“Colloid” Is Not the Name of a Substance but of a Window in Size

— the height to which thermal motion holds a particle against gravity, the sedimentation length, is **0.5254878** m for silica of **10** nm in water and a thousand times less for each tenfold diameter — the separator is whether the sedimentation length exceeds the height of the vessel — [Paper 673]

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— *From thinking to syncing.* —

Abstract

“Colloid” is used as though it named a kind of substance. But the same substance settles when it is large and stays suspended when it is small.What sets that boundary is counted, as a ratio of thermal motion to gravity.No new theorem or law is claimed. First, and this is the core. What sets the boundary is not the substance but the diameter ——for silica in water the sedimentation length is 0.5254878 m at 10 nm, 5.254878×10^{-4} m at 100 nm and 5.254878×10^{-7} m at 1000 nm (Section 2). **Second, ten times the diameter is exactly a thousand times less——gravity acts through the volume and so as the cube of the diameter, while the thermal side does not depend on size at all** (Section 2). **Third, fix the height of the vessel and the edge of the window is fixed——in a vessel 0.1 m tall, the sedimentation length balances at a diameter of 17.3855 nm** (Section 2). **Fourth, the same window appears on the moving side——the time for settling to overtake diffusion is 1.288608×10^{10} s (1.491445×10^{5} days) at 10 nm, 1.288608×10^{5} s (1.491445 days) at 100 nm and 1.288608 s at 1000 nm** (Section 3). **Fifth, changing the density difference moves the window too——at a fixed diameter of 1000 nm, reducing the density difference from 1500 to 10 kg/m^3 raises the sedimentation length from 5.254878×10^{-7} m to 7.882317×10^{-5} m, a factor of 150** (Section 3). **Sixth, the separator is whether the sedimentation length exceeds the height of the vessel——not the name of the substance, but the set of diameter, density difference and height** (Section 4). **Keywords**: colloid, sedimentation length, Brownian motion, Stokes settling velocity, diffusion coefficient, thermal motion.

Scope of this paper (scope note): **No new theorem or law is claimed——sedimentation equilibrium (Perrin 1909), Stokes drag and the Einstein--Stokes diffusion coefficient are all standard (Russel, Saville and Schowalter 1989).Interactions between particles are not included——electrostatic repulsion, van der Waals attraction and aggregation are not treated. A single dilute particle is examined.Concentrated systems are not treated——hindered settling, where particles interact as they fall, is not included.Only spheres are treated——rods, plates and a distribution of sizes are not considered.Representative values are used——the densities of silica and water, the viscosity of water and a vessel 0.1 m tall are representative, not measurements of a particular system.Relation to earlier papers**: **Paper 365 showed that the usual explanation of the Brazil-nut effect fails on the size of the gap, and stated that packing itself was not its subject; there it was the ratio of one diameter to another that decided the mechanism——here too the diameter acts, but what it is compared against is thermal motion.**What is added is **deriving the sedimentation length by diameter to show the cube**, **inverting for the diameter that balances the height of the vessel**, **setting settling against diffusion as times**, **showing that the window moves with the density difference**, and **placing the separator on the sedimentation length against the vessel**.

1. Notation and the Question

Setting: **a sphere of diameter d and density difference $\Delta\rho$ sits in a liquid. The height to which thermal motion can lift it against gravity is the sedimentation length.**

$$l = \frac{k_B T}{\Delta\rho V g}, \qquad V = \frac{\pi}{6} d^3$$

The numerator depends only on temperature; the denominator grows as the cube of the diameter, so l falls as the cube.On the moving side, the speed of settling (Stokes) is compared with the speed of diffusion (Einstein--Stokes).

Question: **is being a colloid decided by the kind of substance, or by size?**

2. The Sedimentation Length Falls as the Cube

Computation 2.1: **for silica in water (density difference $1500\ \mathrm{kg/m^3}$, $293.15\ \mathrm{K}$), the sedimentation length, settling velocity and diffusion coefficient were derived.**

diameter	sedimentation length	settling velocity	diffusion coefficient
10 nm	5.254878×10^{-1} m	8.155897×10^{-11} m/s	4.285824×10^{-11} m^2/s
100 nm	5.254878×10^{-4} m	8.155897×10^{-9} m/s	4.285824×10^{-12} m^2/s
1000 nm	5.254878×10^{-7} m	8.155897×10^{-7} m/s	4.285824×10^{-13} m^2/s
10000 nm	5.254878×10^{-10} m	8.155897×10^{-5} m/s	4.285824×10^{-14} m^2/s

Ten times the diameter gives exactly a thousandth of the sedimentation length, a hundred times the settling velocity and a tenth of the diffusion coefficient.

Computation 2.2: inverting for a vessel 0.1 m tall, the sedimentation length equals the height at a diameter of 17.3855 nm.

> **Observation 2.3**
>
> this is the core: one substance divides in two by diameter.Silica of 10 nm has a sedimentation length of 0.5254878 m and stays spread through any ordinary vessel. Silica of 1000 nm has 5.254878×10^{-7} m, less than its own diameter——and both are silica.

3. The Same Window on the Moving Side

Computation 3.1: the time for settling to overtake diffusion was derived from the diffusion coefficient and the settling velocity: 1.288608×10^{10} s (1.491445×10^{5} days) at 10 nm, 1.288608×10^{5} s (1.491445 days) at 100 nm and 1.288608 s at 1000 nm.

Computation 3.2: holding the diameter at 1000 nm and changing the density difference gives 5.254878×10^{-7} m at 1500 kg/m^3, 7.882317×10^{-6} m at 100 and 7.882317×10^{-5} m at 10.

> **Observation 3.3**
>
> the window is not made of diameter alone.Reduce the density difference and the same diameter falls inside the window. So saying that “colloids run from 1 nm to 1 micrometre” silently fixes a pair, a solid in water——the window is set by diameter, density difference and the height of the vessel together.

4. The Separator

> **Observation 4.1**
>
> **the separator is whether the sedimentation length exceeds the height of the vessel.Above it, the particles stay spread by thermal motion; below it, they gather at the bottom——the name of the substance cannot answer the question; diameter, density difference and height can.**

> **Observation 4.2**
>
> **beside Paper 365.In Paper 365 what decided whether a grain could fall through a gap was a ratio of diameters——here the diameter acts again, but it is compared against thermal motion rather than against another grain. The same "size" is measured against a different partner.**

> **Observation 4.3**
>
> **what is not said.Neither attraction nor repulsion between particles is included, concentrated systems are not treated, and only spheres are examined——what is shown is that the word colloid names not a substance but a window made by a ratio.**

5. Roll Call and Closing

1. **0.5254878 m at 10 nm** (Computation 2.1): **taller than the vessel.**
2. **5.254878×10^{-7} m at 1000 nm** (Computation 2.1): **less than its own diameter.**
3. **a thousandth for ten times** (Computation 2.1): **the cube at work.**
4. **the edge at 17.3855 nm** (Computation 2.2): **in a vessel 0.1 m tall.**
5. **one substance, two behaviours** (Observation 2.3): **the core.**
6. **1.288608×10^{10} s to overtake** (Computation 3.1): **at 10 nm.**
7. **1.288608 s at 1000 nm** (Computation 3.1): **ten orders apart.**
8. **7.882317×10^{-5} m at 10 kg/m^3** (Computation 3.2): **the window moves.**
9. **a window of three quantities** (Observation 3.3): **diameter, density, height.**
10. **length against vessel** (Observation 4.1): **the separator; Paper 365.**

Closing: **A colloid is not a kind of substance.For the same silica in water, the sedimentation length falls from 0.5254878 m at 10 nm to 5.254878×10^{-7} m at 1000 nm, less than a billionth.Ten times the diameter gives exactly a thousandth, and in a vessel 0.1 m tall the boundary lies at 17.3855 nm——the ratio of thermal motion to gravity makes a window, and what falls inside it is called a colloid.The separator is whether the sedimentation length exceeds the height of the vessel.Placed among the earlier papers——in Paper 365 a diameter was compared with another diameter; here it is compared with thermal motion.To be honest——interactions between particles and concentrated systems are not treated, and only spheres are examined.**

References

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