PharmacoLearn

MPH204T Cosmetic and Cosmeceuticals, M.Pharm Semester 2

Unit 4: Design of Cosmeceutical Products

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4.1 Sun protection: what the formulation is defending against

Ultraviolet radiation reaching the skin divides by wavelength and effect. **UVB** (290 to 320 nm) is largely absorbed in the epidermis; it produces sunburn (erythema) and drives direct DNA damage, and it is the band the SPF number measures protection against. **UVA** (320 to 400 nm, with UVA2 320 to 340 and UVA1 340 to 400) penetrates into the dermis, is present all day and through window glass, and drives photoageing (Unit 2) and much of pigmentation, besides contributing to skin cancer risk. Visible light, particularly in darker skin types, adds to melasma pigmentation. Sun protection therefore has two targets, not one: prevent erythema (UVB) and prevent the long wavelength damage (UVA), and a modern sunscreen is judged on both. The product design that follows is the combination of UV filters that absorb or scatter across both bands, a film forming vehicle that lays them evenly on an uneven skin surface, and the cosmetic elegance on which actual user compliance, and therefore real protection, depends.

4.2 Sunscreens: classification of UV filters

UV filters are classified by mechanism and by spectrum, and a formulation is a blend chosen from the table.

Class	Examples	Mechanism and spectrum
Organic UVB absorbers	Octinoxate (ethylhexyl methoxycinnamate), octocrylene, ethylhexyl salicylate, homosalate	Absorb UVB (and short UVA for octocrylene), converting it to heat; the erythema protection workhorses
Organic UVA absorbers	Avobenzone (butyl methoxydibenzoylmethane), the standard UVA1 absorber; bemotrizinol and bisoctrizole, broad modern filters	Absorb UVA; avobenzone is notably photounstable and must be stabilised, classically by octocrylene or by modern filters
Broad spectrum modern organics	Bemotrizinol (Tinosorb S type), bisoctrizole (Tinosorb M type, which also scatters)	Single molecules covering UVB and UVA with high photostability; widely used in the EU and Asia, regulatory status varies by market
Inorganic (mineral) filters	Zinc oxide, titanium dioxide	Absorb and scatter across UVB and UVA (zinc oxide extends furthest into UVA); micronised or nano grades trade whitening on skin against transparency
Secondary protectors	Antioxidants such as vitamin E and vitamin C, anti inflammatory agents	Not filters; they quench the free radicals UV generates and are supporting actives in the formula

Classification by product form completes the picture: creams and lotions (emulsions, the standard), gels (alcohol or aqueous, for oily skin and the scalp), sprays (convenient, film uniformity is a concern), sticks (small areas), and powders and compacts carrying mineral filters for reapplication over make up.

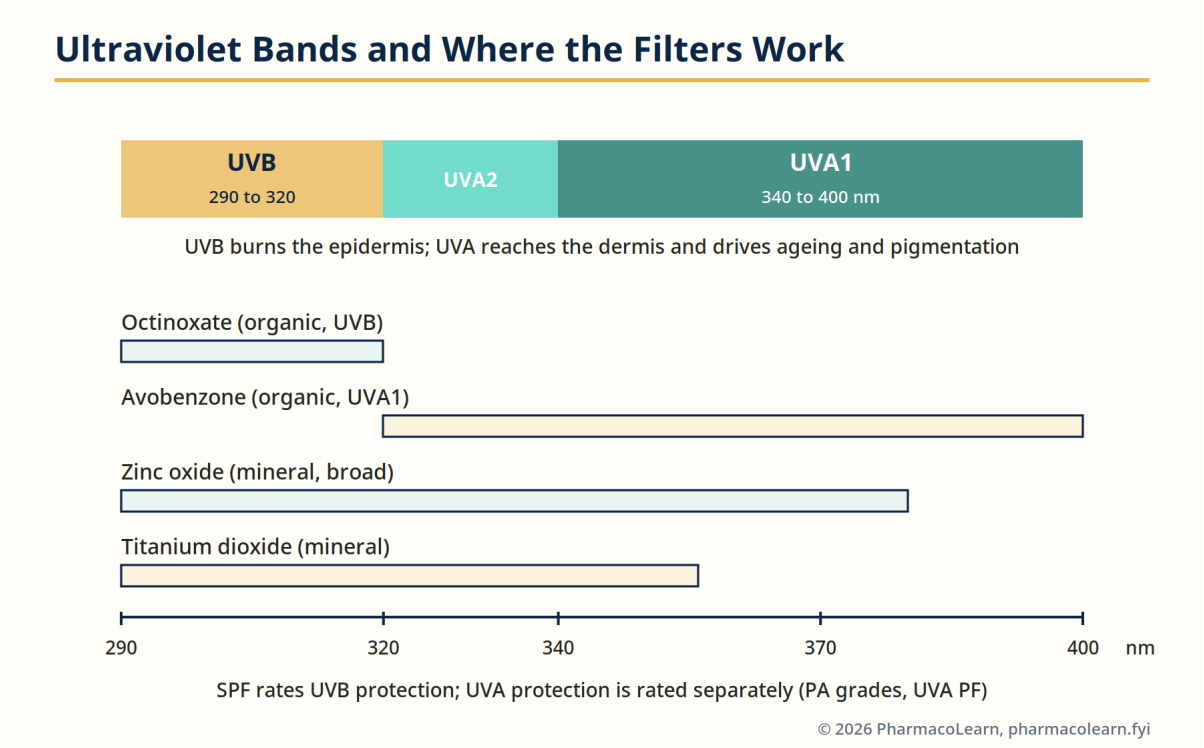

Figure: No single common filter covers the whole ultraviolet range, which is why sunscreens are blends.

4.3 SPF and protection measurement

The **sun protection factor (SPF)** is the ratio of the minimal erythemal dose of UV on sunscreen protected skin to that on unprotected skin, measured in vivo on human volunteers with the product applied at the standard density of 2 milligrams per square centimetre of skin. An SPF 30 product in the test therefore lets one thirtieth of the erythemally effective radiation through, blocking about 97 percent of UVB; SPF 50 blocks about 98 percent, which shows why SPF gains flatten: the number is a reciprocal, not a percentage. Three qualifications matter for design and for honest claims. The test density is roughly double what most users actually apply, so real world protection is substantially lower than the label, a behavioural fact that high SPF partly compensates. SPF says almost nothing about UVA, which is rated separately, by the persistent pigment darkening method expressed as PA grades (PA+ to PA++++) common in Asia, or by the in vitro UVA protection factor and critical wavelength methods used in the EU, where the recommendation is that UVA protection be at least one third of the labelled SPF. Water resistance is a separate tested claim, retention of SPF after standardised water immersion. In vitro methods using plates and spectrophotometry support development but in vivo testing remains the reference for the label.

4.4 Formulation design of a sunscreen

Building a sunscreen from Unit 3 blocks shows what is special about the category. The **filter system** is designed first, for spectrum, photostability and permitted levels in the target market: a UVB absorber base, a UVA absorber, stabilisation of any avobenzone, and mineral filters where a mineral claim or sensitive positioning is wanted. The **vehicle** must dissolve crystalline filters (oily emollients such as C12-15 alkyl benzoate serve as filter solvents), spread to a uniform film, and resist removal by sweat, water and sebum, for which film formers and water resistant polymers are added. **Emulsion type** trades protection against elegance: water in oil systems resist wash off but feel heavy, oil in water systems are the mainstream compromise. Sensory design is not decoration in this category, because a sunscreen worn thin or not at all protects nobody; the elegant product with a slightly lower SPF usually delivers more real protection than the disliked stronger one. Finally the product is **tested as a system**: filters interact, vehicles change filter distribution on skin, and the SPF on the label belongs to the finished formula, never to the filter list alone.

4.5 Regulatory aspects of sunscreens

Sunscreens sit on the drug cosmetic borderline more visibly than any other product in this subject. In India they are regulated as cosmetics under the framework of Unit 1, with labelling and ingredient restrictions applying as for other cosmetics. In the United States they are regulated as over the counter drugs, with monograph conditions for filters, levels and testing, which is why several modern European filters long remained unavailable there; the regulatory status of a filter is a market by market question and a formulator designs the filter system per destination. In the EU, UV filters are a positive list: only filters listed in the regulation's annex may be used, at or below their stated maxima, and the claim rules require that products not be labelled in ways implying total protection, so terms such as "sunblock" and "total protection" are prohibited in the EU, SPF labelling is capped (products testing above 50 are labelled 50+), and the UVA circle logo certifies the one third UVA rule of section 4.3. The common principles across markets: filters are the most tightly controlled cosmetic ingredients in existence, the label number must come from the prescribed test, and claims must not discourage sensible sun behaviour, because no sunscreen at real application thickness gives complete protection.

4.6 Addressing dry skin through cosmeceutical formulation

The moisturizer of section 3.8 is the base design; the cosmeceutical version adds a repair intent and an evidence discipline. Design: combine the three mechanisms with intent, an occlusive phase (petrolatum remains the benchmark, measurably cutting TEWL), a strong humectant system (glycerin at meaningful levels, with urea which is both humectant and, at higher levels, keratolytic for scaly conditions), and barrier lipid replacement (ceramides with cholesterol and free fatty acids). Supporting actives used with good evidence include niacinamide, which increases ceramide synthesis, and colloidal oatmeal in the North American tradition for itch and irritation. Design pitfalls are examinable: fragrance and strong preservatives in a product for barrier damaged skin invite the sensitization Unit 2 predicts; high alcohol "light" textures defeat the purpose; and pH should respect the acid mantle. The claim boundary is comfort and measurable moisturization (corneometry and TEWL are the standard instruments), not the treatment of eczema, which is a drug claim territory a cosmetic must not enter.

4.7 Addressing acne through cosmeceutical formulation

The acne design targets the four factors of Unit 2 within cosmetic limits. Sebum and shine are managed with light, oil free gel vehicles, oil absorbing powders (silica, starches) and mattifying films; the product must not add occlusive, comedogenic load to a follicle already plugging. Follicular hyperkeratinization is addressed with keratolytic actives that cosmetics legitimately use, salicylic acid being the standard (a beta hydroxy acid that is oil soluble and so enters the sebum filled follicle), with glycolic and other alpha hydroxy acids for surface renewal. Cutibacterium acnes and inflammation are moderated by niacinamide, widely used for its anti inflammatory and sebum moderating profile, and by zinc salts in some traditions; benzoyl peroxide and topical retinoids are drug actives in most classifications and are not smuggled into a cosmetic formula. Formulation discipline: non comedogenic testing or ingredient screening supports the positioning, pH and irritation are tightly controlled because acne skin is often also on irritating drug therapy, and claims are limited to care of oily and blemish prone skin. The honest design summary: a cosmetic cannot treat acne, and a well designed one still earns its place by cleansing gently, not adding plugs, delivering salicylic acid properly, and supporting the skin through drug treatment.

4.8 Addressing pigmentation through cosmeceutical formulation

Anti pigmentation design is a layered strategy against the melanin pathway of Unit 2. **Tyrosinase inhibition** is the classic route: arbutin (a glycoside that releases hydroquinone slowly), kojic acid, and in

current practice niacinamide, which works differently, by reducing melanosome transfer from melanocyte to keratinocyte; vitamin C derivatives (ascorbyl glucoside, magnesium ascorbyl phosphate) act as antioxidants and mild inhibitors; newer designed molecules such as thiamidol represent the high end of inhibitor research. **Exfoliation** with alpha hydroxy acids speeds the shedding of already pigmented corneocytes. **Photoprotection is the foundation, not an add on:** a broad spectrum sunscreen, with iron oxide pigments for visible light protection in melasma prone darker skin, without which the other layers are wasted. Design cautions: hydroquinone itself is restricted or drug only in many markets (its cosmetic use has been prohibited in the EU) and is not a casual cosmetic ingredient; irritation from aggressive lighteners causes post inflammatory pigmentation, the exact condition being treated, which is why mildness testing dominates this category; and results are measured in months, a claims and counselling point. Even, supported language: "reduces the appearance of dark spots", with sunscreen in the same regimen.

4.9 Addressing prickly heat through cosmeceutical formulation

Section 2.5 set the mechanism: blocked sweat ducts in hot, humid conditions. The formulation response is subtractive rather than active led. **Powders** are the characteristic product: a talc or starch based dusting powder absorbs surface moisture, reduces skin to skin and skin to clothes friction, and keeps the surface dry so ducts stay open; antiseptic variants exist in the Indian market tradition. **Light lotions**, classically calamine type preparations (calamine with zinc oxide in an aqueous base), cool by evaporation, soothe itch and leave a dry protective film without occlusion. Design rules are the mirror of the moisturizer: avoid heavy oils, waxes and occlusive films in the hot season product; keep textures aqueous and fast drying; include mild soothing agents. Prevention counselling is part of the design brief: loose clothing, cooling, and drying after sweating do more than any ingredient, and a formulation that promises to cure miliaria overclaims; it relieves and helps prevent.

4.10 Addressing wrinkles through cosmeceutical formulation

Anti wrinkle design starts from the honesty of section 2.6: the changes are dermal, the product acts at the surface, and the formulation layers are therefore prevention, optical correction and modest biological support. **Prevention** is the sunscreen of sections 4.1 to 4.5, the single most effective anti wrinkle product ever tested. **Optical and physical smoothing** is immediate: moisturization swells the stratum corneum and softens fine lines, silicone elastomers and soft focus powders fill and blur lines, and film formers give a temporary tightening feel. **Biological support** actives with the best cosmetic evidence are the retinoids, retinol and retinal in cosmetic use (adapalene and tretinoin are drugs), which over months increase epidermal thickness and improve photoaged appearance, at the cost of irritation that the formulation must manage with dose, encapsulation and buffering emollients; vitamin C as an antioxidant and collagen synthesis cofactor, niacinamide, and peptide signal ingredients such as palmitoyl peptides complete the standard active shelf. Packaging is part of the design: retinoids and vitamin C degrade in air and light, so airless, opaque packs are functional, not decorative. Claims stay at appearance, and any product promising to reverse ageing is announcing that it is not a compliant cosmetic.

4.11 Addressing body odor: deodorants and antiperspirants

Unit 2 separated the two designs and this section formulates them. A **deodorant** reduces odor without much affecting sweat: antimicrobial agents (historically triclosan, now more commonly ethylhexylglycerin, farnesol or zinc ricinoleate, which traps odorants chemically) reduce the bacterial manufacture of odor; absorbent powders take up moisture and odorants; fragrance perfumes and masks. A **deodorant antiperspirant** adds aluminium salts (aluminium chlorohydrate is the standard, aluminium zirconium complexes the high efficacy grade) that dissolve in sweat at the duct opening and precipitate as a gel plug in the upper eccrine duct, reducing sweat flow to the surface for a day or more; less sweat also means less

bacterial substrate, so antiperspirants deodorise secondarily. Formats use every block of Unit 3: sticks (wax structured anhydrous), roll ons (emulsions), aerosols (alcohol and propellant systems), creams and gels. Design constraints: aluminium salt solutions are acidic and irritating if misformulated; application to freshly shaved skin stings; white residue on clothes from salts and yellow staining from sweat and salt interaction are the classic consumer complaints the formulation must engineer down.

4.12 Addressing dandruff through cosmeceutical formulation

Dandruff is scalp scaling with itch, driven by the scalp's Malassezia yeasts metabolising sebum in a susceptible individual, with accelerated epidermal turnover shedding visible flakes. The anti dandruff shampoo is the designed answer, built on the shampoo chassis of section 3.10 with an antifungal active block: **zinc pyrithione**, the historical standard antifungal and cytostatic agent (its cosmetic use was prohibited in the EU in 2022 on reproductive toxicity classification, and markets diverge, so its status must be checked per destination); **ketoconazole**, a potent azole antifungal, drug classified in many markets; **selenium sulfide**, antifungal and cytostatic, with a characteristic odour and colour care needed; **piroctone olamine**, a modern cosmetic antifungal with a good tolerance profile; and **salicylic acid** and coal tar (restricted) as keratolytic partners that remove scale so the antifungal reaches the scalp. Delivery is the design problem: a rinse off product has minutes of contact, so actives are chosen and deposited with substantive carriers, and the instructions (leave the lather in contact, use regularly) are part of the product. Cosmetic positioning covers dandruff as a cosmetic condition; severe seborrhoeic dermatitis is medical.

4.13 Addressing dental cavities and bleeding gums through cosmeceutical formulation

Unit 3 built the toothpaste; this section aims its blocks at the oral problems of Unit 2. Against **dental cavities**, the active is fluoride: in the mouth, fluoride converts surface hydroxyapatite towards the more acid resistant fluorapatite, promotes remineralisation of early lesions and mildly inhibits bacterial acid production; the formulation duties are to keep fluoride bioavailable (abrasive compatibility, section 3.11), to dose it at the levels the market's rules prescribe (around 1000 to 1500 parts per million fluoride is the usual adult toothpaste range where permitted), and to design flavour and foaming so that users, especially children, brush long enough, with a pea sized amount and spitting rather than swallowing for the young. Against **bleeding gums** (gingivitis), the design combines mechanical plaque removal support (the abrasive and surfactant system) with antiplaque and antigingivitis agents used in oral cosmetics: stannous fluoride (simultaneously anticaries and antigingivitis, with flavour and stability challenges), zinc citrate against calculus and bacterial metabolism, cetylpyridinium chloride and essential oil systems against plaque bacteria, and triclosan historically. Herbal gum care actives follow in Unit 5. The claim line is exact: toothpaste helps prevent caries and gingivitis; established periodontitis needs a dentist, and bleeding that persists is a referral, not a bigger claim.

4.14 Addressing mouth odor and sensitive teeth through cosmeceutical formulation

Mouth odor design works on volatile sulfur compounds and their bacterial source (Unit 2.9): zinc salts are the core technology, because zinc ions bind sulfur compounds to non volatile products and inhibit the bacteria producing them; cetylpyridinium chloride and chlorhexidine (the latter a drug grade antiseptic with staining and taste side effects that limit cosmetic use) reduce the bacterial load; essential oil rinses combine antimicrobial action with flavour impact; and tongue cleaning is the mechanical half of the regimen, since most odor originates on the tongue coating. Mouthwashes are the delivery format, aqueous or hydroalcoholic solutions of the same blocks. **Sensitive teeth** design follows the hydrodynamic theory: either seal the open dentinal tubules or calm the nerve. Tubule occluding agents include stannous fluoride and arginine with calcium carbonate, which deposit mineral plugs in the tubule openings, and bioactive glass compositions that lay down a hydroxycarbonate apatite layer; nerve desensitising relies on potassium

nitrate, whose potassium ions raise the firing threshold of the intradental nerves over weeks of use. Both mechanisms are slow and cumulative, so the honest product promise is reduced sensitivity with regular use, and the formulation must not sabotage them with an aggressive abrasive that reopens tubules faster than they seal.

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Designing against a Unit 2 problem: the workflow of Unit 4
Problem biology (Unit 2)
   |
   v
Choose the mechanism of intervention
(block, inhibit, absorb, occlude, deposit)
   |
   v
Select actives with evidence at cosmetic doses
   |
   v
Build the vehicle from Unit 3 blocks
   |
   v
Check the claim stays a cosmetic claim
   |
   v
Stability, safety and efficacy testing of the finished product
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