



Measure of Fixative Effect When Evaluating Longevity of Fragrance

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Abstract

Fragrance performance is largely dependent on longevity when applied to skin. The ability for fragrance to retain its scent over long periods of time indicates high quality material. In modern perfumery, fixatives are applied to fragrance in order to extend longevity. This research was conducted in order to determine if fixatives display a visual difference when reducing evaporation rate within fragrance. The study was conducted using one control and two experimental groups; the two experimental groups having a different fixative and control having no fixative. All other variables such as other material were consistent across all three groups. Then a volume amount of each sample was added to a paper strip that was then added to a scale. The scale was checked periodically to check for changes in mass. Overall, the experiment yielded strong results, showing a large reduction in evaporation when fixative is used; thus proving that fixative use in modern perfumery is justified.

Introduction

Perfumery is the act of creating fragrance through a combination of aroma compounds, fixatives and solvents, and essential oils to create a pleasant scent typically in liquid form. This act dates back almost 4000 years with early roots in ancient Mesopotamia¹. Fragrance was seen as something sacred, only saved for the highest class elites, and as offerings to the gods¹⁷. They were seen as a status symbol that indicated class and a sense of being elite. As time went on, the act went from sacred rituals, and upperclass exclusives, to modern possessions that anybody can get their hands on. The quality of fragrance has also developed over time through advances in science and chemistry to create synthetic compounds to replace natural ones¹⁰.

Many regard the quality of a fragrance to be largely dependent on longevity⁹. The way a fragrance loses its longevity is by all the material evaporating away. A fragrance being able to last a long time reduces the need for re-application, as well as reduces hassle and seems more premium. In modern perfumery, chemical fixatives are used to solve this problem². A fixative is something that is set to preserve other materials. In the case of perfumery, it is used to hold the scent longer as well as create more cohesion throughout the materials², as well as extend the time required for the fragrance to evaporate away¹⁰. The use of fixatives can create a solid foundation that the other ingredients can build off of.

Many chemical fixatives utilize natural and synthetic compounds that boast a high molecular weight and low vapor pressure. The high molecular weight causes these compounds

to have much stronger intermolecular forces due to larger electron clouds. The larger electron clouds can promote temporary dipole moments for these compounds, strengthening their intermolecular forces. Additionally, these heavier compounds have a lower molecular speed. This lower molecular speed causes less molecules to escape the liquid state to evaporate into the air. These characteristics are what help fixatives stay on skin and keep fragrance grounded.

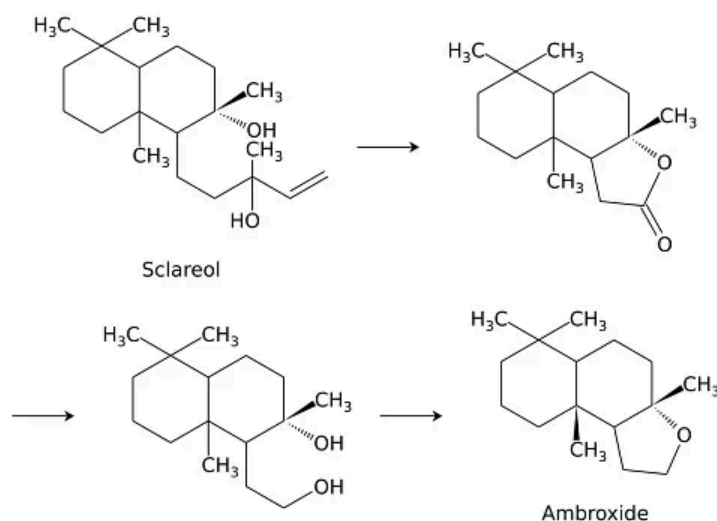


Figure 1. Molecular Structure of Ambroxan¹²

Ambroxan is a semi-synthetic fixative made to imitate sclareol, a natural diterpene found in clary sage⁵. The official name for ambroxan is ambroxide and has chemical formula $C_{16}H_{28}O$. Due to this small natural derivation, the molecule is semi synthetic. The material was first discovered in 1950 by chemists at Firmenich. The purpose behind this discovery was to imitate the ambergris-like compound that was present within scalereol⁴. The chemists sought to create a sustainable, cost effective alternative to real ambergris-a rare substance derived in sperm whales. Ambergris was famous as being a luxury fixative that enhanced longevity as well as created a salty-sweet, earthy base. Ambroxan's power as a base note comes from its extremely low vapor pressure: <0.004 mmHg which causes it to last extremely long on skin, as well as greatly slow down evaporation. Another way that it can hold fragrance extremely well is due to its lipophilic (fat loving) structure. This allows it to exert a Van der Waals force with the lighter more volatile notes and physically hold them down onto the skin¹⁸. A low dose of ambroxan can vastly improve the longevity of a fragrance, without creating much of a trace scent on its own⁸.

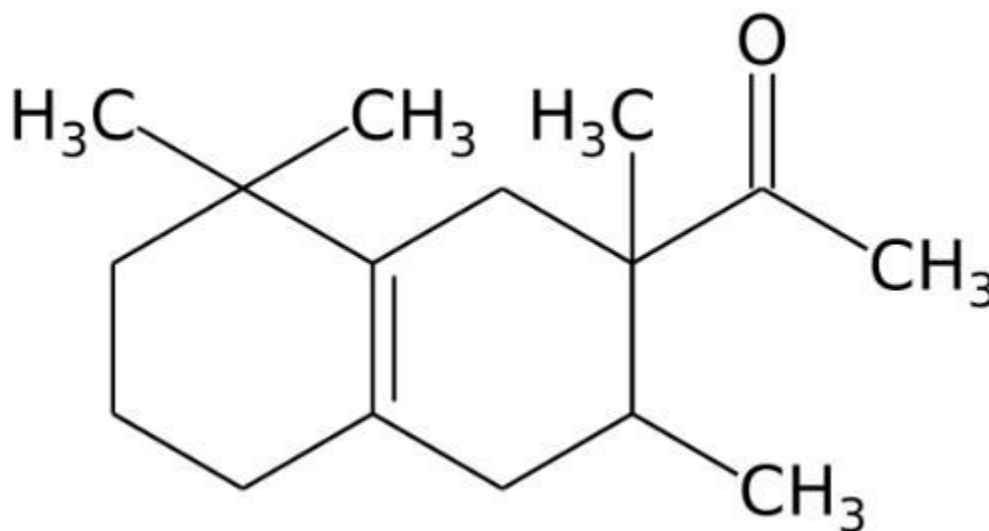


Figure 2. Molecular Structure of Iso E Super²¹

Iso E Super is fully synthetic without any natural origin. It was first synthesized in 1973 in the IFF by John Hall and James Sanders. Iso e Super isn't just one molecule but rather a group of molecules⁶. The main scent profile is characterized by a woody amber subtlety¹¹. However that main scent profile is driven by a minor isomer rather than the major one. Therefore, the scent created by iso e super is driven by a trace constituent rather than the bulk material. Iso E Super also works to slow down the evaporation of fragrance by anchoring the lighter more volatile notes from fading away by similar means of ambroxan. The heavy molecular weight, as well as the van der waals force contributes to this. Additionally due to a liquid pH of around 5.7²⁰ it also has those same forces with skin, allowing it to bind more effectively. Iso E Super also has unique molecular geometry in the way it creates almost a web that all the lighter more volatile molecules get trapped within. Those lighter molecules get trapped within this matrix and evaporate more gradually¹⁹. It also creates a radiant effect that helps the fragrance project smoothly into the air. Iso E super is also regarded as the “msg of perfumery” due to the way it can enhance and blend all the notes together without dominating the scent profile; it should be noted that Iso E Super is used in a vast amount of commercial perfume today⁶. It is greatly preferred by many perfumers and believed to be such an eminent cultural aspect within the genre¹¹.

Fixative Use Background

Fixative inclusion has been promoted to increase the longevity and performance of fragrance. The aim today is to discover if the inclusion of fixative in fragrance, specifically Ambroxan and Iso E Super, should greatly decrease mass loss over time.

Fixatives within fragrance has been a practice that has spanned decades. The process involves including material meant to hold down other material. They work by extending the time that the fragrance materials have on skin through means of decreasing vapor pressure in turn, decreasing evaporation. Vapor pressure is the tendency of a substance to enter the vapor state (gaseous) either by sublimation (solid to gas) or evaporation (liquid to gas)¹³. For the specificities of fragrance, the vapor pressure is usually caused by the act of evaporation rather than sublimation.

The benefits of including fixatives have been shown through experiments. They demonstrate a longer lasting time through mass loss studies⁸. The formulas with fixatives usually have a greater mass through certain intervals of time compared to those without. The thermal stability of fragrances is also benefited through the inclusion of fixative. Samples that include fixative demonstrate a much larger thermal stability when compared to those that don't¹⁴. This results in its ability to stay on skin longer, even with rising or dropping temperatures; this benefits fragrance application especially due to high body temperatures of the human body.

Fixative inclusion in fragrance may potentially increase skin compatibility as well. Through a pH test done by scientists at the School of Pharmacy, KPJ Healthcare University⁸ they concluded that the formula that included fixative demonstrated a lower pH than the sample without fixative: 7.1-7.4 respectively. This lower pH results in better skin compatibility since the ideal pH for skin application falls within the range of 5-7¹⁶. This lower pH limits dryness in the skin, as well as allows for a healthier skin barrier overall¹⁶.

Overall, the inclusion of fixative has demonstrated multivious benefits when included in fragrance. The positives don't only extend to longevity, but also the health of the appliers' skin. This results in many fragrances containing fixatives today².

Methods

Experiments were designed in an attempt to visibly see the effect of fixatives on fragrance. The two fixatives of choice were Iso E Super and Ambroxan. The study was aimed to focus on mass loss on paper strips of fragrance. Slower mass loss results in better longevity and the opposite is also true.

Three fragrance samples were made, each being 2.55 ml. One with ambroxan, one with iso e super, and one control sample without fixative. The exact ingredients were bergamot oil, sandalore (a synthetic form of sandalwood), and hedione. These three being synthetic fragrance

oils created to imitate something natural¹⁰. 200 proof perfumers alcohol is also used, alongside fixatives of choice or control. Alcohol is chosen instead of water due to its ability to thin oils and act as a solvent for the mixture¹⁰. The results were three almost identical fragrances, with the difference being which fixative was present. The fragrances were made in accordance with table 1.

With a scale ready, fragrance was extracted from the samples using an extreme precision pipette at exactly 200 microliters or 0.2 ml. This provided an adequate amount of fragrance that could show visible evaporation. Then the fragrance was injected into labeled cardstock which indicated which fragrance was going on which. The cardstock pieces were 1x3 inches, which had enough room to hold all the fragrance without dripping off. The paper was also weighed beforehand so that the actual amount of fragrance leaving could be recorded.

Weight in grams was initially measured the moment 0.2 ml of fragrance was applied to the paper for each sample. Weighing times include 1hr, 3hr, 8hr, and 24 hrs. While recording the weight during these intervals subtract off the paper mass to find the true amount of fragrance on the scale.

Table 1: Formula of Fragrances

Component	Role	Control	Iso E Super	Ambroxan
Alcohol	Solvent	1.95 mL	1.35 mL	1.35 mL
Bergamot	Top Note	0.30 mL	0.30 mL	0.30 mL
Hedione	Heart Note	0.15 mL	0.15 mL	0.15 mL
Sandalore	Base Note	0.15 mL	0.15 mL	0.15 mL
Iso E Super	Fixative (test variable)	0 mL	0.60 mL	0 mL
Ambroxan	Fixative (test variable)	0 mL	0 mL	0.60 mL
Total		2.55 mL	2.55 mL	2.55 mL

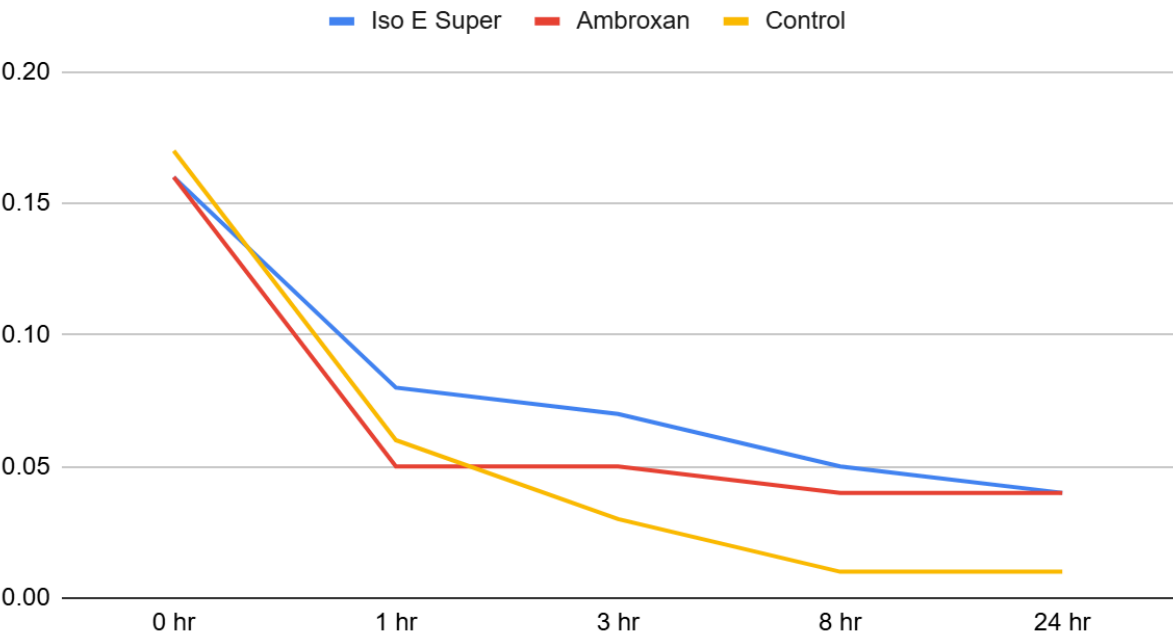
Results

Evaporation Rate

Evaporation is the main indicator that a fragrance scent is disappearing from the skin. Slowing down the rate of evaporation would result in a fragrance that lasts longer, since the physical molecules that produce the scent remain on skin for an extended period of time. In accordance with the graph, the trial that consisted of fixative demonstrated reduced evaporation rate overall. The final mass of the control sample was significantly lower compared to the fixative samples. This demonstrates the effect of fixatives on fragrance when it comes to reducing evaporation. Ambroxan and Iso E super demonstrated the exact same initial and final masses which could indicate their similar properties when it comes to being in a fragrance. The rate of evaporation of the ambroxan group seemed more linear and steady over time whereas the Iso E Super sample demonstrated more of an exponential decrease. The large dip in the first hour is the overall evaporation of the perfumers alcohol. The alcohol diffuses into the air relatively quickly regardless of fixative or no fixative. The real effect of fixative is visualized once the alcohol mostly evaporates. The fixative mainly works by holding down the main ingredients of the fragrance which is clearly demonstrated in the graph. The control sample with no fixative visually shows a larger decline compared to the experimental groups.

Graph 1. Rate of Evaporation of the 3 Samples

Rate of evaporation of different fixative compounds in grams



Cost Analysis

In reference to table 2 the ambroxan sample is ~46% more expensive per 2.55 ml sample compared to the control, and the iso e super sample is 28% more expensive than the control. However, according to the data, the control sample kept around 5.8% of its original mass whereas both experimental groups maintained around 25% of their original mass. This results in almost a 330% increase in mass retention which greatly justifies the slight increase in cost.

Table 2: Cost Breakdown of the Formulas

Component	Role	Control	Iso E Super	Ambroxan
Alcohol	Solvent	\$0.06	\$0.04	\$0.04

Bergamont	Top Note	\$0.12	\$0.12	\$0.12
Hedione	Heart Note	\$0.23	\$0.23	\$0.23
Sandalore	Base Note	\$0.23	\$0.23	\$0.23
Iso E Super	Fixative	x	\$0.20	x
Ambroxan	Fixative	x	x	\$0.32
Total		\$0.64	\$0.82	\$0.94

Discussion

The use of fixatives in modern perfumery are included in order to extend the longevity and increase the performance in fragrance. The main result demonstrates the effectiveness of ambroxan and Iso E Super when reducing evaporation rate. The amount of fragrance that remained on the paper proves so. Including fixatives of choice within the formulation was a key factor in retaining that mass. Visually on the scale, the formulas with fixatives had higher numbers proving the fixative locking down the material. Also, increasing the volume of fragrance added to the strip allowed for more obvious mass changes. The ambroxan and iso e super inclusions worked effectively by grounding the fragrance to the paper strip and extending its longevity. Ambroxan's high molecular weight at 236.4 g/mol allows it to have very tight intermolecular forces that keep it in liquid form. Ambroxan on its own barely evaporates at all. Iso E Super worked in a similar manner, also boasting a high molecular weight that held down fragrance. It additionally involves its unique structure that allows it to grab onto lighter more volatile molecules in order to keep them from evaporating.

The cost results demonstrate that, despite the higher cost, the effects of including fixative within fragrance is greatly justified. Overall the ambroxan and Iso E Super formulas do contain a slight increase in cost, 46% and 28% respectively, incorporating fixative into perfume formulation increases the cost modestly but remains an economically sound choice overall. Many popular fragrances that are at a premium price utilize ambroxan. Some examples include Blue de Chanel, Baccarat Rouge 540, and Louis Vuitton Imagination. When paying high prices, premium quality is expected, which ties into the fact that ambroxan is a large part of what makes those fragrances good.

Key things to note are the lack of precision due to limitations in running the experiment. The inability to attain a lab grade scale greatly reduced precision in the experiment. Before the real experiment was completed, a pilot study was conducted to see if the scale in possession could track real mass loss. The original test involved 100 microliters, but was increased to 200

microliters in order to visualize a greater loss in mass. The pilot study showcased what was needed to run the experiment effectively. The measurements could only be recorded to centigrams rather than milligrams. Being able to record in milligrams may have been able to provide more key insight on smaller differences in mass. It could potentially provide an outcome where one fixative caused more mass retention than the other due to higher precision.

Additionally, this data runs in accordance to other experiments done in the past, all proving the effectiveness of fixative within fragrance. The inclusion of fixatives results in extended longevity^{8,15}. This experiment is just another which co aligns with the already believed fact that fixatives provide large benefits toward fragrance when included in the formula. Currently synthetic fixatives are included in 55.6% of fragrances. Additionally, the old natural fixatives that were commonly used are undergoing chemical re-engineering to further enhance their effectiveness. In around 10 years time the fixative market will increase by almost 1.4 billion dollars, indicating the widespread usage of the material. Overall, chemical fixatives will be a major part of the fragrance market due to how well they work, as well as how cheap and sustainable they are to create²².

Chemical fixatives are already dominating the fragrance market. With the information known, it allows for potential buyers to pick the right fragrances that include these chemical fixatives in order to ensure they are buying quality products. With knowing about fixatives, the buyer would avoid buying fragrance that disappears immediately which could result in better financial decisions overall. This information also may apply outside the realm of perfumery. In the case of soap and candle making at home, the inclusion of fixatives would support a similar effect in increasing the longevity of that scent. Chemical fixatives have established themselves in the market of fragrance, perfumer or not, and that trend will only move forward as advances in technology and science evolve over time.

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