

Cosmetics

•**Definition:** Cosmetic is defined under section 3(aaa) of the **Drugs and Cosmetics Act, 1940** as,

“any article intended to be rubbed, poured, sprinkled or sprayed on, or introduced into, or otherwise applied to, the human body or any part thereof for cleansing, beautifying, promoting attractiveness or altering the appearance, and includes any article intended for use as a component of cosmetic”.

•**Origin:** The word "cosmetic" is derived from the Greek word *kosmetikos*, which means "to adorn" or "beautify".

•**Purpose:** To enhance a person's physical appearance and scent, using a mix of natural and synthetic compounds.

Central Drugs Standard Control Organization (CDSCO) under

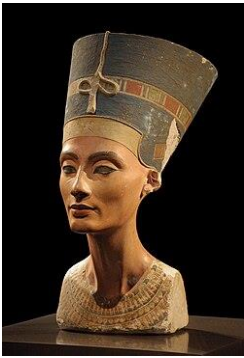
Directorate General of Health Services, Ministry of Health & Family Welfare, Government of India is the National Regulatory Authority of India for Drugs and Cosmetics.

Book Suggestion

Introduction to Cosmetic Formulation and Technology,
Gabriela Baki, Kenneth S. Alexander (Wiley)

A Brief History of Cosmetics

- **Ancient India** In the Indus Valley Civilization, archaeological excavations at Mohenjo-daro and Harappa have revealed small cosmetic containers, applicators, and evidence of pigments used for personal adornment. Traditional Indian practices included the use of kajal (kohl) to darken the eyes, believed to be both aesthetic and protective against glare and the evil eye. The application of sindoor (vermillion) in the hair parting by married women, and the use of mehndi (henna) for body decoration, also trace back to ancient Indian customs and remain culturally significant today
- **Ancient Egypt (4000 B.C.):** Early use of scented oils, ointments, and kohl for aesthetic and protective purposes.
- **Ancient Rome:** Cosmetics were popular among the wealthy, though sometimes frowned upon.
- **Medieval Europe:** Cosmetics were seen as vulgar by the church, but the wealthy still used ingredients like white lead to achieve a pale complexion.
- **19th Century:** Queen Victoria declared makeup improper, but the modern cosmetics industry emerged later with safer, mass-produced products.
- **Modern Era:** Influence from Hollywood, the rise of major brands like Max Factor and Elizabeth Arden and increasing diversity in product offerings.



The bust of Nefertiti with eye-liner applied from the Egyptian Museum of Berlin collection, currently in the Neues Museum.



Jars for cosmetics
Indus valley civilization



Ancient Egypt beauty box, with accessories including a kohl tube

Source: History of Cosmetics, wikipedia

Classification of Cosmetics by Use

Skin Cosmetics: Creams, powders, foundations, moisturizers, and sunscreens.

Hair Cosmetics: Shampoos, conditioners, hair dyes, and styling products.

Nail Cosmetics: Nail polish, removers, and cuticle softeners.

Color Cosmetics: Lipstick, Lip gloss, Lip Balm

Eye Cosmetics: Mascara, eyeliners, and eye shadows.

Oral Cosmetics: Toothpaste and mouthwash.

Classification of Cosmetics by Function

- Decorative:** Products that visibly change a person's appearance, such as lipstick and eye makeup.
- Protective:** Products that shield the body, like sunscreens and protective creams.
- Corrective:** Preparations that address and repair skin imperfections, such as creams for cracked skin.
- Therapeutic:** Cosmeceuticals that deliver both cosmetic and medicinal benefits.

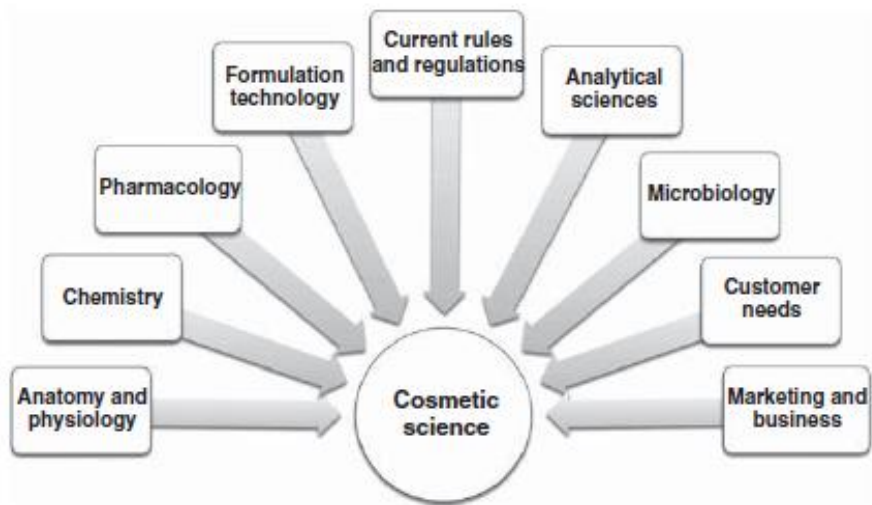
Cosmeceuticals

•**Definition:** A hybrid of cosmetics and pharmaceuticals that offers both aesthetic and therapeutic benefits.

•**Key Difference:** Cosmeceuticals aim to treat the underlying skin issue, while regular cosmetics only cover it up.

•**Examples of Active Ingredients:** Antioxidants (Vitamins A, C, E), sunscreens, retinoids, peptides, and hyaluronic acid.

•**Expert Recommendation:** Often recommended by dermatologists for specific skin concerns.



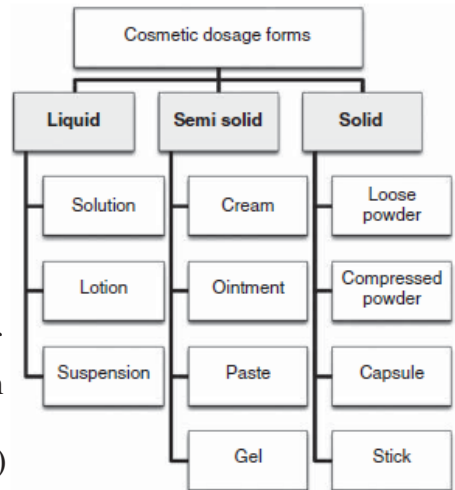
Cosmetic science is a real science, and it is a multidisciplinary field since it includes basic knowledge and a wide range of information from a number of different scientific fields. It is involved with developing, formulating, and producing cosmetics and personal care products.

Dosage form

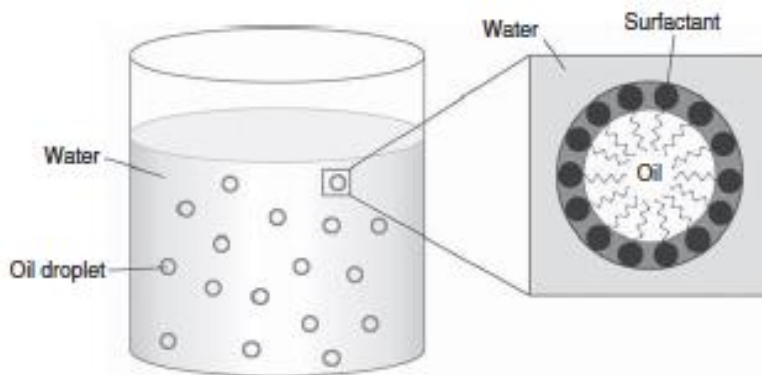
dosage form is defined as the final physical form of a mixture of chemical ingredients (cosmetic ingredients and/or active ingredients) that consumers can take in their hands, purchase, and use as a cosmetic product or an OTC drug–cosmetic product.

Emulsion

The majority of cosmetic raw materials are not miscible or just partially mixable with each other; in these cases, formulators have to choose a dosage form that can contain immiscible ingredients together. According to the FDA's definition, "...an emulsion consists of a two-phase system comprised of at least two immiscible liquids, one of which is dispersed as droplets (this is usually referred to as the internal or dispersed phase) within the other liquid (otherwise known as the external or continuous phase), generally stabilized with one or more emulsifying agents."



There are three essential ingredients for an emulsion, namely an oil phase, a water phase, and an emulsifier. There are two main types of emulsions: O/W and W/O. In an O/W emulsion, oil is dispersed in water; the oil is present in the form of droplets, while the water is present as the outer (continuous) phase. The emulsifier molecules coat the surface of the oil droplets, making them more miscible with water and preventing them from flowing to the surface. In an O/W emulsion, the surfactant molecules have their hydrophilic head groups oriented towards the continuous water phase and their hydrophobic tails facing the oil droplets. Emulsions are the most widely used dosage forms in the cosmetic industry due to their advantages over other dosage forms. They have a unique texture and provide a nice skin feel, and they are used as vehicles to deliver both hydrophilic and hydrophobic ingredients.



An oil-in-water (O/W) emulsion consisting of an oil phase, a water phase, and surfactant molecules surrounding the oil droplets.

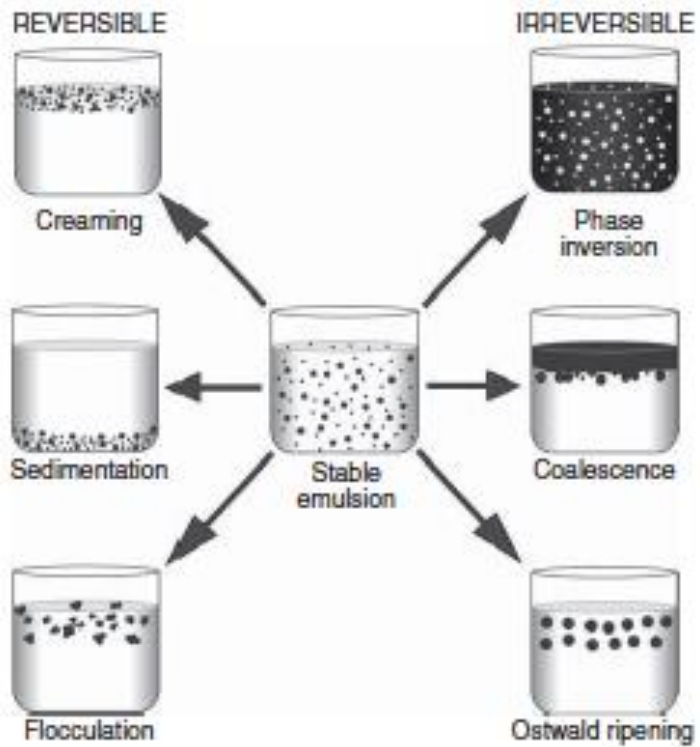
- Generally, O/W emulsions are chosen for applications that require a relatively small amount of fatty materials, such as for hair conditioners, shaving creams, or facial moisturizing creams.
- On the other hand, W/O emulsions are preferred when a larger amount of oil is desired in the formulation. W/O emulsions are greasier, leave a longer-lasting residue, and are more water resistant (as they contain oils in the outer phase). Typical products for which W/O emulsions are preferred include diaper rash products, sunscreens, and barrier creams.
- From a cosmetic perspective, water-in-silicon (W/Si) emulsions are also important. These formulations provide a unique, nongreasy skin feel and quick drying effect, leaving the skin smooth. Examples for such formulations include facial foundations, cream eyeshadows, and certain sunscreens.
- In addition to the simple two-phase emulsions, more complex types may also be formed, such as water-in-oil-in-water (W/O/W) emulsions, which are basically an emulsion in an emulsion.

Instability of Emulsions

Emulsions are thermodynamically unstable formulations, which tend to separate over time (it may take only a few hours to years, depending on the formulation and process parameters).

Separation can be reversible and also irreversible, and the latter needs reformulation. Reversible changes include creaming, sedimentation, and flocculation, while irreversible changes include phase inversion, coalescence, and Ostwald ripening.

- Creaming and sedimentation usually occur due to the density mismatch between the two droplets and the continuous phase. Creaming usually occurs in O/W emulsions. In this phenomenon, the less dense phase (i.e., oil phase) migrates to form a thin, milky layer at the top of the emulsion. Sedimentation usually occurs in W/O emulsions where the denser water phase migrates to form a milky layer at the bottom of the emulsion. Both creaming and sedimentation are reversible by agitation.
- During flocculation, the dispersed droplets aggregate; however, they do not lose their identity. Flocculation often gives a fluffy cloudy appearance, which can be reversed by agitation.
- During phase inversion, the emulsion inverts from one type to another, for example, a W/O emulsion inverts to an O/W. It can happen when the emulsifier becomes more soluble in the dispersed phase than in the continuous phase. This process is irreversible.
- Coalescence is similar to flocculation, except the droplets cluster and merge to form a larger droplet. This is an irreversible process; it leads to complete separation of the two immiscible phases.
- Ostwald ripening is a process in which components of the dispersed phase diffuse from smaller to larger droplets through the continuous phase. Generally, this phenomenon is found in W/O emulsions. It is an irreversible process.



Reversible and irreversible types of physical emulsion instability

Human Skin: Important Features

1. The human skin consists of two main layers, namely the epidermis and dermis.

Underneath the dermis, there is a third layer, called the hypodermis.

2. Epidermis is the outer layer of the skin that functions as a protective layer against external influences.

3. The skin's outermost layer, the SC, is a natural barrier, which has a unique structure, often referred to as the "brick and mortar" structure.

4. The dermis is located under the epidermis, and it functions as a supporting frame to the epidermis, supplying it with nutrients and oxygen via the blood capillaries.

5. Hypodermis is a loose connective tissue that stores fat in the fat cells.

6. In normal skin, there is a continuous movement of water from the deeper layers toward the superficial layer where water eventually evaporates.

7. Human skin is continuously inhabited by many different bacteria and fungi,

which under normal circumstances in a healthy individual are harmless and are

even beneficial. Microbes on the skin are generally divided into two categories:

resident flora and transient flora.

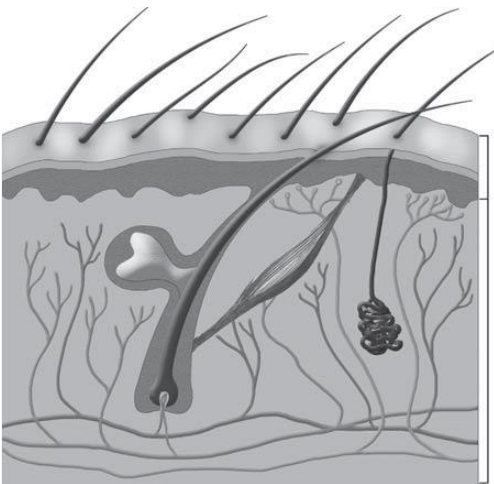
8. Normally, the skin surface is slightly acidic and ranges between pH 4.5 and 5.5.

9. Since the isoelectric point of the proteins found in the skin's upper layers is

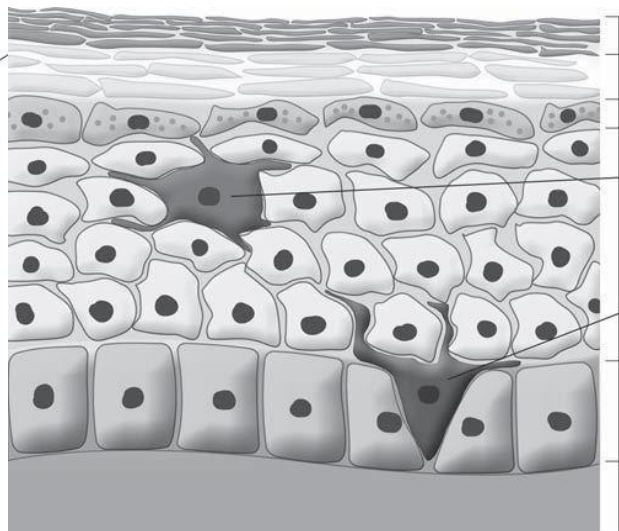
between 3.5 and 4.5, the skin has a negative charge at physiological pH.

10. Human skin can be categorized based on gender, its color, UV sensitivity, vulnerability,

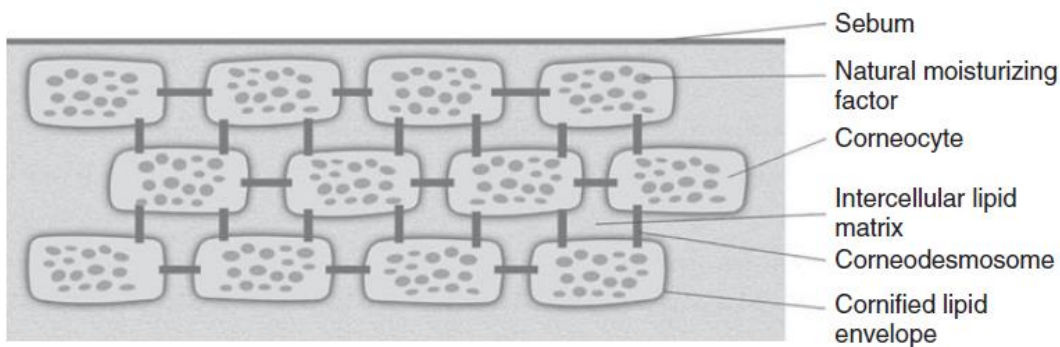
oiliness, healthiness, and special needs, among others.



Structure of human skin



Structure of epidermis



Structure of stratum corneum

The skin's outermost layer, the SC, is a natural barrier, which has a very unique structure, often referred to as the "brick and mortar" structure. The SC is made up of tightly packed, water-resistant dead cells (called **corneocytes**), which are embedded in a complex lipid material (called **intercellular lamellar lipids**). The intercellular lamellar lipid membrane is made up of layers of lipids (the term "lamellar" refers to this layered appearance), and it is mainly made up of ceramides, cholesterol, and fatty acids. This lipid matrix waterproofs the epidermis, prevents dehydration, and provides necessary moisture permeability to the SC. Corneocytes are protected by a **cornified envelope**, which consist of two components: proteins and ceramide lipids. It is believed that the covalently bound lipids provide a hydrophobic surface to the corneocytes, which is important for the water barrier function.⁸ Corneocytes

are bound together with the **corneodesmosomes**. Corneodesmosomes, referred to as rivets of the horny layer, are primarily composed of proteins and ceramide. In the brick and mortar structure, dead cells represent the bricks, while lipids and corneodesmosomes represent the mortar.

Corneocytes contain a blend of hygroscopic compounds, collectively referred to as the natural moisturizing factor (hereinafter referred to as the "NMF"), which plays a vital role in maintaining the hydration of the SC. NMF acts as a natural humectant, i.e., it keeps the skin hydrated. Its main ingredients include amino acids and their derivatives, such as pyrrolidone carboxylic acid, urocanic acid; lactic acid; urea; citrate; sugars and minerals, such as potassium, calcium, sodium, and magnesium. The lipid matrix helps prevent the loss of NMF. Since the NMF components are water soluble,

they are easily leached from the cells, especially when the skin is drier. For this reason, NMF can be washed away, if not protected by the cornified lipid envelope. This is why skin cleansing with soaps can be detrimental to its barrier function. If NMF is lost from the corneocytes, the skin becomes dry, flaky, and uncomfortable. In healthy skin, the SC is impenetrable to irritants and allergens, and water loss is minimized. However, when the skin dehydrates, the corneocytes shrink, causing cracks to appear between them, allowing penetration of external irritants, which trigger a local inflammatory response, causing discomfort, itching and scratching, and further skin damage.

Keratinization, also known as cornification, is the dynamic process of epidermal renewal. It begins in the basal layer where new skin cells, known as keratinocytes, are formed and are continually pushed upward. As keratinocytes are pushed upward through the different layers of the epidermis, they go through a "makeover" where their composition and shape change significantly. By the time the cells reach the third layer, stratum granulosum, most have stopped dividing and have started producing keratin. As keratin develops, keratinocytes becomes flattened cells their membrane thickens, and becomes less permeable. By the time they reach the SC, they are dead skin cells, which are eventually shed from the surface of the skin. This latter process is referred to as **desquamation**. The turnover of the epidermis normally proceeds in about 4 weeks. During that time, the cells are part of the SC for about 2 weeks before being shed from the skin surface. As the connection provided by the corneodesmosomes is very tight, keratinized cells are generally shed in large groups or sheets rather than individual cells.

Trans Epidermal Water Loss (TEWL)

In normal skin, there is a continuous movement of water from the deeper layers toward the superficial layer where water eventually evaporates. A commonly used term with regard to the skin's hydration state is “trans epidermal water loss” (TEWL). It describes the total amount of water lost from the skin (g of water/meter square per hour), a loss that occurs constantly by passive diffusion through the epidermis. Keratinized skin cells, NMF, and intercellular lipids keep TEWL to an acceptable minimum.

Water has two options for crossing the skin from the viable tissues toward the outer environment: active transport by sweating through the sweat glands and passive diffusion through the horny layer. Sweating is a mechanism for body temperature control. In addition, it can express psychological stress. In ontrast, TEWL is not visible to the naked eye. With no air turbulence, the skin is covered by a transition layer where moisture is transferred from the skin surface to the atmosphere. The quantity of water leaving the SC is estimated at 300–400 ml per day under normal conditions, which is about 1/10–1/20 of sweating.

Ingredients of skin cleansing cosmetics

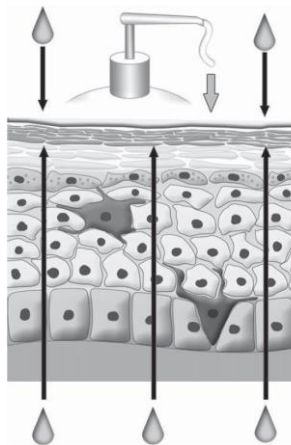
Surfactants (cleansing agents and emulsifiers)	Anionic surfactants- good lathering and detergent properties Cationic surfactants- conditioning agents Amphoteric-As secondary surfactants to help boost foam, improve conditioning. Nonionic-are very mild; thus, commonly used as emulsifiers, conditioning agents, and solubilizers.	Anionic-sodium lauryl sulfate (SLS), sodium laureth sulfate, triethanolamine lauroyl sarcosinate Cationic-amines, alkylimidazolines, alkoxyated amines, and quaternary ammonium Amphoteric-cocamidopropylbetaine; imidazolinium derivatives;cocamidopropylamine oxide; and alkylamino acids. Nonionic-fatty alcohols, poloxamers, lauryl glucoside, cocamide diethanolamine (DEA)(foam stabilizer)
Solvents	media for various formulations.	Water, ethanol, isopropyl alcohol, or mineral oil
Thickeners	provide appropriate rheological properties for the systems as well as contribute to their stability.	cellulose derivatives, gums, acrylates, waxes for the oil phase.
pH Buffers	Alkaline solutions are used for saponification, alter the formulation's pH, thickening via neutralising	NaOH,KOH,NH ₄ OH, citric acid and lactic acid, triethanolamine.

Ingredients of skin cleansing cosmetics (continued)

Skin Conditioning Agents(Moisturizers)	counteract the SC-disruptive properties of soaps and surfactants.	Petrolatum, glycerin, olive oil, almond oil, mineral oil, silicone oils, waxes, panthenol, and allantoin
Preservatives	protection against microbiological contamination.	parabens, phenoxyethanol, methylisothiazolinone, and benzoates.
Abrasives	specific exfoliating components that are responsible for physical cleaning.	seeds (peach, apple, apricot), nut shells (almond, walnut), and grains (such as oats, wheat) polyethylene or polypropylene beads
Astringents	Face toner –major ingredient; tighten pores and refresh the skin	alcohol and witch hazel.
Colourants	contribute to the marketing appeal	Natural and synthetic colorant, titanium dioxide or glycol stearate is used as an opacifier.
Fragrances	Added to facial cleansing preparations to mask the odor of the raw ingredients.	Natural extracts like essential oils(lavender citrus),synthetic fragrance compounds(parfume)
Absorbents	used in facial masks to absorb sebum from the skin. Water insoluble, mainly inorganic compounds.	zinc oxide, titanium dioxide, kaolin, calamine, clay, and natural mud.

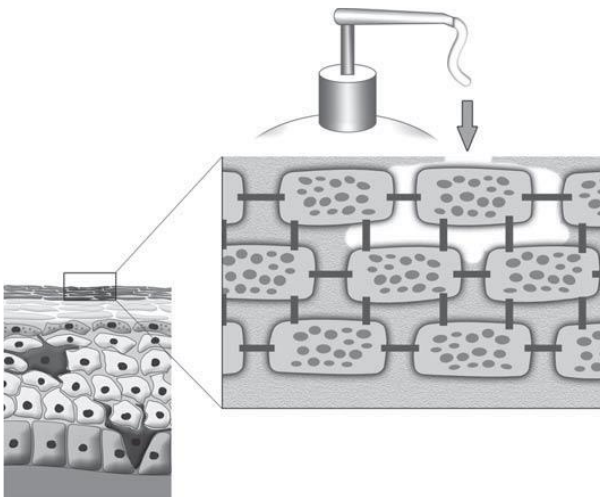
Humectants

Humectants are hygroscopic ingredients that can increase the water content of the top layer of the skin by enhancing water absorption from the dermis into the epidermis. Humectants can hydrate the SC by absorbing water from the external environment. Humectants also allow the skin to feel smoother by filling the holes in the SC through swelling. These ingredients serve to replace the skin NMF that has been washed away or otherwise depleted. Humectants act in the same way as NMF, and indeed, some of the humectants commonly used in moisturizers are components of the skin NMF, e.g., lactic acid and urea. The key functionality of a humectant is to form hydrogen bonds with molecules of water. Examples for humectants include glycerin, AHAs (e.g., lactic acid, glycolic acid), pyrrolidone carboxylic acid, propylene glycol, urea, hyaluronic acid, and sorbitol. The most common humectant used in moisturizers is glycerin. It acts on several different parameters, which makes it the gold standard. It is an effective moisturizer, accelerates the maturation of corneocytes, reduces dryness, and enhances the cohesiveness of intercellular lipids. Overall, when combined with occlusive agents, glycerin has the ability to produce significant moisturizing effects in the skin.



Emollients

Emollients are designed to plasticize, soften and smooth the skin, usually by filling in the void spaces between the corneocytes and replacing the lost lipids in the SC. Emollients can also provide protection and lubrication on the skin surface to minimize chafing and enhance the skin's aesthetic smoothness and softness. The most popular emollients are based on hydrocarbons, such as mineral oil and petrolatum and their derivatives; fatty acids, such as stearic acid, linoleic acid, and lauric acid and their derivatives, such as alcohols and esters; vegetable oils, such as almond oil; synthetic triglycerides; silicones; waxes, such as beeswax, carnauba wax, polyethylenewax, and cetyl alcohol; lanolin derivatives; and polymers. Essential fatty acids (i.e., C18 unsaturated linoleic and alpha-linoleic acids) influence the skin physiology via their effects on skin barrier functions, eicosanoid production, membrane fluidity, and cell signaling.

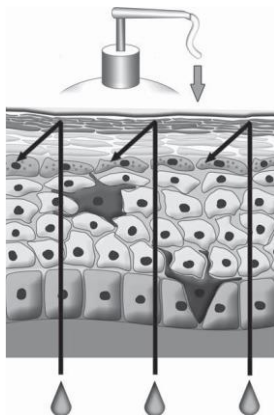


Occlusives

Occlusive agents create a hydrophobic barrier to physically block TEWL from the SC. In moisturizer formulations, occlusives complement the water-attracting nature of humectants. As they prevent water evaporation from the skin, they can be particularly effective in the treatment of dry skin, which is already damaged. They may have additional emollient effects.

Although occlusives are not the most appealing ingredients to most consumers since they are sticky, not easy to remove, and may leave the skin with a greasy feeling, they are very effective in reducing TEWL. The most commonly used ingredient is petrolatum. In addition to forming an impermeable layer on the skin, it can penetrate into the skin's upper layers and initiate the production of intercellular lipids. Lanolin was also very popular in the past; however, its use diminished as it is a known

irritant ingredient and has an unpleasant odor. Today, there are newer occlusives that have cosmetically more appealing characteristics. These include silicone derivatives, such as dimethicone (polydimethylsiloxane). They further enhance the aesthetic quality of the formulation by imparting a "dry touch." They dry very quickly, are easy to apply and remove, do not block the pores on the skin (non-comedogenic), and are able to provide nice and shiny products. Additional examples for occlusives include vegetable oils, fatty acids, fatty alcohols, waxes, and cholesterol.



Ceramides

Ceramides can be naturally found in the SC. They are the most important structural elements of the intercellular lipids, which are necessary to link the protein-rich corneocytes into a waterproof barrier that is capable of protecting the underlying skin tissues and regulating body homeostasis. Ceramides are orderly arranged in lamellar form to act as a membrane and fill the intercellular space in the SC. They function to help maintain the integrity of the skin barrier. There are certain diseases when lipid metabolism in the skin is abnormal, causing a deficiency of ceramide and NMF and impairment of the epidermal barrier function. **It has been shown that ceramides applied externally, in the form of moisturizers, can effectively reduce dry skin symptoms.** These lipid molecules have been used increasingly in recent years in the treatment of dry skin and in cosmeceuticals.

Ingredients of skin moisturizing cosmetic

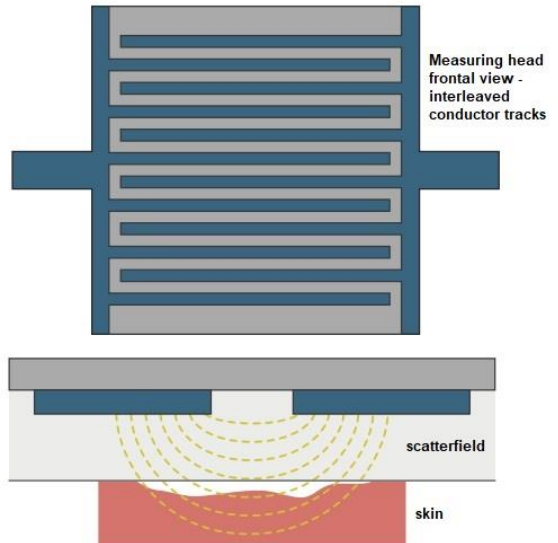
Humectants	-hygroscopic ingredients that can increase the water content of the top layer of the skin. -replace the skin NMF that has been washed away or otherwise depleted. -key functionality of a humectant is to form hydrogen bonds with molecules of water Eg- glycerine, AHAs (e.g., lactic acid, glycolic acid), pyrrolidone carboxylic acid, propylene glycol, urea, hyaluronic acid, and sorbitol.
Emollients	-designed to plasticize, soften and smooth the skin, usually by filling in the void spaces between the corneocytes and replacing the lost lipids in the SC Eg-hydrocarbons, such as mineral oil and petrolatum and their derivatives; -fatty acids, such as stearic acid, linoleic acid, and lauric acid and their derivatives, -vegetable oils, such as almond oil; waxes(beeswax, polyethylene wax) -synthetic triglycerides,
Occlusives	-create a hydrophobic barrier to physically block TEWL from the SC -sticky, not easy to remove, and may leave the skin with a greasy feeling, -In moisturizer formulations, complement the water-attracting nature of humectants. Eg- petrolatum, dimethicone (polydimethylsiloxane), - vegetable oils, fatty acids, fatty alcohols, waxes, and cholesterol.
Skin Rejuvenators	-newest class among moisturizer ingredients. -restore, protect, and enhance the skin's barrier function, thereby reinforcing skin hydration Eg-keratin , elastin and collagen
Ceramides	-waxy lipid molecules, naturally found in the SC, the most important structural elements of the intercellular lipids, -necessary to link the protein-rich corneocytes into a waterproof barrier -reduce dry skin symptoms

Ingredients of skin moisturizing cosmetic

Emulsifiers	-crucial for the stability . -large impact on consistency and viscosity, skin feel, color, odor, and care properties of the final formulation. -most commonly used types include nonionic and polymeric surfactants. - Cationic emulsifiers can also be used; they have additional conditioning properties.
Thickening Agents	-also known as texturizing agents, play an important role in the skin feel of emulsions -They contribute to the stability as well as appropriate rheological property of the formulations - Eg- hydrophilic ingredients, such as gums (e.g., xanthan gum), cellulose derivatives (e.g., hydroxyethyl cellulose), and acrylic polymers, liposoluble ingredients, such as waxes (e.g., cetyl alcohol)
Solvent	-Water is a basic component of emulsions.
Preservatives	-inhibit bacterial growth in the formulation and prevent microbiological deterioration. -parabens and methylisothiazolinone
Antioxidants	-prevent the oxidization of sensitive components(like fats, oils and butters) and thus rancidity - Eg-BHT(Butylated Hydroxytoluene) and BHA(Butylated Hydroxyanisole).
Electrolytes	W/Si emulsions usually contain electrolytes, such as sodium citrate, magnesium sulfate, sodium chloride, or sodium tetraborate, in approximately 1–2% concentration to improve the formulations' stability.
Other Additional Ingredients	-Colouring Agents, -Sunscreen -Fragrances

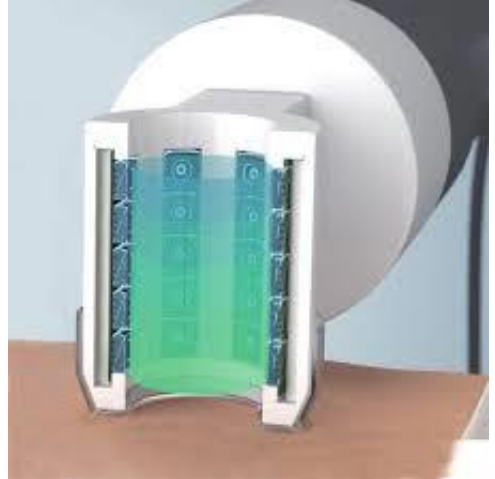
Cosmetic Instruments

Skin Hydration Measurement



Capacitance Method: Corneometry is an example for such methods. The instrument (Corneometer) used for this test consists of a probe that is placed onto a hair-free skin surface with slight pressure. It determines the capacitance of the skin due to its behavior as a dielectric medium. The measurement can detect even the slightest changes in hydration level. A disadvantage of this method is that salts or ions on the skin surface can affect the reading.

TEWL Measurement



TEWL is one of the most commonly measured skin parameters and widely considered an indicator of the skin's barrier function. A damaged SC allows water to evaporate, resulting in high TEWL readings. The device measures the amount of water vapor leaving the skin. Open chamber and closed chamber devices may be used to measure TEWL.

Open chamber devices (such as Tewameter) is open to the atmosphere. They contain water sensors. When the probe is placed on the skin surface in a stable ambient environment, the sensors are able to determine the vapor pressure gradient above the skin surface. This gradient is translated into the amount of water leaving the SC per hour and square meter of the skin surface (g of water/h m^2). The value is an estimate of the skin's ability to retain moisture as well as an index of the extent of possible damage of the skin's water barrier function.

Sebum content measurement

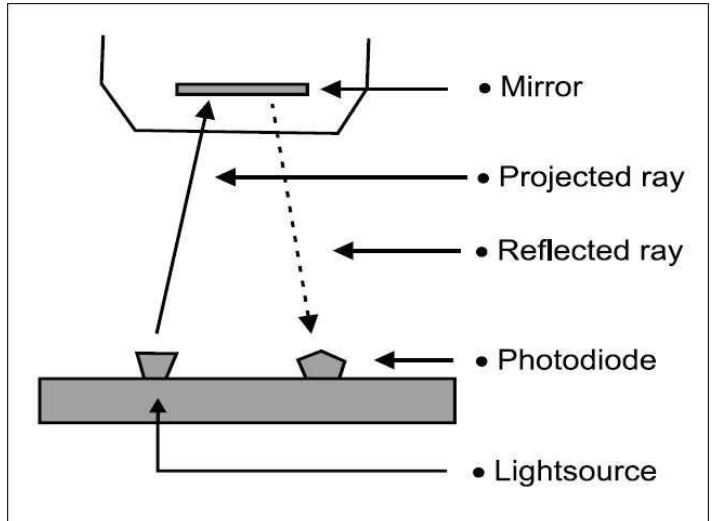
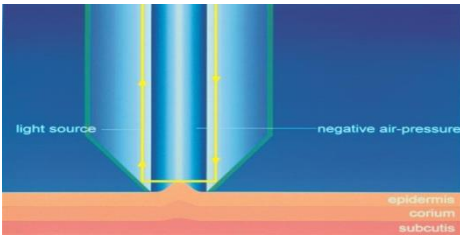
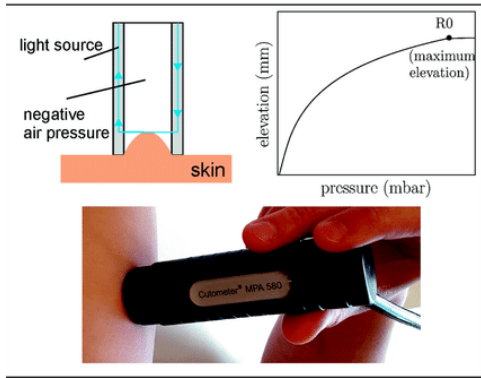


Figure 1: Optical diagram of sebumeter

The Sebumeter works based on the principle of grease spot photometry. The cartridge consists of a special mat tape that becomes transparent when brought in touch with the sebum on skin. The transparency of the exposed mat tape is then measured by a photocell to determine the sebum level. The speciality of the tape is that it does not turn transparent when exposed to any other substance such as water.

B Cutometer



The measuring principle of the Cutometer is based on the **suction method**, where negative pressure deforms the skin mechanically. The pressure is created in the device and draws the skin into the aperture of the probe and after a defined time, releases it again.

Inside the probe, the penetration depth is determined by a **non-contact optical measuring system**. This optical measuring system consists of a light source and a light receptor, as well as two prisms facing each other, which project the light from transmitter to receptor. The light intensity varies due to the penetration depth of the skin. The resistance of the skin to the negative pressure (**firmness**) and its ability to return into its original position (**elasticity**) are displayed as **curves (penetration depth in mm/time) in real time during the measurement**. From these curves a variety of measurement parameters can be calculated related to **elastic** and **visco-elastic** properties of skin surface and **skin aging**.

Sun Care Products

UV radiation represents 5% of the total solar radiation reaching the Earth's surface. As sunlight passes through the atmosphere, all UVC and approximately 90% of UVB radiation are absorbed by ozone, water vapor, oxygen, and carbon dioxide. UVA radiation is less affected by the atmosphere. Therefore, **the UV radiation reaching the Earth's surface is largely composed of UVA (approximately 95%) with a small UVB component (approximately 5%).**

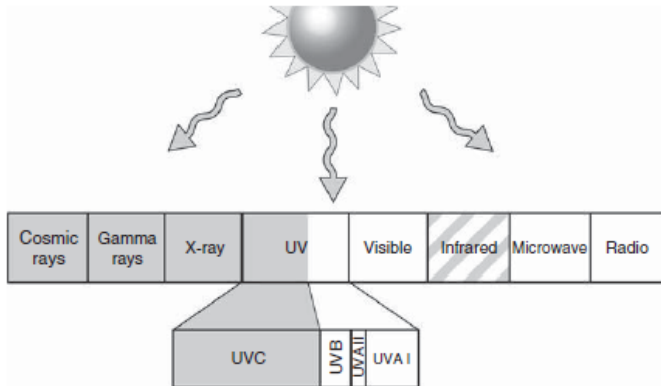


Figure 3.23 Electromagnetic spectrum. The shaded areas indicate rays that do not reach the Earth's surface. Infrared rays are partially filtered out.

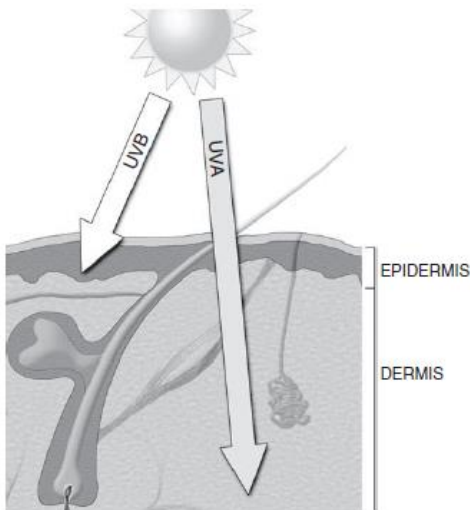


Figure 3.24 Penetration depth of ultraviolet A and B light.

Ultra-Violet (UV) Light

UVC ranges from 100 to 280 nm

UVB radiation ranges from 280 to 320 nm.

UVB rays mainly penetrate the superficial skin layers, i.e., epidermis. UVB radiation is the major cause of sunburn, which is acute skin damage perceived as redness.

UVA radiation ranges from 320 to 400 nm.

Due to their longer wavelength, **UVA rays penetrate deeper into the skin, down to the dermis.**

UV Radiation

UV radiation can be divided into three categories based on wavelength. They differ in their biological activity and the extent to which they can penetrate the skin.

The shorter the wavelength, the more harmful the UV radiation. However, shorter wavelength UV radiation is less able to penetrate the skin.

- UVC ranges from 100 to 280 nm and is blocked out by the ozone layer.
- UVB radiation ranges from 280 to 320 nm. 2 UVB rays mainly penetrate the superficial skin layers, i.e., epidermis. UVB radiation is the major cause of sunburn, which is acute skin damage perceived as redness. Additionally, it has been identified as a leading factor in the development of skin cancer. The immediate result of UVB radiation is skin redness and thickening of the SC, which is a defense reaction of the body to reduce the UVB effect on the epidermis.⁴ The redness and potential pain subside in a relatively short amount of time; however, the underlying damage accumulates over time. This leads to the formation of various types of skin cancer. Additionally, UVB contributes to photoaging and tanning and also has immunosuppressive effects. An advantageous effect of the UVB radiation is that it is responsible for the synthesis of vitamin D in the skin. The intensity of UVB varies by season, location, and time of day. The most significant amount of UVB is experienced in the US between 10 am and 4 pm during late spring and early summer. However, UVB rays can burn and damage the skin all year, especially at high altitudes and on reflective surfaces such as snow or ice.⁶ UVB rays do not significantly penetrate glass.

- UVA radiation ranges from 320 to 400 nm. Due to their longer wavelength, **UVA rays penetrate deeper into the skin, down to the dermis.** These rays can be further subdivided into UVA II (320–340 nm) and UVA I (340–400 nm). On the short term, UVA radiation leads to skin tanning (i.e., browning), which is often considered a sign of health. It is unfortunate since tanning, whether outdoor or indoor tanning, causes cumulative damage over time, leading to photoaging.

UVA has long been identified as a leading factor in photoaging; however, until recently, it was not believed to cause any cancer. Studies over the past decades, however, showed that UVA damages keratinocytes in the basal cell layer where the most of the skin cancers occur. Therefore, on the long term, it can also contribute to and may even initiate the formation of skin cancer. Additionally, UVA weakens the immune system, which also helps the development of skin cancer. Photosensitivity reactions are also primarily mediated by UVA. Tanning beds primarily emit UVA radiation. The lamps used in tanning salons can emit doses of UVA up to 12 times that of the sun. Therefore, indoor tanning is associated with a significantly increased risk of skin cancer, and the risk is higher with use in early life (<25 years). It should be kept in mind that UVA radiation retains the same energy level all day long, every day of the year. Therefore, it has the same damaging effect in the morning as in the late afternoon and during winter as during summer. Additionally, it can penetrate window glass. These facts underline the importance of protection against UVA light

Sun Protection Factor (SPF)

The term “sun protection factor” (hereinafter referred to as “SPF”) was adopted by the FDA to describe the effectiveness of sunscreens. **SPF is a measure that indicates how long it takes for UV rays to redden protected skin** (i.e., skin with a sunscreen) **compared to unprotected skin** (i.e., skin without a sunscreen). As the SPF value increases, sunburn protection increases. The effectiveness of a given SPF is measured in terms of redness (medically termed “erythema”) that appears on the skin after sun exposure. The amount of UV energy required to produce the first visible redness on the skin is referred to as the minimal erythema dose (hereinafter referred to as “MED”). As SPF values are determined from the test that measures protection against sunburn caused by UVB radiation, SPF values only indicate a sunscreen’s UVB protection.

In the Federal Register, SPF is defined as the UV radiation required to produce 1 MED on protected skin after application of 2 mg/cm² of product divided by the UV to produce 1 MED on unprotected skin.

$$SPF = \frac{\text{minimal erythema dose (MED) with sunscreen}}{\text{minimal erythema dose (MED) without sunscreen}}$$

The FDA standard dose for SPF testing is a sunscreen application of 2 mg/cm². Practically, it equals approximately 30 g of sunscreen to cover an average-sized body, including arms, legs, neck, ears, and face.

A popular misconception about SPF is that a higher number means you are completely protected or can stay in the sun much longer without reapplying. SPF (Sun Protection Factor) only measures protection against UVB rays, which cause sunburn. It does not measure UVA rays (which cause aging and deep skin damage) unless the label says **broad-spectrum**. Higher SPF does not mean all-day coverage. Generally, all sunscreens break down from sweat, oil, and sun exposure.

SPF 30 blocks about 97 % of UVB rays. SPF 50 blocks about 98 %. SPF 100 blocks about 99 %. So, the jump from SPF 30 to SPF 50 only gives you an extra 1% of protection. Plus, no sunscreen blocks 100% of UV rays.

Broad Spectrum Protection

The term “broad-spectrum protection” refers to protection against both UVA and UVB rays. It has been shown in studies that using sunscreens with even a high SPF value does not provide appropriate protection against UVA radiation, which is responsible for photoaging and skin cancer formation.

Therefore, in order to prevent

the long-term effects, protection is needed against both types of rays. Due to increasing concerns regarding the skin damaging effect of UVA radiation, the FDA recently issued new requirements for sunscreens. The new rules include testing and labeling requirements for protection against UVA radiation.

Sunscreens that meet the

FDA standard for both UVA and UVB protection can be labeled as “broad spectrum.” This term has been used for a while; however, it did not have an official definition or a standard testing. Now standardized methods are available to measure UVA protection. The new requirements also specify statements that should be used on product labels to indicate whether the product provides protection against aging and skin cancer or just sunburn. Scientific studies have demonstrated that products that are broad-spectrum with SPF 15 or higher can reduce the risk of skin cancer and early skin aging when used with other skin protection measures (e.g., sun protective clothing). According to the new rules, broad-spectrum sunscreens with an SPF 15 or higher

can have the following statement on the labels: “...decreases the risk of skin cancer and early skin aging caused by the sun.”

However, any sunscreen that is not broad spectrum or is less than SPF 15 broad spectrum has to put the following warning statement on its label to inform consumers about the potential adverse effects of sun damage. The warning statement reads as follows: “... Spending time in the sun increases your risk of skin cancer and early skin aging. This product has been shown only to help prevent sunburn, not skin cancer or early skin aging.”

UV Filters

Sunscreens represent a practical approach to photoprotection. Sunscreen ingredients are usually referred to as UV filters and are identified on product labels as active ingredients. UV filters are classified into two groups based on their mechanism of action: physical and chemical sunscreens. A single product usually contains more than one active ingredient, both physical and chemical filters, to achieve the desired SPF value and broad-spectrum protection.

Physical sunscreens, otherwise known as inorganic UV filters, reflect and scatter UV radiation. There are two approved physical filters in the US, namely titanium dioxide (TiO_2) and zinc oxide (ZnO). Both of these ingredients are white powders that are insoluble in the sunscreen product base. Therefore, they are suspended in such products. Inorganic sunscreens can only penetrate the outer layer of the skin. Therefore, they have an excellent safety profile. Additionally, inorganic filters are photostable, independent of the sunscreen base and other ingredients. Inorganic filters provide a broad-spectrum protection since they reflect and scatter both UVA and UVB radiations (TiO_2 offers UVB and UVA II protection, while ZnO provides protection against UVB, UVA II, and UVA I radiations). The main disadvantage of inorganic filters with regular particle size is that they reflect and scatter UV radiation into the visible spectrum ($>400\text{ nm}$), which provide a white appearance on the skin after application. This can make sunscreens cosmetically less appealing and can lead to reduced application by consumers. The reflection spectrum of TiO_2 and ZnO , and, therefore, the white appearance can be, however, modified by decreasing their particle size. The smaller the particle size, the less reflection occurs in the visible spectrum. Therefore, today, TiO_2 and ZnO are commonly used in micronized (i.e., with a particle size of $1\text{--}100\text{ }\mu\text{m}$) and nanonized (i.e., with a particle size of $1\text{--}100\text{ nm}$) forms for an aesthetically more appealing cosmetic look. Another advantage of smaller particles is that they feel lighter on the skin. Products that contain nanoparticles no longer reflect visible light and, therefore, do not appear white but transparent on the skin. However, there is an important fact that should be emphasized: particle size reduction leads to a shift in the UV radiation protection profile of inorganic sunscreens toward the UVB and UVA II range, and the UV protection becomes imbalanced. Using nanosized and microsized particles in combination may improve this situation. Additionally, inorganic filters are more often used in combination with organic filters to provide broad-spectrum protection while maintaining good aesthetics

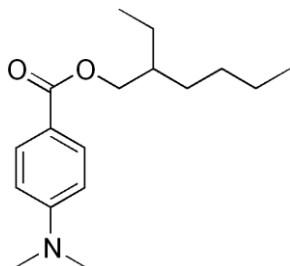
Chemical sunscreens, otherwise known as organic UV filters, are generally aromatic compounds. Their molecular structure is responsible for absorbing UV energy. Organic filters absorb UV rays, which produce excitation of the sunscreen chemical to a higher energy state. Then, they return to the ground state and convert the absorbed energy into longer, lower energy wavelengths (heat). Currently, there are 15 organic sunscreen ingredients approved in the US. Examples for organic UVB absorbing filters include octinoxate, octisalate, and padimate O. Examples for UVA filters include avobenzone, oxybenzone, and meradimate. Organic filters are often combined with one another to achieve the desired broad-spectrum protection.

Organic sunscreens can penetrate the skin due to their lipophilic nature, which may cause safety concerns. An issue with many of the organic sunscreens is their photostability. Upon exposure to UV radiation, the structure of UV filters may be negatively affected and/or destructed. As a result, instead of returning to the ground state, they lose their absorption capacity. Therefore, most formulations contain photostabilizers.

A **chromophore** is the specific part of a molecule responsible for absorbing light and giving that substance its color.

Most chromophores contain a system of alternating single and double bonds (called conjugation). This allows electrons to move freely and easily absorb visible or ultraviolet (UV) light.

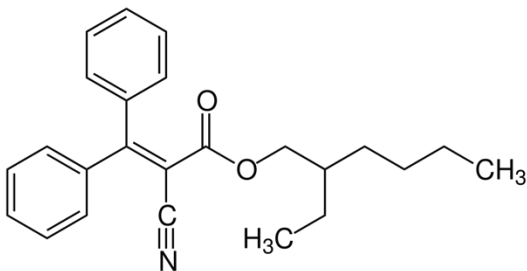
An **auxochrome** is a functional group of atoms attached to a chromophore that modifies the ability of that chromophore to absorb light. An auxochrome does not absorb light by itself. It typically features atoms with one or more non-bonding pairs of electrons (like nitrogen or oxygen) that interact with the pi system of the chromophore.



Padimate O
2-ethylhexyl 4-
(dimethylamino)benzoate

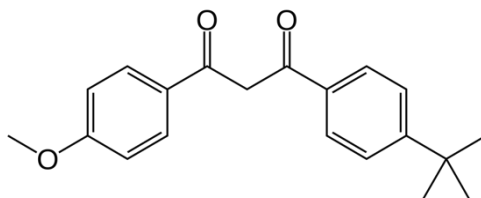
The chromophore of padimate O is the p-dimethylaminobenzoate conjugated system, which consists of a benzene ring substituted with an electron-donating dimethylamino group at the para position and an ester carbonyl group

The core chromophore responsible for the light-absorbing and photo-switching properties of azobenzene is the azo group ($-N=N-$) linking two phenyl (benzene) rings into an extended conjugated π -electron system ($Ph-N=N-Ph$).



Octocrylene
2-Ethylhexyl 2-cyano-3,3-
diphenylprop-2-enoate

The chromophore of octocrylene—an organic compound extensively utilized as a chemical UV filter in sunscreens—is its extended conjugated acrylate system



Avobenzene
3-(4-*tert*-Butylphenyl)-1-(4-
methoxyphenyl)propane-1,3-dione

Sun Care Product Ingredients

Waterproofing agents

-included in formulations to increase their water-resistance properties.
-help the product withstand water in any form, such as sweat, sea or a swimming pool
Eg-silicone oils, such as dimethicone 350, cyclomethicone, and dimethicone/trimethylsiloxysilicate
-polymeric film-formers like Alkylated polyvinylpyrrolidones (PVPs)

Photostabilizers

-help stabilize UV filters through chemical bonds, or help them dispose the UV energy more quickly
Eg-octocrylene (for avobenzene specifically) and TiO₂, polyester-8

Emollients

-lipophilic ingredients that help increase water resistance since they are not washed off easily
-can also serve as solvents for lipophilic organic sunscreens
Eg-mineral oil, shea butter, castor oil, cocoa butter, isopropyl myristate, isohexadecane, paraffin, and silicones.

Water

-essential ingredient in O/W and W/O emulsions as well as in gels.
-also serves as a solvent for water-soluble ingredients

Thickeners

-act as rheology modifiers in the formulations; they affect application, spreadability, and efficacy of sunscreens.
Eg-hydroxy propylcellulose, xanthan gum, C10-30 alkyl acrylate crosspolymer.

Film-forming ingredients

-help form an even and uniform film on the skin after application and drying.
Eg-hydrolyzed wheat protein/PVP crosspolymer, methylcellulose, polyester-7, and acrylates/octylacrylamide copolymer.

Sun Care Product Ingredients (continued)

Preservatives	-Preservatives are necessary when water is present in the formulations Eg-parabens, benzyl alcohol, methylchloroisothiazolinone, methylisothiazolinone, and phenoxyethanol.
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Humectants	-provide moisturization. Eg- sorbitol, glycerin, and propylene glycol.
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Chelating Agents	-contribute to the stability of the system by forming complexes with the metal ions that may cause premature deterioration of the products. Eg-EDTA and its derivatives.
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Propellants	-are essential ingredients in aerosol sunscreens. They help expel the content of the aerosol can. Eg-isobutane and dimethyl ether.
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Additional Ingredients	-pH modifiers (neutralizers), such as citric acid and triethanolamine; -fragrances; and colorants,
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INCI

cosmetic ingredients must be listed by their established or adopted names, which in general are the INCI names. The abbreviation “INCI” stands for the International Nomenclature of Cosmetic Ingredients.

INCI names were created by the PCPC (formerly known as CTFA, Cosmetic, Toiletry, and Fragrance Association) and can be found in the International Cosmetic Ingredient Dictionary and Handbook (otherwise known as INCI dictionary). The first edition of the dictionary was published in 1973; since then, many changes have taken place. In 2013, its 14th edition is used. A committee of the PCPC, called the International Nomenclature Committee (INC), has responsibility to maintain the integrity and validity of the data incorporated into the dictionary. The main purpose of the INCI names as well as dictionary is to standardize ingredient names, minimize language barriers, and help international trade. The same cosmetic ingredient may be manufactured and distributed by multiple suppliers, resulting in different trade names. Using trade names would make understanding ingredient labels more difficult and export/import almost impossible. However, with a standardized nomenclature, it is easier for concerned consumers to make educated decisions by checking ingredient lists and finding ingredients they might be allergic to. In addition, it helps manufacturers use standardized names on their products, which are mutually accepted by many countries.

Topics and Questions

1. Why most of the cosmetic products have the dosage form of emulsion?
2. Discuss various reversible and irreversible processes of emulsion instability.
3. Anatomy of human skin. Structure of SC (stratum corneum).
4. Properties of normal human skin. NMF, Surface charge, pH, TEWL
5. Ingredients of skin cleaning, moisturizing products.
6. Sun care products. What is SPF? Nature of UV radiations and its effect.
7. Ingredients of sun care product. Organic UV absorbing compounds.

Auxochrome and Chromophore.

8. Name and working principle of various Cosmetic instruments: Cutometer, Tewameter, Corneometer, Sebumeter