A Fixative Slows a Scent, but by a Factor That Is Not the Initial Rate Ratio and Grows as the Scent Fades

— Dissolving a volatile component at mole fraction **0.1** in a non-volatile fixative makes its initial evaporation rate **0.100000** of the pure substance, ten times slower in proportion to the dilution — because the more of the component evaporates, the lower its own mole fraction and the slower it goes — [Paper 594]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
September 2026

— *From thinking to syncing.* —

Abstract

A fixative in a perfume makes the scent last. It is easily taken that diluting the volatile component slows it in proportion to the dilution.What this paper shows is that even with Raoult's law for an ideal solution alone, the slowing factor does not stop at the initial rate ratio (the inverse of the mole fraction) but grows as the volatile component evaporates and becomes more dilute.No new theorem or law is claimed. First, the evaporation rate is proportional to mole fraction times vapour pressure——a volatile component dissolved at mole fraction 0.1 in a non-volatile fixative starts evaporating at 0.100000 of the pure rate (Section 2). **Second, and this is the core.The slowing factor grows with the fraction evaporated——at mole fraction 0.1, half takes 13.476649 times as long as for the pure substance, nine-tenths 24.025851 times and 99 per cent 42.865184 times, all beyond the initial factor of 10** (Section 2). **Third, the closed form agrees with the equation of motion——the time factor to evaporate a fraction f is $1 + (F/N_0)\ln(1/(1-f))/f$, agreeing with the numerically solved equation to a relative 1.3×10^{-11}** (Section 3). **Fourth, the form is the same for weaker dilution——at mole fraction 0.5, nine-tenths takes 3.558428 times as long, and at 0.2, 11.233712 times, both beyond the initial rate ratios of 2 and 5** (Section 2). **Fifth, a fixative also smooths the succession of notes——mixing equal moles of two components whose vapour pressures differ by 10^4, the heavy component speeds up 2.000000-fold once the light one has gone, but only 1.111111-fold with eight times as much fixative as each component** (Section 4). **Sixth, the separator is whether one looks at the initial rate or at the time to fade——the rate ratio is set by the mole fraction, the time ratio by the fraction evaporated** (Section 5).
Keywords: fixative, Raoult's law, vapour pressure, evaporation, perfume.

Scope of this paper (scope note): **No new theorem or law is claimed——Raoult's law, the proportionality of the evaporation rate to the vapour pressure, and the time obtained by integrating it are all standard.Only ideal solutions are treated——a real fixative holds back the volatile component through intermolecular attraction (activity coefficients), acting more or less strongly than here; this paper sets the activity coefficient to 1.The evaporation rate coefficient is taken to be constant——gas-phase diffusion, wind and temperature changes are not included.The fixative is taken not to evaporate.The perception of scent is not treated——odour thresholds and olfactory adaptation are not the subject.No perfume is designed, and no substance is named.Relation to earlier papers**: **Paper 333 showed that the constancy of the ratio of osmotic pressure to freezing-point depression follows from an assumption, not from a measurement, and stated in its scope note that it does not set boiling-point elevation and vapour-pressure lowering side by side——this paper takes that seat and looks at how vapour-pressure lowering (Raoult's law) slows the evaporation of the volatile component itself.Paper 392 showed that the boiling point is a property not of the substance alone but of the substance and the pressure together——here too, how fast the same substance evaporates depends on what surrounds it, and how much.Paper 300 showed that sharing a root is decidable——the initial rate ratio and the time ratio come from the same differential equation and share a root; they differ in the moment one looks at.**What is added is **setting out the time factors for three mole fractions and three evaporated fractions**, **checking the closed form against the equation of motion**, **comparing the succession of two components with and without fixative**, and **placing the separator on rate versus time**.

1. Notation and the Question

Setting: **let N moles of a volatile component be dissolved in F moles of a non-volatile fixative.In an ideal solution the component's vapour pressure falls in proportion to its mole fraction $x = N/(N+F)$ (Raoult's law), so with rate coefficient k and pure vapour pressure p**

$$\frac{dN}{dt} = -kp\,\frac{N}{N+F}.$$

The time for a fraction f of the initial N_0 to evaporate is $fN_0/(kp)$ for the pure substance and, in the fixative,

$$t = \frac{fN_0 + F\ln\bigl(1/(1-f)\bigr)}{kp}, \qquad \frac{t}{t_{\text{pure}}} = 1 + \frac{F}{N_0}\cdot\frac{\ln\bigl(1/(1-f)\bigr)}{f}.$$

> **Observation 1.1**
>
> **it is easily taken that diluting the volatile component slows it in proportion to the dilution.Dilute it to mole fraction 0.1 and the evaporation rate falls to a tenth, so the scent lasts ten times as long——whether that holds for the time the scent takes to fade is another question.**

Question: by what factor does a fixative lengthen the time a scent takes to fade?

2. One Volatile Component

Computation 2.1: initial mole fraction and the time factor (pure substance = 1) for each evaporated fraction.

initial mole fraction	initial rate	half	nine-tenths	99 per cent
0.5	0.500000	2.386294	**3.558428**	5.651687
0.2	0.200000	6.545177	**11.233712**	19.606748
0.1	**0.100000**	**13.476649**	**24.025851**	**42.865184**

> **Observation 2.2**
>
> this is the core.At mole fraction 0.1 the initial rate is a tenth, but half takes 13.476649 times as long, nine-tenths 24.025851 times and 99 per cent 42.865184 times——the more of the component evaporates, the lower the mole fraction of what remains, and the slower it goes. A pure substance evaporates at the same rate to the end; a diluted component evaporates less readily the fainter it becomes. The scent weakens but lingers.

> **Observation 2.3**
>
> the form is the same for weaker dilution.At mole fraction 0.5 the initial rate ratio is 2, but nine-tenths takes 3.558428 times as long; at 0.2, ratio 5 against 11.233712——the time factor is the initial rate ratio weighted by $\ln(1/(1-f))/f$, and as f approaches 1 this weight has no bound.

3. Checking with the Equation of Motion

Computation 3.1: as a route separate from the closed form, $dN/dt = -N/(N+F)$ ($kp = 1$, $N_0 = 1$, $F = 9$) was solved by Runge--Kutta and the time at which N falls to $1-f$ was read.The times are 6.738325 for half, 21.623266 for nine-tenths and 42.436532 for 99 per cent, agreeing with the closed form to a relative 1.3×10^{-11} or better.

> **Observation 3.2**
>
> **“slower in proportion to the dilution” is right only for the first instant.The rate ratio concerns the first instant; the time ratio integrates all the dilution that follows——the same differential equation answers 10 or 24 depending on the moment one looks at.**

4. Two Components

Computation 4.1: **equal moles of a light and a heavy component whose vapour pressures differ by 10^4 were mixed.Once the light component has evaporated, the heavy component’s mole fraction rises, without fixative, from 0.500000 to 1.000000, and its evaporation rate grows 2.000000-fold.With eight times as much fixative as each component, it rises only from 0.100000 to 0.111111, and the rate grows only 1.111111-fold.**

> **Observation 4.2**
>
> **a fixative also smooths the succession of notes.Without fixative, the heavy note strengthens as soon as the light note has gone——with plenty of fixative, every component’s mole fraction is set by the fixative, and the loss of one component barely changes the others.**

5. The Separator

> **Observation 5.1**
>
> **the separator is whether one looks at the initial rate or at the time to fade.The initial rate ratio is set by the mole fraction alone; the time ratio is set by the evaporated fraction f and grows as f approaches 1——“how many times longer does a fixative make a scent last” has no single answer until one says how far faded counts as gone.**

> **Observation 5.2**
>
> **taking the seat left by Paper 333.It showed that the constancy of the ratio of osmotic pressure to freezing-point depression follows from an assumption, and set aside vapour-pressure lowering in its scope note——this paper applies that vapour-pressure lowering to the evaporation of the volatile component itself.**

Observation 5.3

beside Paper 392.It showed that the boiling point belongs to the substance and the pressure together—— here too, the evaporation rate is set not by the substance alone but by its proportion to the fixative around it.

Observation 5.4

one root, under Paper 300.The initial rate ratio and the time ratio come from the same differential equation ——they differ only in the moment one looks at.

Observation 5.5

what is not said.Only ideal solutions are treated; real fixatives act differently through intermolecular attraction, and the perception of scent is not treated. No perfume is designed——what is shown is the form that follows from Raoult's law alone: a diluted volatile component evaporates less readily the fainter it becomes.

6. Roll Call and Closing

1. **at mole fraction 0.1 the initial rate is 0.100000** (Computation 2.1): **slower in proportion to the dilution.**
2. **half takes 13.476649 times as long** (Computation 2.1): **already beyond 10.**
3. **nine-tenths takes 24.025851 times** (Observation 2.2): **the core.**
4. **99 per cent takes 42.865184 times** (Computation 2.1): **fainter means slower.**
5. **3.558428 at 0.5 and 11.233712 at 0.2** (Observation 2.3): **the same form.**
6. **equation of motion and closed form agree to 1.3×10^{-11}** (Computation 3.1): **two routes.**
7. **without fixative the heavy note strengthens 2.000000-fold** (Computation 4.1): **after the light note has gone.**
8. **with fixative, only 1.111111-fold** (Computation 4.1): **the succession is smoothed.**
9. **taking the seat left by Paper 333** (Observation 5.2): **vapour-pressure lowering.**
10. **the separator is initial rate or time to fade** (Observation 5.1): **one equation answers 10 or 24.**

Closing: **A fixative in a perfume makes the scent last, and it is easily taken that diluting the volatile component slows it in proportion to the dilution.That is right only for the first instant——dissolved at mole fraction 0.1 in a non-volatile fixative, the component starts evaporating at 0.100000 of the pure rate, ten times slower. But the more of it**

evaporates, the lower its own mole fraction and the slower it goes, so half takes 13.476649 times as long, nine-tenths 24.025851 times and 99 per cent 42.865184 times. At mole fractions of 0.5 and 0.2, nine-tenths takes 3.558428 and 11.233712 times, again beyond the initial rate ratios. The closed form agreed with the equation of motion to a relative 1.3×10^{-11}.A fixative also smooths the succession of notes——with equal moles of two components whose vapour pressures differ by 10^{4}, the heavy note strengthens 2.000000-fold once the light one has gone, but only 1.111111-fold with fixative.The separator is whether one looks at the initial rate or at the time to fade——the same differential equation answers 10 or 24 depending on the moment; under Paper 300 the two share a root.Placed among the earlier papers——this takes the seat for vapour-pressure lowering that Paper 333 left in its scope note; as in Paper 392, the evaporation rate is not set by the substance alone.To be honest——only ideal solutions (activity coefficient 1) are treated, with a constant rate coefficient and a non-volatile fixative. Real fixatives act differently through intermolecular attraction, and the perception of scent is not treated. No perfume is designed and no substance is named.

References

1. Atkins, P., & de Paula, J. (2010). *Physical Chemistry* (9th ed.). Oxford University Press.
2. Prausnitz, J. M., Lichtenthaler, R. N., & de Azevedo, E. G. (1999). *Molecular Thermodynamics of Fluid-Phase Equilibria* (3rd ed.). Prentice Hall.
3. Sell, C. S. (2006). *The Chemistry of Fragrances: From Perfumer to Consumer* (2nd ed.). Royal Society of Chemistry.
4. Yamagishi, Y. (2026). *The Three Hundredth Census: Whether Two Things Share a Root Is Decidable* [Paper 300]. Zenodo. 10.5281/zenodo.22171914
5. Yamagishi, Y. (2026). *That the Ratio of Osmotic Pressure to Freezing-Point Depression Is Constant Follows from an Assumption, Not from a Measurement* [Paper 333]. Zenodo. 10.5281/zenodo.22681740
6. Yamagishi, Y. (2026). *The Boiling Point Is Not a Property of the Substance, but of the Substance and the Pressure Together* [Paper 392]. Zenodo. 10.5281/zenodo.22699237

Yuuki YAMAGISHI (山岸 勇輝)

© 2026 Yamagishi Complexity Torus Lab, Japan · Licensed under Creative Commons Attribution 4.0 International (CC BY 4.0)