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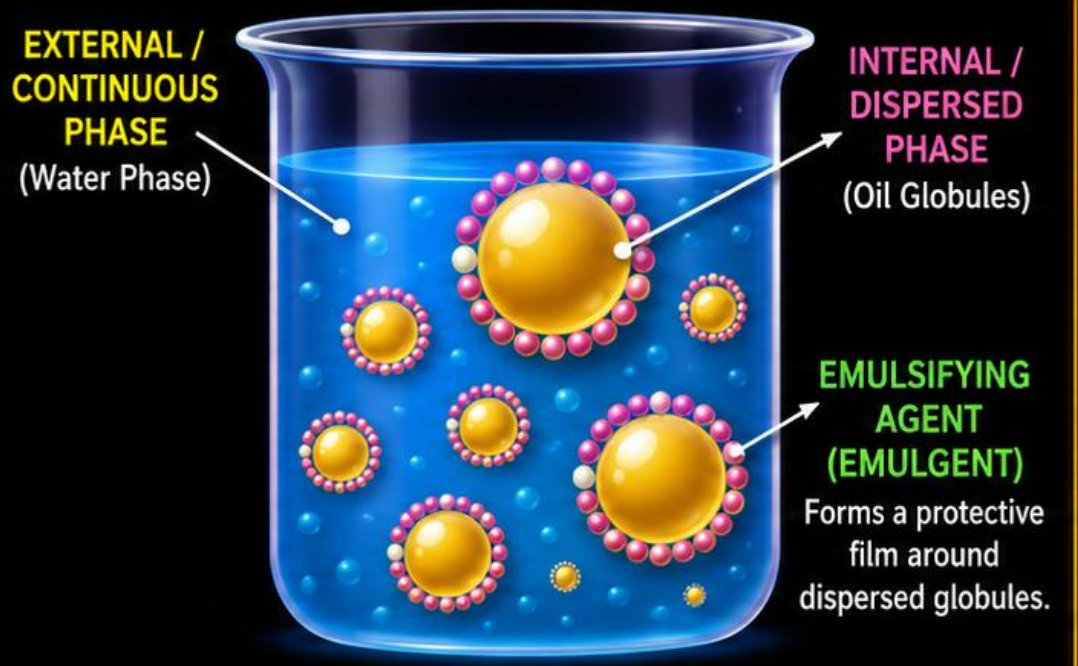
# EMULSIONS
# इमल्शन

## English Explanation

- Emulsion is a **thermodynamically unstable** system of at least two immiscible liquids.
- One liquid is **dispersed as globules** (**internal or dispersed phase**) in another liquid (**external or continuous phase**).
- Stability is maintained by an **emulsifying agent or emulgent**.
- Emulsions are **coarse dispersions** with globule size about **0.1–100 µm**.
- Oil-water oral liquids that **must be shaken before use** are common emulsions.
- Emulgent forms a **protective film** around dispersed globules.
- **Examples**: **oral emulsion**, **cosmetic emulsion**, **parenteral emulsion**, **diagnostic emulsion**.




### TYPES / EXAMPLES OF EMULSIONS

| ORAL EMULSION | COSMETIC EMULSION | PARENTERAL EMULSION | DIAGNOSTIC EMULSION |
|---|---|---|---|
| e.g., Castor oil, Cod liver oil | e.g., Vanishing cream | Fat-soluble vitamins, A, D, E, K, etc. | Radio-opaque emulsion for X-ray |

## हिंदी व्याख्या

- इमल्शन कम-से-कम दो अमिश्रणीय द्रवों की **थर्मोडायनेमिकली अस्थिर** प्रणाली है।
- एक द्रव **छोटे ग्लोब्यूल्स** के रूप में दूसरे द्रव में विसरित रहता है।
- आंतरिक/विसरित चरण = **dispersed phase**; बाह्य/सतत चरण = **continuous phase**।
- इसकी स्थिरता **इमल्सीफाइंग एजेंट** या **इमल्जेंट** से बनी रहती है।
- इमल्शन **स्थूल विसरण** होते हैं, जिनका ग्लोब्यूल आकार लगभग **0.1–100 माइक्रोमीटर** होता है।
- तेल-जल वाले मौखिक द्रव जिन्हें उपयोग से पहले **हिलाना पड़ता है**, सामान्यतः इमल्शन होते हैं।
- **उदाहरण**: **oral**, **cosmetic**, **parenteral** तथा **diagnostic emulsion**।

# TYPES OF EMULSION
# इमल्शन के प्रकार

## English Explanation

- **O/W emulsion**: oil is dispersed phase and water is continuous phase.
- Preferred for internal use; common example: vanishing cream and many oral emulsions.
- **W/O emulsion**: water is dispersed phase and oil is continuous phase.
- Mainly used externally; common example: cold cream.
- Multiple emulsions contain more than two phases.
- **W/O/W** = water globule inside oil droplet dispersed in water; **O/W/O** = oil globule inside water droplet dispersed in oil.
- Multiple emulsions are also called liquid membrane systems.

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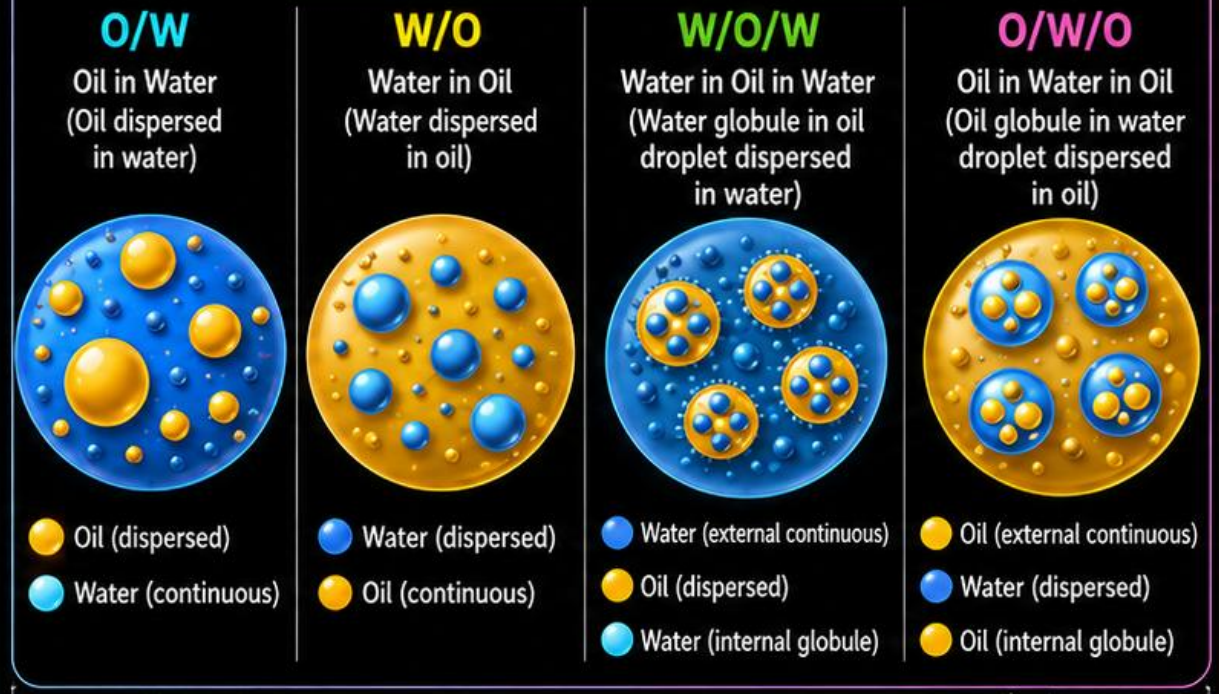
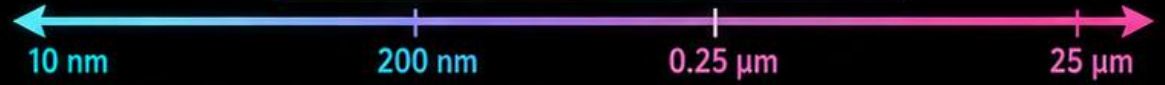
- Micro/nanoemulsion: 10–200 nm, transparent or translucent, thermodynamically stable.
- Fine emulsion: 0.25–25 µm, milky appearance.

## CLASSIFICATION OF EMULSIONS




## SIZE SPECTRUM: EMULSION SYSTEMS




**MICRO/NANOEMULSION**
10–200 nm
Transparent or translucent, thermodynamically stable.

**FINE EMULSION**
0.25–25 µm
Milky appearance.

## हिंदी व्याख्या

- **O/W** इमल्शन में तेल dispersed phase तथा जल continuous phase होता है।
- यह आंतरिक उपयोग के लिए उपयुक्त होता है; उदाहरण: vanishing cream तथा कई oral emulsions।
- **W/O** इमल्शन में जल dispersed phase तथा तेल continuous phase होता है।
- यह मुख्यत: बाह्य उपयोग में काम आता है; उदाहरण: cold cream।
- दो से अधिक चरण वाले इमल्शन को multiple emulsion कहते हैं।
- **W/O/W** = जल-ग्लोब्यूल वाले तेल कण जल में; **O/W/O** = तेल-ग्लोब्यूल वाले जल कण तेल में।
- Multiple emulsions को liquid membrane systems भी कहते हैं।

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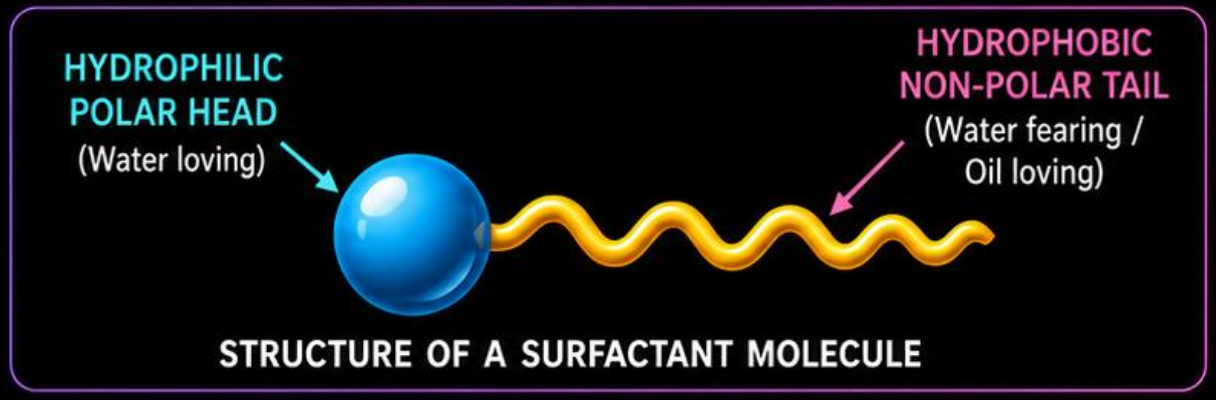
- Micro/nanoemulsion: 10–200 nm, पारदर्शी/अर्धपारदर्शी, thermodynamically stable।
- Fine emulsion: 0.25–25 µm, सामान्यत: milky दिखता है।

# SURFACTANT EMULSIFYING AGENTS

## सर्फेक्टेंट इमल्सीफाइंग एजेंट

## English Explanation

- Surface active agents or surfactants act as important emulsifying agents.
- A surfactant has a hydrophilic polar head and a hydrophobic non-polar tail.
- Anionic agents (negative charge): sodium lauryl sulphate, sodium oleate, sodium cetyl sulphate.
- Cationic agents (positive charge): cetrimide, benzalkonium chloride.
- Non-ionic agents (no charge): Spans, Tweens, Myrj 45, Brij 35, Pluronics.
- Ampholytic agents (charge depends on pH): lecithin.
- These agents reduce interfacial tension and stabilize dispersed globules.




STRUCTURE OF A SURFACTANT MOLECULE

### CLASSIFICATION OF SURFACTANT EMULSIFYING AGENTS

| ANIONIC AGENTS (Negative Charge) | CATIONIC AGENTS (Positive Charge) | NON-IONIC AGENTS (No Charge) | AMPHOLYTIC AGENTS (Charge depends on pH) | FUNCTION |
|---|---|---|---|---|
| sodium lauryl sulphate, sodium oleate, sodium cetyl sulphate. | cetrimide, benzalkonium chloride. | Spans, Tweens, Myrj 45, Brij 35, Pluronics. | lecithin. | Reduce interfacial tension and stabilize dispersed globules. |

## हिंदी व्याख्या

- Surface active agents या surfactants महत्वपूर्ण emulsifying agents होते हैं।
- Surfactant में hydrophilic polar head तथा hydrophobic non-polar tail होता है।
- Anionic agents (negative charge): sodium lauryl sulphate, sodium oleate, sodium cetyl sulphate।
- Cationic agents (positive charge): cetrimide, benzalkonium chloride।
- Non-ionic agents (no charge): Spans, Tweens, Myrj 45, Brij 35, Pluronics।
- Ampholytic agents (pH पर charge बदलता है): lecithin।
- ये agents interfacial tension कम करके dispersed globules को स्थिर करते हैं।

# OTHER EMULSIFYING AGENTS / अन्य इमल्सीफाइंग एजेंट

## English Explanation

- **Hydrophilic colloids** are useful emulsifying agents.
- Natural **plant origin:** acacia, tragacanth, agar, starch, pectin, Irish moss.
- Natural **animal origin:** gelatin, egg yolk, wool fat (lanolin).
- **Semisynthetic agents:** methyl cellulose, sodium CMC, hydroxypropyl cellulose.
- **Finely divided solids** can also stabilize emulsions.
- **Colloiidal clays:** bentonite and veegum.
- **Metallic hydroxides:** magnesium hydroxide, aluminium hydroxide, magnesium trisilicate.
- Such agents form **protective films** or **rigid interfacial barriers** around globules.

## CLASSIFICATION OF EMULSIFYING AGENTS

### HYDROPHILIC COLLOIDS

**NATURAL PLANT ORIGIN**

Acacia
Tragacanth
Agar
Starch
Pectin
Irish Moss

**NATURAL ANIMAL ORIGIN**

Gelatin
Egg Yolk
Wool Fat
(Lanolin)

**SEMISYNTHETIC AGENTS**

Methyl Cellulose
Sodium CMC
Hydroxypropyl Cellulose

### FINELY DIVIDED SOLIDS

**COLLOIDAL CLAYS**

Bentonite Veegum

**METALLIC HYDROXIDES**



Magnesium Hydroxide | Aluminium Hydroxide | Magnesium Trisilicate

Such agents form **protective films** or **rigid interfacial barriers** around globules.

## हिंदी व्याख्या

- **Hydrophilic colloids** भी उपयोगी emulsifying agents होते हैं।
- Natural **plant origin:** acacia, tragacanth, agar, starch, pectin, Irish moss।
- Natural **animal origin:** gelatin, egg yolk, wool fat (lanolin)।
- **Semisynthetic agents:** methyl cellulose, sodium CMC, hydroxypropyl cellulose।
- **Finely divided solids** भी **emulsions** को स्थिर कर सकते हैं।
- **Colloidal clays:** bentonite तथा veegum।
- **Metallic hydroxides:** magnesium hydroxide, aluminium hydroxide, magnesium trisilicate।
- ये एजेंट globules के चारों ओर **protective film** या **rigid interfacial barrier** बनाते हैं।

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# PREPARATION OF EMULSIONS
# इमल्शन की तैयारी

## English Explanation

- Method selection depends on the nature of ingredients and available equipment.
- Dry gum method (continental method, 4:2:1): Oil + Gum + Water.
- A characteristic clicking sound indicates primary emulsion formation; all apparatus must be dry; suitable for most fixed oils.
- Wet gum method (English method): Gum + Water + Oil; used when gum is available as mucilage or must be dissolved first.
- Bottle method (shaking or Forbes bottle method): Gum + Oil, then Water; suitable for volatile and non-viscous oils.
- Fusion method: oil and water are heated separately, then mixed; used for ointments, creams, and lotions.

## METHODS OF PREPARATION

### 1 DRY GUM METHOD
(Continental Method, 4:2:1)


**PROCEDURE**

Trituration in dry mortar until primary emulsion (clicking sound).

### 2 WET GUM METHOD
(English Method)


**PROCEDURE**

Gum is mixed with water first, then oil is added.

### 3 BOTTLE METHOD
(Shaking or Forbes Bottle Method)


**PROCEDURE**

Gum and oil are shaken first, then water is added gradually.

### 4 FUSION METHOD


**PROCEDURE**

Oil and water are heated separately, then mixed.

**GENERAL POINTS**

- Use clean, dry apparatus
- Add liquids slowly
- Avoid air entrapment
- Stir/titrate continuously
- Store emulsion in well-closed containers

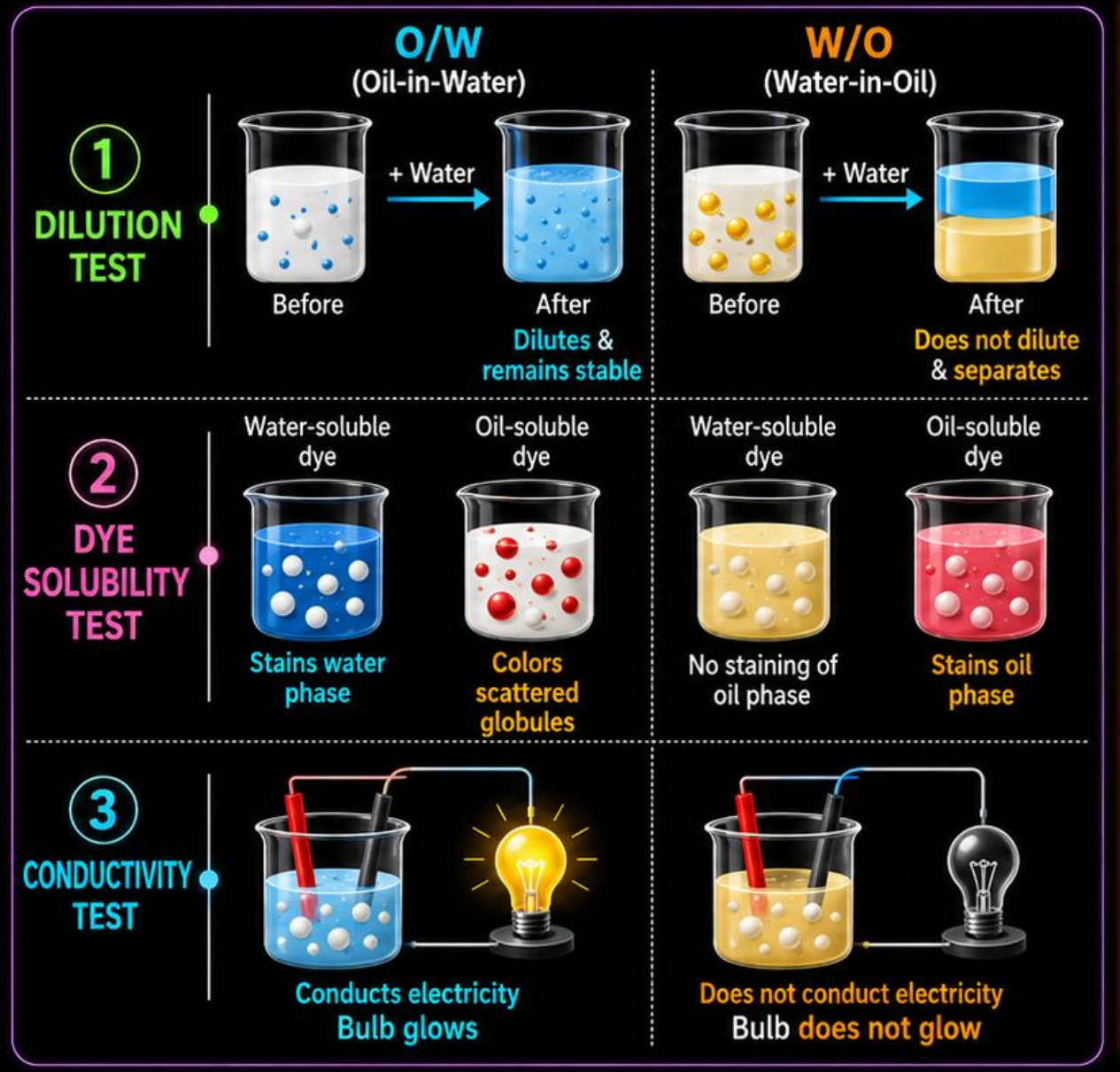
## हिंदी व्याख्या

- विधि का चयन घटकों की प्रकृति और उपलब्ध उपकरणों पर निर्भर करता है।
- Gry gum method (continental method, 4:2:1): Oil + Gum + Water।
- Primary emulsion बनने पर characteristic clicking sound आता है; सभी apparatus सूखे होने चाहिए; यह fixed oils के लिए उपयुक्त है।
- Wet gum method (English method): Gum + Water + Oil; जब gum mucilage के रूप में उपलब्ध हो या पहले जल में घोलना हो, तब उपयोगी।
- Bottle method (shaking/Forbes bottle method): Gum + Oil, फिर Water; volatile तथा non-viscous oils के लिए उपयुक्त।
- Fusion method: oil और water को अलग-अलग गरम करके मिलाया जाता है; ointments, creams और lotions में उपयोगी।

# IDENTIFICATION TESTS – I
# पहचान परीक्षण – I

## English Explanation

- These tests help identify whether the emulsion is **O/W** or **W/O**.
- **Dilution test:** an emulsion mixes with its **continuous phase**.
- **O/W** emulsion dilutes with water and remains **stable**; **W/O** does not dilute with water and **separates**.
- **Dye solubility test:** **water-soluble** dye stains the continuous **water phase** in **O/W**; **oil-soluble** dye stains the **oil phase** in **W/O**.
- In **O/W**, **oil-soluble dye** colors the scattered globules.
- **Conductivity test:** **O/W** conducts electricity and the bulb **glows**.
- **W/O** does not conduct current, so the bulb **does not glow**.




## हिंदी व्याख्या

- ये परीक्षण यह पहचानने में मदद करते हैं कि इमल्शन **O/W** है या **W/O**।
- **Dilution test:** इमल्शन अपने **continuous phase** के साथ मिल जाता है।
- **O/W** इमल्शन जल से dilute होकर **स्थिर** रहता है; **W/O** जल से dilute नहीं होता और परत **अलग** हो सकती है।
- **Dye solubility test:** **O/W** में **water-soluble dye** सतत **जल चरण** को रंग देता है; **W/O** में **oil-soluble dye** तेल **चरण** को रंग देता है।
- **O/W** में **oil-soluble dye** बिखरे हुए globules को रंगता है।
- **Conductivity test:** **O/W** विद्युत का **सुचालक** होता है, इसलिए bulb **glow** करता है।
- **W/O** विद्युत का **सुचालक नहीं** होता, इसलिए bulb **glow नहीं** करता।

# IDENTIFICATION TESTS – II

## पहचान परीक्षण – II

| O/W (Oil in Water) | TEST | W/O (Water in Oil) |
|---|---|---|
|  Dot-pattern fluorescence | 1 FLUORESCENCE TEST   |  Fluorescence throughout |
|  Blue → Pink | 2 $CoCl_2$ / FILTER PAPER TEST  |  No color change |
|  Does not wet (blotting paper remains dry) | 3 BLOTTING PAPER TEST  |  Wets blotting paper |
|  Non-greasy feel | 4 FEEL ON SKIN  |  Greasy feel |
|  Usually white | 5 COLOR  |  Takes color of oil |
|  Upward movement (cream rises) | 6 DIRECTION OF CREAMING  |  Downward movement (cream sinks) |

## English Explanation

- **Fluorescence test:** certain oils fluoresce under UV light.
- **O/W** shows **dot-pattern** fluorescence, while **W/O** shows fluorescence **throughout** the emulsion.
- **$CoCl_2$/filter paper test:** cobalt chloride paper turns from **blue** to **pink** in the presence of water.
- In **O/W**, the paper changes **blue** to **pink**; in **W/O**, there is no color change.
- **Blotting paper test:** **W/O** wets blotting paper, **O/W** usually does not.
- **Feel on skin:** **O/W** feels **non-greasy**, whereas **W/O** feels **greasy**.
- **Color** depends on the external phase: **O/W** is usually **white**, **W/O** takes the **color of oil**.
- **Direction of creaming:** **O/W** generally shows **upward** movement; **W/O** shows **downward** movement.

## हिंदी व्याख्या

- **Fluorescence test:** कुछ तेल UV प्रकाश में **fluorescence** दिखाते हैं।
- **O/W** में **dot-pattern fluorescence** दिखाई देता है, जबकि **W/O** में पूरे इमल्शन में **fluorescence** दिखता है।
- **$CoCl_2$/filter paper test:** cobalt chloride paper जल की उपस्थिति में **blue** से **pink** हो जाता है।
- **O/W** में paper **blue** से **pink** हो जाता है; **W/O** में रंग परिवर्तन नहीं होता।
- **Blotting paper test:** **W/O** blotting paper को गीला करता है, जबकि **O/W** सामान्यतः नहीं करता।
- **Feel on skin:** **O/W** **non-greasy** लगता है, जबकि **W/O** **greasy** महसूस होता है।
- **Color** continuous phase पर निर्भर करता है: **O/W** सामान्यतः **white** होता है, **W/O** तेल का रंग लेता है।
- **Direction of creaming:** **O/W** में **ऊपर की ओर movement**, **W/O** में नीचे की ओर **movement** होती है।

# INSTABILITY OF EMULSIONS – I

# इमल्शन की अस्थिरता – I

## English Explanation

- Emulsions may become unstable during storage.
- Flocculation: dispersed globules aggregate into loose clusters called flocs, but individual identity remains.
- Flocculation is usually reversible by gentle shaking.
- Creaming is upward movement and sedimentation is downward movement of dispersed globules due to density difference.
- Creaming/sedimentation causes layer concentration but the emulsion can usually be redispersed; it is a reversible process.
- Coalescence is the fusion of smaller globules into larger globules.
- Coalescence disrupts the emulsifying film and may lead to complete phase separation.

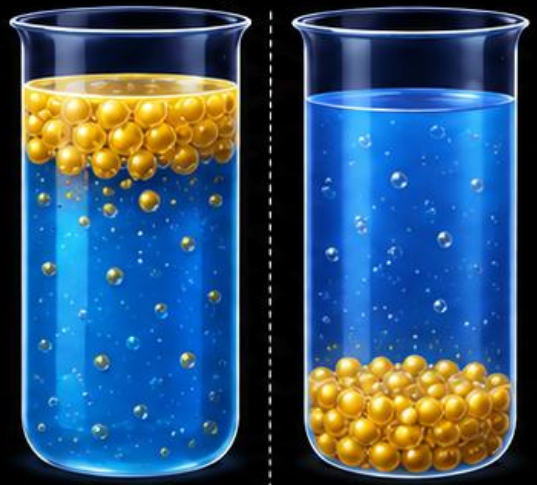
**PROGRESSION OF INSTABILITY**

### 1 FLOCCULATION (Clustering)

Globules form loose clusters (flocs). Individual identity remains.

Usually reversible by gentle shaking.

### 2 CREAMING / SEDIMENTATION (Layer Formation)



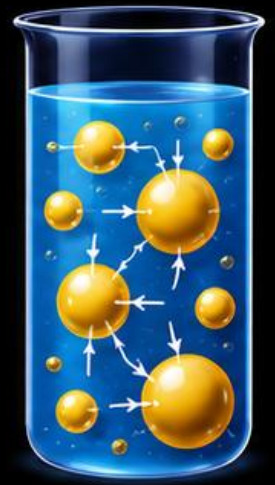
CREAMING (Upward movement)

SEDIMENTATION (Downward movement)

Causes layer concentration. Emulsion can usually be redispersed. It is a reversible process.

Usually reversible by redispersion (gently shaking or stirring).

### 3 COALESCENCE (Fusion)



Small globules fuse to form larger globules.

Irreversible and may lead to phase separation.

## हिंदी व्याख्या

- संग्रहण के दौरान इमल्शन अस्थिर हो सकता है।
- Flocculation में dispersed globules ढीले समूह या flocs बनाते हैं, पर उनकी individual identity बनी रहती है।
- Flocculation सामान्यतः gentle shaking से reversible होता है।
- Creaming ऊपर की ओर तथा sedimentation नीचे की ओर globules का movement है, जो density difference के कारण होता है।
- Creaming/sedimentation में परत का संकेंद्रण होता है, पर इमल्शन सामान्यतः पुनः disperse किया जा सकता है; यह reversible process है।
- Coalescence में छोटे globules मिलकर बड़े globules बनाते हैं।
- Coalescence emulsifying film को नष्ट करता है और phase separation की ओर ले जा सकता है।

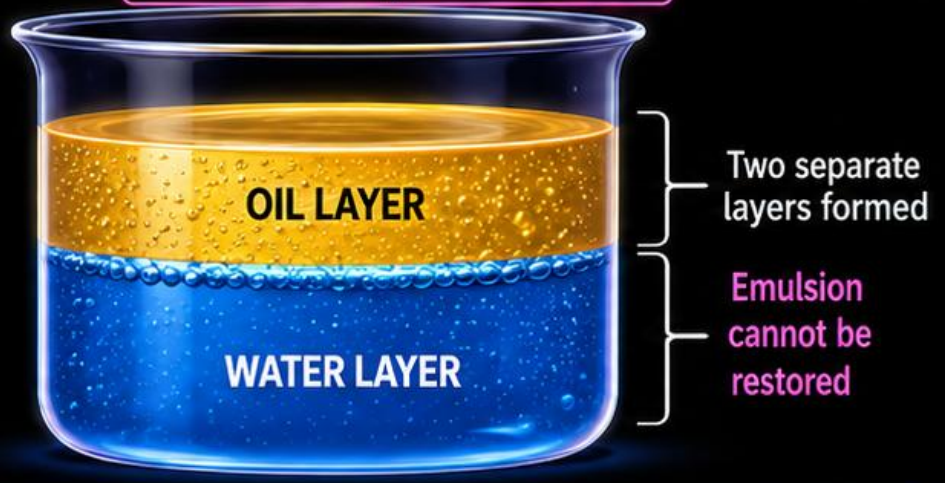
**Key Point:** Flocculation and creaming/sedimentation are generally reversible; coalescence is irreversible and leads to separation.

# INSTABILITY OF EMULSIONS – II
# इमल्शन की अस्थिरता – II

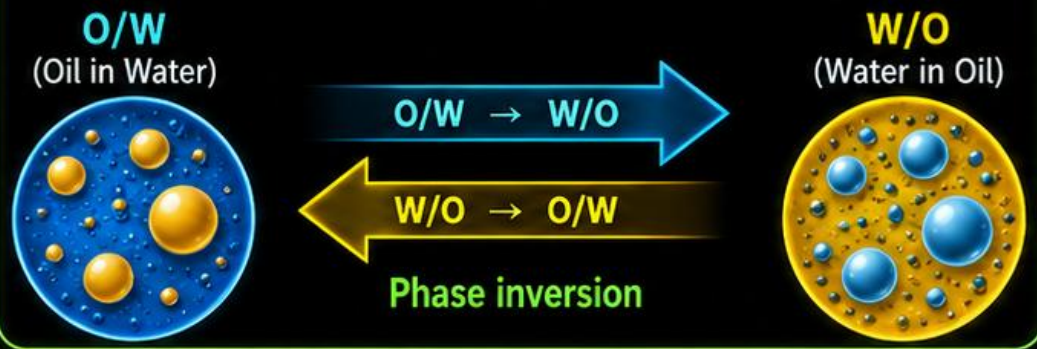
## English Explanation

- **Breaking** or **cracking** is the most severe instability of an emulsion.
- It is an advanced form of **coalescence** in which complete and **irreversible separation** occurs.
- Two separate layers are formed and the emulsion **cannot be restored**.
- **Phase inversion** means change of emulsion type: **O/W** changes to **W/O** or **W/O** changes to **O/W**.
- Phase inversion can be caused by **electrolytes**, change in **phase-volume ratio**, or **temperature change**.
- **PIT (Phase Inversion Temperature)** is the temperature at which the **hydrophilic** and **lipophilic** properties of a surfactant are balanced.
- Phase inversion is generally considered **irreversible** in this context.

## BREAKING / CRACKING




## PHASE INVERSION (CHANGE OF EMULSION TYPE)




**PIT** (Phase Inversion Temperature) — The temperature at which the **hydrophilic** and **lipophilic** properties of a surfactant are balanced.

## हिंदी व्याख्या

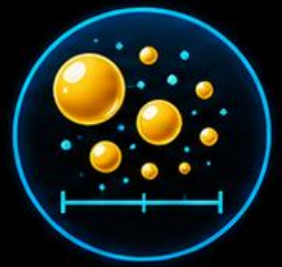
- **Breaking** या **cracking** इमल्शन की सबसे गंभीर अस्थिरता है।
- यह **coalescence** का उनत रूप है, जिसमें पूर्ण और **irreversible separation** हो जाता है।
- दो अलग-अलग परतें बन जाती हैं और इमल्शन पुन: **restore** नहीं किया जा सकत।
- **Phase inversion** का अर्थ है इमल्शन प्रकार का परिवर्तन: **O/W** से **W/O** या **W/O** से **O/W**।
- **Phase inversion electrolytes**, **phase-volume ratio** में परिवर्तन, या **temperature change** के कारण हो सकता है।
- **PIT (Phase Inversion Temperature)** वह तापमान है, जहाँ surfactant के **hydrophilic** और **lipophilic** गुण संतुलित होते हैं।
- इस संदर्भ में **phase inversion** को सामान्यत: **irreversible** माना जाता है।

# FACTORS AFFECTING PHYSICAL STABILITY

## भौतिक स्थिरता को प्रभावित करने वाले कारक

## English Explanation

- Smaller globule size obtained by homogenization increases stability by reducing the creaming rate.
- Uniform particle-size distribution improves stability and helps prevent Ostwald ripening.
- Higher viscosity of the continuous phase slows globule movement and reduces creaming and flocculation.
- Phase-volume ratio = volume of dispersed phase / total volume of emulsion.
- Optimum phase-volume ratio for a stable emulsion is generally 30–60%.
- If dispersed phase rises above about 74%, phase inversion may occur.
- Flow behavior: 5% = Newtonian, 50% = Pseudoplastic, 74% = Plastic.
- Extreme temperature can reduce stability, decrease viscosity, and promote creaming, cracking, or phase inversion.



**PARTICLE SIZE**

Smaller size → higher stability (↓ creaming rate)

**VISCOSITY**

Higher viscosity → slower movement → less creaming & flocculation

**PHASE–VOLUME RATIO**

Optimum 30–60% for stable emulsion


**TEMPERATURE**

Extreme temp. ↓ stability, ↓ viscosity → more creaming, cracking, or phase inversion

**FLOW BEHAVIOR (BASED ON DISPERSED PHASE VOLUME %)**

| Dispersed Phase Volume (%) | 5% | 50% | 74% |
|---|---|---|---|
| Flow Behavior | Newtonian | Pseudoplastic | Plastic |
| Characteristics | Viscosity remains constant with change in shear rate. | Viscosity decreases with increase in shear rate. | High yield value required to start flow; behaves like a solid. |

## हिंदी व्याख्या

- Homogenization से प्राप्त छोटा globule size creaming rate कम करके stability बढ़ाता है।
- Uniform particle-size distribution stability बढ़ाता है और Ostwald ripening को रोकने में मदद करता है।
- Continuous phase की अधिक viscosity globules की गति कम करती है और creaming व flocculation घटाती है।
- Phase-volume ratio = dispersed phase का आयतन / इमल्शन का कुल आयतन।
- स्थिर इमल्शन के लिए optimum phase-volume ratio सामान्यत: 30–60% माना जाता है।
- यदि dispersed phase लगभग 74% से ऊपर हो जाए, तो phase inversion हो सकता है।
- Flow behavior: 5% = Newtonian, 50% = Pseudoplastic, 74% = Plastic।
- अत्यधिक तापमान stability घटाता है, viscosity कम करता है और creaming, cracking या phase inversion बढ़ा सकता है।

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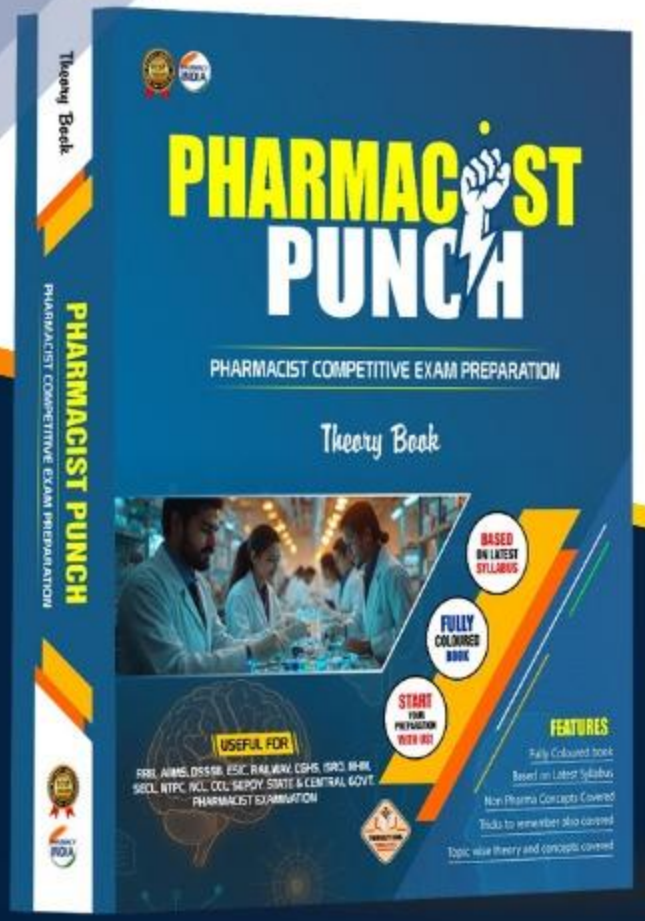


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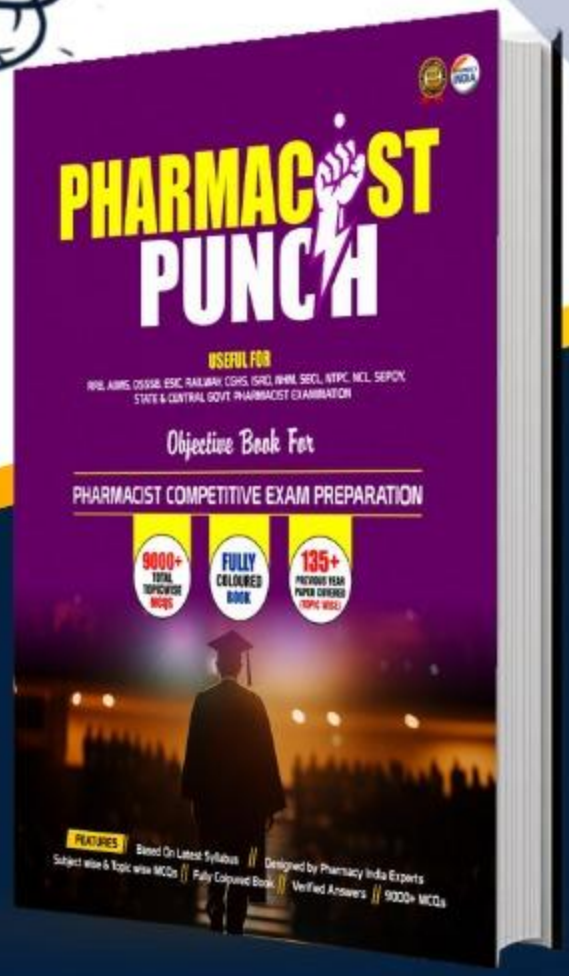


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