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Formulating alcohol-free fragrance formulas with similar olfactory performances as alcoholic-based ones

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1. Introduction

Ethanol is traditionally used in perfumery as a solvent due to its high volatility, low odour, compatibility with oils, and its antimicrobial properties. It allows fine misting and offers a strong blooming effect that enhances the top notes of a fragrance. However, societal shifts and regulatory constraints are now driving demand for alternatives.

Three key consumer trends are accelerating this transition:

- Clean beauty: consumers seek transparent, natural, and safer formulations perceived as eco- and skin friendly. Alcohol-free fragrances avoid skin dryness or irritation, fitting this movement.

- Skinification: Multifunctional products that combine skincare and sensoriality are in demand. Alcohol-free fragrances offer better skin comfort and may support hydration.

- Inclusivity: Non-alcoholic perfumes appeal to a wider audience, including those with sensitive skin, children, or those with religious restrictions against ethanol use.

In addition, Volatile Organic Compounds (VOC) regulations such as California's CARB legislation classify ethanol as a volatile compound, limiting its usage. Its flammability also complicates international transport and e-commerce logistics. In this context, alcohol-free perfumes are not just alternatives but emerging standards.

Over the past decade, the fragrance industry has witnessed a transformation driven by shifting consumer preferences and sustainability imperatives. Alcohol-free formulations, once a niche category, are now positioned as a strategic segment responding to broader trends including e-commerce compatibility, environmentally friendly formulations, and health-conscious life-styles.

Iconic launches like Dior's Bonne Étoile for babies or Hermès' alcohol-free body spray illustrate how leading brands now explore this territory to serve both functionality and market reach. Still, questions remain about consumer satisfaction: many associate alcohol-free scents with lower intensity, limited diffusion or altered olfactory character. These historical drawbacks are being challenged by new technologies, making it crucial to compare olfactory performance scientifically.

The objective of this study was to compare the olfactory performances of a new patented encapsulation technology for alcohol-free perfume formula applications versus the ones of a standard fragrance emulsion and of an alcohol-based version.

2. Materials and Methods

To evaluate the performance of a modern alcohol-free perfume, three formulas containing 14% of the same floral fragrance were assessed:
- An alcohol-based reference containing 68,8% of denatured alcohol,
- A Standard alcohol-free oil in water emulsion containing 7% of surfactants,
- A formulation based on a New Patented Encapsulation Technology containing 3% of surfactants (labelled as NPET formula on the figures).

This new encapsulation technology creates polydispersed droplets of fragrance oil stabilized within an aqueous phase through a transient membrane. This innovation reduces the surfactant level needed, improving fragrance mobility and diffusion.

To compare the performances of those three different fragrance formulas, sensory evaluations were conducted by 8 expert panelists, assessing:
- Fragrance intensity (as per VDI3882- part 1 standard odour intensity scale). This scale ranges from 0-imperceptible to 6- Extremely strong.
- Odour description using laboratory proprietary odour wheel.

Formulas application was done on blotters from one side and on panelists’ forearms on the other side.

Whatever the application support, evaluations took place at three timepoints: T0 (immediately after formulas spraying), T30min (30 minutes after formulas spraying) and T8h (8 hours after formulas spraying). Panelists answers have been collected using a sensory analysis online platform and digital tablets.
For application on blotters, one spray has been applied on each blotter, about 5 cm from the smelling strip. One blotter per panellist and per evaluation time point has been prepared. Blotters corresponding to T30min and T8h evaluation time points have been prepared upfront to regroup all sensory analyses on blotters under the same sensory evaluation session. Each blotter has been coded using a three-digit code to ensure blind evaluation of the formulas. Panelists took breaks between each measurement point to avoid olfactory fatigue.

For application on the forearm, volunteers have been asked not to apply any products on their arms the day of the test. After signing a consent form, they have been asked to wash their hands and forearms with neutral, unscented soap. Formulas spraying on forearms has then been performed in 5.5 cm circular marked zones. One forearm received two products and the other one only one product. The application areas have been randomized for each product and each panelist to avoid any bias related to this parameter. Again, each product has been associated with a 3-digit code. One spray of formula has been deposited in the center of the application area. After spraying, panelists performed 20 rotational movements with one finger (one different finger for each formula) in each application area to ensure even distribution of the formula withing the application area.
Between T30min and T8h evaluations, panelists put on an odour-free long sleeves T-shirt distributed by the laboratory. They were then allowed to go with their daily routine, taking care not to get their forearms wet or apply any products to them. They were also asked not to go to smoky areas. They then returned to the laboratory at the end of the day for the T8h assessment.

A Kruskal-Wallis statistical treatment was performed on the fragrance intensity results collected to conclude whether or not there is a significant difference between the samples (comparison of fragrance intensity over time for one dedicated formula or comparison of formulas at each time point). The Kruskal-Wallis test is a non-parametric test used to compare more than 2 samples. The significance level chosen for the test was $\alpha=0.05$, if a significant difference exists between the samples studied then the p-value is less than 0.05 ($p\text{-value} < 0.05$). A Dunn post hoc test has then been performed to understand which samples can be considered as statistically significantly different from the others. Samples with common letters cannot

be considered as being statistically different. Samples with no letters in common are statistically different.

3. Results

3.1 Evolution of fragrance intensity on skin over time

Figure 1 shows the average fragrance intensities for each sample and each time point, on skin. As a reminder, 8 trained panelists rated the intensity of each sample (on a scale of 0-6). The values presented are the arithmetic mean of the individual scores (n=8).

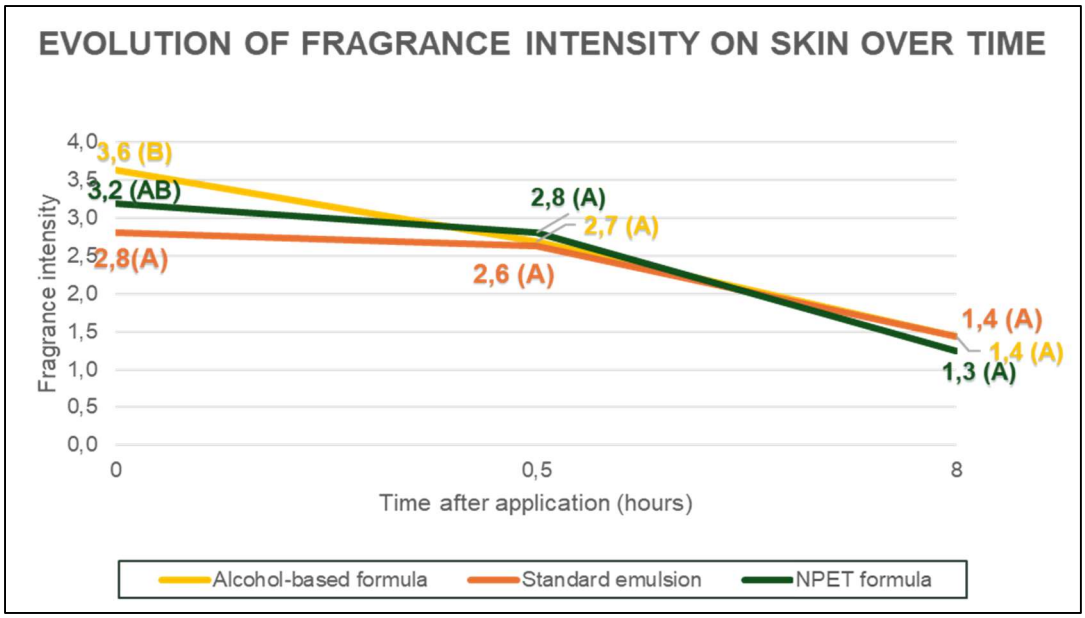

Figure 1. Evolution of fragrance intensity on skin over time. *Letters on the graph correspond to statistical comparison of formulas at a defined time point.*

Statistical analyses show that a significant decrease in fragrance intensity is observed, for each formula, only 8 hours after spraying (output of statistical analysis not displayed on the graph).

The comparison of the formulas at a defined time point shows no significant difference in fragrance intensity between the 3 formulas at both T30min and T8h. Immediately after spraying (T0), standard emulsion has a significantly lower fragrance intensity than alcoholic formula while no significant difference between new patented encapsulation-based formula and alcohol-based one is observed.

These results thus demonstrated that the new patented encapsulation-based formula obtained a fragrance intensity as intense as with alcohol- based one, all over evaluation time.

3.2 Descriptive Odour Profiling

An olfactory profile of the samples was carried out by the same panel of 8 subjects. To do this, the panellists described the odour of the samples according to the referents studied during training sessions. For each sample, the panellists listed the applicable odour descriptors and rated their intensity.

Note that the use of these referents to describe the odour indicates that the perceived odour is close to the known odour of these molecules, however this does not imply their presence in the sample.

The olfactory profiles obtained at T0 on both supports are presented in Figure 2. The values presented are the arithmetic mean of the individual scores for each olfactory descriptor (n=8).

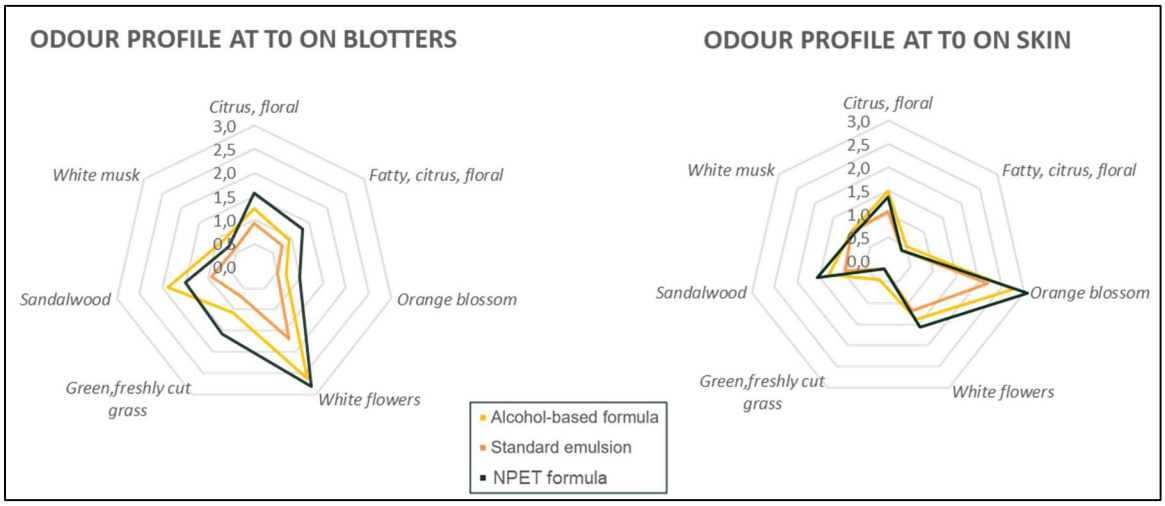

Figure 2. Comparison of odour profile of the 3 formulas at T0 (immediately after spraying). *(a) on blotters (left); (b) on skin (right)*

Odour profiling revealed that new patented encapsulated based (NPET) formula not only maintained fragrance longevity but also accurately preserved the olfactory identity. Overall, the expression of top note with the new patented encapsulated based formula is as intense as with alcoholic base and higher than with standard emulsion. On blotters, citrus, floral notes and green ones have a slightly higher intensity with new patented encapsulated based formula than with alcohol-based formula. On skin, floral notes are slightly more pronounced in the new

patented encapsulated version than in alcoholic based one. This indicates that new patented encapsulated based formula provides an initial lift as per alcoholic based traditional ones.

Standard emulsion seems to exhibit different behavior over time. Figure 3 shows the evolution of odour profile over time for the 3 formulas tested over time.

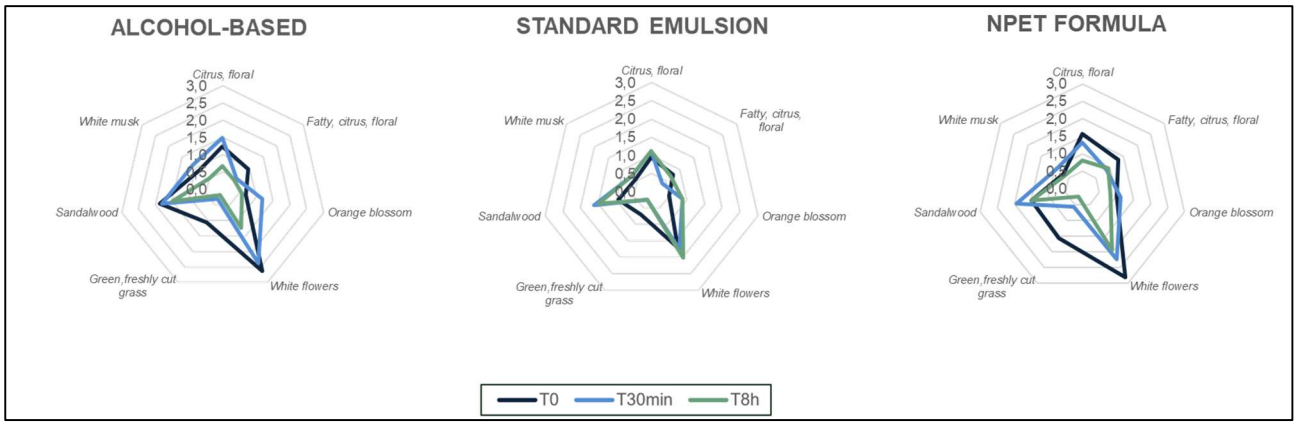

Figure 3. Evolution of odour profile over time for each formula, on blotters.

Those data show that the standard emulsion has a flatter evaporation curve with reduced dynamism and diminished contrast between top and base notes (Figure 3).

Odour profile characterization over time thus highlighted that the new patented encapsulated based (NPET) formula mimics the evaporation curve evolution typically associated with ethanol-based systems.

4. Discussion

Historically, alcohol-free fragrances have suffered from weak olfactory performance, limited diffusion, and unfavourable texture due to high surfactant content. These issues have hindered consumer adoption.

Those results indicate that the new patented encapsulated based formula tested delivered:

- A fragrance intensity comparable to the alcohol-based formula across all time points.
- Higher intensity at T0 compared to a standard emulsion.
- More pronounced citrus and green top notes than the ethanol based version on blotter and slightly enhanced floral character on skin ; as well as dynamic fragrance olfactory expression over time very close to alcohol-based formula.

The new patented encapsulated based formula thus addresses previously cited limitations related to olfactory performance by creating a more stable and mobile oil phase with minimal surfactant interference.

This approach also allows for expanded R&D innovation, encouraging exploration into encapsulation matrices, biodegradable surfactants, and performance-boosting additives compatible with aqueous systems.

Future research could investigate if similar results are obtained with fragrance oils with very different olfactory pyramids.

5. Conclusion

This study shows that with alcohol-free perfumes innovative technologies can rival traditional ethanol-based products. They can provide equivalent intensity and a very similar dynamic olfactory profile over time. Furthermore, they address clean beauty expectations, regulatory shifts, and logistical constraints.

As alcohol-free formats mature, they represent a strategic opportunity for fragrance brands to reach broaden consumers and sustainability needs without compromising performance. Their growing acceptance by consumers, combined with advancements in formulation, opens the door to new sensorial experiences and creative possibilities for perfumers.

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