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*Original Article*

# Cosmetic Formulation Principles, Ingredients, Manufacturing, Evaluation and Product Development

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## ABSTRACT

Cosmetic formulation is the systematic design of products intended to cleanse, perfume, protect, maintain, or improve the appearance of external parts of the human body. A successful formulation combines suitable ingredients, a reproducible manufacturing process, acceptable sensory properties, package compatibility, microbiological quality, physical and chemical stability, and safety under intended conditions of use. This review describes the scientific and practical principles used to develop common cosmetic products, including creams, lotions, gels, cleansers, shampoos, conditioners, sunscreens, decorative cosmetics, lip products, deodorants, and hair-care preparations. Particular attention is given to the function and selection of water, oils, emollients, humectants, surfactants, emulsifiers, rheology modifiers, preservatives, antioxidants, fragrances, colourants, and functional ingredients. The article also discusses formulation calculations, phase design, mixing and homogenisation, pH adjustment, quality-control testing, stability protocols, packaging, scale-up, documentation, and regulatory considerations. Formulation examples are presented as educational starting points rather than validated commercial recipes. Every formula must be adapted to the grade and supplier specifications of its ingredients and verified through appropriate safety, stability, compatibility, and microbiological testing before consumer use.

**Keywords:** cosmetic formulation; emulsions; surfactants; creams; lotions; gels; preservatives; stability testing; quality control; personal care products.

## INTRODUCTION

### Scope and Review Approach

This narrative review focuses only on cosmetic formulation science and product development. It organises established formulation concepts into a practical sequence: defining the product target, choosing ingredients, designing the formula, selecting processing conditions, evaluating the finished product, and maintaining quality during manufacture and storage. Scientific articles, technical reviews, and official regulatory resources were used to support the general discussion. The document is intended for academic learning and should not be treated as a substitute for a qualified cosmetic safety assessment or current local regulatory advice.

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**Relevant conflicts of interest/financial disclosures**: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## 1. INTRODUCTION TO COSMETIC FORMULATION

Introduction to Cosmetic Formulation Cosmetic formulation is an applied discipline that combines chemistry, materials science, microbiology, manufacturing engineering, sensory evaluation, and consumer research. The formulator translates a product brief into a composition that can be manufactured consistently and used safely. A product brief usually identifies the intended user, application site, product format, desired performance, appearance, fragrance profile, price range, packaging type, and expected shelf life. These requirements must be converted into measurable quality attributes, such as pH, viscosity, spreadability, cleansing performance, foam profile, colour, odour, microbial limits, and stability. A cosmetic product is rarely defined by one ingredient alone. Its performance results from interactions among the complete ingredient system and the process used to combine it. A cream, for example, may contain an aqueous phase, an oil phase, emulsifiers, thickeners, humectants, preservatives, and minor additives. Altering one component can change droplet size, viscosity, sensory feel, preservation, or long-term stability. Formulation therefore requires a system-based approach rather than simply collecting ingredients that each have a desirable property. Development normally proceeds through product definition, prototype design, laboratory preparation, initial evaluation, optimisation, safety review, stability assessment, packaging selection, pilot-scale manufacture, and commercial process validation. Each stage should have written acceptance criteria and traceable records. A prototype that looks attractive on the day it is made is not necessarily stable or microbiologically protected. Similarly, a stable product may still fail if it feels sticky, spreads poorly, foams excessively, or cannot be dispensed from its package. Good formulation practice balances function, safety, robustness, cost, and consumer experience. Ingredient selection must consider quality grade, purity, supply reliability, permitted use, compatibility, and the supplier's recommended processing conditions. The final formula should be reproducible with realistic manufacturing equipment and should tolerate reasonable variation in raw materials and process conditions. A disciplined development plan reduces avoidable reformulation and supports a product that remains acceptable throughout its intended life. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 2. Product Design and Formulation Objectives

Product design begins by defining what the cosmetic is expected to do and what it must not do. A moisturising cream, for example, may be designed to reduce the sensation of dryness, spread easily, leave limited greasiness, and remain stable in a chosen container. A facial cleanser may require efficient soil removal while limiting excessive tightness after rinsing. These are different performance targets and may require different surfactant systems, emollients, rheology profiles, and sensory modifiers. Target product profile criteria should be specific enough to guide development. Typical attributes include appearance, colour, odour, pH range, viscosity range at a specified temperature and measurement method, density where relevant, spreadability, dispensing behaviour, and microbial quality. For rinse-off products, foam volume, foam persistence, rinsability, and cleansing performance may be relevant. For leave-on products, tack, residue, absorption perception, and compatibility with layering may be important. Claims should be supported by evidence appropriate to their wording and market. Ingredient choices should be linked to these objectives. A high oil phase may improve richness and occlusivity but can increase greasiness and place greater demands on emulsifier performance. A high humectant level may improve water-binding properties but can increase tack or alter preservation. More thickener does not always mean better stability: excessive viscosity can impair pumping, create stringiness, or prevent proper dispersion during manufacture. A formulation is therefore optimised across several competing attributes. Prototype design is most efficient when one or a small number of variables are changed at a time, unless a planned design-of-experiments approach is being used. The formulator should document the reason for every change and compare results against the original target profile. Raw-material lots, weighing records, process temperatures, mixing speeds, addition order, and cooling profile should be recorded. These details make results interpretable and allow successful prototypes to be reproduced. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 3. Skin and Hair Considerations in Product Design

Cosmetic products are applied to skin, scalp, hair, nails, lips, and other external body surfaces. The physical and chemical characteristics of the application site influence the appropriate product format. Skin products must spread without unacceptable drag, residue, or irritation. Hair products must distribute along fibres, rinse or remain in place as intended, and provide a suitable balance of conditioning, manageability, and appearance. Product claims and ingredients should be selected for the intended cosmetic function rather than implying treatment of disease. Skin feel is influenced by the balance of water, volatile components, humectants, emollients, waxes, polymers, and the structure of the formulation. A light lotion can be designed for quick spreading and a low-residue finish, while a richer cream may be designed for a more protective and persistent film. Neither format is inherently superior; suitability depends on user preference, application area, climate, and intended use. The sensory profile should be evaluated by a suitable method rather than inferred only from the ingredient list. Hair fibre properties also affect formulation design. Shampoos generally rely on surfactants to remove sebum, particulate matter, and product residues. Conditioners commonly use cationic conditioning agents, fatty alcohols, and lubricating ingredients to improve combability and reduce static. The performance of a conditioner depends on deposition, distribution, rinse behaviour, and compatibility with the shampoo routine. Excessive deposition may create build-up or weigh down fine

hair, whereas insufficient conditioning may leave coarse or damaged hair difficult to manage. Formulation should account for the user population and foreseeable use conditions. Products for the eye area, lips, children, or sensitive application sites require particular care in ingredient selection and exposure assessment. Fragrance, colourants, exfoliating ingredients, and certain solvents may need to be limited or excluded depending on the product and market. Claims such as hypoallergenic, dermatologically tested, or suitable for sensitive skin should only be used when supported by appropriate evidence and review. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 4. Cosmetic Ingredients and Their Functions

A cosmetic formula is built from ingredients that provide the main product structure and ingredients that modify performance. The base may include water, oils, surfactants, emulsifiers, solvents, and polymers. Supporting ingredients may include humectants, emollients, preservatives, antioxidants, chelating agents, fragrance, colourants, pH adjusters, and functional actives. The role of an ingredient depends on concentration, grade, chemical structure, interactions, and the environment created by the complete formula. Ingredient selection should begin with function and compatibility. The formulator should review technical data sheets, safety data sheets, certificates of analysis, recommended use levels, processing requirements, storage conditions, and known incompatibilities. Supplier guidance is useful, but it does not replace evaluation in the actual formula. Ingredients from different suppliers can vary in active content, particle size, impurity profile, or viscosity contribution, so specifications should be defined for critical raw materials. Ingredients are commonly described by their International Nomenclature of Cosmetic Ingredients name on product labels where the applicable rules require it. The label name does not, by itself, establish the quality grade, concentration, or suitability of the material. A formulator must distinguish between a raw material's trade name and its composition. A commercial premix may contain a primary ingredient plus carrier, preservative, or solvent; all relevant components must be accounted for in the formula and product information. Each ingredient should have a justified purpose. Unnecessary complexity can increase cost, complicate preservation, create incompatibilities, and make troubleshooting more difficult. A simple formula is not automatically safer or better, but a transparent formula with clear functional logic is easier to evaluate. The formulation record should identify the purpose of each component and the reason its concentration is appropriate for the intended product. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 5. Water, Solvents and Humectants

Water is the principal continuous phase in many cosmetic emulsions, gels, cleansers, and lotions. Its

quality can influence appearance, odour, microbial burden, and stability. Formulation water should meet a defined quality specification suitable for the manufacturing process and intended product. Water systems and storage vessels should be maintained to minimise contamination and biofilm formation. Water quantity is normally adjusted to bring the complete formula to 100 percent after all other ingredients have been accounted for. Solvents are used to dissolve or disperse ingredients, adjust processing, or influence product feel. Their selection depends on polarity, volatility, odour, regulatory status, and compatibility with packaging and other ingredients. A solvent that dissolves an ingredient in a beaker may still cause precipitation after dilution, cooling, or storage. Solubility should therefore be assessed across the expected temperature range and after the complete formula is assembled. Humectants attract and retain water within the formulation and can contribute to a moisturised skin feel. Common examples include glycerin, propanediol, butylene glycol, and certain sugar-derived materials. Their effects depend on concentration and the surrounding formula. Humectants can alter viscosity, water activity, tack, and preservation requirements. The best concentration is the one that achieves the desired performance without unacceptable sensory effects or destabilisation. During development, the formulator should check whether humectants or solvents affect the solubility of preservatives, polymers, fragrance, and functional ingredients. Some polymers hydrate more effectively when added using a specific dispersion technique, while some powders form lumps if added too rapidly to water. Controlled addition, suitable agitation, and sufficient hydration time are essential. Water and solvent losses during heating should also be considered when setting the final batch mass. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 6. Oils, Emollients and Waxes

Oil-phase ingredients provide lubrication, reduce friction, influence water loss from the surface, and contribute to the sensory identity of a cosmetic. They include vegetable oils, mineral-derived emollients, esters, hydrocarbons, silicones where permitted, fatty alcohols, and waxes. These materials differ in polarity, viscosity, spreading behaviour, oxidative stability, odour, and compatibility with emulsifiers. The oil phase should be selected as a blend when necessary to balance cushion, slip, absorption perception, and residue. Emollients improve the feel and flexibility of the skin surface by filling spaces between surface irregularities and reducing friction. Occlusive materials can form a film that limits water loss, while lighter esters may provide a less greasy finish. Waxes and fatty alcohols contribute structure and may increase body or yield stress. However, their melting range and crystallisation behaviour can influence the final texture and long-term stability of a cream or balm. Oxidative stability is important when using oils that contain oxidation-sensitive unsaturated components. Exposure to oxygen, heat, light, trace metals, and unsuitable packaging can accelerate degradation and lead to odour changes, colour changes, or altered performance. Antioxidants may help control oxidation, but they are not a substitute for selecting stable raw materials, controlling processing, and using suitable packaging. Incoming oils should be checked against specifications for odour, appearance, and relevant chemical quality indicators. Oil-phase selection should be evaluated in the complete formula. A blend that feels elegant on its own may become waxy after emulsification or may interact poorly with a polymer or emulsifier. The oil phase also affects emulsifier demand, droplet size, viscosity, and cooling behaviour. A controlled prototype programme can compare different oil blends at a fixed total oil level, then optimise the emulsifier system and process only

after the sensory profile is acceptable. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 7. Surfactants and Cleansing Systems

Surfactants reduce surface and interfacial tension and help water wet surfaces, disperse oily soil, and stabilise foam. Their molecules contain hydrophilic and hydrophobic regions, enabling them to interact with water and oil. Cosmetic surfactants are selected according to cleansing strength, irritation potential, foam behaviour, viscosity response, compatibility, biodegradability profile, and regulatory acceptability. No surfactant is universally best for every application. Anionic surfactants often provide effective cleansing and foam, while amphoteric surfactants can improve mildness and influence viscosity. Nonionic surfactants may provide wetting, solubilisation, or emulsification, depending on structure. Cationic surfactants are commonly used in conditioning systems because they can interact with negatively charged hair surfaces. Combining surfactants can improve the balance of performance, but interactions must be checked because some combinations can precipitate or lose function. Foam volume is not a direct measure of cleansing quality. Foam depends on surfactant chemistry, concentration, water hardness, soil load, viscosity, and agitation. Consumer perception may value creamy, stable foam, but the formula must still rinse adequately and avoid excessive residue. A cleanser should be assessed under realistic use conditions, including dilution with water and exposure to typical soils or styling residues. Surfactant concentrates should be incorporated with controlled mixing to avoid excessive aeration. High shear may be useful for some dispersions but can create persistent foam in surfactant-rich systems. Salt or polymer thickeners may increase viscosity only within a particular concentration window; adding too much can reduce viscosity again or cause instability. Formulation records should specify addition order, temperature, mixing intensity, and the point at which viscosity is measured. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 8. Emulsifiers and Emulsion Science

An emulsion is a dispersion of one immiscible liquid within another, commonly oil droplets in water or water droplets in oil. Cosmetic creams and lotions often use oil-in-water systems because they can provide a relatively light, water-continuous feel and can be diluted or rinsed with water. Water-in-oil systems can provide richer, more water-resistant films. The chosen emulsion type should follow the target product performance and the properties of the ingredients. Emulsifiers adsorb at the oil–water interface and reduce interfacial tension while helping form a protective layer around droplets. Emulsion stability is influenced by emulsifier chemistry and concentration, oil composition, phase volume ratio, droplet-size distribution, viscosity, temperature history, and the

rate of collisions between droplets. A visually uniform emulsion immediately after manufacture may still separate during storage because the system is not necessarily thermodynamically stable. Common physical instability mechanisms include creaming or sedimentation, flocculation, coalescence, and Ostwald ripening. Creaming is upward movement of droplets that are less dense than the continuous phase; sedimentation is the reverse. Flocculation involves droplet clustering without complete merging, whereas coalescence involves droplets merging into larger droplets. A suitable emulsifier system, controlled droplet size, and adequate continuous-phase structure can reduce these risks. Emulsifier selection should consider the oil phase, desired emulsion type, electrolyte content, pH, processing temperature, and sensory targets. Some systems require the oil and water phases to be heated to similar temperatures before combination; others are designed for cold processing. Homogenisation can reduce droplet size, but excessive processing may introduce air or alter polymer structure. Cooling rate and agitation after emulsification also affect crystallisation and final texture. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 9. Rheology Modifiers and Texture Control

Rheology describes how a material flows and deforms under applied force. In cosmetics, rheology affects pouring, pumping, spreading, brush application, foam stability, suspension, and the perception of richness. A product's viscosity is only one aspect of its flow behaviour. Many creams and gels are shear-thinning: they become easier to spread or pump when shear is applied and recover some structure after the force is removed. Rheology modifiers include natural gums, cellulose derivatives, acrylic polymers, clays, fatty alcohols, waxes, and associative thickeners. Their performance depends on hydration, pH, electrolyte level, solvent composition, and interaction with surfactants. A polymer may thicken effectively in water but lose viscosity in a high-salt system. Some powders require pre-dispersion to prevent lump formation, while others need neutralisation to develop their intended viscosity. Texture design should be linked to the product's package and use pattern. A pump lotion must flow through a dip tube and valve; a jar cream may tolerate higher yield stress; a squeeze tube needs enough flow under hand pressure without leaking during storage. Excessively high viscosity can slow filling, trap air, and cause inconsistent dosing. Low viscosity may increase separation or make the product feel watery. Testing should use a specified instrument, spindle or geometry, speed, temperature, and equilibration time. Rheology modifiers can also support physical stability by slowing droplet movement or preventing pigment settling. However, thickening alone cannot correct an inadequate emulsifier system or a chemically incompatible formula. The formulator should investigate the underlying mechanism before increasing thickener. Changes in viscosity during storage can indicate polymer degradation, pH drift, electrolyte interaction, evaporation, or emulsion restructuring. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled

comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 10. Preservatives and Microbiological Protection

Water-containing cosmetics can support microbial growth if the formula, manufacturing process, packaging, and use conditions allow contamination and sufficient nutrients or available water. A preservative system is designed to control microbial proliferation during storage and foreseeable consumer use. Preservation is a product-level requirement: the selected system must function in the actual formula, at the actual pH, and within the intended package. Ingredient lists alone cannot establish that a finished product is adequately protected. Preservative selection depends on product type, pH, solubility, partitioning between phases, compatibility with surfactants and polymers, packaging, and applicable regulations. Some preservatives are more effective against particular groups of microorganisms than others. A preservative may partition into the oil phase or bind to ingredients, reducing the freely available concentration in the aqueous phase. The formulator should follow permitted use limits and supplier recommendations while validating the complete product. Manufacturing hygiene is essential even when a preservative is present. Equipment, utensils, water systems, transfer lines, and filling environments should be controlled. Raw materials should be stored appropriately, and batch vessels should be cleaned and dried according to documented procedures. High initial contamination can overwhelm a preservation system, while contaminated consumer fingers or repeated exposure to water can challenge products packaged in wide-mouth jars. Preservative efficacy should be demonstrated using an appropriate microbiological challenge test or other recognised method suitable for the product category and market. Routine microbial limits testing and a documented contamination-control plan are also important. Natural origin, low water activity, or an airless package may reduce some risks but should not be assumed to eliminate the need for validation. Product claims about being preservative-free should not compromise safety or mislead consumers. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 11. Antioxidants, Chelators and Formula Protection

Cosmetic formulas may undergo oxidation, hydrolysis, colour change, fragrance deterioration, or loss of functional ingredient content during manufacture and storage. Antioxidants are used to slow selected oxidation pathways, while chelating agents bind certain metal ions that may catalyse degradation or affect colour. These ingredients serve different purposes and are not interchangeable. Their effectiveness depends on the degradation mechanism, concentration, pH, phase location, and compatibility. Oil-soluble antioxidants may be useful in formulas containing oxidation-sensitive oils, whereas water-soluble systems may protect selected aqueous ingredients. Chelators can reduce the catalytic influence of trace metals introduced through water or raw materials. A chelator does not replace microbiological preservation, and an antioxidant does not guarantee complete protection against light, oxygen, or heat. A complete protection strategy may combine raw-material selection, low-oxygen processing, suitable antioxidants, opaque or air-restrictive packaging, and appropriate storage. Stability evaluation should monitor signs of degradation relevant to the formula. These may include changes in colour, odour, pH, viscosity, phase appearance, and the content of a selected functional ingredient. If the formula contains oxidation-sensitive oils, a change in odour may be an early warning sign.

Packaging headspace and permeability may also influence oxygen exposure. Results should be compared with pre-established acceptance criteria rather than judged only by informal observation. Adding more protective ingredients is not always beneficial. Antioxidants may have solubility limits, influence colour, or interact with other ingredients. Chelating agents may affect polymer performance or the availability of metal ions required for a desired colour effect. Each addition should have a documented rationale and should be evaluated in the finished product. The goal is a robust protection system, not the largest possible number of additives. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 12. Fragrance, Colour and Sensory Design

Fragrance and colour influence product identity and consumer acceptance, but they also introduce formulation and safety considerations. Fragrance materials can vary in volatility, solubility, allergen profile, and stability. A fragrance that smells pleasant in a concentrate may smell different after dilution, heating, or interaction with the base. Fragrance should be added at a suitable stage and temperature, and the finished product should be evaluated after equilibration and during stability testing. Fragrance solubilisation may require a suitable solubiliser or a carefully designed surfactant system, particularly in clear aqueous products. Too much solubiliser can alter foam, skin feel, or viscosity, while too little may result in haze or separation. In emulsions, fragrance may partition between phases and change droplet structure. The selected fragrance level must comply with applicable restrictions and should be supported by a relevant safety assessment. Colourants are chosen according to the product category, intended application area, stability, and the rules of the market where the product will be sold. Some colourants require pre-dispersion to prevent specks or uneven colour. Pigments can settle, agglomerate, or alter viscosity if the dispersion system is unsuitable. Colour should be assessed under controlled lighting and, where appropriate, measured instrumentally to support batch-to-batch consistency. Sensory evaluation should be structured. Relevant attributes may include spreadability, slip, tack, greasiness, residue, absorption perception, rinse feel, foam character, fragrance intensity, and after- feel. A trained panel or controlled consumer test can identify differences that instrumental testing may not fully capture. Sensory findings should be recorded with the method, sample coding, use conditions, and acceptance criteria to reduce bias. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up. 13. pH, Buffers and Ingredient Compatibility pH is a key formulation parameter for many water-containing cosmetics. It can affect skin feel, preservative performance, polymer viscosity, surfactant behaviour, ingredient solubility, colour stability, and the rate of chemical degradation. The appropriate pH range depends on the complete

formulation and intended application. A target should not be selected solely because it is commonly associated with skin; the finished product must also remain compatible and stable. pH adjustment is normally performed using a suitable acid, base, or buffer system, added gradually with mixing. Concentrated adjusters should not be added directly in large quantities because local extremes of pH can cause precipitation, polymer damage, or uneven neutralisation. pH should be measured using a calibrated meter with an electrode suitable for the sample. Temperature, dilution method, and equilibration time should be defined because they can influence results. Compatibility assessment should include interactions between ingredients and changes during processing or storage. Electrolytes may reduce the viscosity of certain polymers, cationic materials may form complexes with anionic surfactants, and some botanical extracts may change colour or precipitate at different pH values. Fragrance and preservatives can also alter the physical characteristics of a system. A compatibility matrix can help identify high-risk combinations early in development. Buffers can resist pH changes, but they should be used only when needed and at a suitable level. A buffer may introduce salts that affect viscosity, solubility, or preservation. The formulation should be checked after all ingredients have been added and again after a defined equilibration period. pH drift during stability testing should trigger investigation into raw-material variability, chemical reactions, microbial activity, packaging interaction, or inadequate process control. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 13. Cream Formulation and Manufacturing

Creams are semisolid emulsions designed to provide a balance of spreadability, structure, and persistence on the application site. Most are oil-in-water emulsions, although water-in-oil systems are also used for particular sensory or water-resistance objectives. A cream formula commonly contains water, humectants, oil-phase emollients, emulsifiers, consistency agents, rheology modifiers, preservatives, and minor functional ingredients. The exact composition depends on the desired richness, absorption perception, and package. A typical development approach begins by defining the total oil phase and selecting an emulsifier system appropriate to that phase. Water-soluble ingredients are generally incorporated into the aqueous phase, while oil-soluble materials are incorporated into the oil phase. Heat-sensitive ingredients, fragrance, and certain preservatives may be added during cooling if their supplier instructions permit. All phases should be weighed accurately and processed according to a written manufacturing procedure. In a conventional heated process, the oil and water phases are brought to suitable and compatible temperatures, then combined under controlled agitation. Homogenisation is applied when required to obtain a suitable droplet-size distribution. The emulsion is mixed during cooling to maintain uniformity and support the formation of the desired internal structure. High-shear processing, temperature, addition rate, and cooling profile must be optimised for the specific formula rather than copied blindly from another cream. After manufacture, the cream should be allowed to equilibrate before final viscosity and sensory measurements are recorded. Evaluation may include appearance, odour, pH, viscosity, spreadability, centrifugation screening, freeze–thaw exposure where appropriate, accelerated storage, microbial quality, and package compatibility. A cream should not be considered ready for use merely because it appears homogeneous. Stability, safety, and preservation must be demonstrated through appropriate testing. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition,

processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 14. Lotion Formulation and Manufacturing

Lotions are generally lower-viscosity products designed for easy spreading over relatively large areas. They may be emulsions, suspensions, or solutions, depending on their composition. Compared with a rich cream, a lotion often contains a lower structuring-agent level and may use lighter emollients. The product should spread quickly while maintaining sufficient stability to prevent creaming, sedimentation, or phase separation during storage. Formulation decisions should reflect the dispensing system. Pump bottles require a viscosity and flow profile compatible with the pump mechanism, while squeeze bottles require controlled flow under pressure. A lotion that is too thin may leak or dose inconsistently; a lotion that is too thick may be difficult to dispense. Package testing should be conducted with the actual formula, not only with a laboratory substitute. Manufacturing may involve hot or cold processing. In a heated emulsion process, phase temperatures, emulsifier activation, and cooling rate influence final structure. In a cold-process system, ingredient solubility and mixing sequence are especially important. Air entrainment should be minimised because bubbles can distort filling weights, appearance, and viscosity measurements. If deaeration is required, it should be incorporated into the process design. Quality checks commonly include pH, viscosity, appearance, odour, homogeneity, microbial quality, and dispensing performance. A lotion should also be checked for stability after exposure to expected transport and storage conditions. The finished product should be evaluated in the intended package because changes in evaporation, oxygen exposure, or material interaction may affect the formula. Batch records should capture mixing speed, temperature, addition order, and yield. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 15. Gel Formulation and Manufacturing

Gels are structured liquid systems in which a polymer or other network creates a semisolid texture. They may be transparent or opaque and can be designed for rapid spreading, a cooling sensation, low oiliness, or targeted deposition of functional ingredients. Gel performance depends on polymer type, concentration, hydration, pH, electrolyte content, solvent composition, and processing. A visually clear gel is not necessarily more stable or more effective than an opaque gel. Polymer selection should account for the desired clarity, viscosity, skin feel, compatibility, and processing method. Some polymers require gradual dispersion into water followed by a hydration period. Others develop viscosity after neutralisation. If the powder is added too quickly, lumps with dry centres may form and remain difficult to remove. A pre-slurry or controlled vortex addition may improve dispersion, depending on the polymer's properties. Solvents and humectants can change gel structure. High levels of alcohol or electrolytes may reduce viscosity in some

polymer systems, while certain nonionic polymers tolerate a wider range of conditions. Functional ingredients should be screened for solubility and interactions before scale-up. The order of addition is important because adding salts or actives before polymer hydration may prevent the intended network from forming. Gel evaluation should include appearance, clarity where relevant, pH, viscosity or rheology, spreadability, tack, residue, and stability. Syneresis, which is the release of liquid from a gel network, may indicate a weak or incompatible structure. Air bubbles can remain trapped for long periods in highly viscous gels and may require vacuum deaeration or a rest period. Preservative efficacy must be assessed for water-based gels just as it is for other aqueous products. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 16. Facial Cleansers and Body Washes

Facial cleansers and body washes are rinse-off products that use surfactants to remove surface soil, sebum, sweat, and residues. The design objective is not simply maximum detergency; it is a balance of cleansing, rinseability, sensory quality, viscosity, foam, and user tolerance. Facial products may require a different surfactant blend from a body wash because the intended application area and consumer expectations differ. Surfactant blends are selected to achieve a suitable cleansing profile and foam character. Amphoteric and nonionic surfactants may be combined with anionic surfactants to adjust mildness and viscosity. The effect of the blend should be evaluated at the expected dilution during use, because water hardness and soil load can change performance. Foam appearance should be treated as one sensory attribute rather than the sole indicator of cleansing quality. Thickening can be achieved through surfactant structuring, salt response, polymers, or combinations of these methods. The salt curve of a surfactant system may be non-linear: viscosity can increase and then decrease as electrolyte concentration rises. Fragrance, extracts, and other additives can shift this response. Therefore, the final viscosity should be adjusted only after the major ingredients have been incorporated and the system has equilibrated. Manufacturing should minimise aeration and ensure complete dissolution or dispersion. pH is adjusted to the chosen target, and the preservative system is checked for compatibility. Final tests may include appearance, odour, pH, viscosity, foam profile, rinse feel, microbial quality, and package dispensing. Consumer-use simulations should be conducted with suitable safeguards and documented methods. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 17. Shampoo Formulation

Shampoo is a surfactant-based hair-cleansing product intended to remove sebum, dirt, sweat, and styling residues from hair and scalp. Its performance is in-

fluenced by surfactant blend, water hardness, fragrance, viscosity, conditioning additives, and the user's hair type and washing routine. A well-designed shampoo cleans effectively while providing an acceptable rinse feel and avoiding undesirable build-up or excessive dryness perception. Primary surfactants are often combined with secondary surfactants to balance cleansing and foam. Amphoteric surfactants can influence mildness and viscosity, while nonionic materials may assist solubilisation or improve sensory performance. Conditioning polymers or small amounts of emollient may be included where compatible, but excessive deposition can reduce volume or leave hair feeling coated. The correct balance depends on the target product profile. Shampoo viscosity may be adjusted using electrolyte response, polymers, or surfactant-compatible thickeners. Fragrance and extracts can change clarity and viscosity, so the final adjustment should follow their addition. Some conditioning polymers are sensitive to surfactant composition and salt level. The formula should be checked for clarity or opacity as intended, uniformity, pH, viscosity, foam, and rinsability. During manufacture, surfactants should be added in a controlled manner to minimise foam and ensure uniformity. Heat-sensitive ingredients are added at appropriate stages according to supplier instructions. Preservation, microbial quality, and package compatibility are essential because shampoo is repeatedly exposed to wet hands and bathroom conditions. Stability studies should include temperature variation and monitoring for viscosity drift, precipitation, colour change, and fragrance changes. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 18. Conditioner and Hair Mask Formulation

Conditioners and hair masks are designed to improve combability, reduce friction and static, and provide a smoother hair feel. Their structure often relies on cationic conditioning agents, fatty alcohols, emollients, and water. The cationic materials can associate with negatively charged sites on hair fibres, while fatty alcohols contribute a lamellar or structured network that affects viscosity and deposition. The exact system should be selected according to the intended rinse-off performance. Hair masks generally provide a richer sensory profile than lightweight conditioners, although product names do not define a fixed technical standard. Higher levels of fatty materials can increase richness and deposition but may weigh down fine hair or produce a waxy feel. A lighter conditioner may prioritise easy distribution and rinsability. The formulator should compare combing performance, wet feel, dry feel, residue, and ease of rinsing under a controlled method. Manufacturing commonly involves heating the aqueous and oil/conditioning phases to suitable temperatures, combining them under agitation, and cooling while maintaining uniformity. The order of addition and cooling rate influence the structured network. Excessive shear after structure development may change viscosity. Fragrance and heat-sensitive additives should be introduced at a suitable stage, and pH should be controlled according to the complete formula's compatibility requirements. Quality evaluation may include appearance, odour, pH, viscosity, spreadability through wet hair, wet combing force, dry combing, static control, and stability. The product should be tested in the intended packaging and after repeated opening where relevant. Compatibility with the intended shampoo system may influence consumer results, so performance claims should reflect the test conditions and not overstate benefits beyond the evidence. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the

product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 19. Sunscreen Formulation Considerations

Sunscreen products are technically demanding because they must provide the claimed level of protection when used as directed and must remain uniform, stable, and acceptable during application. Depending on the jurisdiction and product category, sunscreen may be regulated as a cosmetic, a drug, or under a specific product framework. Formulation development must therefore begin with the applicable regulatory classification, permitted filters, labelling requirements, and recognised efficacy-testing methods. UV filters may be organic, inorganic, or used in combinations where permitted. Their selection requires consideration of solubility, dispersion, photostability, compatibility, skin feel, and the intended protection claims. Inorganic filters may require careful dispersion to avoid agglomeration and uneven coverage. Organic filters may require suitable solvents or oil-phase systems. The complete formula, rather than the isolated filter concentration alone, influences film formation and performance. Emulsion structure, rheology, spreading, and water resistance can influence the uniformity of the film deposited on skin. A product that is difficult to spread may be applied unevenly; an overly thin product may run or be difficult to dose. Film-forming agents and rheology modifiers can support uniform application, but they may also alter tack, whitening, or wash-off. Packaging and stability must protect the product's intended performance over its shelf life. Claims such as SPF, broad-spectrum protection, and water resistance must be substantiated using applicable validated methods and regulatory requirements. They cannot be established reliably from a theoretical formula or informal laboratory observation. Sunscreen prototypes require appropriate efficacy testing, stability assessment, safety review, and manufacturing controls before market release. The formulator should not advise consumers to rely on an untested homemade sunscreen for UV protection. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 20. Decorative Cosmetics Formulation

Decorative cosmetics include products such as foundation, concealer, powder, blush, eye colour, mascara, and eyeliner. Their formulation involves colour matching, pigment dispersion, film formation, adhesion, transfer resistance, wear, and sensory properties. Product type determines the continuous phase and processing route: powders require controlled blending and particle management, while liquid or cream products may require emulsification, suspension, or film- forming systems. Pigment dispersion is a critical quality attribute. Poor wetting or insufficient dispersion can produce streaks, specks, colour inconsistency, and reduced coverage. The formulator should select suitable dispersants and processing equipment for the pigment type and target particle distribution. Pigment compatibility with the base and packaging must be checked, and colourants must comply with the rules for the product category and application site. Film-forming ingredients can improve wear and transfer resistance, but may increase stiffness, tack, or

difficulty in removal. Powders and absorbent materials influence shine control and texture. Waxes and oils affect glide and adhesion in cream or stick products. The design must balance coverage, blendability, wear time, removal, and comfort. For eye-area products, special attention is needed for ingredient quality, particle characteristics, and contamination control. Quality evaluation may include colour measurement, dispersion quality, payoff, adhesion, transfer, wear, water or sebum resistance where claimed, and package performance. Microbial protection is relevant to water-containing products, while dry powders still require control of raw-material quality and contamination. Batch-to-batch colour standards and retained samples support consistency. Claims must be supported by appropriate testing and should not imply medical effects. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 21. Lip Care and Lip Colour Products

Lip balms and lip colour products are designed for application to the lips, an area where accidental ingestion and repeated exposure may occur. Their formulation requires careful selection of permitted ingredients, colourants, flavours, fragrances, waxes, oils, emollients, and antioxidants. The product format may be a stick, pot balm, liquid gloss, or emulsion. Each format has different requirements for hardness, payoff, spread, shine, and package compatibility. Stick products generally rely on a structured blend of waxes, oils, and butters. The wax blend determines melting behaviour, hardness, break resistance, and glide. Too much hard wax may create drag or brittle sticks, while too much liquid oil may cause sweating, deformation, or poor stability. Controlled heating, complete melting, mixing, and cooling are essential to obtain a uniform structure and reduce defects such as sinkholes or graininess. Liquid lip products may use oils, film formers, pigments, and dispersants to create gloss or long- wear effects. Pigments must be adequately dispersed to prevent uneven colour and settling. Volatile solvents, where used and permitted, require suitable processing controls and packaging. Flavour and fragrance levels must be carefully assessed for the intended use, and the formula should be checked for taste, odour, stability, and potential irritation. Evaluation should include appearance, odour, colour uniformity, payoff, glide, hardness or flow, melting behaviour, package function, and stability. Colourants must be permitted for the intended lip application in the target market. Product safety assessment should account for foreseeable oral exposure. A formula should not be marketed as safe merely because its ingredients are described as natural or food-derived. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 22. Deodorant and Antiperspirant Formulation

Deodorants and antiperspirants serve related but distinct purposes. Deodorants are intended to reduce or

mask body odour, while antiperspirants are designed to reduce sweat output and may be subject to a different regulatory category depending on the market. This distinction influences ingredient selection, claims, testing, and labelling. The formulator should establish the intended product category before selecting active materials or designing the formula. Deodorant formats include sprays, roll-ons, sticks, creams, and gels. Each requires a suitable delivery system and sensory profile. Water-based roll-ons may require solubilisation and preservation, while anhydrous sticks may depend on waxes, powders, oils, and structuring agents. Fragrance can be important but must be compatible with the base and used within applicable safety limits. The formula should dry at an acceptable rate and avoid unacceptable residue on skin or clothing. Antiperspirant formulations require special attention to the permitted active ingredient, its grade, dispersion, pH, and interaction with the vehicle. Their efficacy claims must be supported by appropriate methods and regulatory compliance. Solubility and viscosity can affect delivery from the package, while the active system may influence corrosion or compatibility with package materials. Formulation decisions should be made in accordance with the relevant product framework rather than general cosmetic assumptions. Quality checks may include appearance, pH where applicable, viscosity, drying time, odour, residue, dispensing, package compatibility, stability, and microbiological quality for water- containing products. Aerosol products require additional specialised controls for pressure, flammability, valve performance, and transport. These products should be developed and manufactured using appropriate facilities and safety procedures. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 23. Natural and Botanical Cosmetic Ingredients

Botanical ingredients are used in cosmetics as extracts, oils, powders, hydrosols, or purified constituents. Their composition can vary with species, plant part, growing conditions, harvest time, extraction solvent, processing, and storage. A botanical name alone does not define a consistent raw material. Suppliers should provide identity, composition or marker information where relevant, contaminant limits, microbiological quality, and stability data appropriate to the ingredient. Extracts may introduce colour, odour, electrolytes, sugars, proteins, or other materials that affect viscosity, preservation, and emulsion stability. A botanical extract that appears compatible in water may precipitate after pH adjustment or after addition to a surfactant system. Extracts should therefore be screened at the intended concentration and in the complete base. The carrier and preservative contained in a commercial extract must also be included in formulation calculations. Natural origin does not automatically establish safety, sustainability, efficacy, or low irritation potential. Essential oils and fragrant plant materials can contain sensitising constituents, while poorly controlled raw materials may contain pesticides, heavy metals, adulterants, or microbial contaminants. Safety review should consider the specific material, exposure level, application site, and intended user. Claims such as organic or sustainably sourced should be substantiated according to the relevant standard. Botanical formulas require the same quality discipline as other cosmetic products. Standardisation, traceability, suitable packaging, and stability testing are essential. Colour and odour variation may occur between lots, so raw-material specifications and acceptance limits should be defined. A product should not rely on an assumed therapeutic effect unless the intended claim and product classification permit it and appropriate evidence is available. Practical formulation note: During development, record the exact grade and lot of

each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 24. Encapsulation and Advanced Delivery Systems

Encapsulation systems are used to protect selected ingredients, control their release, improve dispersion, or alter their distribution within a cosmetic formula. Examples include liposomes, polymeric particles, lipid-based carriers, microcapsules, and other structured dispersions. The usefulness of a carrier depends on the ingredient being delivered, the desired benefit, the manufacturing process, and the stability of both the carrier and the finished product. Encapsulation efficiency and loading are important but do not fully describe product performance. Particle size, size distribution, surface properties, leakage, ingredient retention, and compatibility with the base may also be relevant. A carrier may be stable in a simple aqueous dispersion but destabilise when exposed to surfactants, salts, solvents, or pH changes in a finished cosmetic. Testing should therefore occur in the final formula as well as in the initial carrier system. Manufacturing methods vary by carrier type and may include hydration, homogenisation, solvent removal, precipitation, spray drying, or other controlled processes. Each method introduces critical parameters such as temperature, shear, solvent composition, mixing order, and drying conditions. Scale-up can change particle size and loading, so a process that works in a small beaker may require redesign for larger equipment. Claims related to improved delivery, stability, or performance should be supported by suitable analytical and use testing. Particle-containing formulas may require additional characterisation and careful evaluation of exposure and safety. Regulatory requirements can vary depending on the material and market. Advanced delivery technology should be selected because it solves a defined formulation problem, not simply because it appears novel. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 25. Manufacturing Equipment and Process Control

Cosmetic manufacturing equipment ranges from simple mixing vessels to jacketed tanks, rotor– stator homogenisers, colloid mills, vacuum mixers, powder blenders, filling machines, and automated packaging lines. Equipment selection depends on batch size, viscosity, shear sensitivity, heating and cooling requirements, flammability, cleaning needs, and the required level of process control. The equipment must be suitable for contact with the formula and should not introduce unacceptable contamination or material interaction. Critical process parameters may include ingredient addition order, mixing speed, mixing time, temperature, homogenisation energy, vacuum level, cooling rate, and filling temperature. The appropriate parameters depend on the formulation and equipment geometry. A speed setting used in a small vessel cannot be transferred directly to a larger tank because

impeller diameter, vessel shape, and fluid dynamics change. Scale-up should be based on relevant engineering criteria and empirical confirmation. Batch records should identify raw-material names and codes, lot numbers, quantities, operator checks, equipment identifiers, processing steps, in-process observations, deviations, yield, and final test results. Weighing accuracy is especially important for low-concentration ingredients such as preservatives, colourants, or potent functional materials. Clear instructions should distinguish between the order of addition, the required temperature, and the endpoint of each process stage. Cleaning and sanitation procedures should be validated or otherwise demonstrated to be effective for the equipment and product residues involved. Shared equipment can create cross-contamination risks, especially when fragrance, colourants, or sensitising materials are processed. Maintenance, calibration, and preventive checks reduce unexpected variation. Process changes should be reviewed for their potential impact on product quality and safety before implementation. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 26. Quality Control and Analytical Evaluation

Quality control confirms whether raw materials, in-process material, and finished products meet defined specifications. A finished-product specification should be based on product performance, safety, stability, manufacturing capability, and applicable regulations. Typical tests include appearance, odour, pH, viscosity, density where relevant, homogeneity, fill weight, microbial quality, and package function. Additional tests depend on the product format and claims. pH measurement requires a calibrated instrument and a method suitable for the sample. Viscosity measurement requires a specified instrument, geometry or spindle, speed, temperature, and equilibration time. Results obtained using different methods may not be directly comparable. Colour and appearance should be assessed under controlled conditions, while instrumental colour measurement may improve consistency for pigmented products. Sampling plans should define how representative samples are collected and labelled. Microbiological testing is important for water-containing cosmetics and for products where use conditions may introduce contamination. The test programme should align with the product type and applicable requirements. A preservative challenge test evaluates the ability of the finished product to resist specified microbial challenges under a defined protocol. Routine microbial testing and challenge testing answer different questions and should not be treated as substitutes for each other. Analytical methods should be documented, suitable for their intended purpose, and controlled for repeatability. Acceptance limits should be established before routine testing begins. Out-of- specification results require investigation rather than automatic retesting until a passing result appears. The investigation should consider sampling, instrument condition, method execution, raw materials, process deviations, and possible product changes. Retained samples support trend review and investigation of complaints. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change

in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 27. Stability Testing and Shelf-Life

Stability testing assesses whether a cosmetic remains within defined quality and safety limits over time. Relevant changes may include phase separation, colour or odour drift, pH change, viscosity change, precipitation, crystallisation, microbial growth, loss of functional ingredient, or package interaction. A stability plan should be designed around the product's composition, packaging, intended distribution conditions, and likely consumer use. Real-time stability studies evaluate the product under intended storage conditions over a period relevant to its proposed shelf life. Accelerated studies expose the product to elevated or otherwise challenging conditions to identify weaknesses more quickly. Accelerated results can support comparison and risk assessment but do not automatically predict the exact shelf life because elevated temperature may trigger mechanisms that do not occur in the same way under normal storage. Freeze–thaw cycles, centrifugation, temperature cycling, light exposure, and transport simulation may be useful screening tools when appropriate for the product. These tests should be selected based on a defined risk and should have consistent protocols. A product that fails a harsh screening test is not necessarily unsuitable for every market, and a product that passes a short screening test is not proven to have a long shelf life. Stability acceptance criteria should be defined for appearance, pH, viscosity, odour, colour, microbial quality, package integrity, and any critical functional attributes. Testing should use the intended package where possible. Samples should be labelled with batch, package, storage condition, and time point. Deviations should be investigated, and shelf-life decisions should be based on the total evidence rather than one test or one observation. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 28. Packaging and Compatibility

Packaging protects a cosmetic during storage, transport, dispensing, and consumer use. It can influence oxygen and light exposure, evaporation, microbial contamination, dose control, and sensory quality. Common formats include jars, tubes, pumps, bottles, sticks, sachets, and aerosols. The most attractive package is not necessarily the most suitable; the package must function with the formula and the expected use pattern. Compatibility issues include swelling, cracking, stress deformation, corrosion, colour transfer, fragrance absorption, ingredient sorption, leakage, and changes in dispensing performance. Volatile components may permeate through some materials, while oils or solvents may interact with plastics or elastomers. A package that works with water alone may fail with the complete formula. Compatibility testing should use representative product, package components, closure, and storage conditions. Packaging also affects preservation. Wide-mouth jars may expose the product to repeated finger contact, while pumps and tubes can reduce direct contact but do not guarantee sterility. Airless systems may reduce exposure to air and help dispense viscous products, but their performance depends on valve design, viscosity, and correct assembly. Package selection should complement, not replace, a validated preservation strategy. Package testing should evaluate leakage, closure integrity, dispensing, dose consistency, user handling, label adhesion, and transport resistance as relevant. Fill volume and headspace should be controlled. Labels should remain legible and comply with the relevant market's ingredient

declaration, warnings, batch coding, and other requirements. Any change to package material or supplier should be reviewed because it may affect stability and product performance. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 29. Scale-Up and Technology Transfer

Scale-up translates a successful laboratory formula and process into a larger manufacturing operation. It is not simply a matter of multiplying every ingredient quantity. Larger vessels have different heat-transfer rates, mixing patterns, circulation zones, and surface-to-volume ratios. These changes can affect emulsification, polymer hydration, powder wetting, cooling, air entrainment, and final viscosity. Technology transfer should include the approved formula, raw-material specifications, manufacturing instructions, equipment requirements, critical process parameters, in-process controls, finished-product specifications, packaging details, and safety information. The receiving site should review whether its equipment can reproduce the intended process. Any difference in impeller type, vessel geometry, heating capacity, or homogeniser should be evaluated before commercial manufacture. Pilot batches provide an opportunity to test process robustness and identify issues such as slow heating, poor powder dispersion, local overheating, excessive foam, long cooling time, or inconsistent filling. The process should be adjusted using a documented rationale and then confirmed through repeatable batches. A change in mixing time or shear may affect droplet size or polymer structure even when the ingredient quantities remain unchanged. Successful scale-up requires defined acceptance criteria and controlled change management. Deviations should be recorded and investigated, and changes should be assessed for their impact on quality, safety, stability, and regulatory documentation. Manufacturing operators should be trained on critical steps and endpoints. The final process should be sufficiently robust to tolerate normal, controlled variation without unacceptable changes in the finished product. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

### 30. Cosmetic Safety and Regulatory Considerations

Cosmetic safety is a central requirement throughout formulation and manufacture. Safety assessment considers ingredient identity, purity, concentration, exposure, application site, frequency of use, foreseeable misuse, and the characteristics of the intended user. The finished product must be safe under its intended and reasonably foreseeable conditions of use. A safety conclusion cannot be made from the ingredient list alone or from the fact that a product is made in a laboratory. Regulatory requirements differ by country and by product category. Requirements may address permitted or restricted ingredients, colourants, preservatives, labelling, claims, manufac-

turing practices, product information, and safety substantiation. Sunscreens, products making therapeutic claims, and certain specialised products may be regulated differently from ordinary cosmetics. The formulator should identify the target market early and confirm the current applicable requirements before finalising the formula. Ingredient documentation should include identity, specifications, safety data, supplier information, and relevant restrictions. Finished-product documentation should include the formula, manufacturing procedure, test results, stability evidence, packaging details, safety assessment, and complaint or adverse-event procedures where required. Ingredient names and claims must be accurate, and marketing language should not imply a therapeutic benefit that changes the product's regulatory classification without appropriate authorisation. Safety and compliance are continuing responsibilities. Reformulation, a new fragrance, a new package, a different raw-material supplier, or a changed manufacturing process can affect the safety or stability assessment. Product changes should be reviewed and documented. Official regulatory sources should be checked for the target jurisdiction because requirements and guidance can change. Academic examples in this review do not constitute regulatory approval or a completed safety assessment. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 31. Common Formulation Problems and Troubleshooting

Phase separation in an emulsion can result from an unsuitable emulsifier system, inadequate emulsifier concentration, excessive oil loading, large droplets, insufficient continuous-phase structure, or a problematic temperature history. The investigation should begin by documenting when separation appears, whether it is reversible, and whether droplet size or viscosity has changed. Increasing thickener without understanding the cause may temporarily hide the symptom while leaving the underlying instability unresolved. Unexpected viscosity change may arise from pH drift, electrolyte sensitivity, incomplete polymer hydration, temperature differences, air entrainment, raw-material variation, or changes in the emulsion structure. Measurements should be repeated using the same method and temperature before drawing conclusions. The formula should be reviewed for recent changes in ingredients, order of addition, and processing. A controlled trial that changes one variable at a time can identify the cause more efficiently. Precipitation or haze can occur when an ingredient exceeds its solubility limit, when pH changes ionisation, when solvent composition changes, or when incompatible ingredients form a complex. The formulator should examine the precipitate, review ingredient solubility data, and test the suspected variables separately. Heating may temporarily dissolve a precipitate but does not prove that the formula will remain stable during storage. Odour and colour changes may indicate fragrance degradation, oxidation, contamination, interaction with packaging, or instability of a colourant or botanical extract. These changes should be investigated rather than masked with additional fragrance or colour. Microbial concerns require appropriate testing and quality procedures. All troubleshooting should be documented, and corrective action should be confirmed by repeat testing before a revised formula or process is accepted. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised

prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 32. Sustainable and Responsible Formulation

Sustainable formulation considers the environmental and social impacts of ingredients, manufacturing, packaging, transport, and product use. Relevant factors may include renewable feedstocks, biodegradability, aquatic toxicity, energy and water use, supply-chain traceability, land use, and packaging recyclability. No single label or ingredient origin provides a complete assessment. Sustainability decisions should be based on evidence and the product's full context. Replacing an ingredient with a plant-derived alternative can change viscosity, odour, colour, oxidation stability, preservation demand, and supply consistency. A substitution should therefore be treated as a reformulation, not a simple one-to-one exchange. The alternative should be evaluated for function, safety, quality, performance, and environmental claims. Supplier documentation can support the assessment but should be critically reviewed. Concentrated products, refill formats, lighter packaging, and improved manufacturing efficiency may reduce resource use when designed well. However, packaging changes can influence preservation, dosing, contamination, and product waste. A refill system should be evaluated for consumer handling and cleaning, and the primary package must remain compatible with the formula. Sustainability goals should not compromise product safety or encourage unsupported claims. Responsible formulation also includes ethical sourcing, transparent labelling, reduced avoidable waste, and evidence-based marketing. Claims such as green, clean, natural, or eco-friendly can be vague unless clearly defined and substantiated. A practical development programme sets measurable goals, such as reducing packaging mass, increasing recycled content where suitable, or lowering process water use, then verifies the result against a baseline. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up.

## 33. Future Trends and Conclusion

Cosmetic formulation continues to evolve through improved ingredient characterisation, advanced emulsification, digital formulation tools, high-throughput screening, predictive modelling, and more sophisticated sensory and stability measurements. These approaches can shorten development cycles, but their usefulness depends on good experimental design and reliable data. A model can guide ingredient selection or identify risk factors, yet laboratory confirmation remains necessary because real formulas contain complex interactions. Emerging areas include more efficient delivery systems, improved pigment dispersion, multifunctional ingredients, lower-impact raw materials, water-conscious formats, and packaging designed for better protection and use. The adoption of a new technology should be driven by a defined product need. It should be evaluated for manufacturability, safety, stability, consumer acceptability, cost, and regulatory suitability rather than novelty alone. The core principles remain consistent: define a clear target profile, select ingredients for a justified function, understand ingredient interactions, control the manufacturing process, test the finished product, and maintain complete documentation. Formulation quality is not established by appearance

alone. Physical stability, chemical integrity, microbiological protection, packaging compatibility, and safety evidence must be considered together throughout development. In conclusion, cosmetic formulation is a multidisciplinary process that links ingredient science with practical manufacturing and consumer use. Creams, lotions, gels, cleansers, shampoos, conditioners, colour cosmetics, lip products, and deodorants each present distinct formulation challenges, but all require controlled raw materials, a robust process, suitable testing, and compliance with the relevant market's rules. The formulas and methods discussed in this review are educational starting points; every final product requires product-specific validation before use or commercial distribution. Practical formulation note: During development, record the exact grade and lot of each raw material, the amount used, the order of addition, processing temperature, mixing conditions, and the time at which measurements are taken. Compare the prototype against predefined acceptance criteria and retain a representative sample. If the product does not meet its target, investigate the cause systematically before changing several ingredients at once. Any revised prototype should be re-evaluated for compatibility, stability, safety, and package performance. Development checkpoint: The formulator should distinguish between an observation, a possible explanation, and a confirmed cause. For example, a change in viscosity may be observed, but its cause could be temperature, pH, polymer hydration, or emulsion restructuring. Use repeatable methods and controlled comparisons to determine which explanation is supported. This approach improves reproducibility and prevents an apparently successful short-term adjustment from creating a new problem during storage or scale-up. Illustrative Formulation Frameworks The following frameworks describe the typical functional architecture of common cosmetic formats. They are not complete commercial recipes and do not specify universal concentrations. Exact percentages depend on the selected raw-material grades, intended use, target market, supplier guidance, and safety assessment. Water is normally adjusted to the final batch total only after the other components have been calculated. Oil-in-water moisturising cream Aqueous phase: suitable-quality water and compatible humectant. Oil phase: selected emollients, consistency agents, and an emulsifier system. Cool-down phase: compatible preservative, fragrance if required, and heat-sensitive ingredients. Key controls: phase temperatures, homogenisation, cooling profile, pH, viscosity, microbial quality, and stability. Light body lotion Aqueous phase with humectant and a compatible rheology modifier; a moderate emollient phase with an emulsifier system; and suitable preservation. Key controls: pump or squeeze-package compatibility, flow behaviour, spreadability, pH, microbial quality, and phase stability. Aqueous gel Suitable-quality water, a compatible gelling polymer, humectant or solvent if required, pH adjustment where relevant, and a validated preservation system. Key controls: polymer hydration, lump prevention, pH, viscosity, clarity where intended, air removal, and stability. Rinse-off cleanser A blend of compatible surfactants, water, viscosity-control ingredients, pH adjustment, and a compatible preservative system. Fragrance or colour is optional and requires compatibility review. Key controls: addition sequence, aeration, viscosity, pH, rinse feel, microbial quality, and package dispensing. Shampoo A surfactant blend selected for cleansing and foam profile, water, viscosity modifiers, optional conditioning ingredients, fragrance if required, pH adjustment, and preservation. Key controls: surfactant compatibility, salt response, viscosity, foam, rinsability, and stability. Conditioner Water, a compatible cationic conditioning system, fatty alcohols or other structuring materials, selected emollients, preservation, and optional fragrance. Key controls: phase preparation, cooling profile, pH, viscosity, combability evaluation, and package compatibility. Lip balm A structured blend of suitable waxes, oils, emollients, and optional permitted colour or flavour materials. Key controls: melting and cooling, hardness, payoff, odour, oxidation stability, package fit, and ingredients permitted for lip application. All illustrative frameworks require bench-scale trials and a documented safety and quality review. Do not use these outlines as ready-to-apply formulas, and do not omit preservation or testing merely because a product appears simple.

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