



DISPERSING PIGMENTS

THE GOOD, THE BAD AND
THE **COLORFUL**

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Indorama Ventures: Who we are

OUR PURPOSE

Reimagining chemistry together to create a better world.

OUR VISION

To be a world-class sustainable chemical company producing indispensable chemistry that touches billions of lives every day.



Presence in
33 countries



Consolidated revenues of
\$15.6 billion
(FY2023)



Manufacturing facilities
140+



Employees
~26,000

Business segments



Combined PET
(CPET)



Indovinya



Fibers



#1

rPET producer globally



#1

in PET staple fiber production in ASEAN



#1

EO producer in the Americas

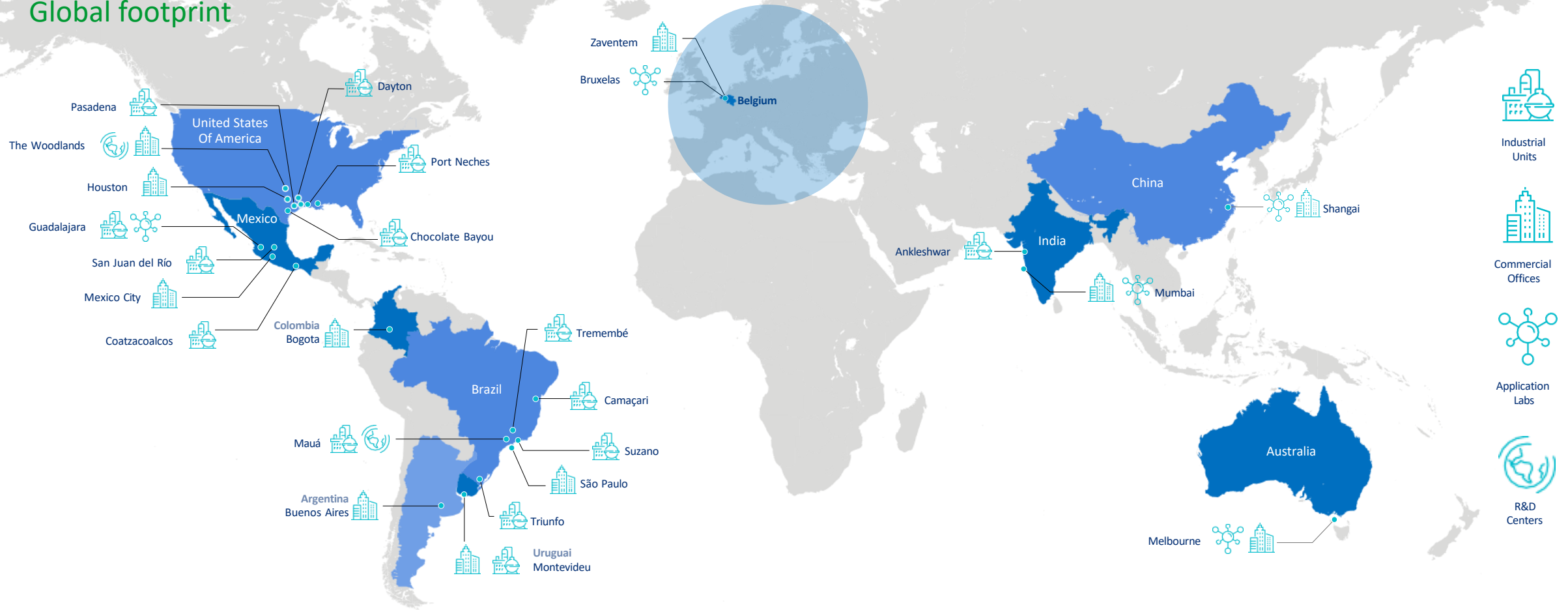


#2

ethoxylation company globally

Indovinya

Global footprint



14 manufacturing sites

7 R&D and Application Centers

Presence in **10** countries

≈ **3,000** employees

AGENDA

1. Introduction
2. What Is In A Gallon Of Paint?
3. Basic Coatings Terms And Calculations
4. Dispersion
5. Dispersants
6. OXITIVE® 8000 Series
7. Questions



PAINT FORMULATION



Paint formulation is a challenge where the interplay of the **RAW MATERIALS** can be significant.



Raw materials are added with the purpose to address specific **PROPERTIES OF THE COATING** but can affect other properties both positively and negatively.

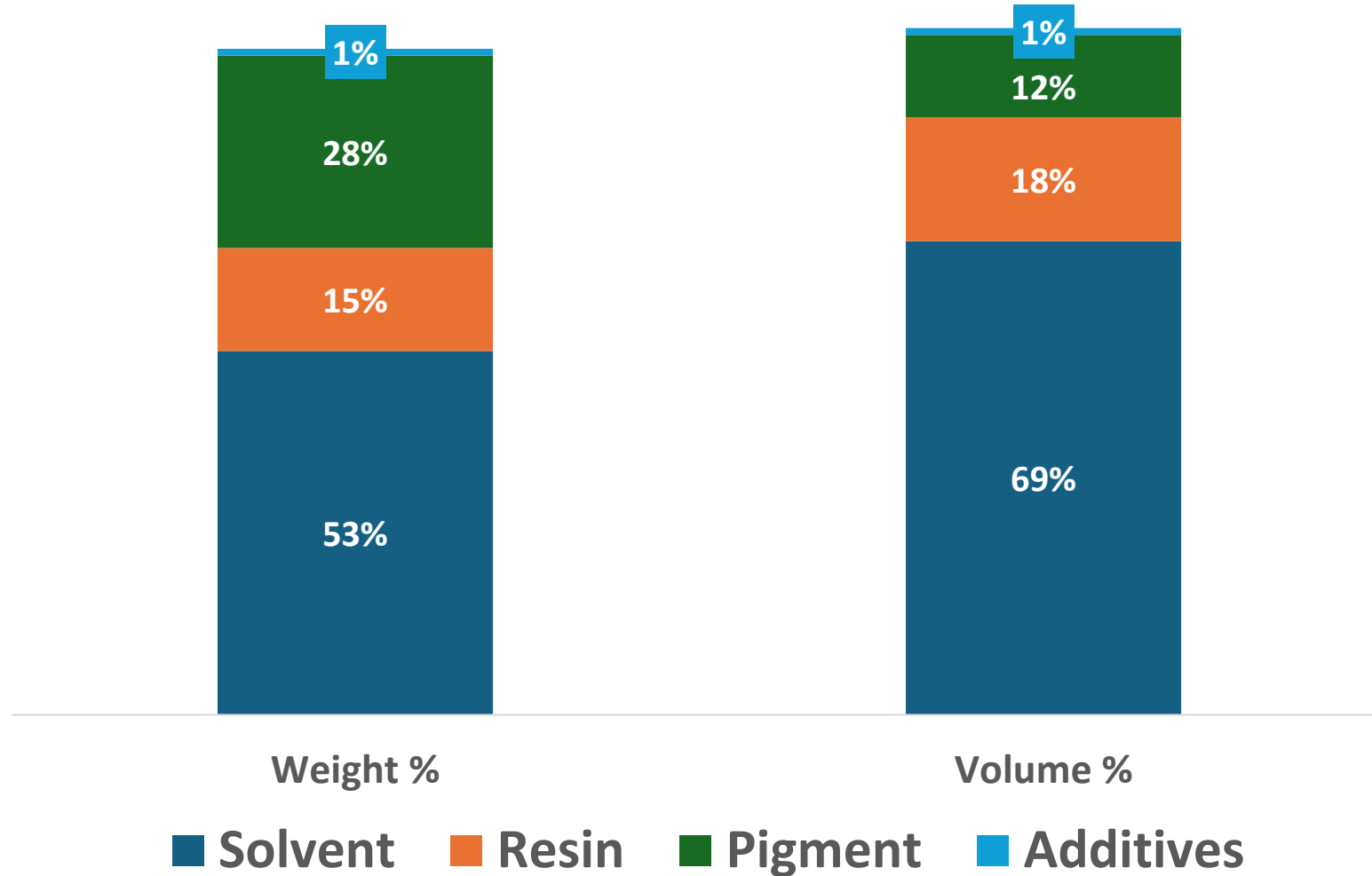


This includes:

- Additives that can change appearance, quality, durability, application and weatherability
- Solvents for application ease
- **PIGMENTS FOR COLOR**, hiding and effect
- Resins for film properties



WHAT IS IN A GALLON OF PAINT?



ADDITIVES

Used in **SMALL**
quantities

Generally **HIGH IN**
COST

Used to facilitate
production or to
improve certain
properties

Absolutely
NECESSARY in a paint

MORE IS NOT BETTER !

BASIC COATINGS TERMS:

PIGMENT OIL ABSORPTION

The amount of oil a pigment absorbs

The amount of linseed oil **NEEDED TO WET OUT THE PIGMENT** and just fill the interstices at maximum packing

Dates back to alkyd times

Size, shape and particle size distribution affects this important property

Determined **in the lab**, not theoretically

Oil Absorption = $\frac{\text{Pounds of linseed oil}}{100 \text{ pounds of pigment}}$

BASIC COATINGS TERMS:

PIGMENT SURFACE AREA

Surface area measures the **amount of surface area per given mass of pigment** (usually *Meter² / gram*).

It is measured by **nitrogen absorption** and is a modernization of the oil absorption test.

Most pigment suppliers will provide both the oil absorption and surface area for their pigments.

Some resin manufacturers do not list how well their resins will wet out pigments, and additive manufacturers tend to give wide ranges of **USE FOR BROAD PIGMENT GROUPS**.

This can limit how well this pigment property can be used.

BASIC COATINGS TERMS:

PVC

PVC: Pigment Volume Concentration

Used to determine the **PIGMENT LOADING**

Above **Critical PVC** dry hide starts

Above the **Critical PVC**, the resin will not totally encompass all pigment

As PVC increases, gloss and flexibility decreases

$$\text{PVC} = \frac{\text{Volume of pigment} \times 100}{\text{Volume of Pigment and Resin}}$$

BASIC COATINGS TERMS:

PVC

FINISH	PVC
High Gloss	15 – 20
Semi Gloss/Pearl	20 – 40
Eggshell	30 – 45
High Quality Flat	50 – 60
Inexpensive Flat	60 – 80



BASIC COATINGS TERMS:

P:B

P:B: Pigment to Binder Ratio

Only calculated with prime pigments

Ratio of prime pigment weight to weight of resin solids

Used to determine the amount of pigment needed for hiding

P:B = $\frac{\text{Weight of prime pigment}}{\text{Weight of resin solids}}$

BASIC COATINGS TERMS AND CALCULATIONS:

P:B

Typical P:B ratios needed to hide (1 mil dry)

PIGMENT	P:B Ratio
TiO ₂	1.0 – 1.1
Organic Yellows/Reds	0.5 – 2.0
Iron Oxide	0.2 – 0.4
Red/Yellow	0.1 – 0.2
Phthalo Blue/Green	0.05 – 0.1
Carbon Black	0.6 – 0.8
Off-White/ Beige	0.3 – 0.6
Medium Grey	0.2 – 0.4



PIGMENTS

PRIMARY

- Inorganic
- Organic
- Carbon Black

EXTENDER

- Calcium Carbonate
- Alumina
- Talc
- Ceramic Microspheres
- Barytes
- Fumed Silica
- Clay
- Silica
- Nepheline Syenite
- Other

OTHER SPECIALITY PIGMENTS

- Nanoparticles
- Anti-corrosive
- Effect

PRIMARY PIGMENTS

IMPARTS COLOR AND PROVIDES HIDING



INORGANIC PIGMENTS

ORGANIC PIGMENTS

CARBON BLACK

Examples	TiO ₂ , Iron Oxide	Phthalo Blue, Hansa Yellow	Carbon Black
Relative Cost	Low to moderate	Moderate to high	Low to moderate
Exterior Durability	Excellent	Poor to good	Excellent
Color Types	Muddy to bright colors	Bright clean colors	Black
Heat Resistance	Very High	Low to medium	Medium to high
Hiding Power	Good to excellent	Poor to excellent	Superior hiding
Dispersion Ease	Easy	Hard	Very difficult
Oil Absorption	Low	Medium to high	Extremely high

EXTENDER PIGMENTS

LOW-COST FILLER THAN CAN:

- **Control gloss**
- **Improve hiding**
- **Affect pH**
- **Affect rheology or settling**
- **Affect exterior durability**
- **Improve or diminish properties**
 - **Hardness, abrasion resistance, water penetration, chemical resistance, scratch resistance and tack...**



EXTENDER PIGMENTS

PIGMENT	GLOSS REDUCTION	OIL ABSORPTION	HARDNESS	PROPERTIES
Calcium Carbonate	LOW	LOW	MEDIUM	Good general filler with high pH
Talc	HIGH	HIGH	SOFT	Inexpensive flattener, very soft
Clay	MEDIUM	HIGH	MEDIUM	General purpose filler
Barytes	LOW	LOW	MEDIUM	General purpose filler with high density
Mica	MEDIUM	MEDIUM	MEDIUM	In exterior paints will lower water penetration
Alumina	LOW	LOW	MEDIUM	Spacer and stain resistance
Ceramic Microspheres	LOW	LOW	HARD	Abrasion resistance, colored
Silica	MEDIUM	MEDIUM	HARD	Good clarity and hardness
Fumed Silica	HIGH	HIGH	HARD	Flattener with anti sag/settle
Nepheline Syenite	LOW	LOW	MEDIUM	Good general filler with high pH

OTHER PIGMENTS

NANOPARTICLES

Abrasion resistance, exterior durability, hardness...

ANTI-CORROSIVE PIGMENTS

Improve corrosion resistance but can lower gloss
and can contain heavy metals.

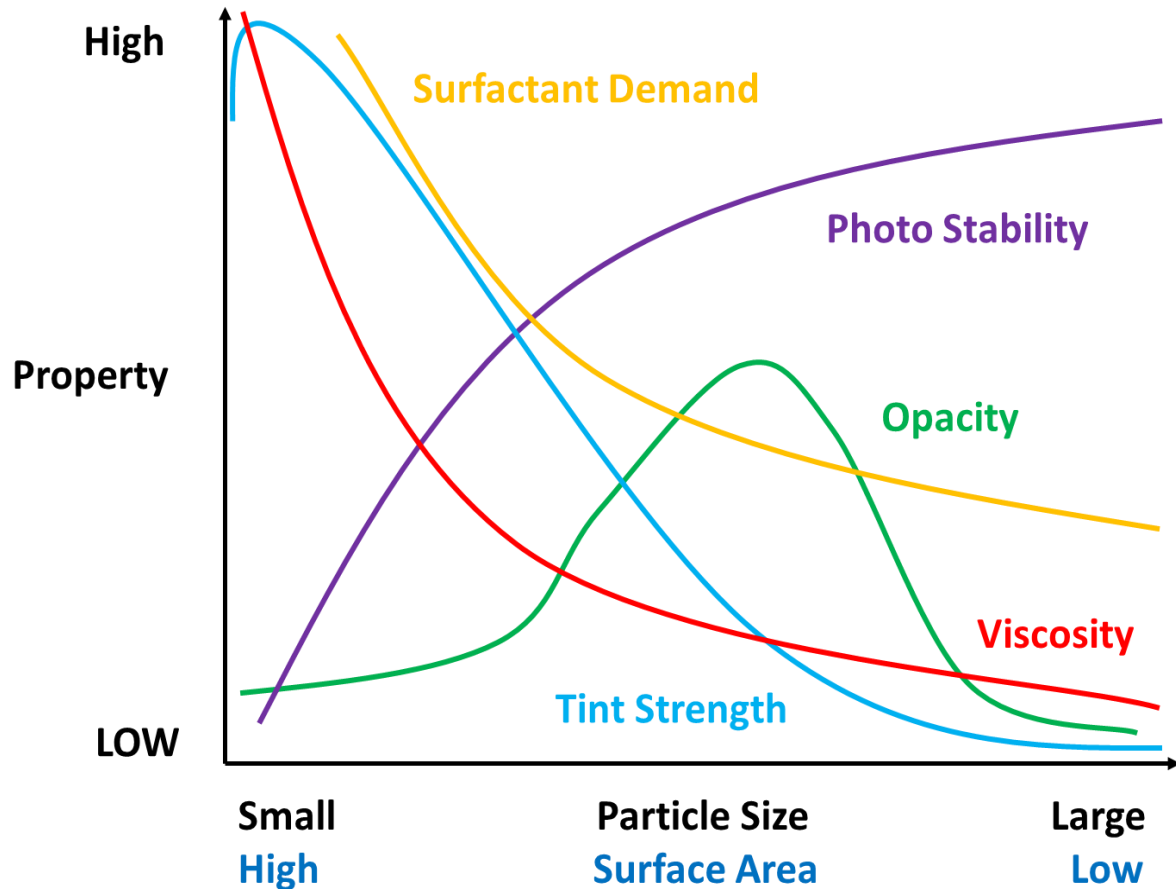
EFFECT PIGMENTS

Metallic
Holographic



PIGMENT PROPERTIES:

PARTICLE SIZE



DENSIRED PROPERTY

PREFEREED PARTICLE SIZE

Low Viscosity

LARGE

Low Dispersant Demand

LARGE

Increased Photo Stability

LARGE

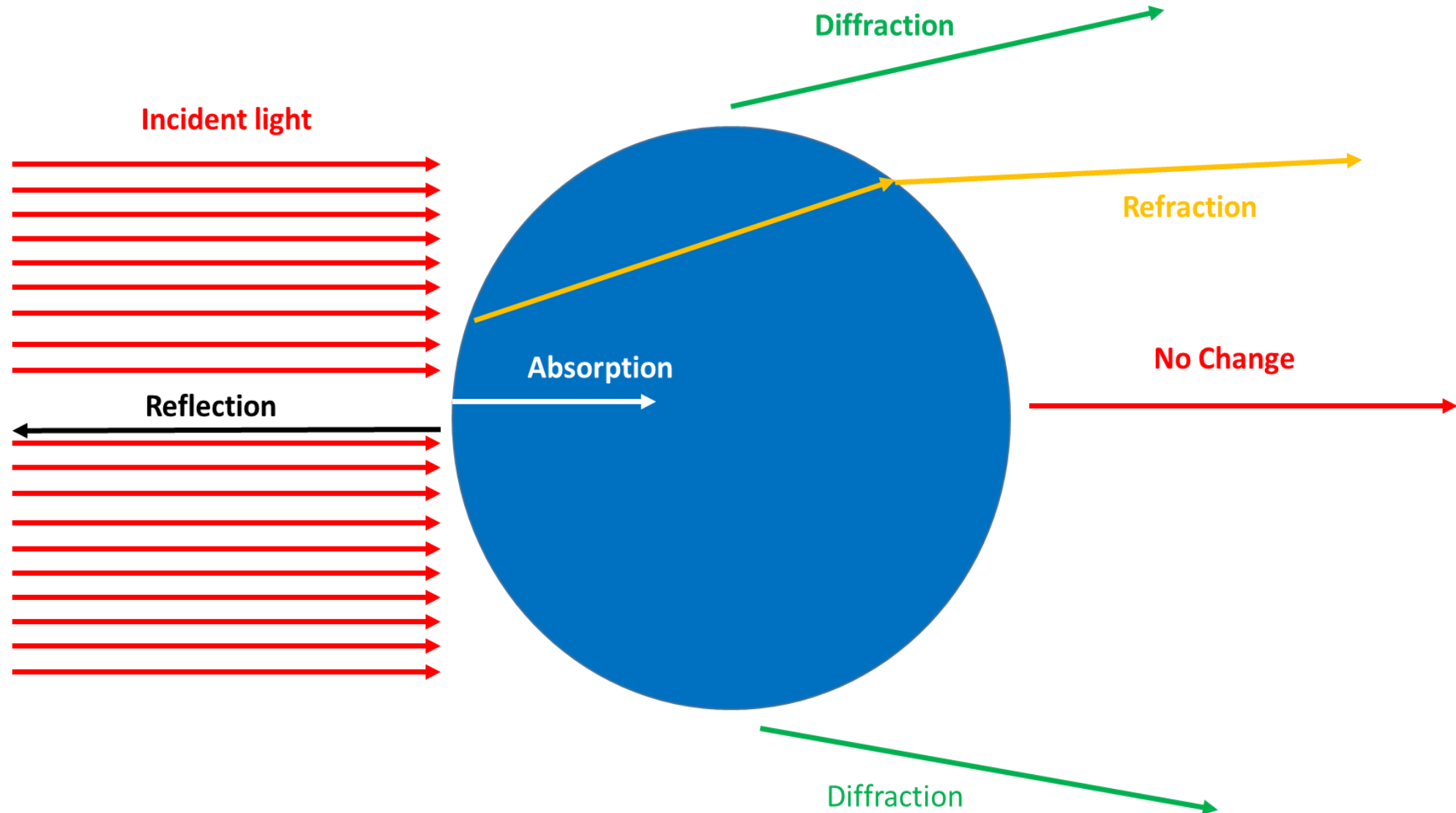
Higher Opacity

MEDIUM

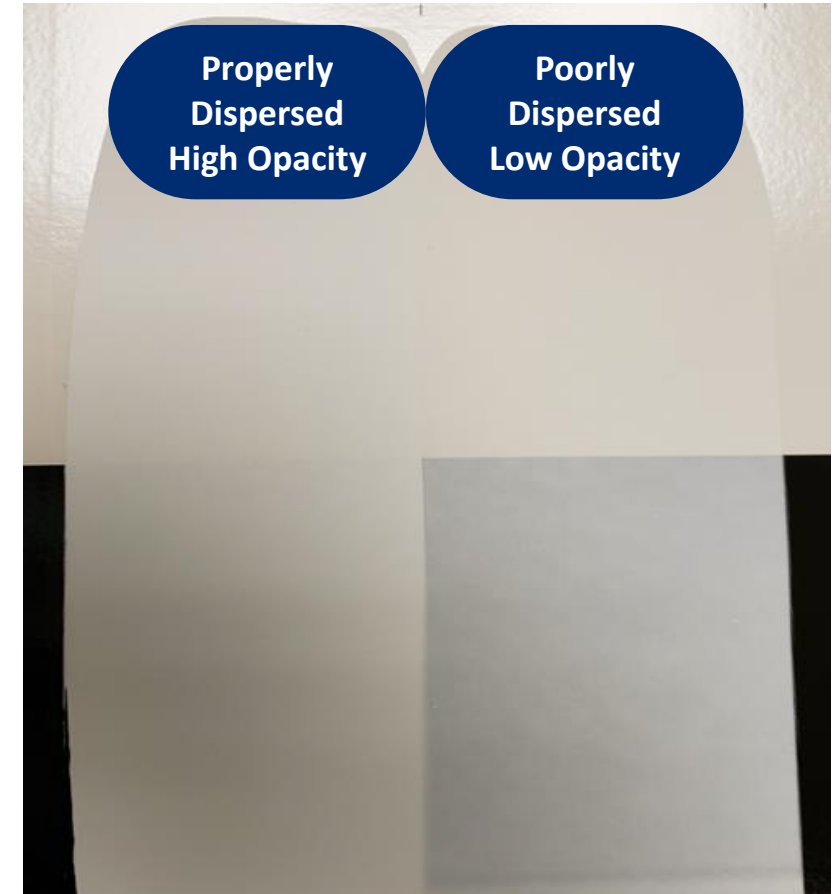
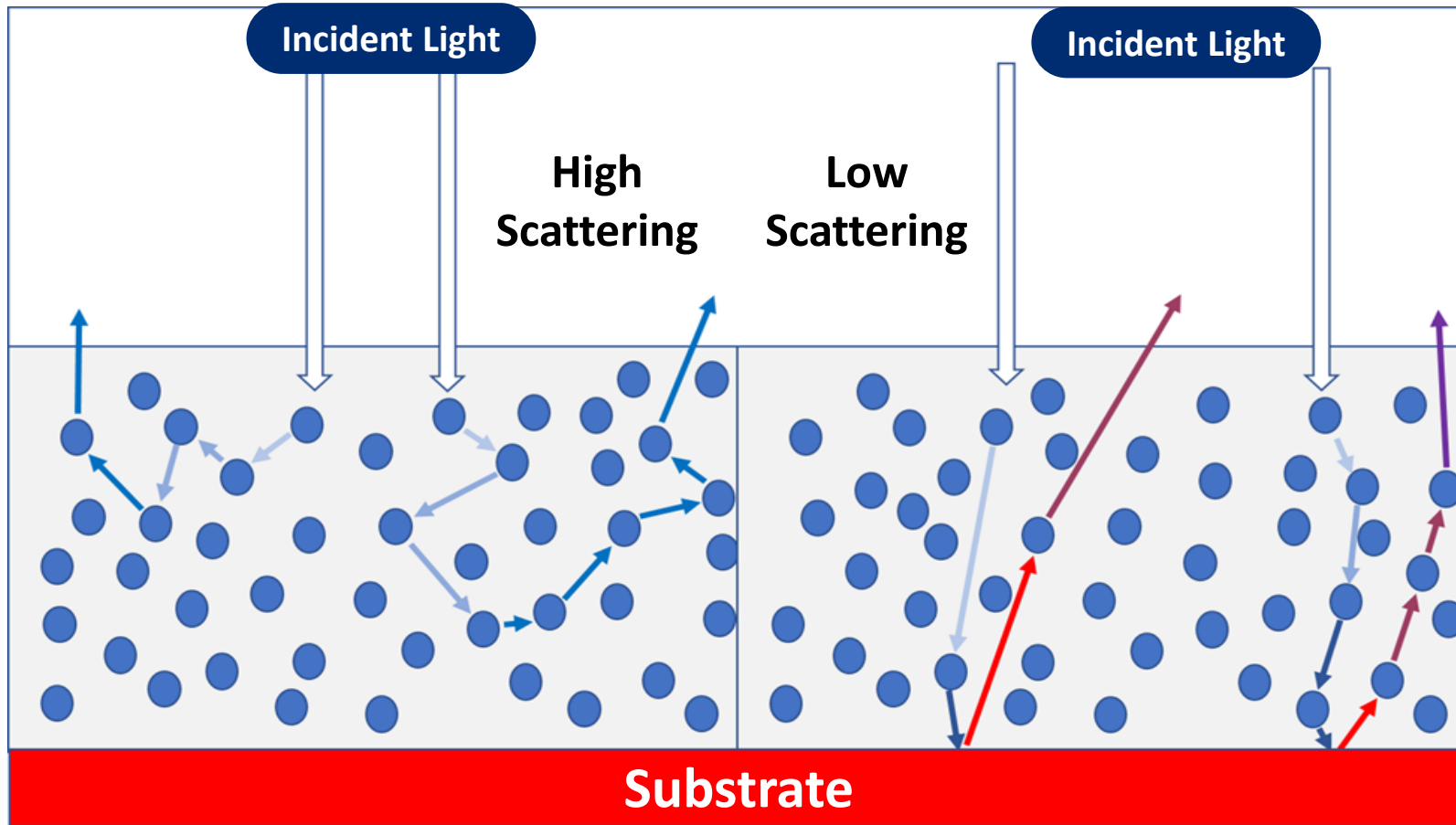
Higher Tint Strength

SMALL

HOW PIGMENTS WORK – LIGHT INTERACTION

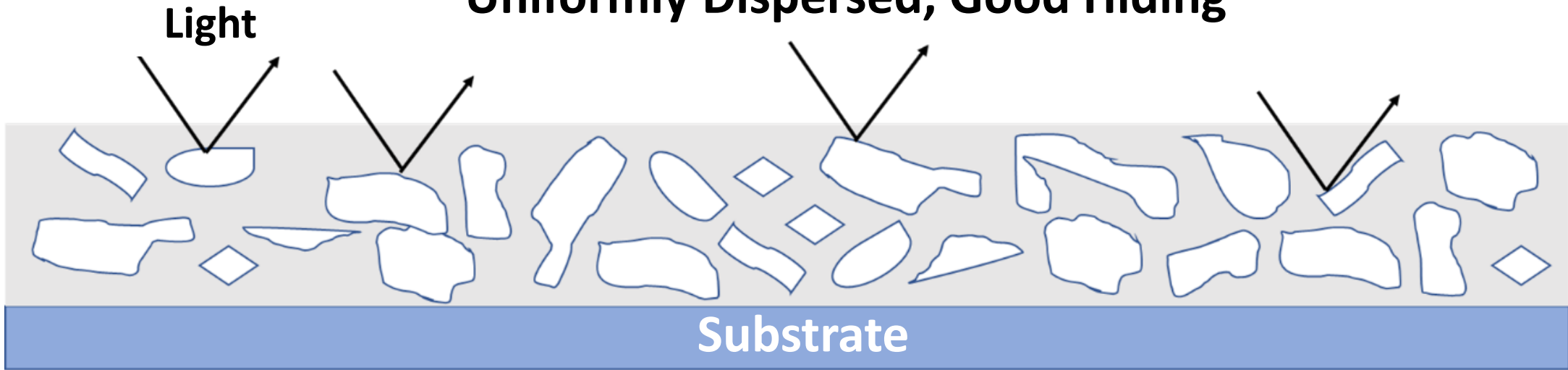


HOW PIGMENTS WORK - OPACITY

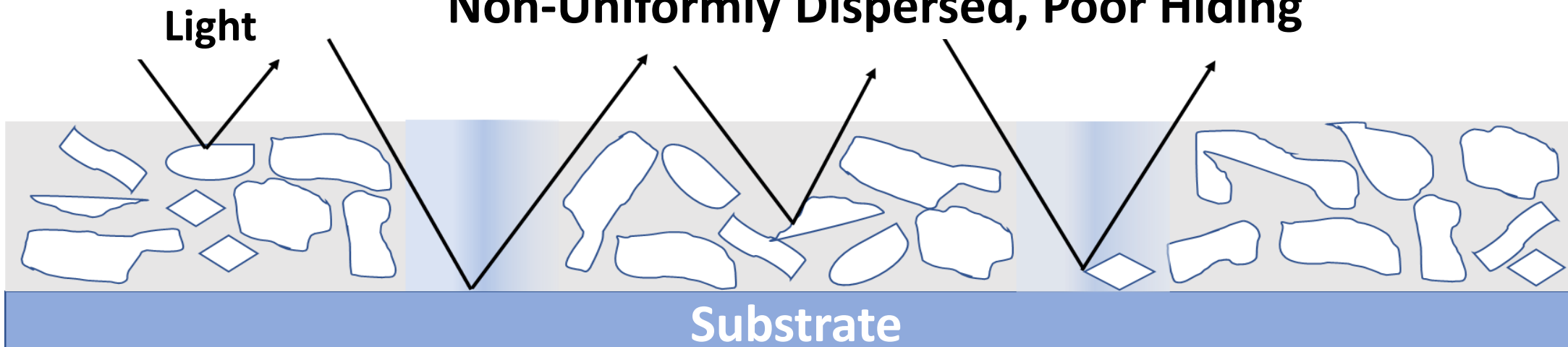


HOW PIGMENTS WORK - OPACITY

Uniformly Dispersed, Good Hiding



Non-Uniformly Dispersed, Poor Hiding



WHAT IS DISPERSION?

DISPERSION is the process by which non-soluble substances are uniformly incorporated into a liquid phase, and stabilized against settling or separation, when mixing is removed.



A GOOD DISPERSION...

Breaks up clumps
(aggregates and
agglomerates) **BUT DOES
NOT GRIND THE PIGMENT.**

MAXIMIZES hiding power,
tint strength, gloss... and
eliminates grit.

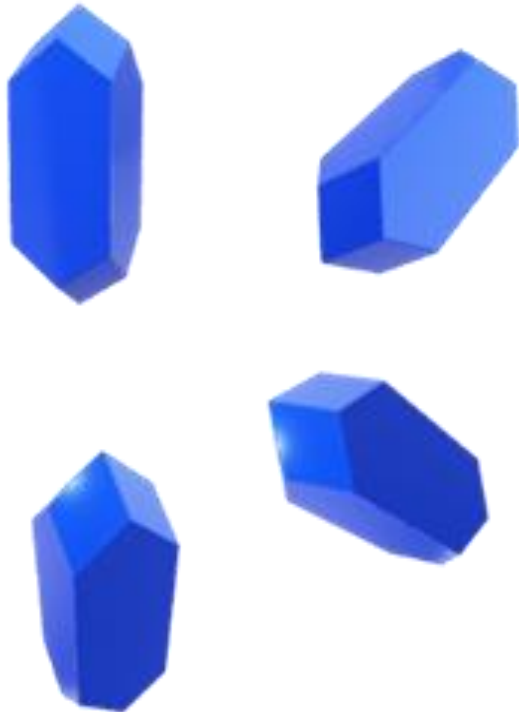
Ensures **UNIFORM
PIGMENT** in the paint.

SAVES TIME AND MONEY
(Fewer QC corrections)



DISPERSION - PARTICLES

PRIMARY PARTICLES



AGGREGATE



AGGLOMERATE



THE THREE STEPS OF DISPERSION

“Wetting” of the pigment.

“Pigment Grinding” particle size reduction.

“Stabilization” of the pigment against settling by the dispersant.



DISPERSION - WETTING

“Wetting” of the pigment.

Displaces contaminants (moisture, air...) from the pigments surface with a combination of resin, solvent and/or dispersant.

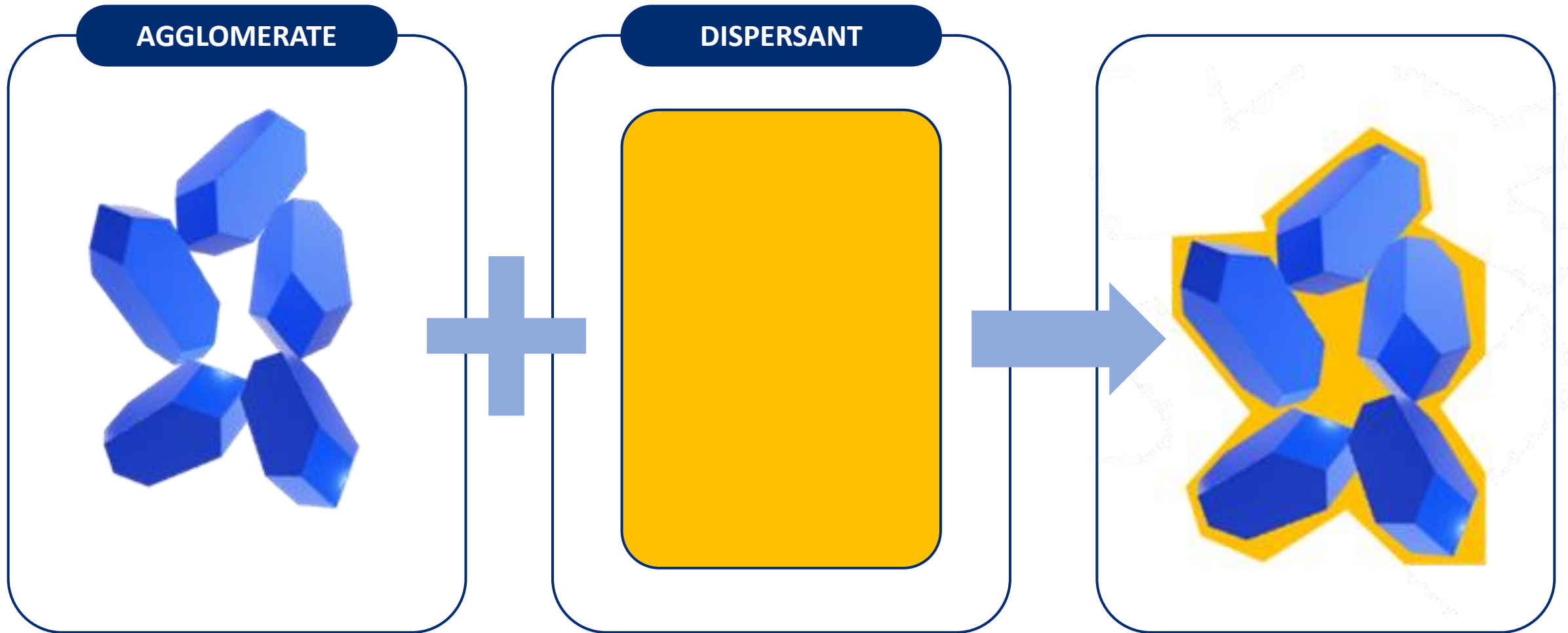
Organic and alumina treatments on the pigment aids in the wetting process.

Surfactants with lower surface tension will normally wet the surface quicker.

The **MOST CRITICAL STEP** in the dispersion.

DISPERSION - WETTING

WETTING OF THE PIGMENT



DISPERSION - GRINDING

**“Pigment Grinding”
particle size reduction.**

Mechanical breaking up of the chunks, clumps and clusters.

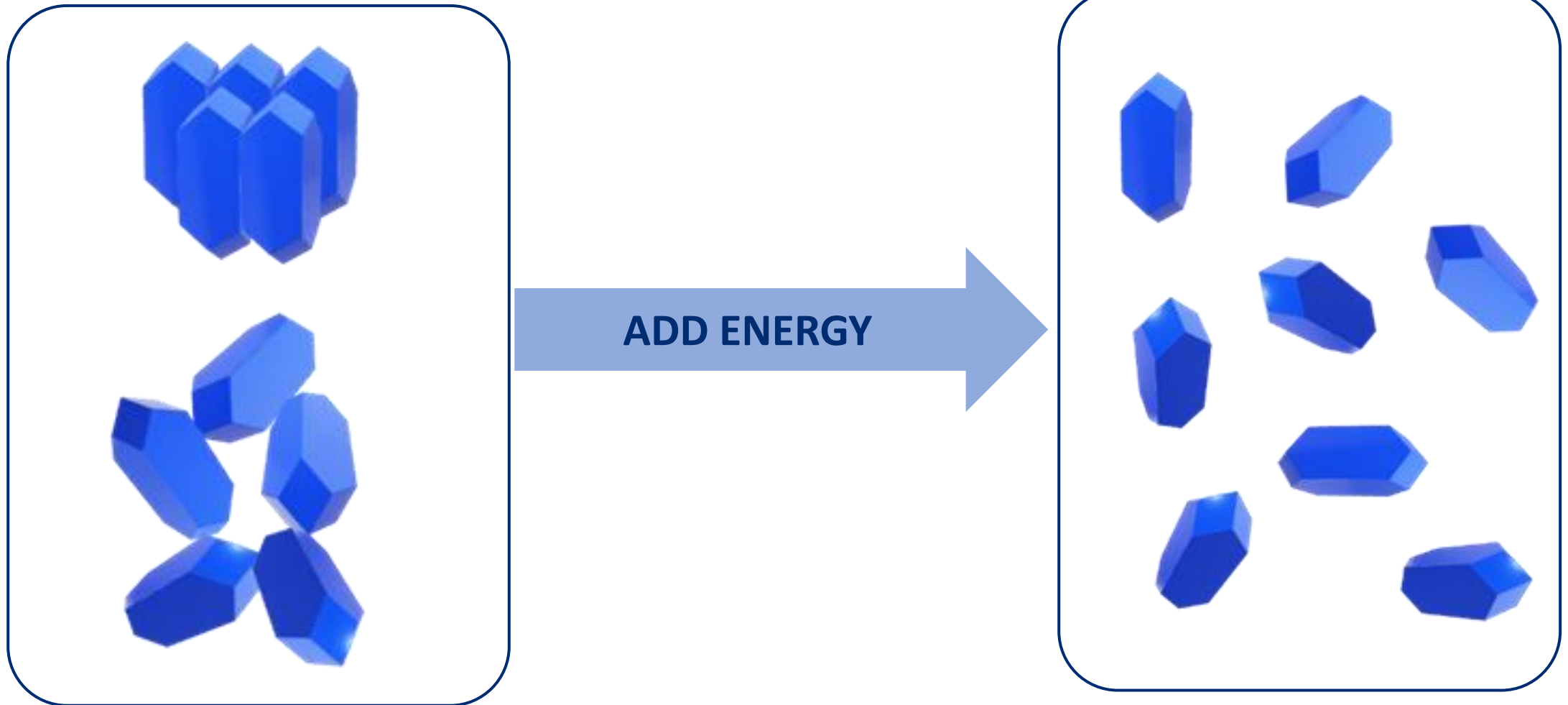
Individual particles are not ground up, just **separated** from each other.

Really **de-agglomeration or dispersion...** not grinding.

Do Not Reduce The Primary Particle Size!

DISPERSION - SEPARATION

DISPERSION OF THE PIGMENT



DISPERSION - STABILIZATION

“Stabilization” of the pigment against settling by the dispersant.

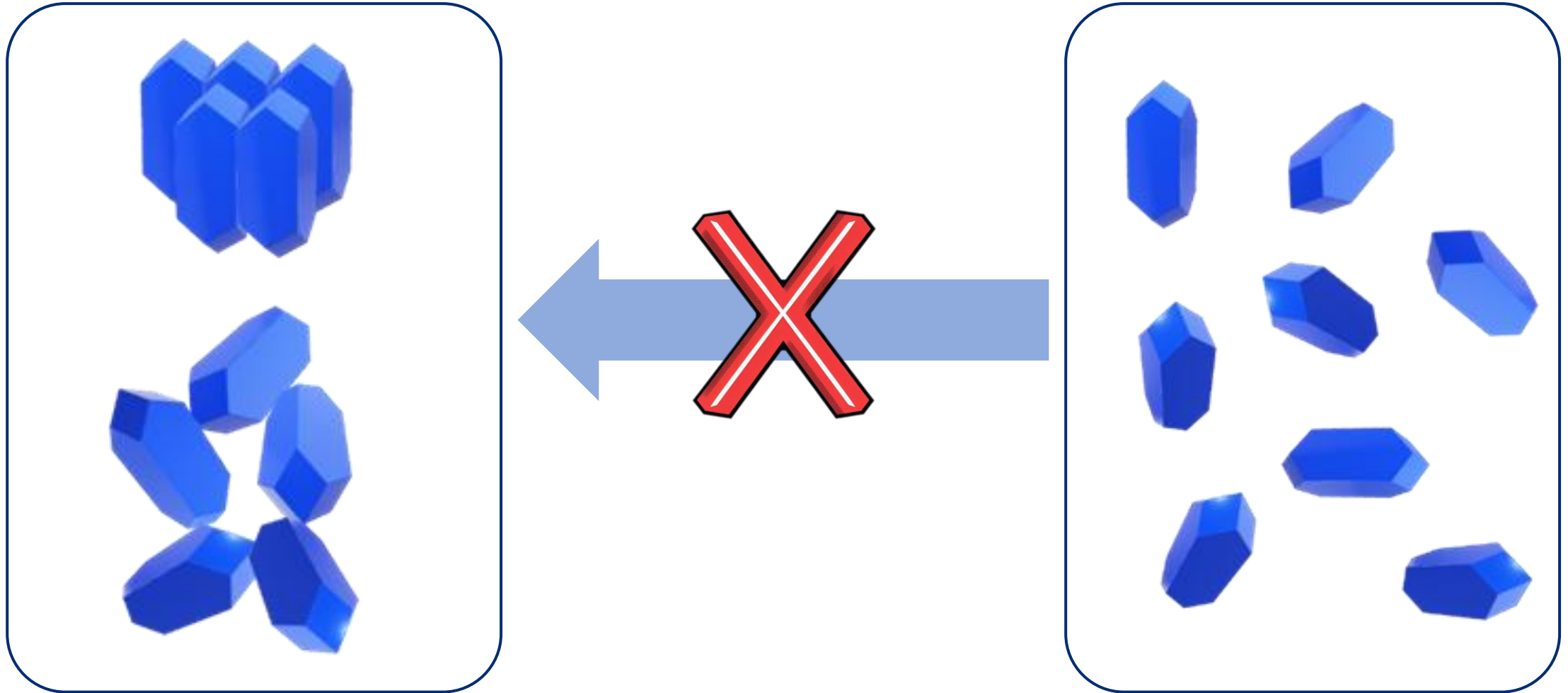
2 STEPS:

Movement of the wetted pigment particles into the liquid vehicle to **permanently separate particles.**

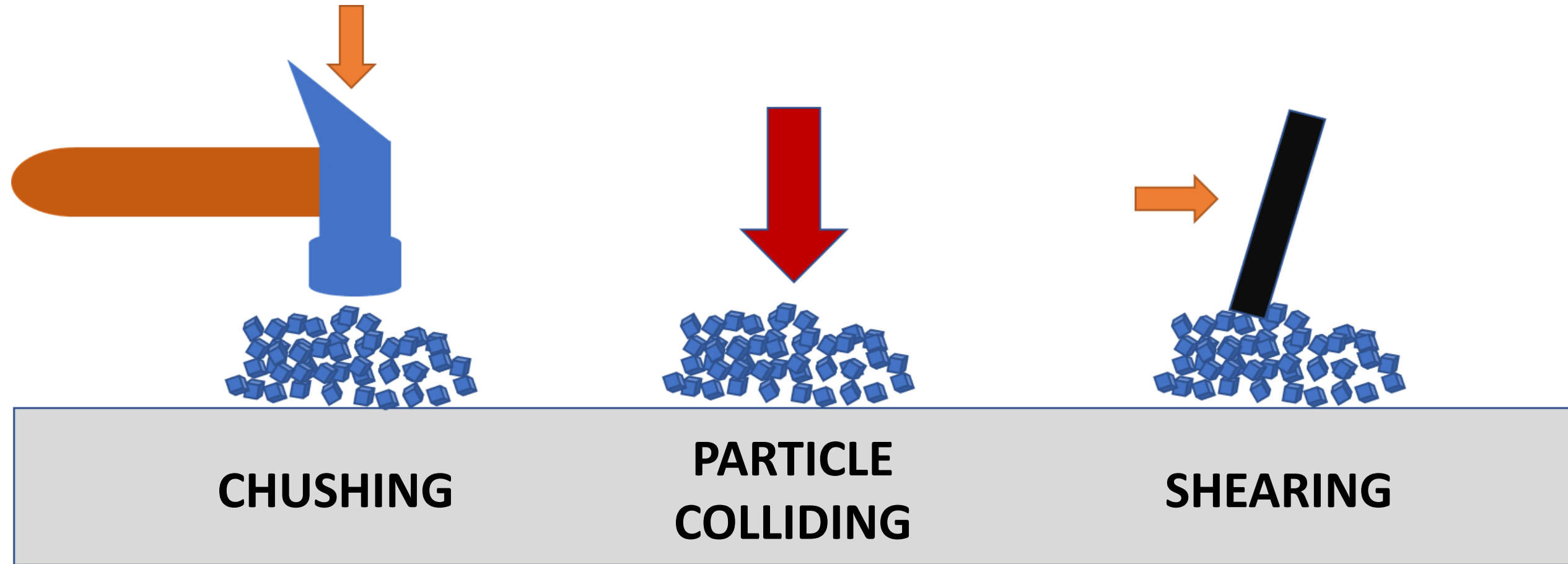
Stabilizing the dispersion to **prevent re-agglomeration, settling, kickout or flocculation.**

DISPERSION - STABILIZATION

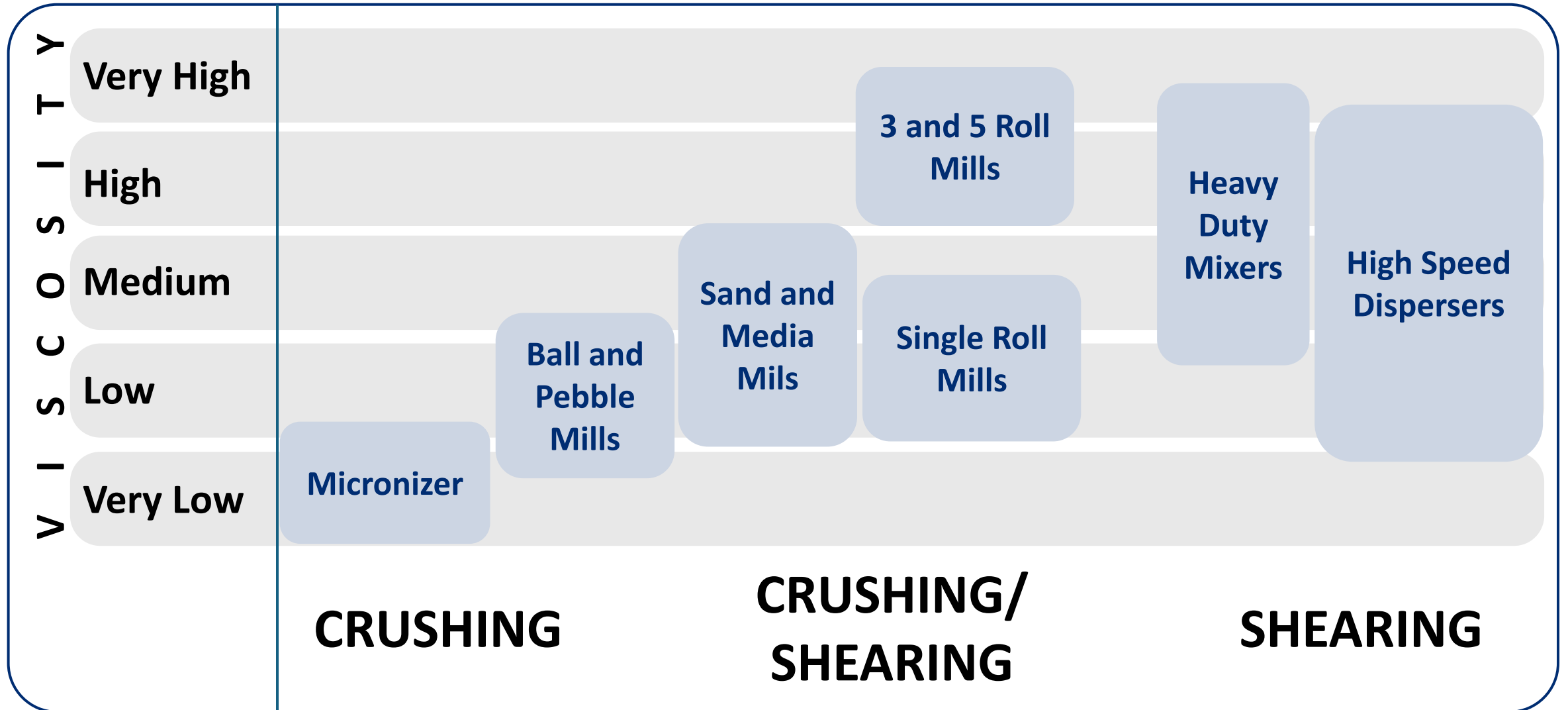
STABILIZATION OF THE PIGMENT



TYPES OF MECHANICAL DISPERSION FORCES



TYPES OF DISPERSION EQUIPMENT



DISPERSION EQUIPMENT

1.

Micronizes

2.

Ball and Pebble Mills

3.

Sand and Media Mills

4.

1,3 and 5 Roll Mills

5.

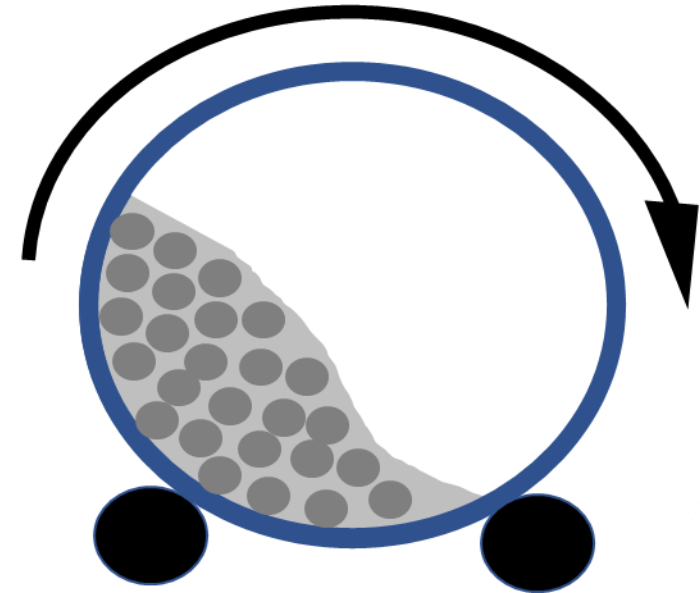
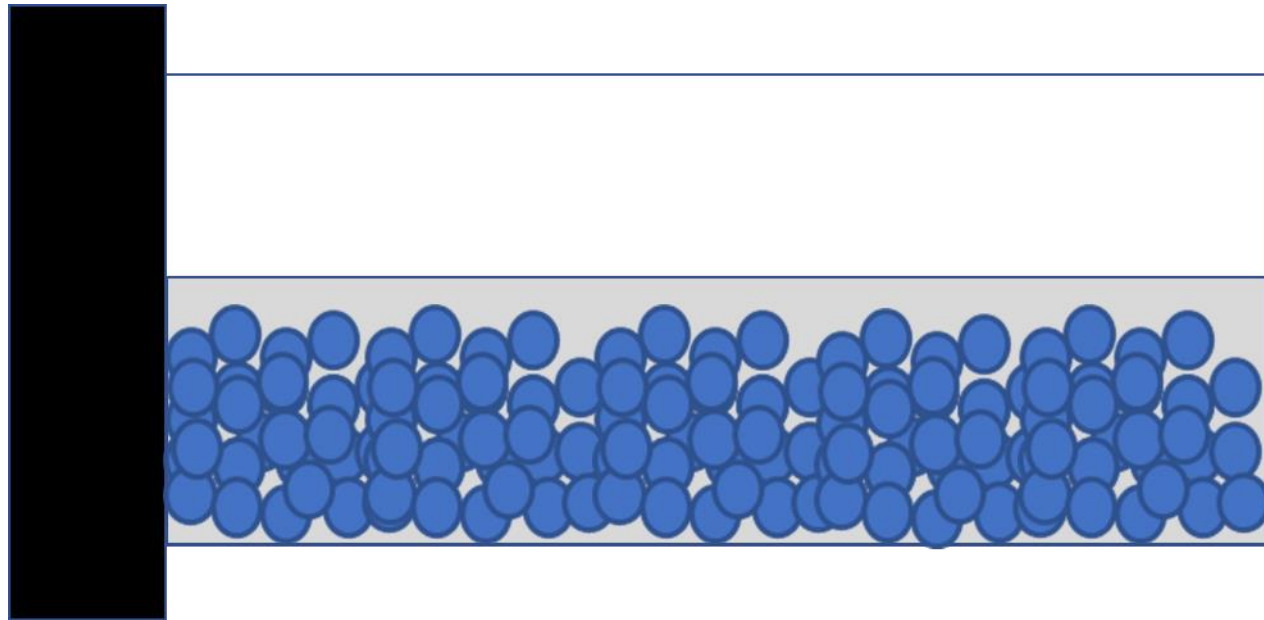
Heavy Duty Mixers and Basket Mills



DISPERSION EQUIPMENT

Ball and Pebble Mills

- Large Horizontal Drum 5-20 feet in diameter and 10-40 feet long
- Ceramic, stainless steel or stone balls $\frac{1}{2}$ inch to 6 inches in diameter
- Drum filled 50-75% with balls
- Slow rotation of the drum causes the balls to roll on top of each other



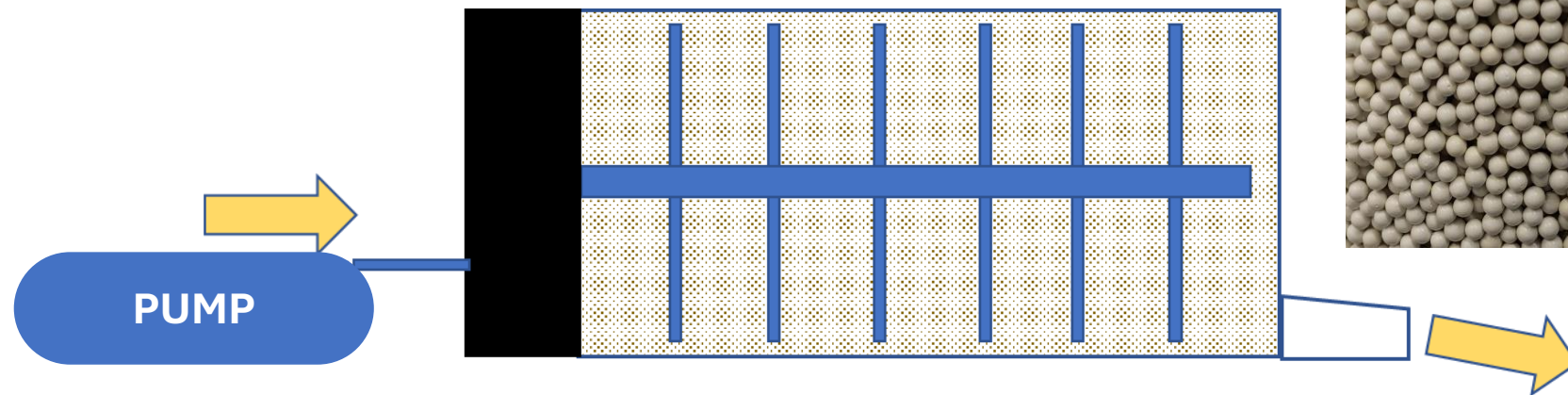
DISPERSION EQUIPMENT

Sand or Media Mill

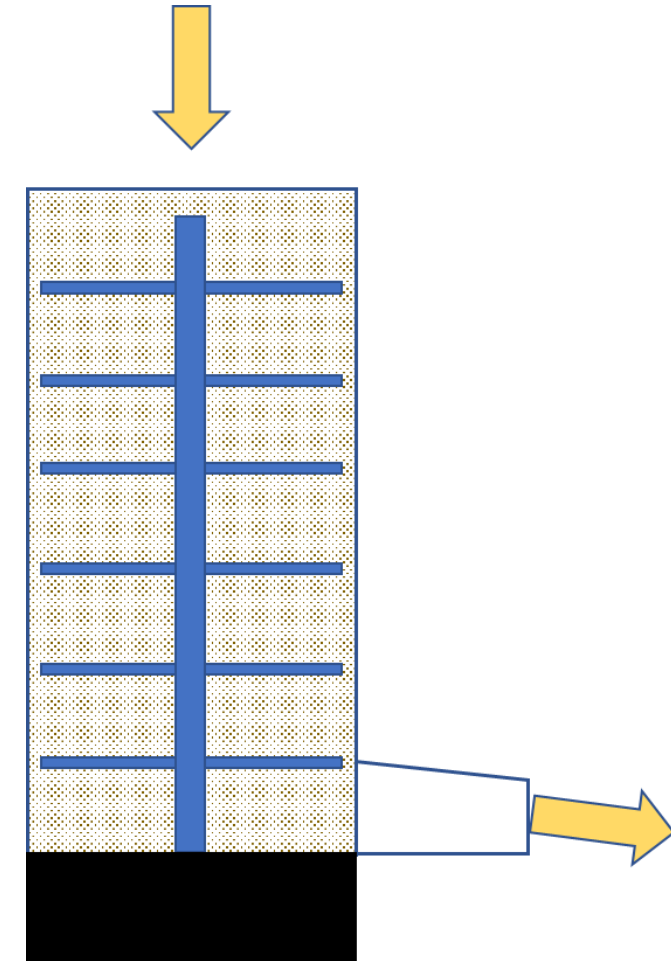
- Small media size up to several millimeters in diameter
- Horizontal or Vertical
- Rotating plates or paddles move the beads
- Gravity feed for vertical mills
- Pump feed for horizontal mills.



Horizontal Sand Mill

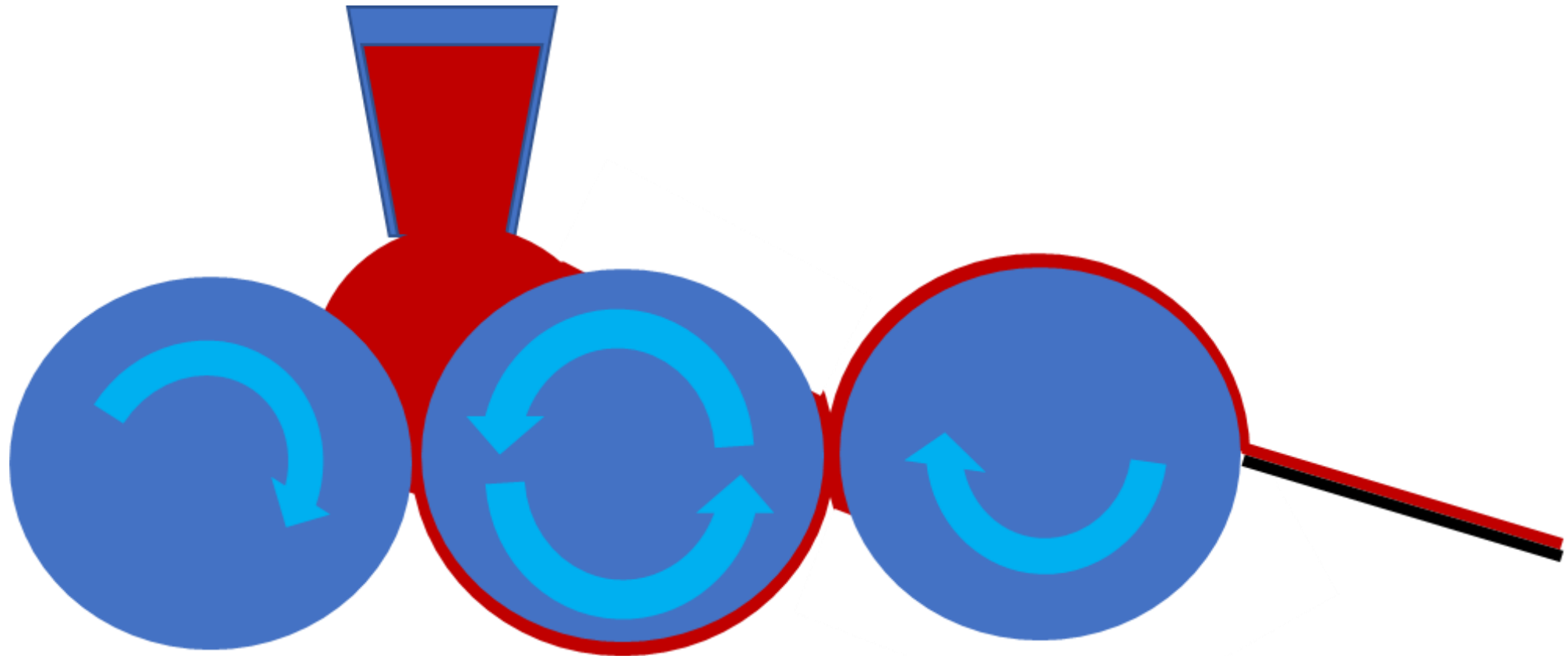


Vertical Sand Mill



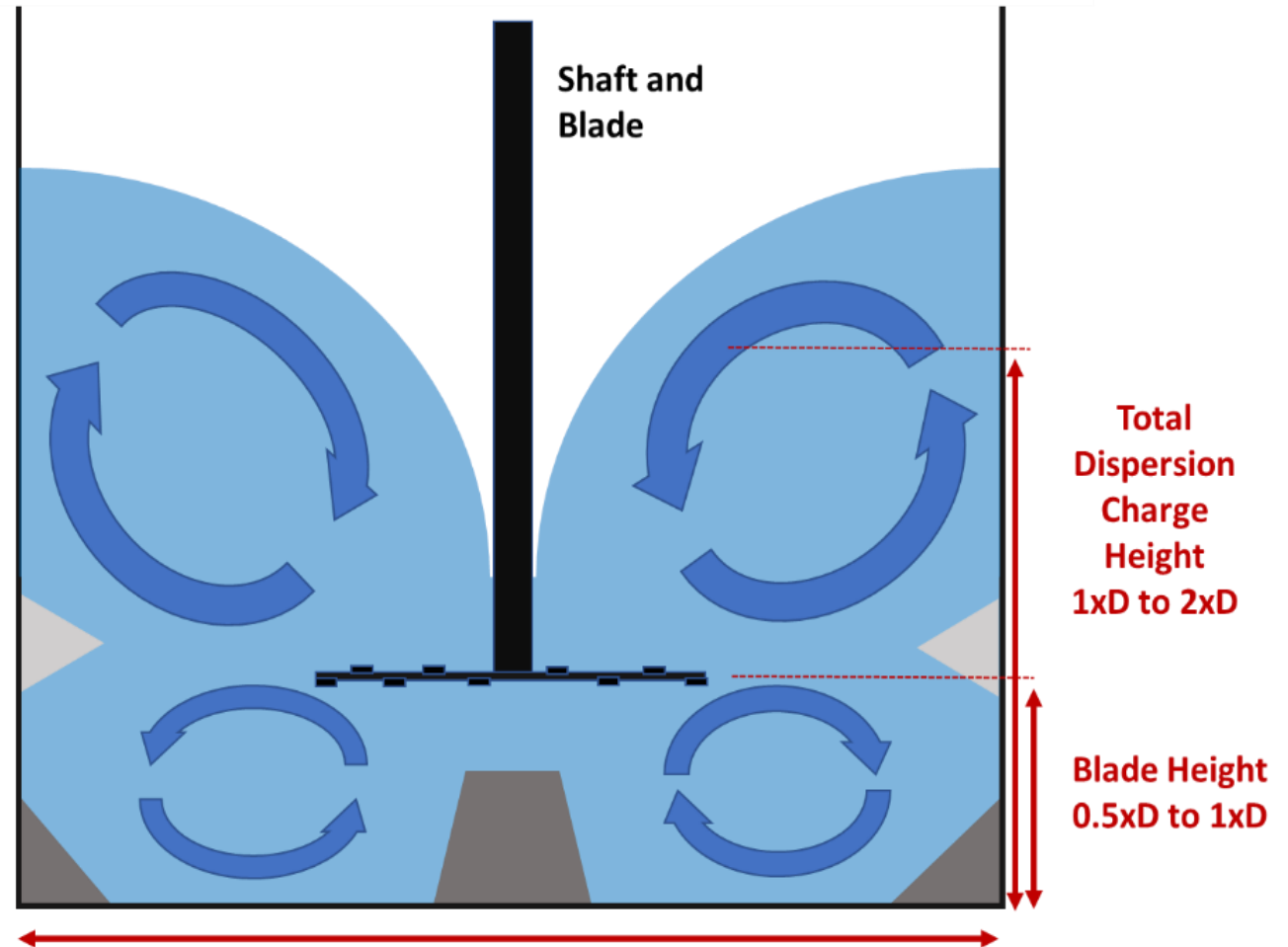
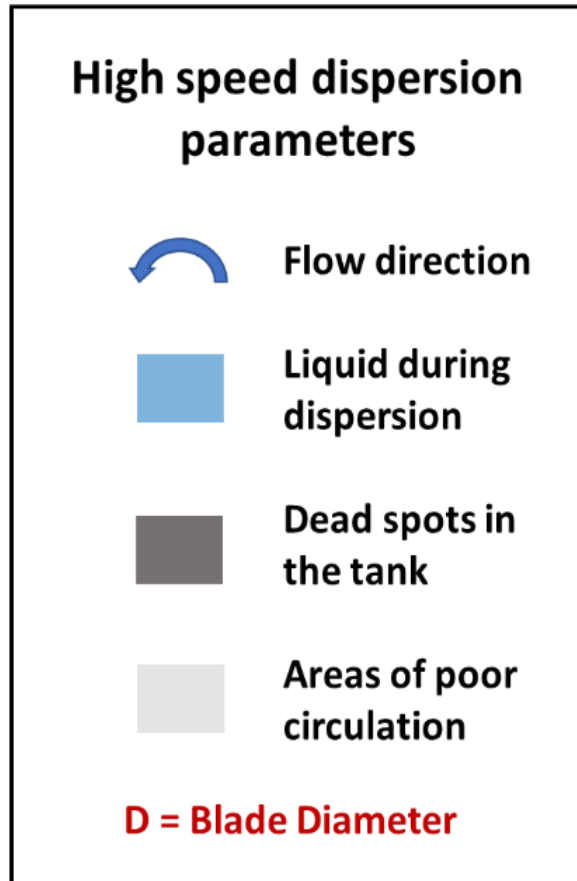
DISPERSION EQUIPMENT

3 and 5 Roll Mills



DISPERSION EQUIPMENT

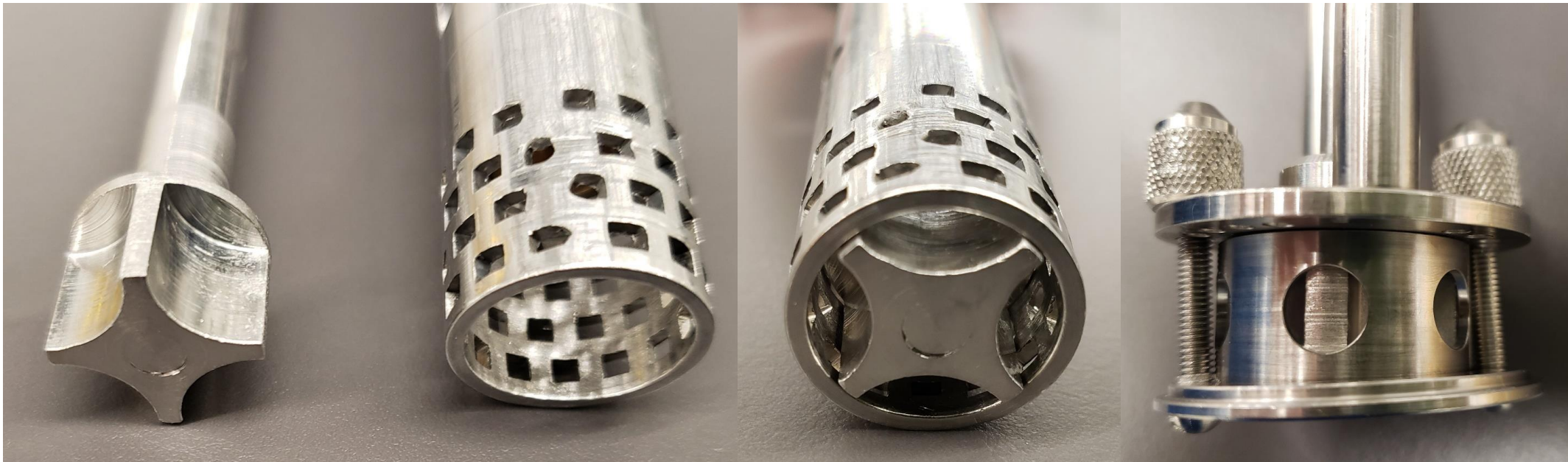
High Speed Disperser



DISPERSION EQUIPMENT

Heavy Duty Dispersers

- Rotor / Stator or Basket Mill
- Fixed outer “Stator” and internal rotating “Rotor”



HIGH SPEED DISPERSER

High Speed Disperser

- 25% of the dispersion takes place on the blade by shear
- 70% of the dispersion occurs in laminar flow as each layer of mill paste accelerates at as different rate
- The remaining 5% occurs as the mill paste circulates in the tank

Percentages from “Practical Paint Making” by George Goodwin



HIGH SPEED DISPERSION TIPS

High Speed Dispersion Tips

- ✓ Keep the top of the blade covered
- ✓ Minimum blade speeds of 4500 FPM (Maximum 5500 FPM)
- ✓ (FPM = 3.14 x Blade Diameter in feet x RPM)
- ✓ Lower speeds just heat up a batch without dispersing the pigment
- ✓ Dispersing more than 30 minutes could overheat the batch, break down resins or surfactants, and could over grind the pigment...

MORE IS NOT BETTER!

Adding more of raw material will **NOT** make the mill paste better

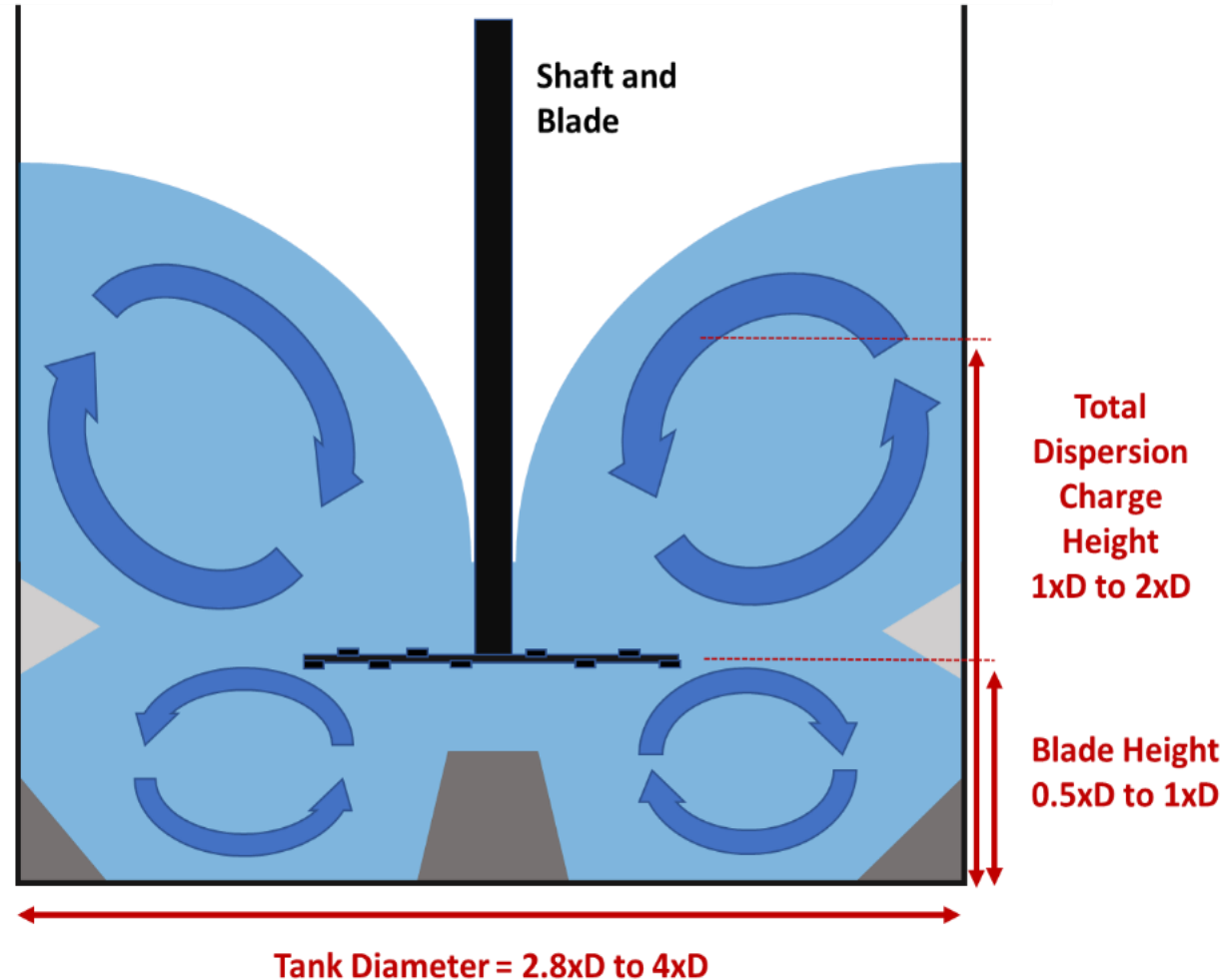
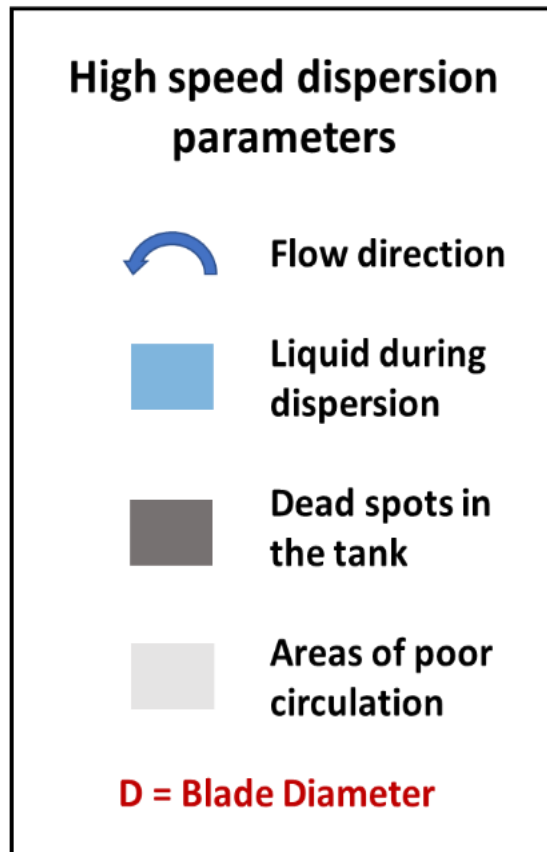
Mill base composition is the primary factor in **EFFICIENT DISPERSION**

More wetting agent **MAY BE WORSE** than too little

More resin or solvent may increase particle spacing and prevent shear forces from **DISPERSING THE PIGMENT**

HSD (HIGH SPEED DISPERSION)

High Speed Dispenser



VARIABLES INFLUENCING DISPERSING

PIGMENT TYPE

- Particle size and oil absorption
- Type and amount of inorganic treatment (dispersant demand)
- Moisture (high moisture increases inter – particles adhesion)

STORAGE CONDITIONS

- Moisture pick up
- Age

WORKING EFFICIENCY

- Mill base formulation
- Efficiency of dispersion unit / dispersion time and energy
- Mill Base volume and viscosity
- Mill base shock
- Quality of formula ingredients



WHAT HAPPENS WHEN PIGMENTS ARE NOT PROPERLY DISPersed?

Poor Hiding

Low tinting
strength

“Trashy” Looking
paint

Low or irregular
gloss

Color “rub-up”
(flocculation)

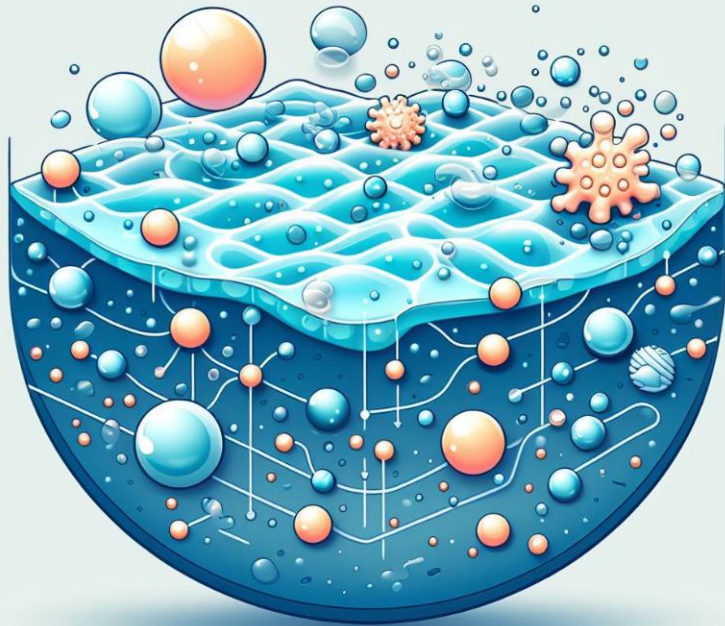
Settling

PHYSICAL CHEMICAL PROPERTIES

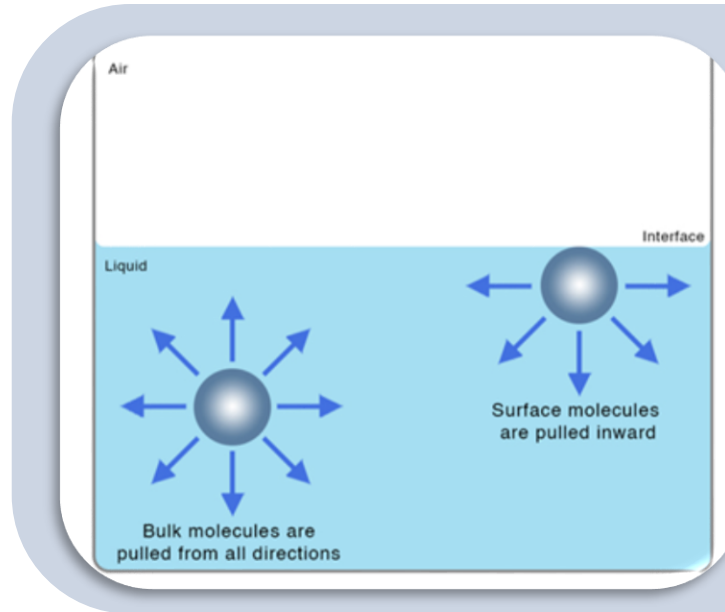
STATIC SURFACE TENSION

What is the definition of surface tension?

$$dW = \gamma d\sigma$$



What happens when a surfactant is added to water?



Intermolecular Forces

SUBSTANCE

SURFACE TENSION
(mN.m⁻¹)

Benzene

28.9

Mercury

472.0

Methanol

22.6

Water

72.8

EFFECT OF SURFACTANTS ON THE SURFACE TENSION

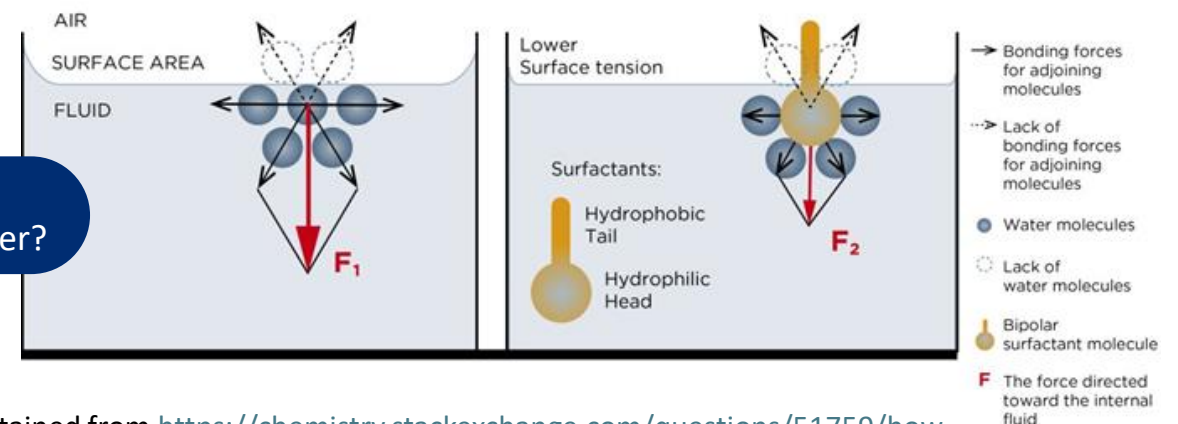
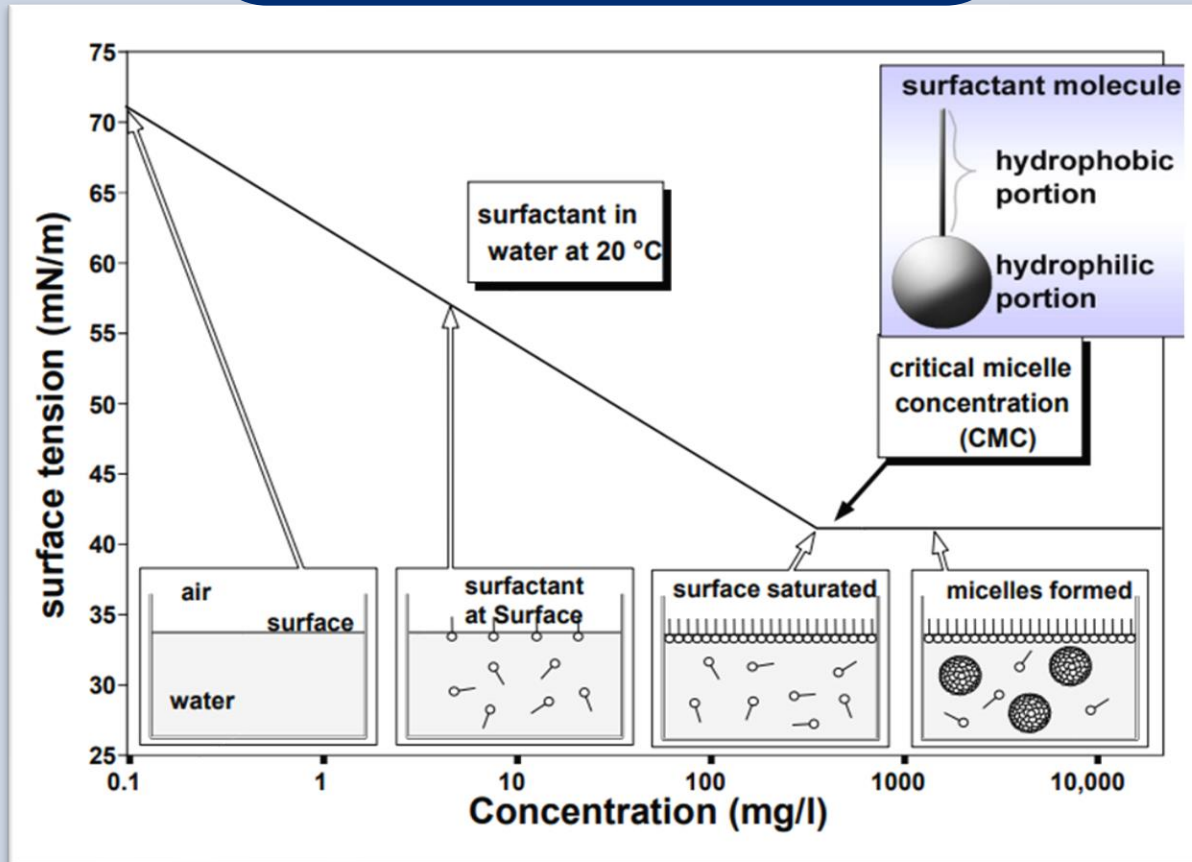


Image obtained from <https://chemistry.stackexchange.com/questions/51759/how-can-proteins-reduce-surface-tension>

PHYSICAL CHEMICAL PROPERTIES

STATIC SURFACE TENSION AND USEFUL PHYSICAL CHEMICAL PARAMETERS

Surfactant behavior in water and Surface Tension curves



Surface excess concentration ($\mu\text{mol}\cdot\text{m}^{-2}$)

$$\Gamma = -\frac{1}{RT} \cdot \frac{d\sigma}{d\ln c}$$

Area occupied by the molecule (\hat{A}^2)

$$A = \frac{1}{N\Gamma}$$

Adsorption free energy ($\text{kJ}\cdot\text{mol}^{-1}$)

$$G = RT \ln \frac{\text{CMC}}{\text{molarity of solvent}}$$

PHYSICAL CHEMICAL PARAMETERS

CONTACT ANGLE

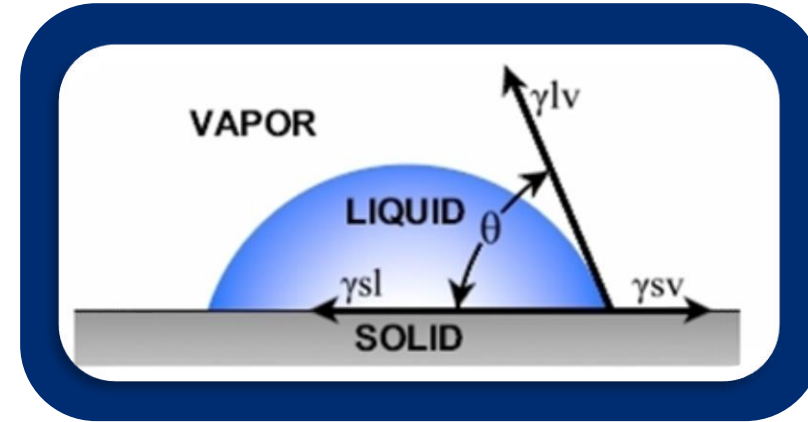
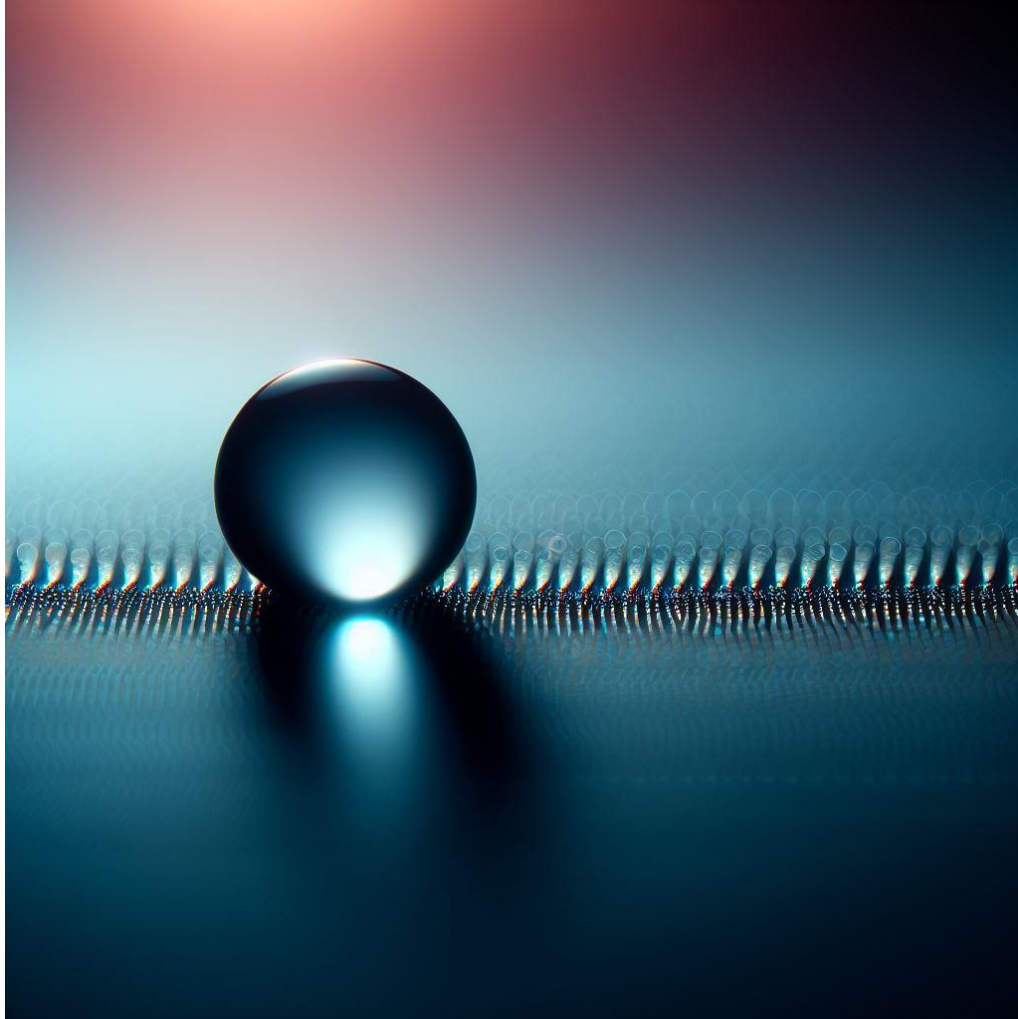


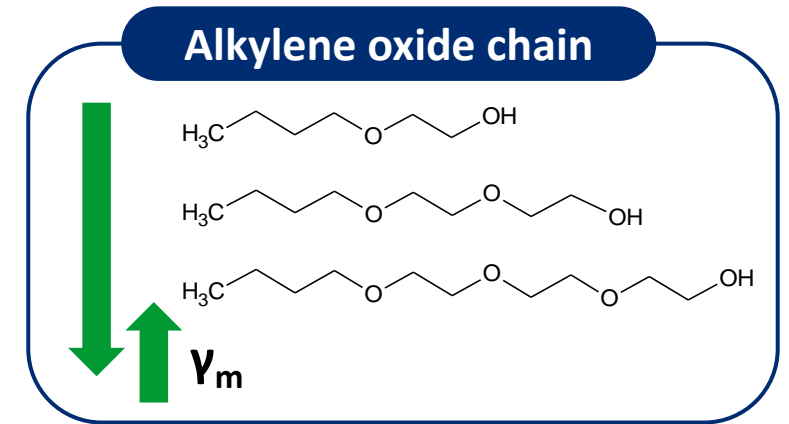
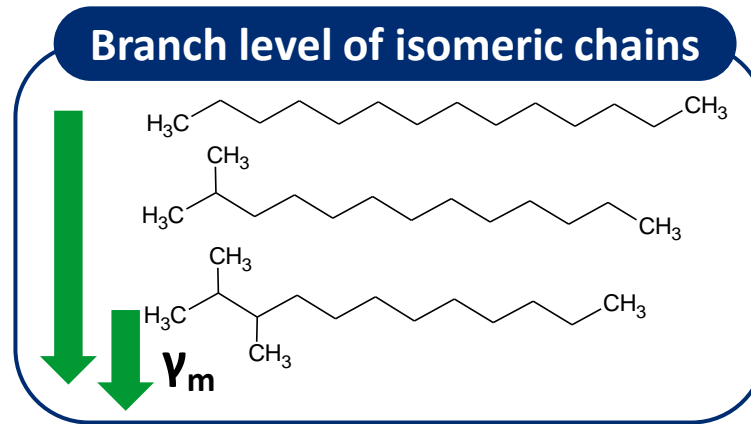
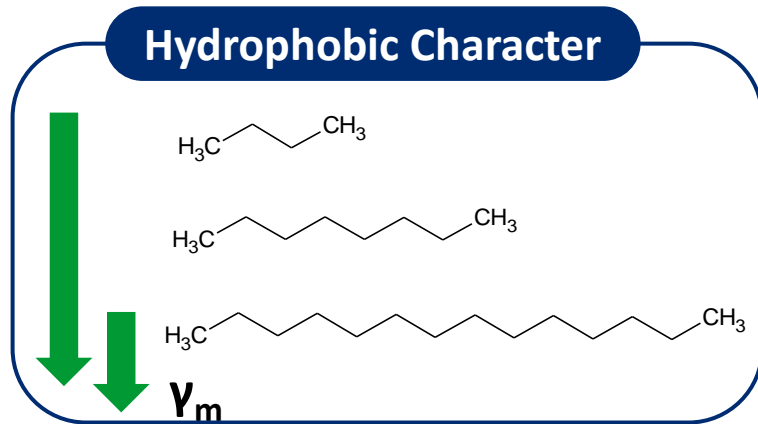
Image obtained from http://www.ramehart.com/contact_angle.htm

$\alpha = 0^\circ$		Spreading
$\alpha < 90^\circ$		Good Wetting
$\alpha = 90^\circ$		Incomplete wetting
$\alpha > 90^\circ$		Incomplete wetting
$\alpha > 180^\circ$		Nonwetting

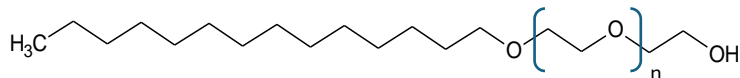
Image obtained and adapted from <https://www.sciencedirect.com/science/article/abs/pii/B9780323461399000086>

PHYSICAL CHEMICAL PARAMETERS

GENERAL TRENDS FOR NONIONIC SURFACTANTS

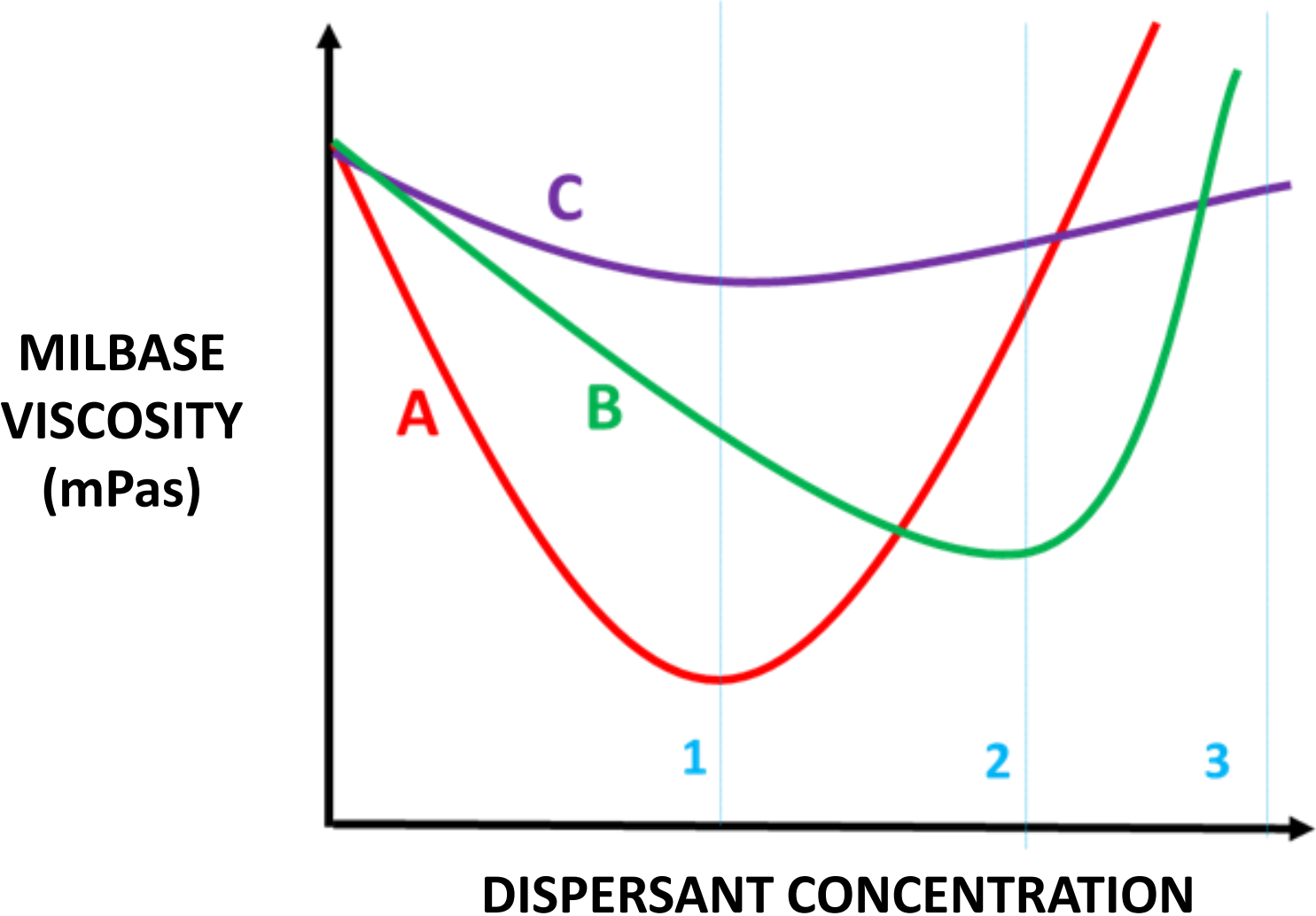


Lauryl alcohol with different degrees of ethylene oxide content



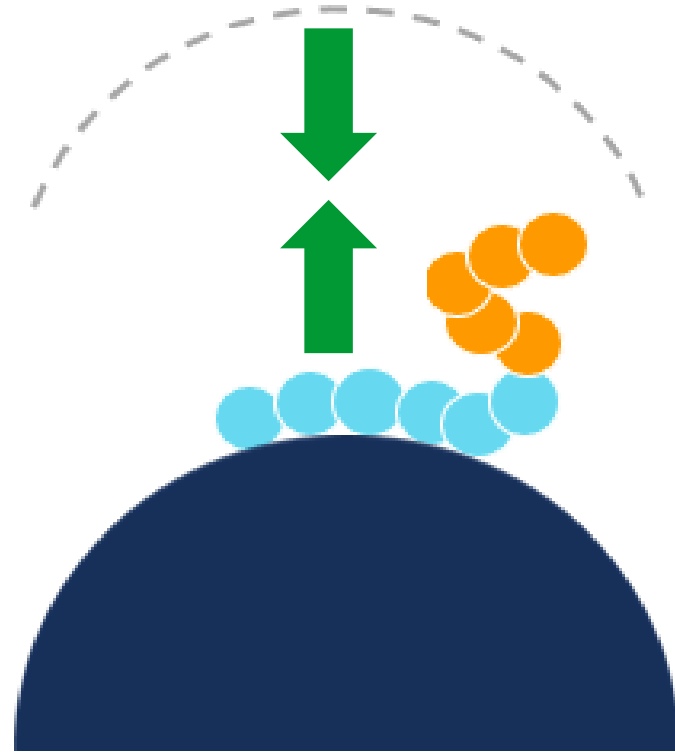
Sample	γ_m (mN.m ⁻¹)	t_i (ms)	t^* (s)	t_m (s)	Wetting time (s)	Contact angle
5 EO	27.0	34.7	0.21	8.0	11	34.3
6 EO	25.9	12.4	0.12	10.3	8	39.1
7 EO	24.4	8.1	0.12	26.1	7	39.9
8 EO	29.1	4.8	0.07	14.5	7	50.0
9 EO	31.2	2.9	0.05	13.2	11	54.6
10 EO	32.7	2.3	0.04	14.1	32	65.3
12 EO	34.7	3.2	0.04	5.7	29	65.5
23 EO	42.7	0.3	0.01	11.6	610	81.1

DISPERSING AGENT – DISPERSANT DEMAND

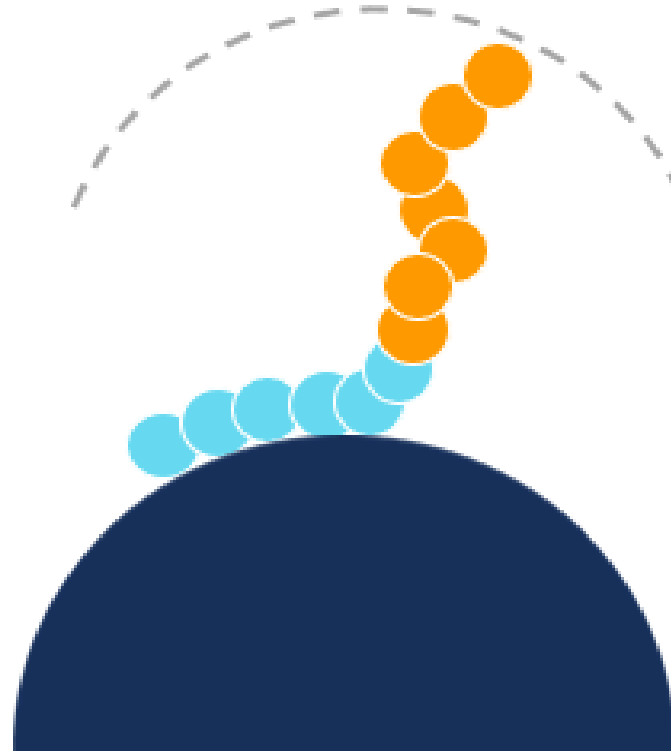


PIGMENT AFFINITY

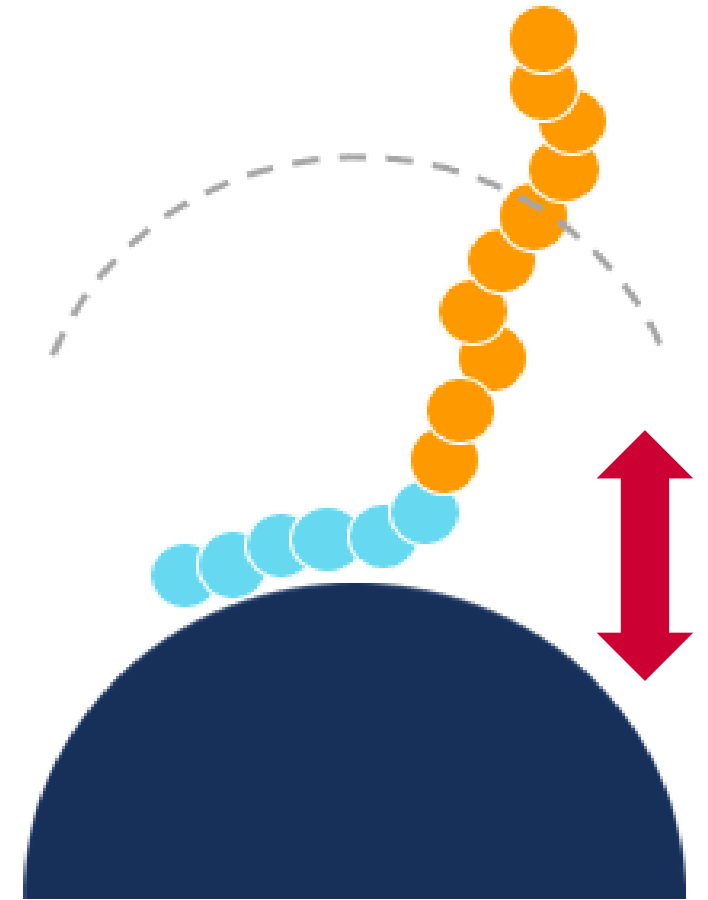
EFFECT OF TAIL LENGTH



Too short tail length – poor steric stabilization



Optimum tail length – good steric stabilization

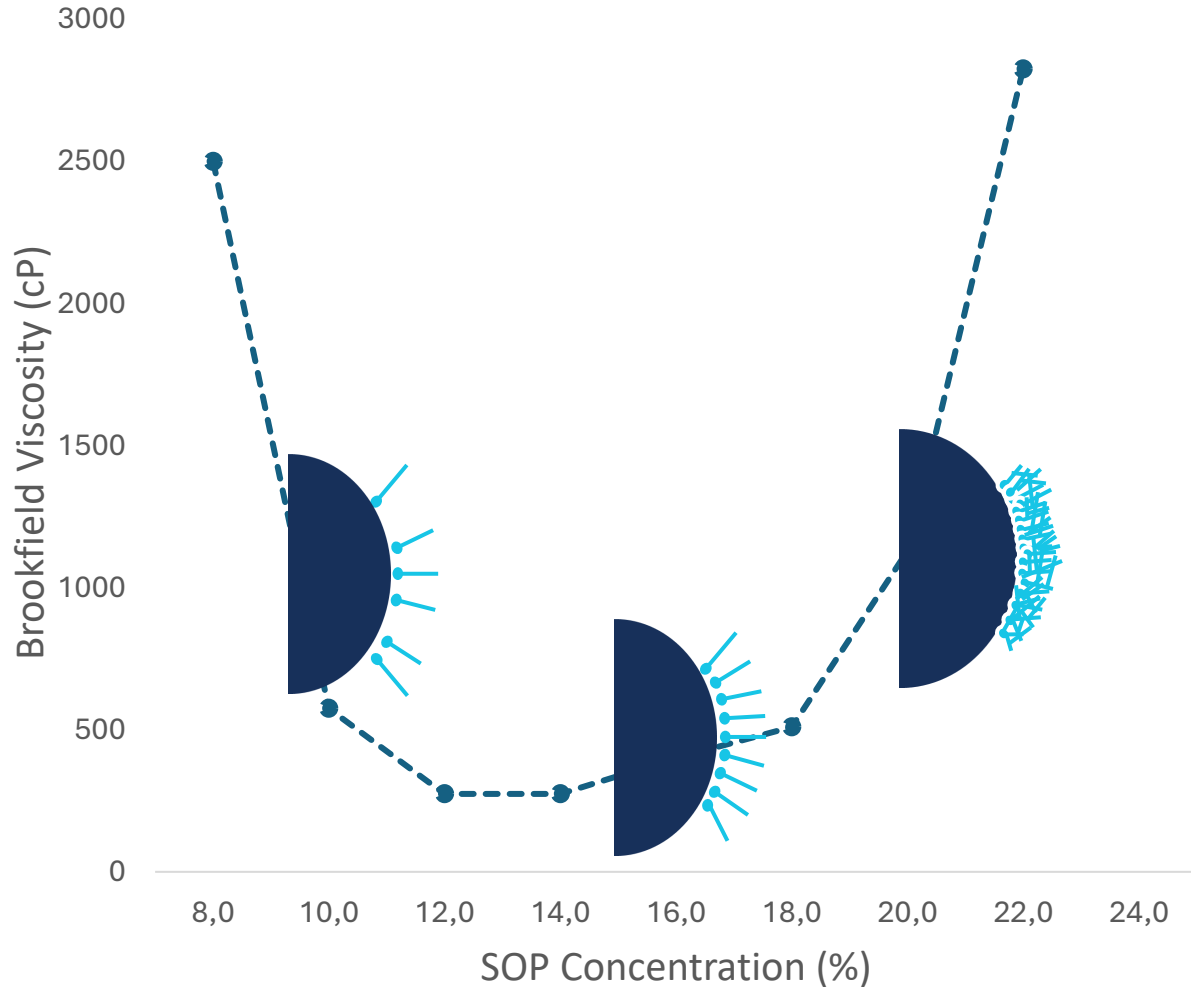
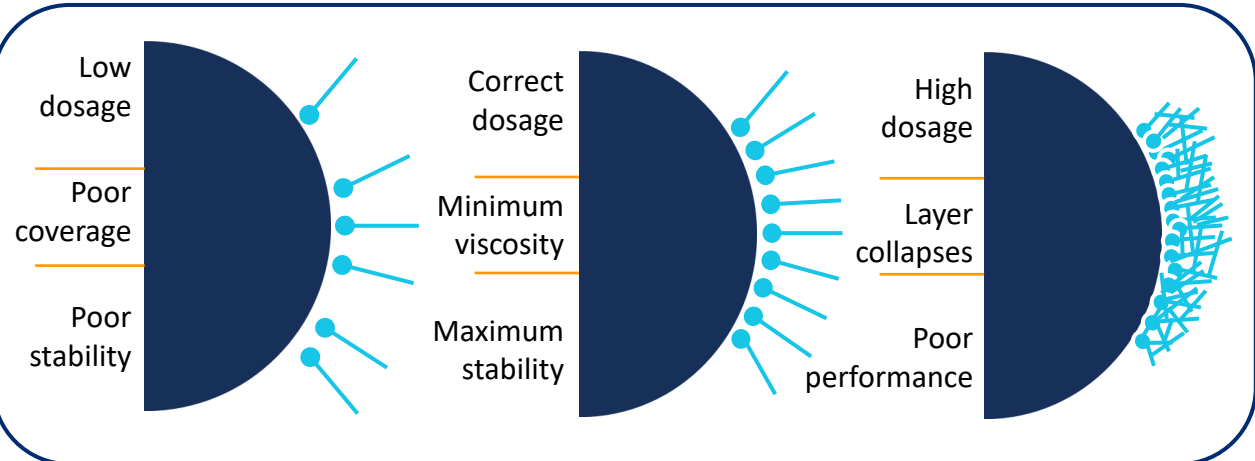


Too long tail length – poor steric stabilization

An appropriate selection of tail length is fundamental for optimizing pigment dispersions

DOSAGE SELCTION

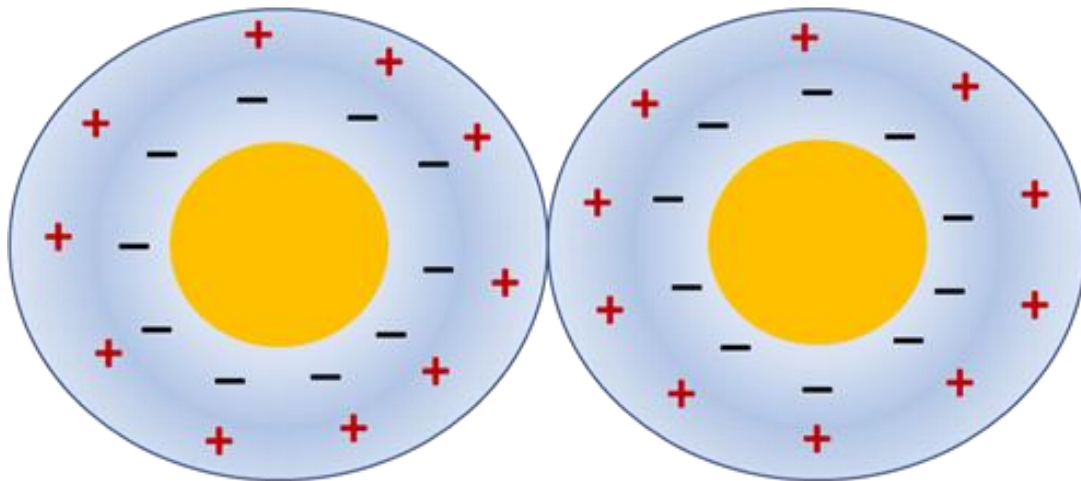
SURFACTANT DEMAND AND ITS IMPACT ON STABILITY AND PERFORMANCE



DISPERSING AGENTS

Charge Stabilization

Electrostatic Repulsion



+ Positive Charge

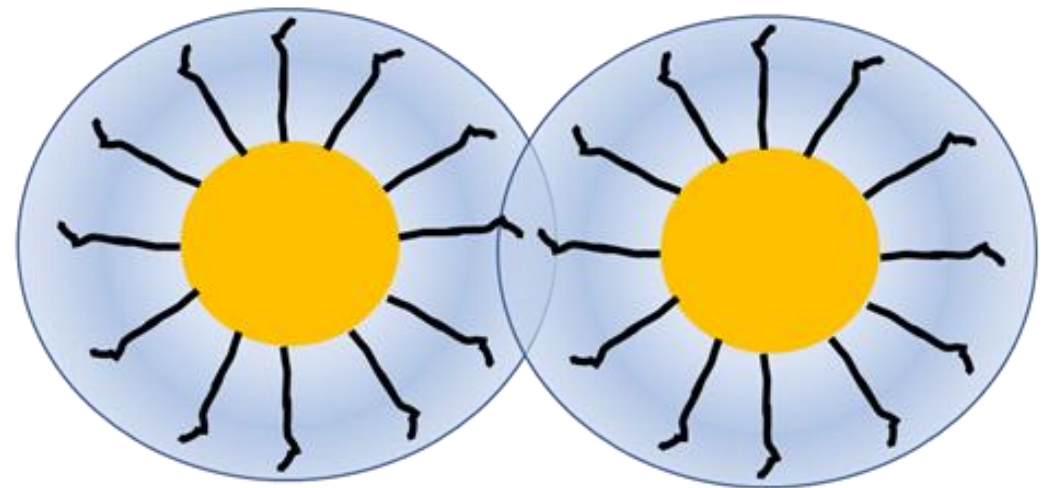
● Pigment Particle

- Negative Charge

● Stabilized Area

Steric Stabilization

Steric/Osmotic Repulsion



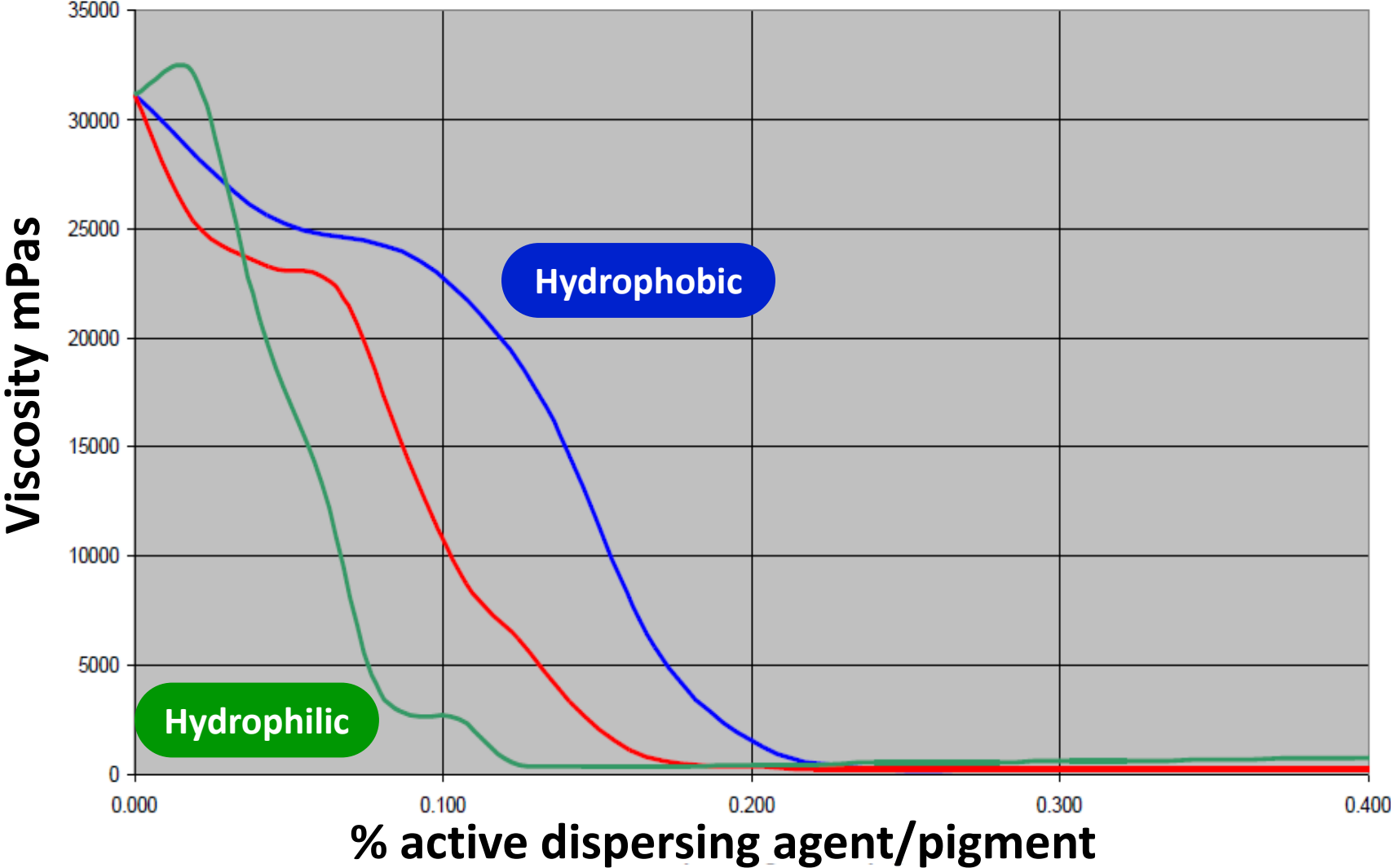
} Polymer Chain

● Pigment Particle

● Stabilized Area

DISPERSING AGENTS

HYDROPHILIC VERSUS HYDROPHOBIC



OXITIVE® 8000 SERIES

DISPERSING AGENTS

WATER-BASED

UNIVERSAL

SOLVENT BASED

WATER-BASED
PAINTS

SOLVENT BASED
PAINTS

Challenges Regarding Composition and VOC Limitations

OXITIVE® 8000 dispersing agents are APEO-Free and present zero to low VOC content

VOC of colorant added at the Point-of-Sale shall not exceed **50 g/L** above the level allowed for product without colorant.

Prohibited ingredients: Alkylphenol ethoxylates, Hazardous air pollutants



OXITIVE® 8000 SERIES

PROPERTIES DESIRED ON A PIGMENT CONCENTRATE

Maximum **PIGMENT LOAD & LOW VISCOSITY**

STABILITY – agglomeration and flocculation resistance

Maximum **TINTING STRENGTH**






































































































Good **COMPATIBILITY** with different systems

LOW IMPACT on final coatings properties



OXITIVE® 8000 SERIES

 Recommended use
  Standard Performance
  Good Performance
  Excellent Performance

PRODUCT	FUNCTION			PIGMENTS				APPLICATION		PERFORMANCE				APPEARANCE @25°C	SOLIDS (wt%)	HBL	CMC (g/L)	SURFACE TENSION 0.1% @25°C (mN/m)
	Dispersing agent	Wetting agent	Compatibilizing agent	Carbon Black	Organic	Inorganic	Titanium Dioxide	Waterborne Systems	Alkyd solvent-borne system	Dispersant demand	Viscosity reduction	Tinting strength	Reduced rub-out					
OXITIVE® 8201														Paste	~100	13.5	0.02	43.1
OXITIVE® 8216														Liquid	~100	12.7	0.01	40.8
OXITIVE® 8225														Solid	~100	14.5	0.03	45.9
OXITIVE® 8254														Solid	~100	17.0	0.06	44.6
OXITIVE® 8122														Liquid	~98	-	0.03	43.9
OXITIVE® 8123														Liquid	~98	-	0.04	43.7
OXITIVE® 8125														Liquid	~45	-	0.06	43.3
OXITIVE® 8184														Liquid	~100	-	0.07	47.4
TERIC® 465														Liquid	~97	13.4	-	38.7
TERIC® 1836														Liquid	~100	12.2	-	37.7



PERFORMANCE TESTS

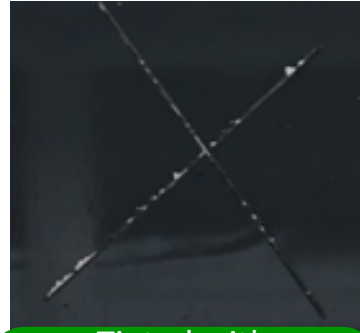
COMPATIBILITY WITH DIFFERENT SYSTEMS

ALKYD SOLVENT-BORNE ENAMEL

Adherence evaluation according to ASTM D3359 – Method A



White base



Tinted with
OXITIVE® 8201

WATERBORNE ACRYLIC SEMIGLOSS PAINT

Leaching evaluation according to ASTM D7190

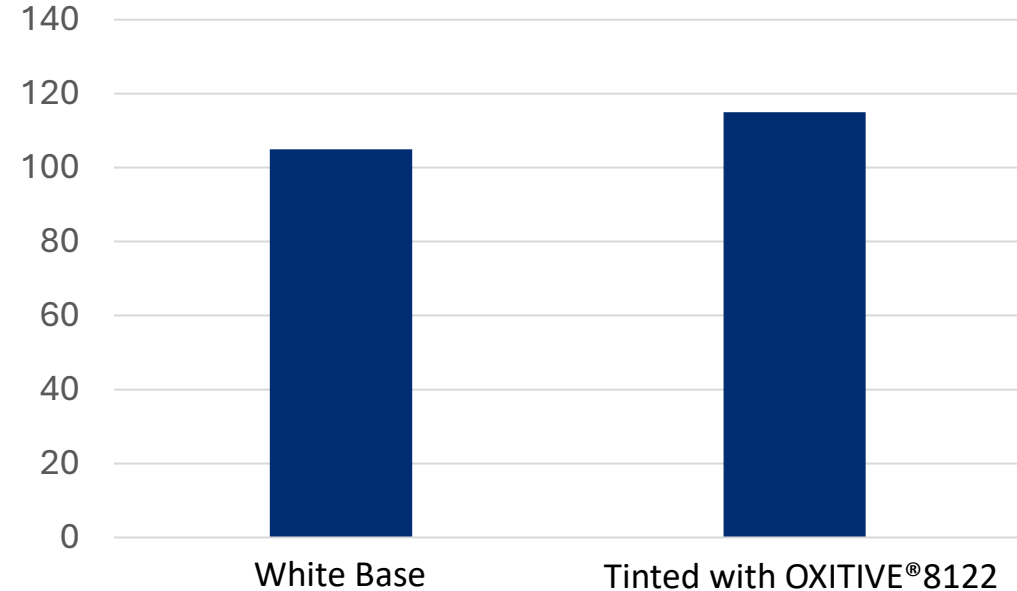


White base



Tinted with
OXITIVE® 8216

WATER-BASED ACRYLIC MATTE PAINT



Scrub resistance evaluation according ASTM Method A D2486

Pigment concentrates prepared with **OXITIVE® 8000** dispersing agents present **low impact on final coatings properties.**

OXITIVE® 8000 SERIES CONCLUSIONS



AVAILABLE GRADES for different types of pigment



Reduces viscosity, maximizes pigment load and **TINTING STRENGTH**



COMPATIBILITY with waterborne and some solvent-borne systems



Enhances stability and **REDUCES RUB-OUT**



Available grades for **UNIVERSAL PIGMENT CONCENTRATES**



HIGH ACTIVES content and **LOW USE LEVELS** required



Enables the formulation of **LOW TO ZERO-VOC** Pigment Concentrates



QUESTIONS?





Contato

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