PARTICLE TECHNOLOGY

Why form matters as much as molecule

Micronization · Agglomeration · Encapsulation

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FOLLOW ALONG ON YOUR PHONE

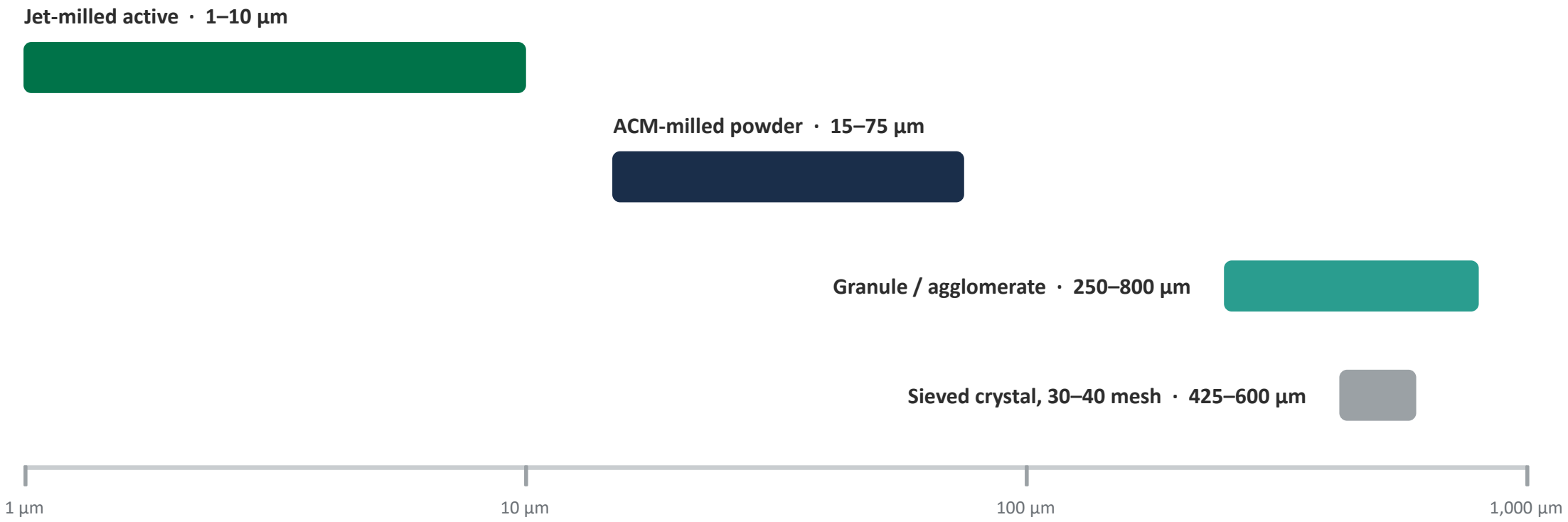
Notes you keep

THE PREMISE

The same molecule, four different products

Chemistry is identical. Particle size, shape and surface are not. That is what the customer is actually buying.

Three orders of magnitude, inside a single product line.



THE FRAMEWORK

There are only three things you can do to a particle

Every process in this talk is a variation on one of them.

1

MICRONIZATION

Make it smaller

Reduce size to increase surface area. Faster dissolution, better uniformity, smoother mouthfeel.

Pharma word: milling

2

AGGLOMERATION

Make it bigger

Bind fines into larger, stronger particles. Better flow, less dust, instant dispersion.

Pharma word: granulation

3

ENCAPSULATION

Wrap it

Put a barrier between the active and everything else. Taste, stability, timed release.

Pharma word: coating

LEVEL-SET

Same process, two vocabularies

Half this room says one word, half says the other. It causes real confusion on spec sheets.

FOOD & NUTRITION	PHARMACEUTICAL
Agglomeration	Granulation
Encapsulation	Coating
Micronization	Milling / size reduction
Beadlet	Pellet
Instantizing	Wetting / dispersibility

If a supplier sends you a spec for “granulated, coated pellets,” they are describing an agglomerated, encapsulated beadlet. Same product.

LEVEL-SET

The five numbers that decide whether a powder works

These are what you argue about on a certificate of analysis.

- **Particle size distribution** — It is a distribution, not a single number. One figure hides both tails. A slide of its own follows.
- **Bulk vs. tapped density** — How much of your powder is actually air, and how much it settles. Covered in detail shortly.
- **Friability** — How readily a granule breaks back into fines during handling. A granule that survives the bag but not the auger solved nothing.
- **Wettability** — Not the same as solubility. A soluble powder can still float, clump and refuse to disperse.
- **Hygroscopicity** — Milling creates new surface area. More surface means faster moisture pickup, and caking in the drum.

LEVEL-SET

Reading a particle size spec

One conversion worth memorising, and one number that misleads.

MESH ↔ MICRONS

100 mesh = 150 µm

Double the mesh, halve the microns.

50 mesh	→	**300 µm**
100 mesh	→	**150 µm**
200 mesh	→	**75 µm**
400 mesh	→	**38 µm**

Those are the real US sieve openings, not approximations. More holes per inch means smaller holes.

WHAT THE D-NUMBERS MEAN

D50 Half the material is finer, half is coarser. A median, not an average, and not a maximum.

D90 90% is finer than this. The coarse tail, and where grit complaints come from.

D10 10% is finer than this. The fine tail, and where dust and flow problems come from.

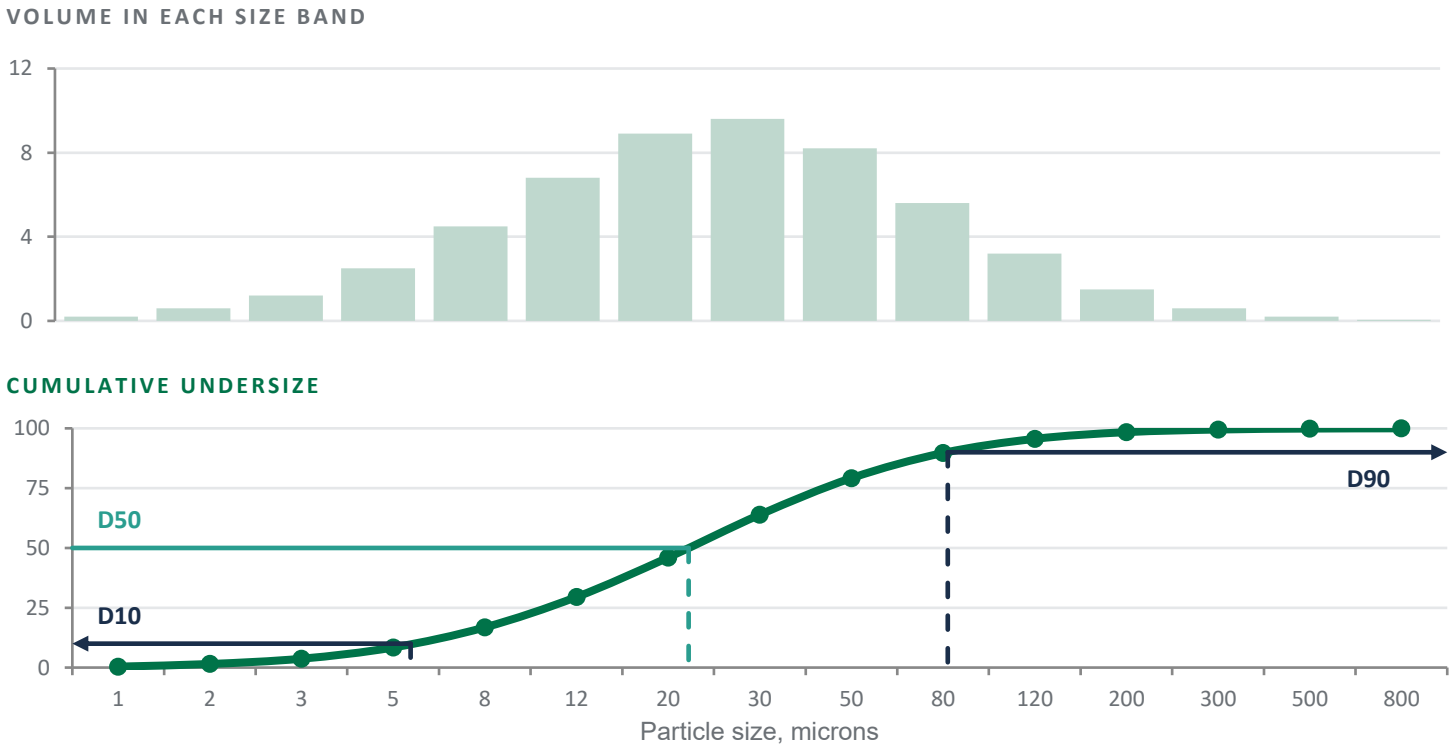
Same D50. Very different powder.



LEVEL-SET

How to read a laser diffraction result

This is the plot every particle size report puts in front of you.



Worked example: D10 ≈ 6 µm · D50 ≈ 22 µm · D90 ≈ 82 µm · span 3.5

Two plots, one picture

The bars are how much material sits in each size band. The line is cumulative: at any size, the share of the sample finer than that.

The numbers come off the line

Find 50% on the vertical axis of the lower plot, run across to the curve, then drop down to the size. That is D50. Same move at 10% and 90%.

Span is the width

(D90 minus D10) divided by D50. Under about 1.5 is tight. Over 3 is broad, and the tails will misbehave.

Two peaks is a finding

A second hump means two populations: agglomerates, a contaminant, or a blend that never blended. Worth a phone call.

LEVEL-SET

Bulk density decides what fits in the box

You buy powder by weight. Every process downstream handles it by volume.

WHAT IT ACTUALLY MEASURES

Mass per unit volume, including the air between the particles. A poured powder is typically 40–60% empty space.



Poured Tapped

Same mass.
Less volume.

Hausner ratio = tapped ÷ bulk

Under 1.25: flows freely
Over 1.40: expect bridging

AND THE DIRECT TEST: FLODEX

Hausner infers flow from settling. Flodex measures it: the smallest orifice, in mm, the powder falls through unaided. Lower is better.

WHY IT COSTS YOU MONEY

- **Freight and warehousing**

  You ship and store cubes, not kilos. Double the bulk density and the same tonnage takes half the pallets.

- **Package and capsule fit**

  A bottle and a capsule shell are fixed volumes. Too light a powder and the dose physically will not fit.

- **Fill accuracy**

  Augers and dosators meter by volume. Lot-to-lot density drift becomes fill-weight drift, and overfill to stay legal.

- **Segregation in the blend**

  Large density differences between components separate on every transfer and every truck ride.

Why you would make a particle smaller

Surface area is the lever. Everything on this slide follows from it.

1	**Dissolution rate**	Dissolution scales with exposed surface area. Halve the diameter and you roughly double the area per unit mass. The same active goes into solution faster.
2	**Content uniformity**	In a low-dose blend, fewer and larger particles means more variation per unit. Smaller particles mean more of them, and a tighter dose.
3	**Mouthfeel and texture**	The palate detects grit somewhere around 25–30 µm. Below that, a suspension reads as smooth rather than sandy.
4	**Color, opacity and coverage**	Finer pigment or titanium-free opacifier scatters more light per gram. Better coverage at lower loading.

How fine is fine enough? Ask the tongue.

In food, the palate is the specification that matters.

Most palates begin to register grit somewhere around 25 to 30 microns.

Under 15 µm	15 – 25 µm	25 – 40 µm	Over 40 µm
reads as creamy	smooth, at the edge of detection	graininess starts to register	clearly gritty

It is not size alone

Hard, angular particles are detected sooner than soft ones, and a fatty or viscous matrix hides far more than water does. The same micron figure feels different in chocolate and in a beverage.

Chocolate is the benchmark

Refined to roughly 20 to 25 microns, which is precisely why it reads as smooth rather than sandy. It is the most useful reference point most people already have.

Granules break the rule

A 400 micron agglomerate can feel perfectly fine if it collapses before the tongue registers it. What matters is how long the particle survives in the mouth, not only how big it started.

Two mills, two entirely different mechanisms

Choosing between them is a purchasing decision, not a science one.

AIR CLASSIFYING MILL (ACM)

Mechanical impact + attrition

Typical D50	15–75 µm
Heat	Significant at the contact point
Distribution	Broader; classifier holds the top cut
Throughput	High
Cost per kg	Low
Contamination	Wear parts erode into the product

JET MILL

Particle-on-particle, compressed gas

1–10 µm
Net cooling: expanding gas is endothermic
Naturally narrow
Low
Several times higher: compressed gas is the bill
No moving parts in the chamber

Justify a jet mill on exactly three grounds: heat sensitivity, a sub-10 µm target, or a contamination-free requirement. Otherwise you are paying a multiple for a cut you did not need.

Finer is not better. Finer is a trade.

Every gain in surface area is paid for somewhere else.

Flow collapses

Fine powders bridge, rathole and flood. The material that dissolves beautifully may not make it out of the hopper.

Dust and static

More airborne fines, more housekeeping, more segregation in transit and more product on the floor.

Explosibility rises

Reducing particle size lowers minimum ignition energy and raises Kst. It constrains where the material can be handled.

Compression suffers

Fines trap air and resist forming a strong compact. Tablet hardness and capping problems follow.

Moisture pickup

New surface area is new opportunity for water. Hygroscopic actives cake faster after milling.

Some materials refuse

Waxy, ductile or low-melting solids smear instead of fracturing. Cryogenic milling, chilled below the glass transition, is the answer.

Where the money actually is: the plant floor

This is the least glamorous slide in the deck and the one your operations people care about most.

FINE POWDER

— Bridges and ratholes in the hopper

— Floods the feeder, then starves it

— Fill weights drift; overfill to stay legal

— Segregates on every transfer

— Dust loss, cleanup, downtime

AGGLOMERATED

+ Flows consistently, gravity does the work

+ Steady feed rate: line speed goes up

+ Tighter fill weight, less giveaway

+ Blend stays uniform to the press

+ Dust drops sharply

Higher run rates and less overfill are recurring savings. They show up every shift, not once.

Dispersibility is four problems, not one

A powder has to clear four hurdles to get into solution. Only the last one is solubility.

1

Wetting

Liquid has to displace the air held at the particle surface. Fail here and the powder sits on top, dry, refusing to take on water at all.

2

Sinking

The wetted particle has to submerge. Too light, or too much trapped air, and it rafts on the surface however hard you stir.

3

Dispersing

Clusters have to break apart. Fail here and the outer layer hydrates into a gel skin that seals dry powder inside: the fisheye.

4

Dissolving

The actual solvation step. This is usually the fastest of the four, and almost never the one that is failing.

The useful part

Almost every complaint that arrives as “it will not dissolve” is actually failing at step one or step three. The chemistry is fine. The surface is the problem, and the surface is something we can change.

Change the surface, not the molecule

Three levers, roughly in the order we reach for them.

1

Build a porous agglomerate

Voids let water wick inward by capillary action instead of sealing the outside. Counterintuitively the fix for a powder that will not wet is usually a bigger particle, not a finer one.

2

Add a surface-active agent

A thin layer of deoiled lecithin applied while the granule is forming lowers the contact angle, so water grabs the particle instead of beading off it. Fractions of a percent, and it stays label-friendly.

3

Get the density right

Too light and the powder rafts on the surface no matter how long it is stirred. Agglomerate density decides whether a wetted particle actually sinks.

Why the timing matters

The surfactant goes on in the fluid bed while the granule is still building, so it ends up on the outside, exactly where the water meets it. Blended in afterwards it does very little.

Direct compression: fewer steps, lower cost per tablet

Granulation is not only about flow. It is about removing process stages.

Wet granulation route

Blend → wet mass → dry → mill → blend → compress

Six stages. Drying is the bottleneck and the energy cost. Heat-sensitive actives may not survive it.

Direct compression route

Blend → compress

Two stages. No water, no drying, no thermal exposure. Faster changeover and less equipment time.

The trade

A directly compressible grade costs more per kilogram than raw powder. It earns that back in throughput, yield and eliminated process steps, which is a conversation with operations, not procurement.

Five reasons to put a barrier around an active

You are buying separation: between the active and the tongue, the air, the moisture, or the stomach.

1

Taste and odour

Bitter, metallic, sulphurous or fishy actives become usable in formats where flavour cannot carry them.

2

Stability

A barrier against oxygen, moisture, light and pH. Extends shelf life and protects label claim through the process.

3

Incompatibility

Two ingredients that react in the same blend can coexist when one of them is shelled.

4

Liquid to solid

An oil or a liquid extract becomes a free-flowing powder. New formats open up immediately.

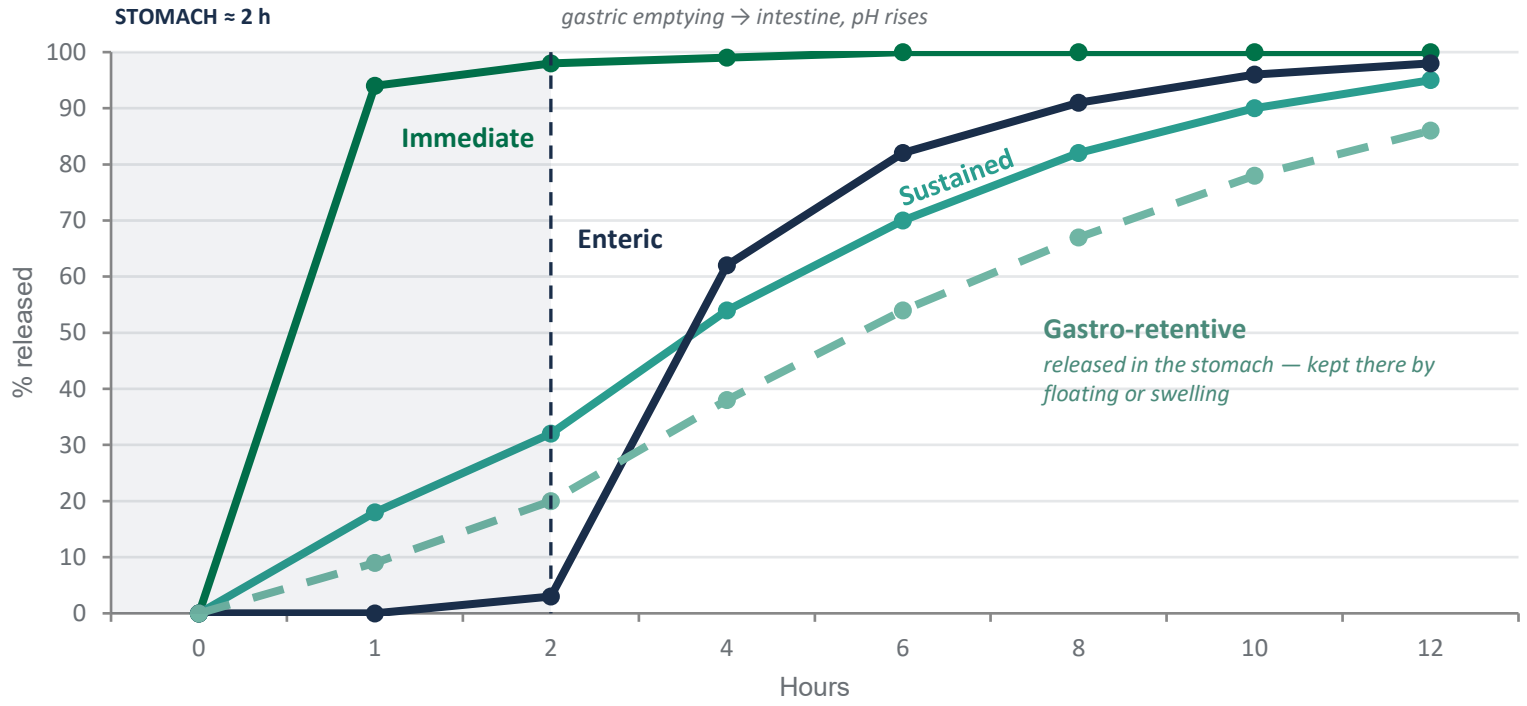
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Controlled release

Decide where and when the active is released rather than letting the gut decide.

Release is a design choice, not a property

The same active, four different shells, four different curves.



Immediate

Fast onset. Energy, pain relief, anything the consumer must feel.

Sustained

Flattens the peak, extends the window. Fewer doses per day.

Enteric

Survives stomach acid, releases in the intestine. Probiotics, enzymes, acid-labile actives.

Gastro-retentive

Stays in the stomach longer for narrow absorption windows.

Illustrative profiles. Actual curves are formulation- and shell-specific.

What the shell is actually made of

Four families do almost all the work in food and supplement encapsulation.

CELLULOSICS

Ethylcellulose
HPMC
HPMC phthalate

Ethylcellulose is insoluble in water but permeable, which makes it the workhorse for sustained release. HPMC dissolves cleanly, so it is used where you want the film gone on contact.

LIPIDS & WAXES

Hydrogenated oils
Mono- and diglycerides
Stearates, carnauba

Applied molten, so no solvent is involved. Excellent moisture barrier, and the melting point of the shell becomes the release trigger.

HYDROCOLLOIDS

Sodium alginate
Pectin, gum acacia
Maltodextrin

Water-soluble carriers that dominate spray drying. Alginate gels on contact with calcium, which is how you form a bead without heat or solvent.

PROTEINS

Gelatin
Whey protein
Zein

Strong film formers. Zein is alcohol-soluble and resists gastric acid, making it one of the few genuinely clean-label enteric options.

Keep this straight

MCC is not a shell. Microcrystalline cellulose builds the sphere you then coat: core material, not coating. The two get confused on specs constantly.

Designing the trigger

Decide what should open the shell, then pick the material that answers to it.

Water contact	**HPMC · maltodextrin · gum acacia**	Immediate release. The film simply dissolves and the active is free.
Time and diffusion	**Ethylcellulose, blended with a pore-forming HPMC**	Sustained release. Rate is set by how thick the coat is and how much pore former is in it.
pH change	**Shellac · sodium alginate · zein**	Enteric. Intact through gastric acid, then opens as pH climbs past roughly 5.5 in the intestine.
Heat or shear	**Lipid and wax shells**	Releases at a designed melting point, or when the particle is chewed or compressed.

Two dials Thickness sets the rate. Composition sets the trigger. Both are paid for in loading, because every percent of shell is a percent that is not active.

Turning a liquid into a powder opens new markets

The clearest commercial case in the whole discipline.

AS A LIQUID

— Sold into liquid formats only

— Volatile losses, oxidation, odour

— Difficult to dose accurately by hand

— Drum handling, decanting, residue

AS AN ENCAPSULATED POWDER

+ Tablets, capsules, sticks, bars, gummies

+ Volatiles held in the shell

+ Weighs and doses like any other powder

+ Ships and stores as a dry solid

Worth noting

Encapsulated actives are diluted by definition: the shell is part of the weight. A 20% oil powder means five kilos to deliver one kilo of active, which changes both the formulation maths and the freight.

PUTTING IT TOGETHER

Start with the symptom, not the technology

Almost every request we receive arrives as one of these sentences.

- *“It tastes terrible.”*
  Encapsulate → taste-masking shell
- *“It loses potency on the shelf.”*
  Encapsulate → barrier shell
- *“It dissolves too slowly.”*
  Micronize → increase surface area
- *“It releases too fast.”*
  Encapsulate → controlled-release shell
- *“It clumps and won't mix.”*
  Agglomerate → instantized granule
- *“It won't flow; the line keeps stopping.”*
  Agglomerate → free-flowing granule
- *“It's gritty in the mouth.”*
  Micronize → below the grit threshold
- *“It's a liquid and I need a powder.”*
  Encapsulate → spray dry to a solid

PUTTING IT TOGETHER

What it means for your format

The same three techniques, translated into the formats people actually buy.

Capsules

The shell is a fixed volume, so bulk density decides whether the dose fits at all. Raise density by agglomerating and the same milligram count drops into a smaller, easier-to-swallow capsule.

Tablets

Judged on flow and compressibility, not potency alone. Directly compressible granules remove process steps, and coated beadlets put controlled release inside a conventional tablet.

Gummies

Heat and moisture at depositing are brutal on sensitive actives. An encapsulated active survives the cook, and taste masking carries bitter botanicals. Keep the particle fine or grit is detected instantly.

Stick packs and sachets

Filling is volumetric and fast. An agglomerated powder feeds consistently, so the line runs quicker, fill weight tightens, and higher bulk density means a shorter stick and less film per unit.

Powder beverages

Judged entirely on whether it disperses in a shaker bottle. An instantised agglomerate wets and sinks instead of rafting on the surface as fisheyes.

Oral pouches and lozenges

The product sits in the mouth for minutes, so taste masking and release rate are the entire experience. Grit is unforgiving over that contact time.

The overage argument

An active that survives the process and the shelf does not need to be over-dosed to still meet label claim at expiry. Removing an overage is a direct material saving on every batch, and it is the easiest number a customer can check for themselves.

WORKING TOGETHER

Six answers and we can scope a project

Bring us a problem rather than a specification. The specification is usually the last step, not the first.

1

The active

What it is, and what it does badly today

2

Target format

Tablet, capsule, stick, gummy, bar, beverage

3

Dose per serving

Drives how much shell you can afford to carry

4

Process conditions

Heat, shear, moisture and pH it must survive

5

Shelf life

How long, at what temperature and humidity

6

Label constraints

Organic, non-GMO, allergen, kosher, halal, clean label

THE TAKEAWAY

You are not buying a powder. You are buying a behaviour.

Smaller, bigger, or wrapped: the molecule stays the same. What changes is how it flows, how it tastes, how long it lasts and how fast your line runs.



particle.littoral.app

Brian Dixon
Current Company's Chief Nerd

QUESTIONS

What would you ask? Three to get us started.

Can you protect a heat-sensitive active?

Where does my line lose time: flow, fill weight, or dust?

What do customers really complain about: taste, grit, or clumping?



Ask on your phone