

Mixing the Unmixable Multiplies the Boundary by a Thousand

— Dividing 1 mL of oil from 1 mm drops into 1 μm drops takes the interface from 0.0030 to **3.0000** m^2 — a surfactant cuts the energy to **1/6** but not to zero — nothing mixed; separation merely became slow — [Paper 444]

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— *From thinking to syncing.* —

Abstract

Shake oil and water hard enough and they look mixed. This paper shows that they have not mixed—the finer the division the more boundary there is and the higher the energy. Separation has merely become slow. No new theorem or law is claimed. First, this is the core of the paper. Dividing 1 mL from 1 mm drops into 1 μm drops takes the interfacial area from 0.0030 to **3.0000** m^2 , a factor of **1000** (Section 2). Second, the area goes inversely with the radius as $3V/r$, and inversion confirms it (Section 2). Third, the number of drops is then 2.387×10^{11} (Section 2). Fourth, the interfacial energy is 0.090000 J and rises with finer division. It does not fall (Section 3). Fifth, a surfactant cuts it to **1/6**, or **0.015000** J, but not to zero (Section 3). Sixth, the separator is whether the energy fell or the time lengthened (Section 4). **Keywords:** emulsification, interfacial tension, surfactant, emulsion, interfacial area.

Scope of this paper (scope note): No new theorem or law is claimed—interfacial tension, emulsification and the action of surfactants are all standard. Thermodynamics is not derived—no rigorous free-energy treatment is given; only the interfacial term is put into numbers. The entropy of mixing is not treated—the contribution from the motion of the droplets is small against the interfacial term for large drops, but it is not quantified here. The routes of breakdown are not treated—coalescence, Ostwald ripening and creaming are separate mechanisms and are not the subject. The tensions are not asserted—0.03 N/m and 0.005 N/m are representative and move with the system. Micelles are not discussed—association of surfactants and the critical micelle concentration are not the subject. Relation to earlier papers: Paper 443 showed that taking water away beats turning the heat up—there too the axis to move was not the one assumed. Paper 300 showed that common root and distinct root can be decided—“stable” and “slow” are distinct roots by that criterion. Paper 430 showed that widening the contact does not change the friction—there area did not act; here area is the whole story. Paper 433 showed that an effect continues after the cause is gone—there too a long time constant made something look finished. What is added is giving the interfacial area at four radii, confirming by inversion that it equals $3V/r$, giving the number of drops as 2.387×10^{11} , setting the energy with and without a surfactant side by side, showing that it does not reach zero, and placing the separator at “energy or time”.

1. Notation and the Question

Setting: Divide a volume V into equal spheres of radius r ; the count and total area follow.

$$n = \frac{V}{\frac{4}{3}\pi r^3}, \quad A = n \cdot 4\pi r^2 = \frac{3V}{r}$$

The interfacial energy is $E = \gamma A$ for an interfacial tension γ . Below, $V = 1$ mL with $\gamma = 0.03$ N/m (no surfactant) and 0.005 N/m (with).

Observation 1.1

Shake oil and water hard enough and they look mixed. It goes white and the boundary disappears—one wants to say they mixed.

Observation 1.2

But leave it and it separates. In minutes, or in days—given time it returns.

Question: What happens when it is shaken.

2. The Boundary Multiplies by a Thousand

Computation 2.1: Take the count and total area for 1 mL divided at four sizes.

Radius [μm]	Count	Total area [m^2]
1000	2.387×10^2	0.0030
100	2.387×10^5	0.0300
10	2.387×10^8	0.3000
1	2.387×10^{11}	3.0000

Observation 2.2

Divide the radius by a thousand and the area multiplies by exactly **1000**. From 0.0030 to 3.0000 m^2 —since $A = 3V/r$, it is an inverse relation.

Observation 2.3

Three square metres out of one millilitre. The area of a small room’s floor—that much boundary made inside a teaspoon of oil.

Observation 2.4

The number of drops is 2.387×10^{11} . Two hundred billion—the count goes as the inverse cube, so it rises far faster than the area.

Observation 2.5

The volume has not changed. Still 1 mL—what increased is the boundary alone.

3. The Energy Rises Rather Than Falls

Computation 3.1: Take the interfacial energy at 1 μm , with and without a surfactant.

Interfacial tension [N/m]	Energy [J]
0.030 (without)	0.090000
0.005 (with)	0.015000

Observation 3.2

Both are positive. The finer the division, the higher the energy—so left alone it moves downhill, which means towards separating.

Observation 3.3

A surfactant cuts the energy to 1/6. From 0.090000 to 0.015000 J—exactly the ratio of tensions, 0.03/0.005.

Observation 3.4

But not to zero. 0.015000 J—so long as there is a boundary, the energy is positive.

Observation 3.5

At exactly zero tension the energy is exactly 0. The other side of the boundary—and there the two liquids really do mix. That, however, is a different phenomenon.

Observation 3.6

So emulsifying makes the slope gentler. It neither levels the slope nor reverses it—only the rate of rolling changes.

4. The Separator

The separator: did the energy fall, or did the time lengthen.

Observation 4.1

Real mixing lowers the energy. As salt dissolving in water—it does not separate however long one waits.

Observation 4.2

Emulsifying raises it. Shaking puts work in—and what was put in is stored in the interface, to be returned eventually.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “stable”—one thermodynamically, one kinetically.

Observation 4.4

And the way to tell them apart is to wait. Given time it separates—“it has not separated yet” is not “it will not separate”.

Observation 4.5

The same shape as Paper 433. There a time constant longer than a human life made something look finished—here a separation time longer than the shelf life makes something look mixed.

Observation 4.6

To be honest—only the interfacial term has been put into numbers. The motion of the droplets also contributes an entropy term—small against the interfacial term for large drops, but not quantified here.

Observation 4.7

One last thing—there is more than one way to break down. Coalescence, Ostwald ripening, creaming—which is fastest is not treated; only that every route runs downhill.

5. Roll Call and Closing

1. 0.0030 m^2 at a radius of 1 mm (Computation 2.1): the starting point.
2. 3.0000 m^2 at $1 \text{ }\mu\text{m}$ (Computation 2.1): a factor of 1000.
3. The area is $3V/r$ (Observation 2.2): inverse.
4. 2.387×10^{11} drops (Computation 2.1): two hundred billion.
5. The volume stays 1 mL (Observation 2.5): only the boundary grew.
6. The energy is 0.090000 J (Computation 3.1): positive, and rising.
7. A surfactant gives 0.015000 J (Computation 3.1): one sixth.
8. Still not zero (Observation 3.4): so long as a boundary exists.
9. Zero tension gives 0 (Observation 3.5): the other side of the boundary.
10. The separator is energy or time (Observation 4.3): distinct roots by Paper 300.

Closing: Shake oil and water hard enough and they look mixed—it goes white and the boundary disappears—but leave it and it separates in minutes or in days. What shaking does is multiply the boundary—dividing 1 mL from 1 mm drops into $1 \text{ }\mu\text{m}$ drops takes the interfacial area from 0.0030 to 3.0000 m^2 , exactly a factor of 1000, since $A = 3V/r$. Three square metres of boundary made inside a teaspoon of oil, across 2.387×10^{11} drops—two hundred billion. The volume is still 1 mL; what increased is the boundary alone. And the energy rises rather than falls—at $1 \text{ }\mu\text{m}$ the interfacial energy is 0.090000 J and grows with finer division, so left alone the system moves downhill, which means towards separating. A surfactant cuts it to $1/6$, or 0.015000 J —exactly the ratio of tensions—but not to zero, since so long as there is a boundary the energy is positive. At exactly zero tension the energy is exactly 0 and the two liquids really do mix, but that is a different phenomenon. So emulsifying neither levels the slope nor reverses it; it makes the slope gentler, and only the rate of rolling changes. One thing separates them—did the energy fall, or did the time lengthen. Real mixing lowers the energy, as salt dissolving in water, and does not separate however long one waits. Emulsifying raises it, storing the work of shaking in the interface to be returned eventually. They are distinct roots by the criterion of Paper 300, one thermodynamic and one kinetic. And the way to tell them apart is to wait: “it has not separated yet” is not “it will not separate”. The same shape as Paper 433, where a time constant longer than a human life made something look finished; here a separation time longer than the shelf life makes something look mixed. To be honest—only the interfacial term has been put into numbers. The

motion of the droplets also contributes an entropy term, small against the interfacial term for large drops but not quantified here. One last thing—there is more than one way to break down—coalescence, Ostwald ripening, creaming. Which is fastest is not treated; only that every route runs downhill.

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