithin*

* same deoiled lecithin in the same amount into both thickeners

A = pre-neutralized sodium acrylate copolymer
B = sclerotium gum
C = xanthan gum
D = pullulan

DOE n°1 Synergistic effect and DOE n°2 Viscosity gain

Thickeners were introduced into water in equal dosage at two extreme levels, targeting a total concentration of 0.5% and 1.5% for DOE n°1 / 0% and 2% for DOE n°2 . Intermediate combinations were explored by varying the concentration of each factor (polymers) at either level 1 or 2 based on their concentration into in the respective thickener, as follows:

	DOE n°1	DOE n°2
Level 1	% factor (polymer) in 0.25 % thickener (Acry or Nat)	% factor in 1% thickener = Presence of factors
Level 2	% factor (polymer) in 0.75 % thickener (Acry or Nat)	Absence of the factors

TRIALS	FACTORS				INTERACTIONS										
	Acry		Nat		2nd order interactions					1st order interactions					
N°	A	B	C	D	ABC	ABD	ACD	BCD	ABCD	AB	AC	BC	AD	BD	CD
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	2	1	2	2	2	2	1	1	1	2	2	2
3	1	1	2	1	2	1	2	2	2	1	2	2	1	1	3
4	1	1	2	2	2	2	1	1	1	1	2	2	2	2	4
5	1	2	1	1	2	2	1	2	2	2	1	3	1	3	1
6	1	2	1	2	2	1	2	1	1	2	1	3	2	4	2
7	1	2	2	1	1	2	2	1	1	2	2	4	1	3	3
8	1	2	2	2	1	1	1	2	2	2	2	4	2	4	4
9	2	1	1	1	2	2	2	1	2	3	3	1	3	1	1
10	2	1	1	2	2	1	1	2	1	3	3	1	4	2	2
11	2	1	2	1	1	2	1	2	1	3	4	2	3	1	3
12	2	1	2	2	1	1	2	1	2	3	4	2	4	2	4
13	2	2	1	1	1	1	2	2	1	4	3	3	3	3	1
14	2	2	1	2	1	2	1	1	2	4	3	3	4	4	2
15	2	2	2	1	2	1	1	1	2	4	4	4	3	3	3
16	2	2	2	2	2	2	2	2	1	4	4	4	4	4	4

For both DOE, the variation of each factor at level 1 or 2 was studied according to the left-hand side of the table below. For DOE n°1, in the right-hand side of the matrix, the corresponding interactions between factors were calculated. In this area, the numbers (1 to 4) correspond to the different combinations: 1 = A1B1, 2 = A2B2, 3= A1B2, 4= A2B1.

All the trial responses were evaluated according to the viscosity of the gels. The pH of resulting gels was around 6-6.5.

Viscosity values were collected in steady shear flow in the shear rate range of 0.5 s^{-1} to 100 s^{-1} at 25°C. Each viscosity measurement was repeated 10 times. DOE calculations were based on the viscosity collected at 0.5 s^{-1}, which is the most representative of the thickeners' interactions when the product is at rest.

Applications studies

The formula compositions were designed to be representative of ingredients commonly selected by formulators in gel and gel creams.

	GELS							GEL CREAMS						
	First set				Second set			Without electrolytes				With electrolytes		
Composition (%)	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Water	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP	QSP
Acry	1.5	0.5		0.5	1.5		1.5	1.5	0.5		0.5	1.5		1.5
MCG**								10.0	10.0	10.0	10.0	10.0	10.0	10.0
Nat			1.5	1.5	0.0	1.5	1.5			1.5	1.5		1.5	1.5
Antioxidant	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chelating agent	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Preservative	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0*	3.0*	3.0*
pH target	5.0-5.3							5.0-5.3						

- *Viscosity analysis*

A viscosimeter (Brookfield, LV) with spindle 4 (6 rpm, 1 min) was used to evaluate formulated products at 24h.

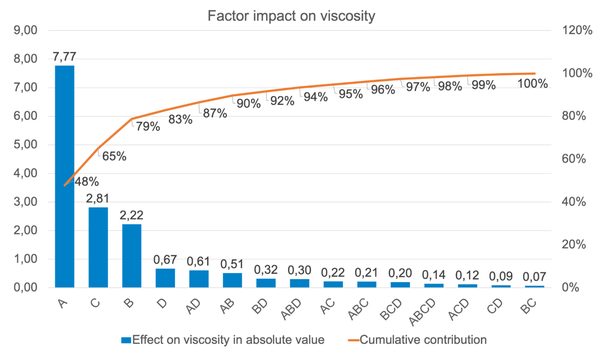
- *Sensorial analysis*

Two gels were formulated at the same targeted viscosity and pH and evaluated, in blind conditions, by a panel of 14 formulators according to aspect, application on the skin, and skin feel after application criteriae.

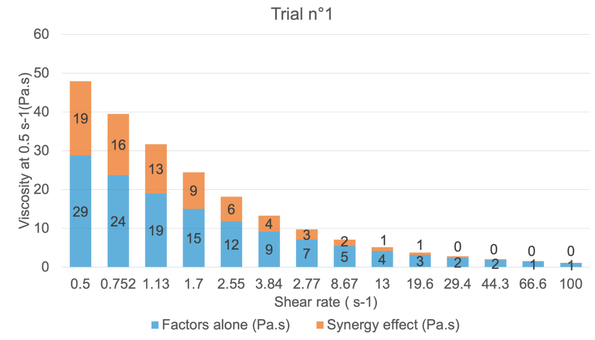
- Composition 01: 1.5% Acry / 13800 cPs, pH = 5.10
- Composition 04 : 0.5% Acry + 1.5% Nat / 15500 cPs / pH = 5.10

RESULTS and DISCUSSION

DOE n°1 Synergistic effect



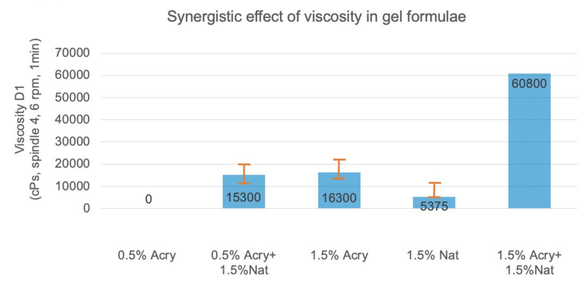
DOE n°2 Viscosity gain

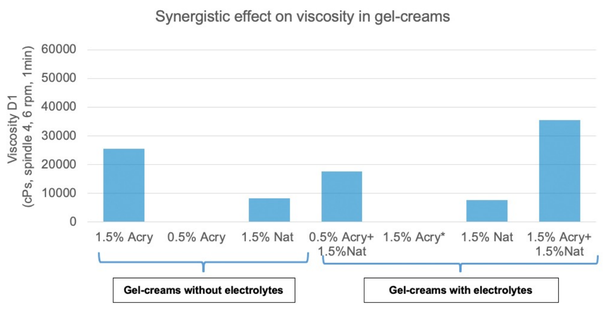


The contribution of first and second order interactions re presents 17% of the viscosity which is partly driven by polymer chain interactions. It emphasizes that the mesh network and its stiffness can be optimized by combining different mechanisms of swelling.

The synergistic effect between the two thickeners represents around 40% of the total viscosity value up to 8-9 s^{-1} .Indeed, as the polymers chains become aligned under higher shear rates, they may no longer be able to interact.

Applications studies



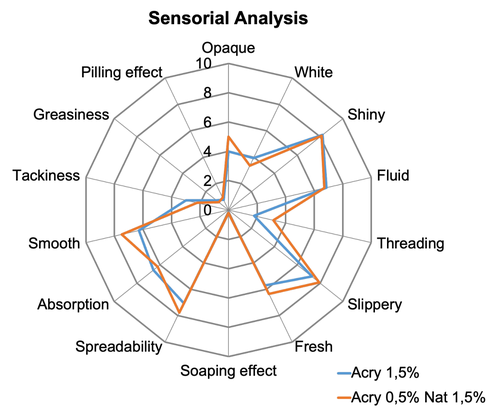


In gel formulae:

- Whatever the Acry batch used, 0.5% Acry did not generate measurable viscosity.
- **Combination 0.5% Acry and 1.5% Nat provides same viscosity than 1.5% Acry while providing a more natural overall composition**.
- The viscosity was almost tripled by combining 1.5% Nat and 1.5% Acry, in comparison to the contribution of individual thickeners alone.

In gel-cream formulae:

- Without electrolytes, same trend is observed in a lesser extent : impact of the oil phase on viscosity in an acrylate-based system does not allow to mimic the viscosity of 1.5% Acry with this ratio of thickeners.
- **With electrolytes,** whereas formula separated in two phases* with 1.5% Acry, **the addition of 1.5% Nat not only stabilized the formula but also tripled the viscosity obtained with 1.5% Nat alone.**



The gel formulated with a third of acrylate-based polymer, but at the same viscosity, was globally preferred for its sensorial attributes compared to the same gel formulated with acrylate only (based on sensorial analysis and spontaneous comments from 10 panelists out of 14 : « more: cushiony / comfortable / cocooning »).

The association allowed to combine the key attributes of both thickeners separately (freshness upon application/ quick break effect from acrylates, smoothness and comfort from association with polysaccharide-based polymers).

According to these results, depending on the formula (with or without oily phase) and the level of natural ingredient added to acrylate-based thickeners (for instance lecithin), **the NOI gain can reached up to 1%* without compromising neither viscosity nor sensoriality.**
*: This gain corresponds to reduction of Acry from 1.5% to 0.5%

CONCLUSIONS

The work presented above demonstrates a viscosity synergism between acrylate-based polymers and polysaccharides. It should promote a broad-spectrum application of this combination, enabling not only the reduction of acrylate polymer use within more natural formulae but also the reinforcement of stability in the presence of electrolytes in natural and/or conventional cosmetics. This valuable knowledge will enable brands to develop greener formulae as per the ISO16128 norm, while ensuring textures mimicking the sensorial profile and other key attributes of pure acrylate systems.

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