NOTESKARTS

COSMETIC SCIENCE

B.Pharmacy 8th Semester

UNIT 2 — Detailed Study Notes

As per AKTU / PCI Syllabus

Skin Care: Face Wash | Moisturizing Cream | Cold Cream | Vanishing Cream | Antiperspirants & Deodorants

Hair Care: Conditioning Shampoo | Hair Conditioner | Anti-Dandruff Shampoo | Hair Oils | Hair Dye (PPD)

Oral Care: Toothpaste (Bleeding Gums, Sensitive Teeth) | Teeth Whitening | Mouthwash

PRINCIPLES OF FORMULATION — SKIN CARE PRODUCTS

Skin care product formulation is based on understanding skin physiology, ingredient compatibility, stability, and consumer sensory preferences. All skin care formulations share common building blocks that are combined in varying ratios to achieve specific functions.

GENERAL PRINCIPLES OF SKIN CARE FORMULATION:

1. Identify skin type and target condition (oily, dry, sensitive, combination)
2. Select appropriate vehicle/base (emulsion, gel, solution, anhydrous)
3. Choose actives compatible with vehicle and skin type
4. Add excipients: emulsifiers, thickeners, humectants, emollients, preservatives
5. Optimize pH (4.5-6.5 for most skin products)
6. Ensure stability (temperature, light, pH, microbial)

Building Blocks of Skin Care Products

Building Block	Role	Examples
Water Phase (Aqueous)	Vehicle; major component (60-80%)	Purified water, floral waters, hydrosols, aloe vera
Oil Phase (Lipid)	Emollient; barrier repair; 5-30%	Mineral oil, plant oils, butters, silicones, fatty alcohols
Emulsifier	Stabilizes oil-water interface	GMS, Polysorbate 60, Cetyl alcohol, Lecithin
Humectant	Attracts and retains moisture	Glycerin, hyaluronic acid, propylene glycol, urea
Thickener / Rheology modifier	Controls viscosity and texture	Carbomer, xanthan gum, cetyl alcohol, HPMC
Preservative	Prevents microbial contamination	Phenoxyethanol, parabens, sodium benzoate, EDTA
Active Ingredient	Provides specific skin benefit	Retinol, niacinamide, kojic acid, peptides, AHAs
Fragrance / Masking agent	Consumer appeal; odor masking	Essential oils, synthetic fragrance, linalool
pH adjuster	Maintains optimal pH 4.5-6.5	Citric acid, sodium hydroxide, triethanolamine
Antioxidant	Prevents rancidity of oils	Vitamin E (tocopherol), BHT, BHA, rosemary extract

FACE WASH (Facial Cleanser)

> A face wash is an aqueous-based cosmetic preparation designed to remove dirt, excess sebum, make-up, pollutants, and dead skin cells from the facial skin without disrupting the skin's natural lipid barrier or altering its pH.

Principles of Formulation

- **Primary Goal:** Effective cleansing with minimum skin irritation and barrier disruption
- **pH Control:** Formulated at pH 5.0-6.5 to match skin's natural pH (acidic mantle = 4.5-5.5)
- **Surfactant Selection:** Mild surfactant blends preferred; amphoteric + nonionic with anionic to reduce irritation
- **Foam quality:** Rich, creamy lather improves consumer perception; controlled by surfactant blend ratio
- **Skin-feel:** Post-wash skin should feel clean but not tight or dry

Building Blocks of Face Wash

Ingredient Category	Conc.	Examples	Function
Primary surfactant	10-20%	Sodium Laureth Sulfate (SLES), Sodium Lauroyl Sarcosinate	Main cleansing agent; foaming
Secondary surfactant	3-10%	Cocamidopropyl Betaine (CAPB), Decyl Glucoside	Reduces irritation; improves foam; conditioning
Co-emulsifier / foam booster	1-5%	Cocamide DEA, Cocamide MEA	Stabilizes foam; thickens formulation
Humectant	2-8%	Glycerin, propylene glycol	Prevents post-wash dryness; skin conditioning
Thickener	0.3-2%	Carbomer, Xanthan gum, NaCl (salt)	Controls viscosity; improves texture
Active ingredient	Variable	Salicylic acid 0.5-2%, Niacinamide 2-5%, Tea tree oil 0.5-1%	Acne control, brightening, antimicrobial
Preservative	0.5-1%	Phenoxyethanol, Sodium benzoate	Prevents microbial growth

Chelating agent	0.05-0.1%	Disodium EDTA	Inactivates hard water metal ions; preservative booster
pH adjuster	q.s.	Citric acid, NaOH	Maintain pH 5.0-6.5
Fragrance	0.1-0.5%	Essential oils, synthetic fragrance	Consumer appeal

Types of Face Wash

Type	Target Skin	Key Difference in Formulation
Foaming Face Wash	Oily/acne-prone	Higher surfactant conc. (15-20%); salicylic acid 0.5-2%; lower oil content
Cream/Milky Face Wash	Dry/sensitive	Lower surfactant (8-12%); higher glycerin; emollients added (5-10% oils)
Gel Face Wash	Combination/normal	Carbomer-thickened; transparent; balanced surfactant blend
Micellar Water	All types, sensitive	Non-foaming; micelles in water; no rinse needed; very gentle
Medicated Face Wash	Acne, dandruff	Contains SA 0.5-2% or benzoyl peroxide 2.5-5% or ketoconazole 2%

Advantages and Disadvantages of Face Wash

Advantages	Disadvantages
Effective removal of excess sebum, dirt, pollutants, and makeup	Foaming face washes can strip natural oils causing dryness
Convenient rinse-off format; suitable for daily use	May alter skin microbiome with repeated use
Can deliver active ingredients (SA, niacinamide) while cleansing	Over-cleansing disrupts the acid mantle (normal pH 4.5-5.5)
Wide variety available for different skin types	Some surfactants (SLS) can cause irritation and sensitization
Prepares skin for better absorption of subsequent skincare	Active ingredients have short contact time (wash-off) — reduced efficacy
Maintains hygiene; prevents acne from blocked pores	Preservatives and fragrances may cause allergic contact dermatitis

Application in Cosmeceutical Formulation

- **Salicylic Acid Face Wash (Acne Cosmeceutical):** SA 0.5-2% penetrates follicle, exfoliates keratin plug, reduces comedones — marketed as cosmeceutical anti-acne cleanser
- **Glycolic Acid Face Wash (Anti-aging cosmeceutical):** AHA at pH 3.5-4.0 promotes gentle exfoliation, improves texture and tone — short contact time limits irritation
- **Vitamin C Face Wash:** Ascorbic acid at 5-15% for antioxidant benefit and brightening — must be formulated at very low pH for stability
- **Niacinamide Face Wash (2-5%):** Reduces sebum, minimizes pores, brightens — ideal for oily acne-prone skin
- **Kojic Acid Cleanser:** 0.5-1% kojic acid for skin brightening; tyrosinase inhibitor; used in pigmentation-focused cosmeceuticals

MOISTURIZING CREAM

> A moisturizing cream is a semi-solid emulsion (O/W or W/O) that replenishes skin moisture by combining humectants (attract water), emollients (soften skin), and occlusives (prevent water loss) to restore and maintain the skin's moisture balance.

Principles of Formulation

- **Three-Component Moisture Strategy:** (1) Humectants attract water, (2) Emollients soften and smooth, (3) Occlusives seal moisture in
- **Emulsion Type:** O/W (oil-in-water) = light, non-greasy; W/O (water-in-oil) = richer, more occlusive
- **Barrier Repair:** Must contain ceramides, fatty acids, cholesterol in correct ratio (1:1:1) for optimal barrier function
- **pH:** 5.0-6.5 for most moisturizers; anti-aging creams may be lower (3.5-4.5) for AHA activity
- **Skin type specificity:** Oil content varies: oily skin = 5-15%, normal skin = 15-25%, dry skin = 25-40% oil phase

Building Blocks of Moisturizing Cream

Ingredient	Conc.	Examples	Function
Water (aqueous phase)	50-80%	Purified water, rose water	Major vehicle; base of O/W emulsion
Emollient oils	5-30%	Mineral oil, shea butter, jojoba oil, squalane	Soften skin; improve texture; barrier repair
Fatty alcohol/Wax	2-8%	Cetyl alcohol, stearyl alcohol, beeswax	Emulsion stabilizer; thickener; emollient

Emulsifier (HLB 8-16 for O/W)	2-8%	GMS (Glyceryl Monostearate), Cetyl alcohol, PEG-100 Stearate	Stabilize O/W emulsion
Humectant	3-15%	Glycerin, hyaluronic acid, sodium PCA, panthenol	Attract and retain moisture
Occlusive agent	1-10%	Petrolatum, beeswax, dimethicone	Seal moisture; reduce TEWL
Active ingredient	Variable	Retinol 0.025-0.3%, Vit C 10-20%, Niacinamide 5%	Anti-aging, brightening, barrier repair
Preservative	0.5-1%	Phenoxyethanol, parabens, potassium sorbate	Prevent microbial contamination
Antioxidant	0.05-0.5%	Vit E (tocopherol), BHT	Prevent oil oxidation and rancidity
Fragrance/Essential oil	0.1-0.5%	Rose, lavender, chamomile	Consumer appeal; aromatherapy benefit

Types of Moisturizing Creams

Type	Emulsion	Key Features
Light Day Moisturizer	O/W	Low oil (5-15%); non-greasy; may contain SPF; suitable for all skin types
Rich Night Cream	W/O or O/W	High oil content (20-40%); nourishing; retinol/peptide actives; no SPF
Eye Cream	O/W	Very gentle; fragrance-free; caffeine, peptides, HA; small particle size for periorbital area
Body Lotion	O/W	Higher water content (70-80%); lighter than face cream; urea 2-5% for dry skin
Anti-aging Cream	O/W or W/O	Retinol 0.025-0.3%, peptides, HA, AHAs; pH adjusted for AHA activity

Advantages and Disadvantages

Advantages	Disadvantages
Restores and maintains skin moisture balance	May feel greasy (especially W/O creams) — poor cosmetic elegance for oily skin
Repairs and strengthens skin barrier	Emulsion stability issues (creaming, coalescence, Ostwald ripening)
Can deliver multiple actives simultaneously	Emulsifiers and preservatives may cause sensitization
Reduces TEWL and prevents skin dryness	Active ingredients (retinol, Vit C) may be unstable in aqueous base
Available in multiple textures for different skin types	Some occlusives (petrolatum) may be comedogenic for acne-prone skin
Long-lasting moisturization throughout the day	Fragrance can cause allergic contact dermatitis in sensitive skin

Application in Cosmeceutical Formulation

- **Retinol Moisturizing Cream:** Retinol 0.025-0.3% in emollient-rich base; stimulates collagen; anti-aging cosmeceutical; must be packaged in opaque, airless pump
- **Ceramide Moisturizer:** Ceramides:fatty acids:cholesterol = 1:1:1; repairs compromised barrier; used for eczema-prone, sensitive skin
- **Vitamin C Moisturizer:** L-ascorbic acid at pH 2.5-3.5; antioxidant + brightening; very unstable — stabilized forms (sodium ascorbyl phosphate) used
- **Peptide Cream:** Signal peptides (Argireline, Matrixyl) in moisturizing base; stimulate collagen and elastin production

COLD CREAM

> Cold cream is a W/O (water-in-oil) emulsion-type skin care preparation characterized by a cooling sensation upon application, caused by the evaporation of water from the external phase. It was historically the first commercial cosmetic emulsion.

Principles of Formulation

- **Emulsion Type:** W/O — water is dispersed in continuous oil phase; ratio oil:water = 50-60:40-50
- **Cooling Effect:** Water evaporates from skin surface upon application, creating cooling sensation — key characteristic
- **Historical Base:** Original formulation (Galen's Cold Cream, 150 AD): beeswax + olive oil + rosewater + borax
- **Modern Modification:** Mineral oil replaced olive oil; synthetic emulsifiers replaced borax-beeswax system

- **Chemistry:** Borax (sodium tetraborate) + beeswax → saponification → sodium cerotate (soap) = natural emulsifier; reaction occurs at 60-70°C

Building Blocks of Cold Cream

Ingredient	Conc.	Examples	Function
Mineral oil	30-50%	White mineral oil (light)	Main oil phase; emollient; cleanser; makes W/O base
Beeswax	10-15%	White beeswax (bleached)	Oil phase thickener; contributes to W/O emulsification with borax
Water	30-45%	Purified water, rosewater	Internal phase; cooling agent on evaporation
Borax (Sodium Tetraborate)	0.5-1%	Na2B4O7.10H2O	Reacts with beeswax free acids to form soap emulsifier; alkaline pH adjustment
Emulsifier	2-5%	Lanolin, cetyl alcohol, Span 80, Arlacel 83	Stabilize W/O emulsion; modern cold creams use synthetic emulsifiers
Humectant	2-5%	Glycerin, sorbitol	Reduces skin dryness; adds smoothness
Preservative	0.1-0.3%	Methylparaben, propylparaben	Prevents microbial contamination of water phase
Fragrance	0.1-0.5%	Rose fragrance, linalool	Consumer appeal; masks the odor of mineral oil

Classic Borax-Beeswax Emulsification Reaction:

> **Beeswax (free fatty acids: cerotic acid) + Borax (alkaline) → Sodium cerotate (soap) = W/O emulsifier**

This in-situ soap formation stabilizes the W/O emulsion. Modern formulations use pre-formed synthetic W/O emulsifiers instead.

Manufacturing Process of Cold Cream

- **Step 1 (Melt oil phase):** Heat beeswax + mineral oil + other oil phase ingredients to 70-75°C until completely melted
- **Step 2 (Prepare water phase):** Dissolve borax in purified/rose water; heat to 70-75°C
- **Step 3 (Emulsification):** Add water phase slowly to oil phase with continuous stirring — W/O emulsion forms; borax-beeswax reaction occurs
- **Step 4 (Cool with stirring):** Cool to 40-45°C with constant stirring to ensure homogeneity
- **Step 5 (Add heat-sensitive ingredients):** Add fragrance, preservative at 40°C to prevent loss by evaporation

- **Step 6 (Final mixing and filling):** Mix thoroughly; fill into wide-mouth jars or collapsible tubes

Advantages and Disadvantages of Cold Cream

Advantages	Disadvantages
Excellent cleansing action — removes waterproof makeup and heavy sebum	Very greasy feel; not suitable for oily or acne-prone skin
Cooling and soothing effect on application (water evaporation)	W/O emulsion may block pores if not removed completely
Highly moisturizing and emollient — excellent for very dry skin	May leave oily residue on skin and clothing
Forms protective barrier on skin — good for chapped lips, dry hands	Borax-based formulations are alkaline — may irritate sensitive skin
Long shelf life due to W/O emulsion (water protected from microbes)	Heavy and thick — poor cosmetic elegance compared to O/W creams
Useful as a cleansing cream for removing thick stage makeup	Not suitable as a leave-on moisturizer under sunscreen or makeup

Application in Cosmeceutical Formulation

- **Ultra-rich Barrier Cream:** Cold cream base + ceramides + niacinamide — used as cosmeceutical for very dry, eczema-prone, or barrier-compromised skin
- **Medicated Cold Cream:** Addition of zinc oxide (5-15%), calamine — used as soothing, anti-inflammatory cosmeceutical for sunburn, minor rashes
- **Cleansing Cosmeceutical:** With glycolic acid 2-5% at appropriate pH — AHA cleansing balm for resurfacing effect

VANISHING CREAM

> Vanishing cream is an O/W (oil-in-water) emulsion that 'vanishes' into the skin upon application, leaving no visible oily film. It is lightweight, non-greasy, and contains high water content. The term 'vanishing' refers to its disappearing quality on the skin.

Principles of Formulation

- **Emulsion Type:** O/W (oil-in-water) — oil dispersed in continuous water phase; ratio oil:water ≈ 15-20:80-85
- **Key Ingredient:** Stearic acid — reacts with alkali (potassium hydroxide / triethanolamine) → potassium stearate soap → O/W emulsifier
- **Soap Emulsification:** Reaction: Stearic acid + KOH → Potassium stearate (soap) + H2O; ratio of saponification determines emulsion stability
- **'Vanishing' mechanism:** High water content (75-85%) evaporates rapidly; thin oil film remaining becomes invisible on application
- **pH:** Slightly alkaline (pH 6.5-7.5) due to alkali used in soap emulsification; may be buffered down

Building Blocks of Vanishing Cream

Ingredient	Conc.	Examples	Function
Stearic acid (triple pressed)	10-20%	Stearic acid BP/USP	Oil phase + reacts with alkali to form soap emulsifier (potassium stearate)
Alkali (for soap formation)	1-3%	KOH, Triethanolamine (TEA), NaOH	Reacts with stearic acid to form in-situ emulsifier (soap)
Water	70-85%	Purified water	Major external phase; enables 'vanishing' effect on evaporation
Humectant	3-10%	Glycerin 5%, propylene glycol	Prevents skin dryness; smooth application feel
Additional emollient	0-5%	Cetyl alcohol, lanolin, isopropyl myristate	Improves emolliency and stability of emulsion
Preservative	0.1-0.3%	Methylparaben 0.2%	Prevents microbial contamination
Fragrance	0.1-0.5%	Floral fragrances	Consumer appeal

Potassium Stearate Emulsification Reaction:

> **Stearic acid ($C_{17}H_{35}COOH$) + KOH → Potassium stearate ($C_{17}H_{35}COOK$) [soap] + H_2O = O/W emulsifier**

Approximately 75-80% of stearic acid is saponified to form soap; remaining free stearic acid forms the oil phase. This dual role of stearic acid (as both oil phase and soap precursor) is unique to vanishing cream.

Manufacturing Process of Vanishing Cream

- **Step 1 (Melt oil phase):** Melt stearic acid + other oil phase ingredients at 70-75°C
- **Step 2 (Heat water phase):** Dissolve alkali (KOH/TEA) + humectant (glycerin) + water; heat to 70-75°C
- **Step 3 (Emulsification):** Add water phase to oil phase with vigorous stirring; soap forms in-situ; O/W emulsion develops with pearlescent appearance
- **Step 4 (Cooling):** Cool slowly to 40°C with gentle continuous stirring to maintain homogeneity and proper crystallization of stearate soap
- **Step 5 (Add heat-sensitive ingredients):** Add fragrance, preservative, heat-sensitive actives at 40°C
- **Step 6:** Fill into wide-mouth jars; allow to cool to room temperature

Advantages and Disadvantages of Vanishing Cream

Advantages	Disadvantages
Lightweight, non-greasy — 'vanishes' on application; excellent for oily skin	Less moisturizing than cold cream; not suitable for very dry/chapped skin
Excellent cosmetic elegance; suitable as makeup base (primer)	Soap-based system may be mildly alkaline — irritation for sensitive skin
Absorbed quickly — no white cast or shiny appearance after application	Lower oil content = less barrier protection against water loss
Good base for pigmented products (tinted moisturizer, BB cream)	Stearic acid + alkali system is sensitive to pH changes
Suitable for daytime use under sunscreen and cosmetics	May feel sticky or tight in very low humidity conditions
Can be easily converted to medicated or cosmeceutical cream	Shorter contact time of actives compared to W/O systems

Cold Cream vs Vanishing Cream — Key Comparison

Parameter	Cold Cream	Vanishing Cream
Emulsion Type	W/O (Water in Oil)	O/W (Oil in Water)
Feel on Skin	Greasy, heavy, rich	Light, non-greasy, 'vanishes'
Primary Emulsifier	Borax + beeswax (soap) / Span 80	Stearic acid + KOH/TEA (potassium stearate soap)
Water Content	30-45%	70-85%
Oil Content	40-60%	10-20% (stearic acid)
Target Skin Type	Very dry, chapped, mature	Normal, oily, combination
Use	Cleansing, night cream, barrier protection	Day cream, makeup base, primer
Moisturizing Power	High (occlusive)	Moderate (humectant-based)
Cooling Effect	Yes — water evaporates on application	Yes, but less pronounced than cold cream

Application in Cosmeceutical Formulation

- **Tinted Vanishing Cream / BB Cream:** Vanishing cream base + iron oxides + zinc oxide — cosmeceutical with skin tone correction, SPF, and skincare in one
- **AHA Vanishing Cream:** Glycolic acid 5-10% at pH 3.5-4.0 in vanishing cream base — exfoliating cosmeceutical for textural improvement
- **Anti-pigmentation Day Cream:** Niacinamide 5% + kojic acid 1% in vanishing cream base — ideal as light, non-greasy cosmeceutical for pigmentation

ANTIPERSPIRANTS AND DEODORANTS

> Deodorants prevent or mask body odor by inhibiting bacterial growth. Antiperspirants reduce sweating by partially blocking sweat ducts. Both target body odor from axillary (underarm) region.

Body Odor — Mechanism

Body odor origin: Eccrine sweat (water + electrolytes) is odorless. Apocrine sweat (protein-rich) from axilla/groin is metabolized by resident bacteria (Corynebacterium, Staphylococcus) → volatile fatty acids and thioalcohols → characteristic odor.

- **Key bacteria:** Staphylococcus epidermidis, Corynebacterium species, Anaerococcus species
- **Malodorous compounds:** 3-methyl-2-hexenoic acid, 3-methyl-3-sulfanylhexan-1-ol (thioalcohol), isovaleric acid

Antiperspirants — Actives and Mechanism

Active Ingredients in Antiperspirants:

Active Ingredient	Conc.	Mechanism of Action
Aluminium Chlorohydrate (ACH)	15-25%	Most popular; Al3+ ions react with sweat duct mucopolysaccharides → form gelatinous plug → blocks eccrine duct
Aluminium Zirconium Tetrachlorohydrex-Gly (AZAG)	10-20%	Most effective; gly (glycine) complex; deeper duct penetration; FDA-approved for 'clinical strength' products
Aluminium Chloride Hexahydrate	6-20%	Most potent; used in hyperhidrosis treatment; irritating at high concentrations; prescription at >20%
Aluminium Sesquichlorohydrate	15-25%	Intermediate between ACH and AlCl3; good efficacy with less irritation
Potassium Alum (natural crystal)	Various	Natural crystal deodorant; mild astringent; minimal antiperspirant effect

Mechanism of Antiperspirant Action — Detailed:

- **Step 1:** Aluminium salt solution applied to underarm skin
- **Step 2:** Al3+ ions penetrate into eccrine sweat duct lumen
- **Step 3:** Al3+ reacts with glycoproteins (mucins) in sweat → forms insoluble aluminium hydroxide gel [Al(OH)3]
- **Step 4:** Gel physically occludes/narrows the eccrine duct opening
- **Step 5:** Increased intraluminal pressure from sweating → further gel compaction → duct temporarily sealed
- **Result:** Sweat output reduced by 20-50% (OTC) to >50% (prescription strength)
- **Note:** Effect is temporary (1-2 days); duct regenerates; NOT permanent; only eccrine (not apocrine) glands targeted

Deodorants — Actives and Mechanism

Active Ingredients in Deodorants:

Active Ingredient	Conc.	Mechanism of Action
Triclosan (being phased out)	0.1-0.3%	Broad-spectrum antibacterial; inhibits fatty acid synthesis in bacteria; FDA concerns over safety led to phase-out
Benzalkonium Chloride (BAK)	0.1-0.2%	Quaternary ammonium; disrupts bacterial cell membrane; broad-spectrum
Ethanol (SD Alcohol 40)	40-60%	Bactericidal; disrupts microbial cell membranes; evaporates quickly; drying effect
Zinc Ricinoleate	0.5-2%	Odor absorption mechanism; chelates malodorous molecules; not antibacterial but traps odor
Zinc Oxide	1-5%	Mild antibacterial + astringent; absorbs sweat; used in natural deodorants
Magnesium Hydroxide	2-5%	Natural antibacterial; raises underarm pH to inhibit odor bacteria (Corynebacterium prefer acidic pH)
Fragrance / Essential oils	0.5-3%	Mask residual odor; tea tree oil adds antimicrobial benefit; lavender, citrus commonly used

Formulation Building Blocks of Antiperspirants/Deodorants

Dosage Form	Key Ingredients	Formulation Notes
Roll-on liquid	Al salt solution, ethanol, water, conditioning agents	Simple aqueous solution; 15-25% Al salt; most common form; pH 3-4
Stick (solid)	Al-Zr salt, stearyl alcohol, cyclopentasiloxane, wax	Anhydrous or low-water; AZAG + silicone base; waxy matrix; sodium stearate thickener
Cream	Al salt, emollients, emulsifiers, water	Emulsion base; higher moisturization; less common; good for sensitive skin
Aerosol spray	Al salt, ethanol, propellants (butane, propane)	Rapid drying; most popular globally; 15-20% Al salt in alcoholic solution
Gel	Al salt, carbomer, ethanol, water	Clear transparent gel; carbomer thickened; pH adjusted 3.5-4.5

★ EXAM IMPORTANT POINTS

Q: What is the mechanism of antiperspirant? Al3+ ions form gel in eccrine duct → physical blockage of sweat

Q: Difference between deodorant and antiperspirant? Deodorant = kills odor bacteria; Antiperspirant = reduces sweating

Q: Which Al salt is most effective antiperspirant? Aluminium Zirconium Tetrachlorohydrex-Gly (AZAG) — 'clinical strength'

Q: What is the source of body odor? Apocrine sweat + bacteria (Corynebacterium, Staph) → volatile fatty acids and thioalcohols

Q: How does zinc ricinoleate work in deodorant? Chelates/traps malodorous molecules — not antibacterial

PRINCIPLES OF FORMULATION — HAIR CARE PRODUCTS

Hair care formulations target the hair shaft, scalp, and follicle environment. Understanding hair chemistry (keratin structure, disulfide bonds, surface charge, pH) is essential for effective product development.

HAIR CHEMISTRY PRINCIPLES:

Hair shaft = Cuticle (protective scales) + Cortex (keratin, melanin) + Medulla

Hair is negatively charged at neutral pH (isoelectric point = pH 3.67) — attracts cationic conditioning agents

Disulfide bonds (S-S): responsible for hair strength; broken by perming/relaxing agents

Normal hair pH should be maintained at 4.5-5.5 to keep cuticle scales lying flat

Damaged hair: lifted cuticle, loss of proteins, reduced disulfide bonds, increased negative charge

CONDITIONING SHAMPOO

A conditioning shampoo (2-in-1 shampoo) is a formulation that simultaneously cleanses the hair and scalp while depositing conditioning agents onto the hair shaft during rinsing, providing both cleansing and conditioning in a single step.

Principles of Formulation

- **Challenge:** Cleansing and conditioning are opposing functions — surfactants remove oils while conditioners deposit oils. 2-in-1 technology resolves this through coacervate deposition.
- **Coacervate Deposition Technology:** Anionic surfactant (SLES) + cationic polymer (Polyquaternium-10) form coacervates (complex); these deposit on hair during rinsing as surfactant concentration drops below CMC
- **pH:** 5.0-6.5 to keep cuticle flat; too alkaline raises cuticle causing frizz and damage
- **Silicone deposition:** Silicone (dimethicone) emulsified in shampoo deposits on hair during rinsing, reducing friction, adding shine, and providing detangling

Building Blocks of Conditioning Shampoo

Ingredient	Conc.	Examples	Function
Primary surfactant	8-15%	SLES (Sodium Laureth Sulfate), Sodium Lauroyl Sarcosinate	Cleansing; foaming
Secondary surfactant	3-8%	Cocamidopropyl Betaine (CAPB), Decyl Glucoside	Reduce irritation; foam quality; conditioning effect
Foam booster	1-3%	Cocamide DEA, Cocamide MEA	Stabilize and boost foam
Cationic polymer (key conditioning agent)	0.1-1%	Polyquaternium-10, Polyquaternium-7, Guar hydroxypropyl trimonium chloride	Deposits on hair; reduces static; improves wet/dry combing; core of 2-in-1
Silicone (conditioning, shine)	0.5-3%	Dimethicone 350-1000 cSt, Cyclomethicone, Amodimethicone	Deposits on hair fiber; lubricates; reduces friction; adds shine and softness
Thickener	0.5-2%	Carbomer, Xanthan gum, NaCl (1-3%)	Viscosity control; NaCl is simplest and cheapest thickener for surfactant systems
Pearlizing agent	1-3%	Glycol distearate, Ethylene glycol distearate (EGDS)	Opaque pearl/shimmery appearance; consumer appeal
Preservative	0.5-1%	DMDM Hydantoin, Methylisothiazolinone, Phenoxyethanol	Prevent microbial contamination
Active ingredient	Variable	Keratin hydrolysate 0.5-2%, Biotin 0.1%, Panthenol 0.5-1%	Hair strengthening, repair, growth support
Fragrance	0.2-0.5%	Fresh, fruity, floral fragrances	Consumer appeal; product differentiation

Coacervate Deposition — Detailed Mechanism

The 2-in-1 mechanism (Procter & Gamble patent, 1987):

- **During washing:** Anionic surfactant (SLES, negatively charged) and cationic polymer (Polyquaternium, positively charged) form soluble complex — coacervate — no deposition on negatively charged hair
- **During rinsing:** As water dilutes the formulation, surfactant concentration drops below CMC → complex becomes insoluble → precipitates as a coacervate phase
- **Deposition:** Coacervate contains silicone and cationic polymer → deposits on negatively charged hair surface → net conditioning + silicone deposition
- **Effect:** Hair feels smooth, soft, detangled — 2-in-1 effect achieved in a single rinsing step

HAIR CONDITIONER

> A hair conditioner is a leave-on or rinse-off formulation that repairs, smooths, and protects the hair shaft by depositing cationic conditioning agents, lipids, proteins, and silicones on the negatively charged hair surface — restoring shine, softness, and manageability.

Principles of Formulation

- **Mechanism of conditioning:** Hair is negatively charged → cationic conditioners (quaternary ammonium compounds) are attracted to hair surface by electrostatic interaction → adsorb onto hair → smooth cuticle scales
- **BTAC system:** Behentrimonium Chloride (BTAC) or Cetrimonium Chloride (CTAC) are the primary conditioning actives — quaternary ammonium compounds
- **Lipid penetration:** Some lipids (cetyl alcohol, fatty acids) penetrate the cuticle into the cortex — restore lost lipids in chemically damaged hair
- **pH:** 4.5-5.5 — acidic pH keeps cuticle scales closed (flat); alkaline = raised cuticle = frizz
- **Emulsion type:** Typically O/W emulsion with high water content; quaternary ammonium compound emulsified with fatty alcohols (cetyl/stearyl alcohol)

Building Blocks of Hair Conditioner

Ingredient	Conc.	Examples	Function
Quaternary ammonium compound (QUAT)	0.5-4%	Behentrimonium Chloride (BTAC), Cetrimonium Chloride (CTAC), BTMS-25	PRIMARY conditioning agent; adsorbs to hair; reduces static; smooth cuticle
Fatty alcohol	3-8%	Cetyl alcohol, Stearyl alcohol, Cetearyl alcohol	O/W emulsion stabilizer; occlusive emollient; improves slip and softness
Emollient/lipid	1-5%	Dimethicone, Cyclomethicone, plant oils (argan, coconut), shea butter	Conditions hair shaft; reduces frizz; adds shine
Cationic polymer	0.1-0.5%	Polyquaternium-11, Polyquaternium-37	Additional conditioning; film formation on hair; wet combing improvement
Protein hydrolysate	0.5-2%	Hydrolyzed keratin, hydrolyzed wheat protein, silk amino acids	Penetrates into cortex; fills protein voids in damaged hair; strengthens
Humectant	2-5%	Glycerin, panthenol, sorbitol	Moisturizes hair shaft; prevents moisture loss
Water	60-80%	Purified water	Base of O/W emulsion

Preservative	0.5-1%	Phenoxyethanol, Methylchloroisothiazolinone/MIT	Prevent microbial contamination of water phase
Fragrance	0.2-1%	Floral, fruity, fresh fragrances	Consumer appeal; product identification
pH adjuster	q.s.	Citric acid	Adjust to pH 4.5-5.5

Types of Hair Conditioners

Type	Format	Key Features
Rinse-off Conditioner	Emulsion	Applied after shampoo; left for 2-3 min; rinsed off; most common type
Deep Conditioning Mask	Thick emulsion	Higher QUAT + protein + lipid content; left 10-30 min; intensive repair for damaged hair
Leave-in Conditioner	Light spray/cream	Lower QUAT; not rinsed; applied on damp hair; adds day-long conditioning
Detangling Spray	Aqueous spray	Very light; detangling polymers; fine mist; for children and curly hair
Hot Oil Treatment	Anhydrous oil	Pure lipid; coconut, argan, olive oil; no water; deep penetration into cortex

ANTI-DANDRUFF SHAMPOO

> An anti-dandruff shampoo is a medicated cosmetic (quasi-drug) designed to reduce visible dandruff flaking, scalp scaling, and associated itching by targeting the causative yeast (Malassezia species) and regulating scalp cell turnover.

Pathophysiology of Dandruff

Dandruff (seborrhoeic dermatitis of scalp) involves three key factors:

- **1. Malassezia species:** Lipophilic yeast (M. globosa, M. restricta) — metabolizes sebum triglycerides → releases oleic acid → penetrates scalp → triggers inflammation and hyperproliferation
- **2. Scalp sebum:** Provides substrate for Malassezia growth; oily scalp = more sebum = more yeast = more dandruff
- **3. Individual susceptibility:** Immune response to Malassezia metabolites; genetic factors; stress; hormonal changes
- **Result:** Rapid scalp cell turnover (every 7 days vs normal 30 days) → large visible corneocyte clumps = dandruff flakes

Anti-Dandruff Actives — Mechanism of Action

Anti-Dandruff Active	Conc.	Mechanism of Action
Zinc Pyrithione (ZPT)	1-2%	Most widely used; inhibits Malassezia enzymes (electron transport chain); biostatic (fungistatic); disrupts fungal membrane; Head & Shoulders uses this
Selenium Sulfide (SeS2)	1-2.5%	Reduces scalp cell turnover (cytostatic); antifungal; selenium inhibits fungal enzyme; strong smell; very effective
Ketoconazole	1-2%	Imidazole antifungal; inhibits ergosterol synthesis in Malassezia → disrupts fungal cell membrane; most potent; prescription at 2%
Coal Tar	0.5-5%	Keratolytic + cytostatic + antifungal; reduces cell turnover; dark color; strong smell; carcinogenic risk limits use
Salicylic Acid	1.8-3%	Keratolytic; solubilizes the 'glue' (protein) holding flakes together; does not kill Malassezia directly
Piroctone Olamine	0.5-1%	Newer, milder antifungal; inhibits fungal amino acid uptake; better cosmetic profile than ZPT
Climbazole	0.5-2%	Imidazole antifungal; similar to ketoconazole; used in OTC anti-dandruff products in Europe

Building Blocks of Anti-Dandruff Shampoo

Ingredient	Conc.	Examples	Function
Primary surfactant	8-15%	SLES, Sodium Lauroyl Sarcosinate	Cleansing base; foaming
Secondary surfactant	3-8%	CAPB, Decyl Glucoside	Mild co-surfactant; foam quality
Anti-dandruff active	1-2%	Zinc Pyrithione, Ketoconazole, SeS2, Piroctone Olamine	Core therapeutic/cosmeceutical ingredient
Conditioning agent	0.5-2%	Cationic polymer, silicone emulsion	Counter dryness from anti-dandruff agents
Thickener	0.5-2%	Carbomer, HPMC, NaCl	Viscosity control
Solubilizer (for ZPT)	0.5-1%	Zinc sulfate, surfactant blend	Keeps ZPT dispersed uniformly in formulation

pH adjuster	q.s.	Citric acid	pH 5.0-6.5; optimal antifungal activity
Preservative	0.5-1%	Phenoxyethanol	Microbial protection

Advantages and Disadvantages of Anti-Dandruff Shampoo

Advantages	Disadvantages
Treats root cause (Malassezia) while cleansing scalp	Some actives (selenium sulfide, coal tar) have strong, unpleasant odor
Convenient; no additional product needed	Long-term use may cause resistance (Malassezia adaptation)
ZPT and piroctone olamine suitable for daily use	Coal tar is dark, messy, carcinogenic — limited use
Available OTC — easy access for consumers	May cause scalp dryness with repeated use (surfactant over-cleansing)
Ketoconazole provides strong antifungal activity for severe cases	Ketoconazole can interact with cytochrome P450 enzymes if absorbed
Some formulations combine dandruff control with hair conditioning	Color-treated hair may be affected by selenium sulfide and coal tar

HAIR OILS

> Hair oils are anhydrous (water-free) or oil-in-water emulsion preparations containing one or more lipid ingredients that condition the hair shaft, scalp, and promote hair health by lubricating, nourishing, and penetrating the cortex.

Classification of Hair Oils

Type	Examples	Characteristics
Penetrating Oils	Coconut oil, Olive oil, Avocado oil	Rich in lauric acid/oleic acid; penetrate the cortex; reduce protein loss; pre-wash treatment
Surface/Sealing Oils	Mineral oil, Argan oil, Jojoba oil	Cannot penetrate; coat hair shaft surface; reduce TEWL from hair; add shine
Drying Oils	Castor oil (linoleic-rich types)	Contain polyunsaturated FA; oxidize slowly; used in pomades and hair wax
Essential Oils	Rosemary, Peppermint, Tea tree oil	Highly diluted in carrier oil; stimulate scalp circulation; antimicrobial; aromatherapy

Traditional Indian Hair Oils	Brahmi oil, Amla oil, Bhringraj oil	Ayurvedic base (sesame/coconut) infused with herbs; promote hair growth and scalp health

Building Blocks of Hair Oil

Ingredient	Conc.	Examples	Function
Base/Carrier oil	60-95%	Coconut oil, Mineral oil, Castor oil, Sesame oil	Primary vehicle; main conditioning and moisturizing effect
Emollient oil	5-30%	Argan oil, Jojoba oil, Olive oil, Almond oil	Improve texture; shine; softness; penetrating or surface effect
Silicone	1-10%	Dimethicone, Cyclopentasiloxane, Phenyl Trimethicone	Exceptional shine and smoothness; heat protection; reduces frizz
Essential oil	0.5-2%	Rosemary EO, Peppermint EO, Tea Tree oil	Scalp stimulation; antimicrobial; fragrance; Ayurvedic benefit
Vitamin/antioxidant	0.1-1%	Vitamin E (tocopherol), Vitamin A palmitate	Prevents rancidity of oils; hair nourishment
UV filter	0.1-0.5%	Benzophenone-4	Protects hair color from UV degradation
Herbal extract	0.5-5%	Amla, Brahmi, Bhringraj, Fenugreek extracts	Traditional hair growth promotion; scalp nourishment

Role of Oils

Oil	Key FA Composition	Hair Benefits
Coconut Oil	Lauric acid (47%)	Best penetrating oil; reduces protein loss during washing; pre-wash and post-wash; anti-fungal (caprylic acid)
Argan Oil	Oleic (46%), Linoleic (33%)	Non-penetrating; surface conditioning; excellent shine; heat protection; rich in Vitamin E
Castor Oil	Ricinoleic acid (90%)	Thick and viscous; seals split ends; scalp massage oil; promotes blood circulation

Jojoba Oil	Liquid wax ester	Most similar to sebum; non-comedogenic; excellent scalp moisturizer; long shelf life
Rosemary EO	Camphor, borneol	Stimulates scalp blood circulation; may promote hair growth (similar efficacy to minoxidil 2% in studies)
Amla Oil	Vitamin C, tannins	Traditional strengthening; reduces premature graying; Ayurvedic classic

CHEMISTRY AND FORMULATION OF PARA-PHENYLENEDIAMINE (PPD) BASED HAIR DYE

> PPD (para-phenylenediamine) is the primary oxidative hair dye intermediate used in permanent hair coloring. It penetrates the cortex, oxidizes in the presence of hydrogen peroxide, and forms large, colored polymeric molecules that become trapped within the hair shaft.

Classification of Hair Dyes

Type	Examples / Mechanism	Duration and Notes
Temporary	Rinse-off colorants; large molecules; coat surface only	1-2 washes; no H2O2; no penetration
Semi-permanent	Small molecules; penetrate cuticle; no H2O2	6-12 washes; no gray coverage
Demi-permanent	Low H2O2 (3%); smaller intermediates	12-26 washes; partial gray coverage
Permanent (oxidative)	PPD + H2O2; penetrate to cortex; polymerize	Permanent until hair grows out; full gray coverage

Chemistry of PPD-Based Oxidative Hair Dye

Components:

- **1. Dye Intermediates (Primary intermediates):** PPD (para-phenylenediamine), PTD (para-toluenediamine), para-aminophenol — these are oxidized by H2O2 first
- **2. Couplers (Secondary intermediates):** Resorcinol, m-aminophenol, 1-naphthol, 2-methylresorcinol — react with oxidized intermediates to produce specific colors
- **3. Oxidizing agent:** Hydrogen Peroxide (H2O2) — 3-12% (10-40 vol) — oxidizes intermediates AND bleaches existing melanin
- **4. Alkalizing agent:** Ammonia (ammonium hydroxide) — swells and opens cuticle; raises pH to 9-11 for dye penetration; activates H2O2

Step-by-Step Chemistry of Color Formation:

> **STEP 1: Ammonia swells and opens cuticle scales (pH 9-11) → dye molecules enter cortex**

STEP 2: H2O2 oxidizes PPD → para-quinone diimine (PQD) [reactive intermediate]
STEP 3: PQD reacts with coupler (e.g., Resorcinol) via electrophilic coupling → forms indo-dye intermediate
STEP 4: Further oxidation → indo-amine dye polymer (large molecule, colored)
STEP 5: Large polymer trapped inside cortex (too large to diffuse out) → PERMANENT color

Color Generated by Different Coupler Combinations:

Intermediate (PPD/PTD)	Coupler	Color Produced	Hair Shade Result
PPD	Resorcinol	Blue-violet indo-dye	Dark brown/black
PPD	m-Aminophenol	Yellow-orange indo-dye	Golden/auburn
PTD (para-toluenediamine)	1-Naphthol	Blue indo-dye	Dark brown
para-Aminophenol	2-Methylresorcinol	Red indo-dye	Red/copper shades
PPD + PTD combination	Resorcinol + m-AP mix	Complex polymeric dye	Customized natural shades

Role of Hydrogen Peroxide

- **Oxidation:** Oxidizes PPD to para-quinone diimine (reactive electrophile)
- **Melanin bleaching:** H2O2 oxidizes and destroys natural melanin in cortex — creates 'blank canvas' for synthetic color
- **Volume/Concentration:** 10 vol (3%) = deposit color; 20 vol (6%) = deposit + slight lift; 30 vol (9%) = strong lift; 40 vol (12%) = maximum lift (bleaching)
- **Stability:** H2O2 stabilized with trace amounts of phosphoric acid, acetanilide — prevents premature decomposition

Role of Ammonia

- **Swells cuticle:** Raises pH to 9-11 → opens cuticle scales → allows dye molecules to penetrate to cortex
- **H2O2 activation:** Alkaline pH activates H2O2; perhydroxyl ion (HO2-) is the active bleaching species, formed only in alkaline conditions
- **Ammonia alternatives:** Ethanolamine (MEA), monoethanolamine — 'ammonia-free' dyes; less volatile; less pungent but less effective cuticle swelling

Building Blocks of PPD Hair Dye Formulation

PPD hair dye is a 2-part system: Part A (Color Cream) + Part B (Developer/Oxidant):

Ingredient	Conc.	Part	Function
PPD (or PTD)	0.5-4%	A	Primary dye intermediate; oxidizes to para-quinone diimine

Couplers (Resorcinol, m-AP)	0.1-2%	A	React with PQD to produce specific colors
Ammonia (NH4OH)	5-15%	A	Cuticle swelling; pH elevation; H2O2 activation
Oleic acid / fatty acid	5-15%	A	Cream base; penetration enhancer for dye; conditioning
Cetearyl alcohol	5-15%	A	Thickener; cream consistency; emollient
Propylene Glycol	5-10%	A	Co-solvent; penetration enhancer; keeps PPD soluble
Surfactant blend	3-8%	A	Emulsification; foam; help distribute dye evenly
Hydrogen Peroxide (H2O2)	3-12%	B	Oxidizer; melanin bleacher; activates dye coupling
Phosphoric acid	0.01-0.05%	B	H2O2 stabilizer; prevents premature decomposition
Chelating agent (EDTA)	0.05-0.1%	B	Sequesters metal ions; prevents H2O2 decomposition
Conditioning agents	1-5%	B	Cetyl alcohol, silicone — reduce damage from H2O2

Advantages and Disadvantages of PPD Hair Dye

Advantages	Disadvantages/Risks
Permanent, long-lasting color — lasts until hair grows out	PPD is a potent allergen — causes contact dermatitis in 1-5% of users
Full gray hair coverage — most effective method for gray coverage	Must perform patch test 48 hours before each use
Wide range of shades possible — from black to light blonde	Ammonia causes pungent odor and may cause respiratory irritation
Dye integrates into cortex — resistant to washing and fading	H2O2 damages hair protein (keratin) and lipid structure
Cost-effective compared to salon permanent treatments	PPD classified as contact allergen by EU; restricted concentration: max 6% in EU
Can be formulated to match natural hair shades precisely	Repeated use increases sensitization risk — allergic reactions worsen with each exposure

★ EXAM IMPORTANT POINTS

Q: What is PPD? Para-phenylenediamine — primary intermediate in permanent oxidative hair dye

Q: Role of ammonia in hair dye? Swells/opens cuticle (pH 9-11); activates H2O2; enables dye penetration

Q: Role of H2O2 in hair dye? Oxidizes PPD to PQD (reactive); bleaches natural melanin

Q: Why is PPD dye permanent? Dye polymer forms INSIDE cortex — too large to diffuse out with washing

Q: PPD allergy precaution? Patch test 48 hours before EVERY use — allergy can develop at any time

Q: Ammonia-free dye uses? Monoethanolamine (MEA) — less volatile but less effective cuticle swelling

Q: Para-quinone diimine (PQD) is formed from? Oxidation of PPD by H2O2

PRINCIPLES OF FORMULATION — ORAL CARE PRODUCTS

Oral care products maintain oral hygiene, prevent dental disease, and address specific conditions (sensitivity, bleeding gums, discoloration). They must be safe for oral mucosal contact and are regulated as cosmetics (toothpaste, mouthwash) or OTC drugs (fluoride toothpaste in USA).

ORAL CARE CHEMISTRY:

Oral pH: Normal saliva pH = 6.2-7.6; after eating, pH drops to 4.5 (acid attack on enamel)

Enamel = hydroxyapatite [Ca10(PO4)6(OH)2] — dissolves below pH 5.5

Fluoride converts hydroxyapatite → fluorapatite (acid-resistant) — prevents caries

Dental plaque = biofilm of bacteria; Streptococcus mutans = primary caries pathogen

Dentinal tubules: fluid movement triggers tooth sensitivity (Hydrodynamic theory)

TOOTHPASTE FOR BLEEDING GUMS

Toothpaste for bleeding gums is formulated to address gingivitis — the primary cause of gum bleeding — by incorporating antibacterial agents, anti-inflammatory actives, and astringents that reduce plaque, control bacterial load, and improve gingival health.

Cause of Bleeding Gums

- **Primary cause:** Dental plaque accumulation → gingivitis → inflammation of gingival tissue → capillary fragility → bleeding on brushing
- **Secondary causes:** Vitamin C deficiency (scurvy), blood disorders, anticoagulant therapy, systemic diseases (diabetes, leukemia)
- **Pathogen:** Porphyromonas gingivalis, Fusobacterium nucleatum, Treponema denticola — key gingivitis-associated bacteria

Building Blocks and Active Ingredients

Ingredient	Conc.	Examples	Function
Abrasive	20-40%	Hydrated silica (mild; RDA 30-60),	Removes plaque, stain, and food debris mechanically

		Dicalcium Phosphate, Calcium Carbonate	
Fluoride	0.1-0.15% F-	Sodium Fluoride (NaF), Sodium Monofluorophosphate (MFP), Stannous Fluoride	Prevents caries; Stannous fluoride (SnF2) additionally has antibacterial properties
Antibacterial / anti-plaque active	0.2-0.5%	Triclosan 0.3%, Zinc citrate 2%, Chlorhexidine 0.05%	Reduces bacterial plaque load; controls gingivitis
Anti-inflammatory active	Variable	Allantoin 0.5%, Vitamin E acetate 0.5%, Bisabolol 0.1%	Reduces gingival inflammation; soothes gum tissue
Astringent	Variable	Zinc chloride 1%, Stannous fluoride 0.4%, Alum (potassium alum)	Tightens gum tissue; reduces bleeding tendency
Vitamin C (Ascorbic acid)	0.1-0.5%	Ascorbic acid, Sodium ascorbate	Supports collagen synthesis in gum tissue; addresses vitamin C deficiency-related bleeding
Binder/thickener	0.5-1.5%	Carboxymethyl Cellulose (CMC), Carbomer, Carrageenan, Xanthan gum	Gel consistency; prevent syneresis; toothpaste texture
Humectant	20-30%	Glycerin (15-25%), Sorbitol (10-20%)	Prevent drying; maintain paste consistency; sweeten mouthfeel
Detergent/Foaming agent	1-2%	Sodium Lauryl Sulfate (SLS), Sodium Lauroyl Sarcosinate	Foaming; helps distribute paste around mouth; mild cleansing
Sweetener	0.05-0.3%	Sodium Saccharin, Xylitol, Stevia	Palatability; Xylitol also inhibits S. mutans
Flavor	0.5-1.5%	Peppermint oil, Spearmint oil, Eucalyptol	Taste and freshness; patient compliance
Water	15-30%	Purified water	Vehicle; dispersant

Actives for Bleeding Gums — Mechanism

Active	Conc.	Mechanism Against Bleeding Gums
Stannous Fluoride (SnF2)	0.454%	Sn2+ ions: antibacterial (disrupts bacterial cell wall) + fluoride: caries prevention; reduces inflammation-causing bacteria

Triclosan	0.3%	Broad-spectrum antibacterial; inhibits fatty acid synthesis; reduces plaque and gingivitis; often combined with copolymer PVM/MA for substantivity
Zinc Citrate	2%	Inhibits bacterial metabolism; reduces plaque; astringent effect on gum tissue; reduces calculus formation
Chlorhexidine	0.05%	Most effective antibacterial; cationic; disrupts bacterial membrane; substantive (binds up to 12 hours); reduces plaque and gingival inflammation
Allantoin	0.5%	Anti-inflammatory; promotes tissue healing and cell regeneration; soothes irritated gum tissue
Vitamin C	0.1-0.5%	Essential for collagen synthesis in periodontal ligament and gingival tissue; deficiency causes capillary fragility and bleeding

TOOTHPASTE FOR SENSITIVE TEETH

> Desensitizing toothpaste is formulated to reduce dentin hypersensitivity — the sharp, short-lived pain caused by stimuli (cold, heat, sweet, acidic, tactile) acting on exposed dentinal tubules — either by occluding the tubules or by desensitizing pulpal nerves.

Mechanism of Dentin Hypersensitivity

Brannstrom's Hydrodynamic Theory:

- Exposed dentin → open dentinal tubules → stimuli (cold/hot/sweet) → fluid movement in tubules → **activates A-delta nerve fibers at pulp-dentin border → sharp pain**
- **Causes of exposure:** Gingival recession, enamel erosion (acidic diet), bruxism, abrasive toothbrushing, dental procedures

Two Mechanisms of Desensitization

Mechanism	How It Works	Active Ingredients
Nerve Desensitization	Potassium ions increase extracellular K+ around nerve endings → repolarization prevented → nerve cannot fire → pain signal blocked	Potassium Nitrate (KNO_3) 5%, Potassium Chloride 3.75%, Potassium Citrate 5.5%
Tubule Occlusion	Agents physically block open dentinal tubule openings → fluid movement prevented → no hydrodynamic stimulation → no pain	Calcium sodium phosphosilicate (NovaMin), Stannous Fluoride 0.454%, Strontium Acetate 8%, Arginine + $CaCO_3$ (Pro-Argin technology), Hydroxyapatite nano-particles

Building Blocks of Desensitizing Toothpaste

Ingredient	Conc.	Examples	Function
Desensitizing active	Various	KNO3 5%, Stannous Fluoride 0.454%, Arginine 8%, NovaMin 5%, Strontium Acetate 8%	Core desensitizing ingredient — either nerve or tubule mechanism
Fluoride	0.1-0.15%	NaF 1450 ppm, MFP 0.76%	Caries prevention; SnF2 also helps occlude tubules
Mild abrasive	15-30%	Hydrated silica (very low RDA <40), Calcium Carbonate	Low abrasivity critical — high RDA worsens dentinal exposure
Humectant	20-30%	Glycerin, Sorbitol	Consistency; prevent drying
Binder	0.5-1.5%	Carboxymethyl cellulose, Carbomer	Gel consistency; holds formulation together
Detergent	0.5-1.5%	Sodium Lauroyl Sarcosinate preferred over SLS	Foaming; avoid SLS in sensitive formulations — SLS can irritate exposed dentin
Flavor	0.5-1%	Mild mint (low menthol) or unflavored	Compliance; avoid strong menthol which can aggravate sensitivity

Active Ingredients — Detailed Mechanism

Active	Conc.	Mechanism
Potassium Nitrate (KNO3)	5%	K+ ions diffuse along open dentinal tubules → accumulate around A-delta nerve endings → hyperpolarize (block) nerve firing → pain signal not transmitted; takes 2-4 weeks for effect
Stannous Fluoride (SnF2)	0.454%	Sn2+ ions + F- → deposit stannous fluoride crystals inside tubule opening → partial tubule occlusion; also antibacterial; dual action
Arginine + CaCO3 (Pro-Argin)	8% Arg	Arginine (positively charged at oral pH) attracts to negatively charged dentin → concentrates CaCO3 at tubule openings → calcium deposits form a sealing plug; fast-acting — relief within minutes
NovaMin (Calcium Sodium Phosphosilicate)	5-15%	Releases Ca2+ and PO4 3- ions in saliva → forms hydroxyapatite-like layer at tubule openings → biomimetic re-mineralization and sealing

Strontium Acetate	8%	Older technology; Sr2+ ions replace Ca2+ in hydroxyapatite at tubule openings → strontium apatite plug formed → effective but slower than newer technologies

TEETH WHITENING

> Teeth whitening (bleaching) is the use of chemical oxidizing agents (hydrogen peroxide, carbamide peroxide) to break down intrinsic and extrinsic stain chromogens in the enamel and dentin, resulting in a lighter tooth shade.

Classification of Tooth Stains

Type	Cause	Location / Removal
Extrinsic Stains	Tea, coffee, red wine, tobacco, chromogenic bacteria	On enamel surface; removed by abrasives and polishing (toothpaste, dental cleaning)
Intrinsic Stains	Tetracycline antibiotics, fluorosis, trauma, aging (natural yellowing)	Within enamel and dentin; only bleaching agents (H2O2) can remove
Internalized Stains	Extrinsic stains that have penetrated enamel cracks	Require bleaching for removal

Whitening Agents — Types and Mechanism

Whitening Agent	Conc.	Mechanism of Action
Hydrogen Peroxide (H2O2)	6-35%	Diffuses through enamel to dentin; produces free radicals (HO.) and perhydroxyl ions; oxidizes double bonds of chromogen molecules (conjugated carbon chains = stain color) → smaller, colorless fragments
Carbamide Peroxide (CP)	10-22%	Urea + H2O2 complex; releases H2O2 slowly on contact with water; 10% CP ≈ 3.35% H2O2; slower, gentler action; standard for home whitening trays
Sodium Percarbonate	5-8%	Releases H2O2 when dissolved in water; used in whitening toothpastes and strips; milder than pure H2O2
Sodium Perborate	Variable	Releases H2O2; used in walking bleach technique (internal bleaching of non-vital teeth)

Whitening Product Types

Product Type	Active Conc.	Formulation and Use

In-office bleaching	25-40% H_2O_2	Professional application; light/laser activation; results in 1 hour; maximum efficacy; risk of sensitivity
Take-home whitening trays	10-22% CP	Custom tray fitted by dentist; worn 4-8 hours/day or overnight; 2-4 weeks treatment
OTC whitening strips	5-14% H_2O_2 or 10-20% CP	Thin polyethylene strip coated with whitening gel; applied to teeth 30 min daily for 2-4 weeks
Whitening toothpaste	0.5-2% H_2O_2 or abrasives	Dual action: mild H_2O_2 bleaching + abrasive polishing of extrinsic stains; daily use; mild effect
Whitening mouthwash	1-3% H_2O_2	Rinse twice daily; short contact time; mild extrinsic stain removal; maintenance use
Whitening pen / gel	5-18% H_2O_2	Applied directly to tooth surface with brush; quick spot treatment; 15-30 min contact time

Building Blocks of Whitening Gel (Tray Whitening)

Ingredient	Conc.	Examples	Function
Bleaching active	10-35%	Carbamide Peroxide 10-22%, Hydrogen Peroxide 3-35%	Primary whitening agent; oxidizes chromogens
Desensitizing agent	5%	Potassium Nitrate 5%, Fluoride 0.25%	Counter sensitivity caused by bleaching; nerve desensitization
Thickener/gelling agent	0.5-2%	Carbopol (Carbomer), HPMC, Glycerin	Gel consistency; adheres to tray; prevents rapid washout
Humectant/carrier	20-40%	Glycerin, Propylene Glycol	Maintain gel consistency; slow drying; improve active contact
pH adjuster	q.s.	Sodium hydroxide, phosphoric acid	pH 5.5-7.0 optimal for whitening; acidic too irritating; alkaline decomposes H_2O_2
Chelating agent	0.05-0.1%	EDTA	Stabilize H_2O_2; prevent metal-catalyzed decomposition
Flavor	0.1-0.5%	Peppermint, spearmint	Patient compliance

Advantages and Disadvantages of Teeth Whitening

Advantages	Disadvantages
Highly effective for intrinsic stain removal — significant shade improvement	Most common side effect: tooth sensitivity (20-70% of users) and gingival irritation
Non-invasive — no drilling or structural modification of teeth	Temporary effect — staining recurs with continued use of staining agents
Professional results achievable at home with OTC products	Tetracycline stains and fluorosis respond poorly — may require veneers
Boosts confidence and improves smile aesthetics	High H2O2 concentrations can damage enamel protein and increase porosity
Multiple formats (strips, trays, toothpaste) for different budgets	Not suitable for crowns, veneers, or composite restorations — only natural enamel bleaches

MOUTHWASH (MOUTH RINSE)

> Mouthwash is an aqueous oral rinse formulation that provides adjunctive oral hygiene benefits beyond brushing, including antibacterial action, plaque reduction, caries prevention, gingival health, fresh breath, and tooth whitening — depending on the active ingredients incorporated.

Classification of Mouthwash

Type	Key Active	Target / Benefit
Cosmetic Mouthwash	Flavor, fluoride (low level)	Fresh breath only; no therapeutic claim; masking of halitosis
Fluoride Mouthwash	NaF 0.05-0.2%, SnF2	Caries prevention; for high-risk caries patients; after orthodontic treatment
Antibacterial Mouthwash	Chlorhexidine 0.12-0.2%, CPC 0.05-0.1%	Plaque and gingivitis control; pre/post-surgical use; anti-dandruff scalp rinse
Essential Oil Mouthwash	Thymol, Eucalyptol, Menthol, Methyl Salicylate (Listerine formula)	Antibacterial; plaque and gingivitis control; fresh breath
Whitening Mouthwash	H2O2 1-3%	Mild extrinsic stain removal; whitening maintenance
Dry Mouth Mouthwash	Xylitol, CMC, betaine	Moisturizes oral mucosa; saliva substitute for xerostomia
Anti-halitosis Mouthwash	Zinc gluconate/acetate, CHX, CPC	Neutralizes VSCs (volatile sulfur compounds) causing bad breath

Building Blocks of Mouthwash

Ingredient	Conc.	Examples	Function
Water	60-80%	Purified water	Major vehicle; solvent for all components
Alcohol (ethanol)	0-27%	SD Alcohol 38-B; Ethanol	Solubilizes essential oils and flavor; antibacterial; preservative; cooling effect
Antibacterial active	Variable	Chlorhexidine 0.12%, CPC 0.05%, Triclosan 0.03%	Core therapeutic ingredient for antibacterial mouthwash
Essential oils blend	0.05-0.09%	Thymol 0.064%, Eucalyptol 0.092%, Menthol 0.042%, Methyl Salicylate 0.06% (Listerine formula)	Broad-spectrum antibacterial; disrupt bacterial cell wall; anti-inflammatory
Fluoride source	0.005-0.04%	Sodium Fluoride 0.05-0.2%, Stannous Fluoride 0.1%	Caries prevention; remineralization
Humectant	5-20%	Glycerin, Propylene glycol	Prevent drying of mucosa; improve texture; stabilize flavor
Surfactant	0.1-1%	Polysorbate 80, Tween 80, PEG-60	Solubilize essential oils in water; help distribute actives throughout mouth
Anti-halitosis agents	0.05-0.5%	Zinc gluconate, Zinc acetate, Zinc chloride	Neutralize VSCs by forming non-volatile zinc-sulfur complexes; eliminates bad breath chemically
Sweetener	0.01-0.1%	Sodium Saccharin, Xylitol	Improve palatability; patient compliance
Flavor	0.5-1.5%	Peppermint, Spearmint, Eucalyptus, Menthol	Fresh taste; breath freshening; patient compliance
Color	Trace	FD&C Blue No. 1, FD&C Green No. 3	Visual appeal; product identity (blue, green, gold mouthwashes)
Preservative	0.05-0.1%	Sodium benzoate, Methylparaben	Additional microbial protection of water phase

pH adjuster	q.s.	Phosphoric acid, Sodium citrate buffer	pH 4.5-7.0; controls stability; irritation minimized

Active Ingredients — Mechanism

Active	Conc.	Mechanism Against Oral Bacteria / Halitosis
Chlorhexidine Gluconate	0.12-0.2%	Cationic biocide; binds to negatively charged bacterial surface → disrupts cell membrane → bacterial death; substantive (binds to oral mucosa and tooth surface for 12 hours continuous release); 'gold standard' anti-plaque agent
Cetylpyridinium Chloride (CPC)	0.05-0.1%	Quaternary ammonium compound; cationic; penetrates and disrupts bacterial cell membranes; broad-spectrum antibacterial; less substantive than CHX; used in most commercial mouthwashes (Scope, Listerine Cool Mint)
Essential Oils (Listerine Formula)	Various	Thymol (0.064%) + Eucalyptol (0.092%) + Menthol (0.042%) + Methyl Salicylate (0.06%); disrupt bacterial cell wall; penetrate biofilm; reduce plaque and gingivitis comparable to CHX; approved by ADA
Hydrogen Peroxide	1-3%	Oxidizing agent; releases oxygen which inhibits anaerobic bacteria; breaks down VSCs; mild whitening; kills bacteria in deep gingival pockets
Zinc Salts	0.05-0.5%	Zinc2+ chelates sulfur in VSCs (H2S, methyl mercaptan) → forms insoluble zinc sulfide → odorless; also disrupts bacterial enzyme systems; anti-calculus effect (inhibits crystal growth)
Sodium Fluoride (NaF)	0.05-0.2%	Fluoride ions incorporated into enamel → fluorapatite formation → acid resistance; inhibit bacterial enzyme (enolase) in glycolysis → reduce acid production by S. mutans

Manufacturing of Mouthwash

- **Step 1:** Dissolve flavor blend and essential oils in alcohol
- **Step 2:** Dissolve humectants (glycerin, PG) and sweeteners in water separately
- **Step 3:** Dissolve antibacterial actives (CHX or fluoride) in water phase
- **Step 4:** Add surfactant (Polysorbate 80) to solubilize essential oils
- **Step 5:** Combine alcohol phase + water phase with stirring; add color
- **Step 6:** Adjust pH with buffer system (phosphoric acid / sodium citrate)
- **Step 7:** Quality check: clarity, pH, alcohol content, active ingredient assay, microbial limit test
- **Note:** Alcohol-free formulations use polysorbate/PEG system to solubilize essential oils; include additional preservative (benzalkonium chloride, sodium benzoate)

Advantages and Disadvantages of Mouthwash

Advantages	Disadvantages
Reaches areas inaccessible to toothbrush — interdental spaces, tongue dorsum	Chlorhexidine: brown tooth staining with prolonged use; tastes bitter
CHX provides 12-hour substantive antibacterial protection	Alcohol-containing mouthwash (20-27%) may cause dry mouth; alcohol concern for children and recovering alcoholics
Fluoride mouthwash provides additional caries protection beyond toothpaste	Should not be used immediately after brushing — dilutes fluoride from toothpaste
Effective adjunct to brushing and flossing for gingivitis prevention	CHX reduces taste sensation; interferes with taste perception during use
Fresh breath provides immediate psychological benefit and confidence	Not a substitute for mechanical plaque removal (brushing and flossing)
Multiple formats target specific conditions (sensitivity, whitening, dry mouth)	Some essential oil mouthwashes are alcoholic — burning sensation; low patient compliance

★ EXAM IMPORTANT POINTS

Q: What is the mechanism of chlorhexidine in mouthwash? Cationic biocide; binds to bacterial membrane; substantive (12 hours release)

Q: Listerine formula consists of? Thymol 0.064% + Eucalyptol 0.092% + Menthol 0.042% + Methyl Salicylate 0.06%

Q: How does zinc reduce bad breath? Chelates VSCs (H_2S, methyl mercaptan) → forms non-volatile zinc sulfide → odorless

Q: Why is CHX not used long-term? Causes brown staining of teeth; alters taste perception

Q: What is the role of alcohol in mouthwash? Solubilizes essential oils; antibacterial; cooling effect; preservative

Q: What type of fluoride mouthwash for daily use? NaF 0.05% (low-dose daily) or NaF 0.2% (weekly rinsing)