

White Is Made by a Difference, Not by a Colour

— The same “white powders” scatter as **1** to **0.006944** once mixed into a resin, a factor of **144** — wet the paper and the difference falls from **1.70** to **1.37**, taking **35.1** per cent of the scattering with it — match the index and the white vanishes exactly — [Paper 442]

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— *From thinking to syncing.* —

Abstract

A white powder is taken to be white. This paper shows that whiteness is not a property of the powder—it is made by the difference from its surroundings, and vanishes when the difference does. No new theorem or law is claimed. First, titanium dioxide, calcium carbonate and quartz are all equally white powders on their own (Section 2). Second, this is the core of the paper. Mixed into a resin they scatter as **1**, **0.006944** and **0.001736**, a factor of **144** or more (Section 2). Third, shrink the difference by a ratio and the scattering falls by its square; inversion returns **0.006944444** (Section 2). Fourth, wetting paper takes the difference from **1.70** to **1.37** and the scattering falls by **35.1** per cent (Section 3). Fifth, match the indices exactly and the scattering is exactly **0** (Section 3). Sixth, the separator is a property of the powder against a difference from its surroundings (Section 4). **Keywords:** light scattering, refractive index contrast, hiding power, white pigment, Mie scattering.

Scope of this paper (scope note): No new theorem or law is claimed—light scattering, hiding power from index contrast and optical clearing are all standard. Scattering theory is not derived—no exact Mie calculation is performed; only the approximation that scattering goes as the square of the difference is used, which is coarse where the particle size approaches the wavelength. Optimal particle size is not discussed—that hiding power depends on size is standard, but only the index difference is varied here. No pigment is recommended—which material to use is not the subject. The indices are not asserted as measurements—2.70, 1.60, 1.55, 1.50 and 1.33 are representative and vary with wavelength. Colour is not treated—colour from absorption is not the subject; only white from scattering. Relation to earlier papers: Paper 441 showed that the metal reacting most readily is the one that does not corrode—there another quantity hid inside the name of a material; here whiteness is not fixed by the material alone. Paper 300 showed that common root and distinct root can be decided—“the powder is white” and “it whitens when mixed” are distinct roots by that criterion. Paper 424 showed that dividing turns a move in the denominator into an event—here too, a pairing of two quantities settles the result. Paper 440 showed that the direction is fixed only once two metals are paired—the same shape: a property undetermined alone. What is added is setting the difference in air against the difference in resin for three pigments, giving the ratio of scattering as a factor of 144 or more, confirming the square relation by inversion, giving the fall on wetting as 35.1 per cent, placing the matched case at exactly 0 as the other side of the boundary, and placing the separator at “property or difference”.

1. Notation and the Question

Setting: For a particle of index n_p in a medium of index n_m , the scattering goes roughly as the square of the difference.

$$I \propto (n_p - n_m)^2$$

Take air as 1.00, water as 1.33 and resin as 1.50.

Observation 1.1

A white powder is taken to be white. Held in the hand they all look alike—so whiteness looks like a property of the powder.

Observation 1.2

But what appears in the expression is a difference. $n_p - n_m$ —the particle alone does not fix it.

Question: Change the surroundings, and how much does the whiteness change.

2. The Same White Powders, Scattering 144 Times Apart

Computation 2.1: Take the difference in air and in resin for three powders.

Pigment	Index	Against air	Against resin
Titanium dioxide	2.70	1.70	1.20
Calcium carbonate	1.60	0.60	0.10
Quartz	1.55	0.55	0.05

Observation 2.2

In air, all three differences are of the same order.1.70, 0.60, 0.55—which is why all three look white as powders.

Observation 2.3

In resin they separate by orders.1.20 against 0.10 against 0.05—calcium carbonate is **0.0833** of titanium dioxide, quartz only 0.0417.

Computation 2.4: Take the scattering (the square of the difference) with titanium dioxide at 1.

Pigment	Scattering
Titanium dioxide	1.000000
Calcium carbonate	0.006944
Quartz	0.001736

Observation 2.5

Calcium carbonate is under one per cent of titanium dioxide. A factor of 144—the same “white powder”, with that much difference in hiding power.

Observation 2.6

The value matches the square of the ratio of differences exactly. $0.0833^2 = 0.006944444$ —an inversion, confirming the computation.

3. Wet It and the White Fades

Computation 3.1: Take the difference when the voids in paper change from air to water.

State	Index in the voids	Difference
Dry paper	1.00	1.70
Wet paper	1.33	1.37

The scattering falls to **0.6494**, a drop of **35.1** per cent.

Observation 3.2

Nothing about the paper changed. The fibres and the pigment are as they were—only what fills the voids changed.

Observation 3.3

And the whiteness falls by more than a third. Which is why wet paper goes translucent—soak it in oil and it goes further, because oil has a higher index than water.

Observation 3.4

Match the indices exactly and the scattering is exactly 0. Because the difference is zero—the other side of the boundary, where the particle optically ceases to exist.

Observation 3.5

By the same reasoning, a heap of powder is white and dissolves clear. Sugar, salt—not that it dissolved, but that the difference went.

4. The Separator

The separator: a property of the powder, or a difference from its surroundings.

Observation 4.1

If it were a property, it would stay white anywhere. White wherever it is put—and it does not.

Observation 4.2

If it is a difference, changing the surroundings removes it. And it does—by wetting, mixing, soaking.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “white”—one a property of a substance, one a property of a pairing.

Observation 4.4

So the hiding power of a paint cannot be read from the pigment alone. It is fixed only when paired with the index of the resin—the same shape as Paper 440, where the direction was fixed only once two metals were paired.

Observation 4.5

And since it goes as the square, halving the difference quarters the scattering. The change is amplified—a small difference in the difference becomes a large difference in appearance.

Observation 4.6

To be honest—the square relation is an approximation. It is coarse where the particle size approaches the wavelength—what does not change is that a zero difference gives zero scattering.

Observation 4.7

One last thing—hiding power also depends on particle size. Only the index difference has been varied here—choosing an optimal size is another axis, not treated.

5. Roll Call and Closing

1. In air: **1.70, 0.60, 0.55** (Computation 2.1): **the same order.**
2. In resin: **1.20, 0.10, 0.05** (Computation 2.1): **separated by orders.**
3. Calcium carbonate at **0.0833** (Observation 2.3): **relative to titania.**
4. Scattering **0.006944** (Computation 2.4): **a factor of 144.**
5. Matching the square of the ratio (Observation 2.6): **0.006944444.**
6. Wetting takes **1.70 to 1.37** (Computation 3.1): **only the voids change.**
7. Scattering falls **35.1 %** (Computation 3.1): **paper goes translucent.**
8. Matched indices give exactly **0** (Observation 3.4): **the other side.**
9. Dissolving clear is the same (Observation 3.5): **the difference goes.**
10. The separator is property or difference (Observation 4.3): **distinct roots by Paper 300.**

Closing: A white powder is taken to be white—held in the hand they all look alike, so whiteness looks like a property of the powder—but what appears in the expression is a difference $n_p - n_m$, and the particle alone does not fix it. Change the surroundings and they separate by orders—in air the differences for titanium dioxide, calcium carbonate and quartz are 1.70, 0.60 and 0.55, of the same order, which is why all three look white as powders. In resin they become **1.20, 0.10 and 0.05**, calcium carbonate being **0.0833** of titanium dioxide. Since scattering goes

as the square, the strengths are **1, 0.006944** and 0.001736—a factor of **144** or more. That value matches the square of the ratio of differences exactly, $0.0833^2 = 0.006944444$, an inversion that confirms the computation. And when the difference shrinks, the white fades—when the voids in paper change from air to water the difference falls from 1.70 to **1.37** and the scattering by **35.1** per cent. Nothing about the paper changed: the fibres and pigment are as they were, and only what fills the voids changed. That is why wet paper goes translucent, and soaking it in oil goes further because oil has a higher index than water. Match the indices exactly and the scattering is exactly **0**, where the particle optically ceases to exist—and a heap of sugar or salt going clear on dissolving is the same thing: not that it dissolved, but that the difference went. One thing separates them—a property of the powder, or a difference from its surroundings. A property would stay white anywhere, and it does not; a difference is removed by changing the surroundings, and wetting, mixing and soaking all remove it. They are distinct roots by the criterion of Paper 300, one a property of a substance and one of a pairing. So the hiding power of a paint cannot be read from the pigment alone but only when paired with the index of the resin—the same shape as Paper 440, where the direction was fixed only once two metals were paired. And since it goes as the square, halving the difference quarters the scattering, so a small difference in the difference becomes a large difference in appearance. To be honest—the square relation is an approximation, coarse where the particle size approaches the wavelength. What does not change is that a zero difference gives zero scattering. One last thing—hiding power also depends on particle size. Only the index difference has been varied here; choosing an optimal size is another axis, not treated.

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