Cosmetic Formulations: A Beginners Guide

Belinda Carli
B Nat Ther., Dip Cos Sci

Written and edited by Belinda Carli
Cover design by Hanna Moon

For general information on our other publications and courses or to obtain technical support, please contact Student Administration at +61 7 5446 4680 or info@personalcarescience.com.au

Carli, Belinda

Cosmetic Formulations: A Beginners Guide – 7th ed.

1. Cosmetic formulation. 2. Cosmetic chemistry. 3. Cosmetic safety. 4. Cosmetic ingredients.

Disclaimer: This book, general advice and formula and methods contained within has been developed and written by a Qualified Cosmetic Chemist. Costs associated with producing a sample of any of these formulas is the user's responsibility including any reworks or fails. IPCS recommends a 100g lab scale sample be made and pilot production prior to full scale production.

Please refer to supplier Safety Data Sheets (SDS/MSDS) to ensure safe handling of all raw materials. IPCS holds no responsibility for inappropriate use of materials selected, the formulations or methods, in part, or as a whole.

It is a condition of use of any guidance, formulas or methods within this book that the user holds full responsibility for ensuring safe and correct use and storage of any materials they source and use, as well as ensuring compliance with local regulations and 'clean product preparation' steps are followed when producing samples, especially for use by others. Evaluations of the safety, stability, regulatory compliance and suitability of any formulas, methods and finished products are the sole responsibility of the user and/or Brand putting the product onto the market.

The information provided is of a general nature and does not represent brand or product specific advice. IPCS shall not be responsible for any damages resulting from use of or reliance on this information.

About the Author

Belinda Carli is the founder and Director of the Institute of Personal Care Science. She has consulted for various clients on a range of issues covering the development, manufacture, registration, importation and promotion of complementary medicine, food and cosmetic products for over 10 years. She also provides tailored training for organisations on issues specific to their needs, such as GMP and Regulatory Compliance; prepares and delivers training and guidance documents as regulations change; and training modules in the development and formulation of personal care products. She has been a regular presenter at major International events such as PCHi China, PCHi India, In-Cosmetics events globally and Australian ASCC conferences; as well as providing training to ASEAN regulators. She is also the Official Technical Advisor to the in-cosmetics Group overseeing technical content and the formulation labs at all in-cosmetics exhibitions. Her work can be found in many International publications including SPC Magazine, Australasian Journal of Cosmetic Science and Professional Beauty.

Her work involving product development and formulations has extensively focused on natural products involving cosmeceutical and plant based actives. She has worked on several national and international brands from concept to launch and beyond, including formulation and sample development, marketing materials, claims substantiation and regulatory requirements for Australia and overseas. As such she has been exposed to varying projects with clients in a variety of situations to provide a broad knowledge base of different regulatory, development and marketing requirements particularly relevant to the personal care, food and complementary medicine sectors.

She has a Bachelor of Natural Therapies from Southern Cross University, a Diploma of Cosmetic Science from the UK Society of Cosmetic Chemists and Certificate IV in Training and Assessment from TAFE Queensland. She is a member of the Australian Society of Cosmetic Chemists (ASCC), Association of Therapeutic Goods Consultants (ATGC) and an active Member of NASAAs Organic Standards Committee. She was a finalist in the 2010 Australian Telstra Business Women’s Awards in 3 categories

Contents

Chapter 1: Cosmetic product forms and ingredients	**1**
Finished product forms	1
Cosmetic ingredient functions	3
Vocabulary of cosmetic science	8
The role of pH in personal care science	11
Chapter 2: How cosmetic formulas are put together	**13**
How to read (and write) cosmetic formulas	13
Formulation development	14
Chapter 3: How to select ingredients	**30**
Company philosophy	30
How to choose ingredients functionality	31
Preservatives	31
Antioxidants	36
Chelating agents	38
Gums and thickeners	40
Oils, butters and waxes	43
Fragrances and essential oils	44
Emulsifiers	48
Surfactants	50
Sourcing raw materials and information	51
How to build your network	52
Chapter 4: What is natural?	**54**
Organic ingredients	54
Certified organic ingredients	55
Natural ingredients	56
Derived from nature	57
Nature identical ingredients	59
Synthetic ingredients	59
Determining natural/synthetic status	60
Chapter 5: Cosmetic product safety	**62**
Company responsibilities	62
Reliable safety information	64
Formulating mild products	68
General safety considerations	69
Common irritant ingredients	70
Anti-irritant formulation principles	71
Allergens in cosmetics	72
Hypoallergenic products	72
Comedogens in personal care	73

Chapter 6: Ingredient lists and claims **75**

Cosmetic products 75
Ingredient lists 76
Ingredient composition 77
INCI names and CAS numbers 80
INCI names for botanical materials 84
Claims 85
Misleading and deceptive conduct and free from claims 87

Chapter 7: Formulary **94**

1. Foaming face cleanser 99
2. Crème face cleanser 100
3. Simple body wash 101
4. Toner/mist 102
5. Oily skin cream (face) 103
6. Normal skin cream (face) 104
7. Dry skin cream (face) 105
8. Hand lotion 106
9. Body lotion 107
10. Body butter 108
11. Citrus lip balm 109
12. Peppermint lip balm 110
13. Body scrub 111
14. Facial exfoliator 112
15. Dry hair shampoo 113
16. Oily hair shampoo 114
17. Dry hair conditioner 115
18. Oily hair conditioner 116
Appendix A: Formulation and method sheet template 117
Appendix B: Manufacturing flow chart for Lanette O 118

Chapter 1: Cosmetic product forms and ingredients

As a beginner formulating cosmetics, you don't need a chemistry degree or even much understanding about chemistry to be able to make your own products. You do need to know which ingredients to put together, what different ingredients will do when put together, and how to process them, to get a finished product. Let's start by taking a look at some introductory concepts to get you ready to make your own ingredient selections, and build your own formulations.

1. Finished product forms

Different cosmetic products will take on different forms. Some may be runny like water, others runny like honey, some semi-solid or cream like and some solid bars or balms. When we talk about product forms, we often also refer to viscosity. The viscosity of a product is its resistance to flow: how readily will it flow if the bottle, or jar, is tipped over?

The viscosity and form of a product is important for a few reasons:

- **to make it easy to apply** – for example, you need shampoo to pour from a bottle but then stay in your hand while you apply it to your head
- **to make it easy to dispense and use the right amount** – for example, a body lotion can often be pumped out and spreads easily over large areas of our body for convenience
- **to suit consumer perceptions** – for example, consumers will judge the conditioning benefits of a conditioner by how viscous (thick/creamy) it is. If a conditioner is so thick it needs to come in a jar, they will instantly perceive the product must be deeply conditioning for the hair. Body butters are also very viscous, giving the perception, before a consumer has even tried the product, that it is deeply moisturizing for the skin.

When we talk about viscosity, we are therefore talking about how the product flows. Don't worry about trying to memorise all of this information – just think about some of the cosmetic products you've used over your lifetime to picture the different product forms and it will start to make sense.

Finished products can take one of a number of forms:

- **liquid:**
  - used to describe products that flow freely. Viscosity of the product can still vary from runny like water to runny like honey.
  - needs to be packaged so as to prevent leakages during transportation and use.
  - ingredients to be used in liquid products need to maintain free flowing properties; which limits the use of materials that will alter viscosity.
  - water based liquids can only contain small amount of oils appropriately solubilized (you'll learn about solubilizing soon).
- **gel:**
  - thicker than a liquid, gels have limited flow properties.
  - usually formed through the use of gums or thickening agents, gels may also vary in their appearance; being completely transparent through to translucent (cloudy/semi-see through) or even opaque (can't see through them).

- the viscosity of gels can be altered by the addition of more or less gum or thickening agent as appropriate.
- gels may be water based, like hair styling gels; or oil based, like viscous hair oils.

- **foaming gel:**
  - used to describe foaming products with a honey like viscosity, such as shampoos and liquid body washes.
  - a gel form is preferred by consumers for such products because it prevents product from running out of the hand during application.
  - these products have limited flow capacity for ease of use but must also foam up.
  - gums and thickening agents as well as sodium chloride and the combination of surfactants used can alter the viscosity and form of this type of product (you'll learn more about this later too).
- **serum:**
  - serums can vary from low viscosity gels through to almost lotion-like.
  - the key feature of serums is that they are used to deliver key ingredients in a light product form.
  - they may be water based or oil based, depending on the ingredients they are being used to deliver.
  - they may be formulated much like a gel or like a very low viscosity lotion depending on whether you want a transparent, translucent or milky looking product.
- **lotion:**
  - lotions are low viscosity emulsions.
  - an emulsion is a mixture of two normally immiscible substances by use of a material to hold them together (an emulsifier). For example, most lotions are what we call 'oil in water (o/w) emulsions'. This means they are composed of finely dispersed oil droplets suspended in a continuous water phase. What we see is a white milky product, because the oil droplets are too small to be seen without the use of an electron microscope!
  - lotions can vary in viscosity from low viscosity lotions suitable to be used as serums or moisturising 'milks' to high viscosity lotions that are almost the same viscosity as light creams.
  - lotions can often readily be pumped or squeezed from packaging with little effort, or may run semi-freely.
  - the viscosity of lotions can be altered through the use of different emulsifying agents (emulsifying waxes), consistency factors (such as beeswax or other waxes) or gums and thickening agents.
  - higher quantities of internal oil phase ingredients often also increase the viscosity of these products.

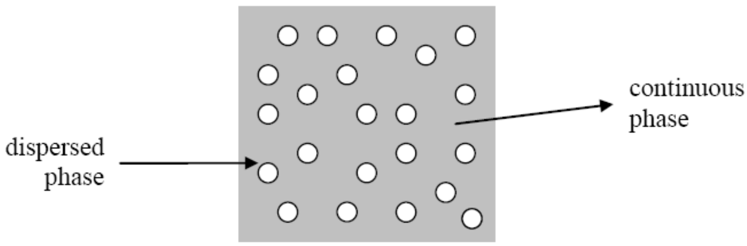

Figure 1: emulsions are a mixture of immiscible substances:

an internally suspended dispersed phase, and an external continuous phase

- **cream:**
  - creams are emulsions of medium to high viscosity.
  - creams may be:
    - o/w = oil in water emulsions = droplets of oil in a water continuous phase OR
    - w/o = water in oil emulsions = droplets of water in an oil continuous phase
  - w/o creams tend to be higher in viscosity because they have a high oil content.
  - o/w emulsions tend to have a light after-feel on the skin being water based; while w/o tend to have a greasier after feel and are oil based.
  - creams are ideally packaged in jars or small bottles with wide serum or pump nozzles. Higher viscosity creams are only suitable in jars because they are too thick to pump effectively.
  - the viscosity of creams can be altered through the use of varying quantities of emulsifying agents (emulsifying waxes), consistency factors (various waxes) as well as gums and/or polymer thickening agents.
  - higher quantities of oil phase ingredients can alter the skin feel of these products (tending toward more moisturising and/or more greasy) as well as increase the viscosity of the product.
- **powders:**
  - utilised readily in the colour cosmetics industry to make eye shadows, blushes, pressed and loose powders and mineral make up.
  - powders rely on various consistency factors, oils and viscosity modifying agents to set into pressed powders.
- **other forms:**
  - **balms:** often mostly or completely oil based, balms are usually a semi-solid consistency. Their consistency may be altered through the use of more or less, and various types of, consistency factors such as waxes.
  - **muds:** using clays, these are often semi-solid products that vary greatly through the use of different clays and presence of oils, water, gums and thickeners in the base product.
  - **scrubs:** using various bases such as oil, emulsions (creams), gels and foaming gels, scrubs contain various sized particles to mechanically exfoliate the skin.

When selecting ingredients to be used in a personal care formulation, you need to start thinking about the types of ingredients that are going to provide you with the required finished product form consistency. This may help you streamline your selections as well as steer you away from the use of various other ingredients.

2. Cosmetic ingredient functions

The International Cosmetic Ingredient Dictionary and Handbook lists over 70 different functions for ingredients found in personal care products today. We will consider the more commonly used ones here, along with their primary role in products. Remember, ingredients may serve more than one role, and may have secondary roles in a formulation besides those listed here.

When reviewing these ingredients, we have provided you with information as to the general natural/synthetic status of the named materials; but please make sure you request and check the material flow chart and processing methods used for the exact material you intend to use or make claims about to ensure accuracy of information, as different suppliers may use different sources of materials to those we have listed here. You'll learn more about the natural or synthetic status of ingredients in a coming section.

Key to abbreviations:

(N) = natural
(NDM) = derived from nature with minimal processing
(NDS) = derived from nature complexed with, or processed using, synthetic chemicals
(NI) = nature identical ingredients
(S) = synthetic ingredients

- **abrasives –** used to remove skin cells or plaque from teeth, these functional ingredients are commonly found in body scrub/exfoliating products and toothpastes. Common abrasives, by product types, include:
  - body exfoliants – Avena sativa (oat) kernel meal *(N),* Juglans regia (walnut) shell powder *(N),* hydrogenated jojoba wax *(NDM).*
  - toothpaste abrasives – silica *(normally S, check documentation),* sodium bicarbonate *(N).*

- **antioxidants –** used in products to reduce oxidation or rancidity from occurring over time. These supportive ingredients not only help lengthen the shelf life of the product, but may also be marketed as nurturing for the skin. Common vitamin and plant extract antioxidants include:
  - vitamin –tocopherol (vitamin E) *(may be NDM or S, depending on source, further documentation checks would be required to determine).*
  - plant extracts – Camellia sinensis leaf extract (green tea extract), Chamomilla recutita (chamomile) flower extract, Rosmarinus officinalis (rosemary) leaf extract, Vitis vinifera (grape) seed extract *(normally N but you will need to check the status of any solvents and/or preservatives present on the product CofA)*

- **chelating agents –** also known as sequestrants, these supportive ingredients help improve the stability of products by binding with metal ions that may be present in other raw materials. Chelating agents are also important in foaming products to bind to the ions in hard water and prevent the deterioration of foam under such conditions. Common chelating agents include:
  - citric acid *(NI),* disodium EDTA *(S),* tetrasodium EDTA *(S).*

- **colourants –** used to colour a product or colour the skin. Colours in cosmetics such as eye shadows or blush products are considered functional ingredients; while colours in personal care products to improve its appearance in a bottle are considered added extras. Examples include:
  - superficial colour in a product – Acid Green 1 *(S),* Basic Yellow 40 *(S).*
  - colouring cosmetic products – iron oxide red *(considered to be NDM),* chromium oxide green *(considered to be NDM).*

- **cosmetic astringents –** commonly used in skin toners, cosmetic astringents induce a tightening and toning effect on the skin. They are also used in aftershave lotions. Common examples of these functional ingredients include:

- alcohol *(may be N or S depending on source, further documentation checks would be required),* Hamamelis virginiana (witch hazel) extract *(normally N but you will need to check the status of any solvents and/or preservatives present on the product CofA).*

- **emulsion stabilisers –** emulsions are the white, creamy complexes formed when oil and water are mixed; such as body lotions and skin creams. Emulsion stabilisers do not form the emulsion, but help improve the stability of emulsions once formed, preventing it from separating out into separate oil and water phases. These supportive ingredients can be either derived from natural sources, or composed of synthetic materials; and may also be thickening agents. Common examples include:
  - xanthan gum *(N)*
  - cellulose gum, hydroxyethyl cellulose *(both NDS)*
  - acrylates/C10-30 alkyl acrylate crosspolymer, carbomer *(S)*

- **exfoliants –** exfoliants help remove dead skin cell layers by dissolving the intracellular 'cement' holding surface skin cells together. Chemical exfoliants are functional ingredients and usually found in skin whitening or skin peel products, in the presence of a low pH. Common exfoliants include**:**
  - glycolic acid, lactic acid, salicylic acid *(normally N or NDM but may be NI; further documentation checks would be required)*

- **fragrances –** required only to be listed as 'fragrances' on a product label, they are added to enhance the consumers experience of using a product or can be used to mask undesirable odours. Essential oils would also be classified as fragrances, although their full name must appear on product labels. Fragrances are considered added extras *(may be a combination of N, NDM, NDS, NI and S; further documentation checks would be required),* while essential oils *(normally N),* depending on their application, may be considered functional ingredients (if used to control oily skin, for example) or added extras (if used for their scent only). Since the scope of fragrances is so large and varied, no examples are provided here.

- **hair conditioning agents –** used to condition the hair, these functional ingredients also improve the appearance, gloss and shine of hair while facilitating styling and reducing static of the hair. They can also be used to improve the texture of hair that has been dried through styling, chemical exposure or environmental drying. Hair conditioning agents can be synthetically made or derived from and/or complexed with natural ingredients. Common examples include:
  - guar hydroxypropyltrimonium chloride, behentrimonium methosulfate *(both NDS)*
  - amodimethicone, cetrimonium chloride, polyquaternium-7, quaternium-22 *(all S)*

- **hair fixatives –** used to hold hair styles in place, fixatives are functional ingredients that form a continuous film to hold hair in its place. Common examples include:
  - acrylic acid/VP crosspolymer, VP/VA copolymer *(both S)*

- **opacifying agents –** added to shampoos and shower gels to make them appear pearlescent; opacifying agents are considered added extras, and give consumers the impression the product is rich and creamy simply because it looks pearly in nature. Common examples include:
  - glycol stearate *(S),* propylene glycol stearate *(S),* stearamide MEA stearate *(NDS).*

- **pH adjusters –** used to adjust the pH of the finished product to a desired range, these supportive ingredients are also commonly referred to as acids (lower the pH) or bases (raise the pH). Common examples include:
  - acids – citric acid *(NI),* lactic acid *(normally N).*
  - bases – potassium hydroxide *(N),* sodium hydroxide *(N),* triethanolamine (TEA) *(S).*

- **preservatives –** used to prevent or retard microbial growth, preservatives are supportive ingredients. A lot of misinformation exists about the natural status of some preservatives; so it is best to check any claims you wish to make with the raw material supplier by asking them for a statement of natural or synthetic origin for the preservative in question. Common preservatives include:
  - diazolidinyl urea, methyl paraben, phenoxyethanol, propyl paraben, sodium hydroxymethylglycinate *(all S).*

- **skin conditioning agents –** one of the two biggest categories in cosmetic chemistry, skin conditioning agents are functional ingredients that can be broken into the following categories:
  - **emollients –** used to impart softness to the skin by remaining on or in the upper layers of the skin, reducing flaking and improving the appearance of smoothness. They include ingredients such as:
    - cocoglycerides, caprylic/capric triglycerides *(both NDM).*
    - PEG-6 caprylic/capric glyceride, isopropyl myristate *(both NDS).*
    - dimethicone, mineral oil *(both S).*
  - **humectants –** retard moisture loss by holding water within the surface layers of the skin and drawing in moisture from the surrounding air. Humectants can also have a supportive role in helping retard moisture loss from the finished product. Common examples include:
    - glycerin *(may be NDM or NI depending on source, further documentation checks would be required),* propylene glycol *(S)* and sodium hyaluronate *(may be NDM or NI depending on source, further documentation checks would be required).*
  - **miscellaneous –** with the many specialty ingredients available today, there is seemingly endless choices when it comes to skin conditioning agents. These are grouped together under the heading of 'miscellaneous' and include various plant extracts, algae extracts *(normally N but check solvents and preservatives),* dimethicone complexes *(S)* and hydrolyzed proteins *(may be NDM or NDS depending on source, further documentation checks would be required).*
  - **occlusive –** these agents block the evaporation of water from the surface of the skin, keeping it moist and increasing its water content. They include ingredients such as:
    - Butyrospermum parkii (shea butter), Simmondsia chinensis (jojoba) seed oil *(both N)*
    - caprylic/capric triglyceride *(NDM).*
    - dimethicone, propylene glycol dioleate *(both S).*

- **solvents –** liquids used to dissolve constituents or act as carriers in cosmetic and personal care products. Solvents are predominantly classified as structural ingredient but may serve a functional role as well. Common examples are:
  - water *(N),* alcohol *(may be N or S depending on source, further documentation checks would be required),* butylene glycol *(S),* glycerin *(may be NDM or NI depending on source, further documentation checks would be required),* propylene glycol *(S).*

- **sunscreen agents –** used to protect the skin from UV radiation, these functional ingredients can be chemical (act by absorbing UV light; also known as organic sunscreen agents) or physical (act by reflecting or scattering UV light; also known as inorganic sunscreen agents). Common examples include:
  - organic (chemical) sunscreen agents – benzophenone-3, butyl methoxydibenzoylmethane, ethylhexyl methoxycinnamate *(all S).*
  - inorganic (physical) sunscreen agents – titanium dioxide, zinc oxide *(both considered NDM).*

- **surfactants –** the biggest category in cosmetic chemistry, surfactants are functional ingredients also known as surface-active agents because of their ability to modify the surface of a substance. They can be broken into the following categories:
  - **cleansing agents –** cleansing surfactants are able to produce a foam and clean the surface of the skin and hair. They can be synthetic in origin or derived from natural sources. Common cleansing agents include:
    - cocoyl glucoside, decyl glucoside *(both NDM).*
    - cocamidopropyl betaine, sodium lauryl sulfate, sodium methyl cocoyl taurate *(all NDS).*
    - sodium C14-16 olefin sulfonate *(S).*
  - **emulsifying agents –** used to mix the oil and water phases in an emulsion, these functional ingredients enable creams and lotions to be made. They are predominantly derived from natural sources. Common examples include:
    - cetearyl alcohol, stearic acid *(both NDM).*
    - ceteareth-20, PEG-100 stearate *(both NDS).*
  - **solubilisers –** used to solubilise a substance that is normally insoluble in a continuous medium. A common example of this is face toners or room fresheners, where a fragrance oil is solubilised in an aqueous (water) base. Solubilisers enable the oil phase to be homogenously dispersed in the aqueous base, and prevent an oil layer from forming at the top of the finished product. Common examples include:
    - laureth-20, PEG-40 hydrogenated castor oil, polysorbate 80 *(all NDS).*

- **viscosity increasing agents – aqueous –** structural ingredients used to thicken the water soluble components of a personal care formulation, they can be natural, derived from nature or synthetic. Common viscosity increasing agents – aqueous include:
  - agar, xanthan gum *(N).*
  - guar hydroxypropyltrimonium chloride, hydroxyethylcellulose *(both NDS).*
  - acrylates/C10-30 alkyl acrylate crosspolymer, carbomer *(both S).*

- **viscosity increasing agents – nonaqueous –** structural ingredients used to thicken the oil soluble components of a personal care formulation, they can be natural, derived from nature or synthetic. Common viscosity increasing agents – nonaqueous include:
  - beeswax, Euphorbia cerifera (candelilla) wax *(N).*
  - stearalkonium bentonite *(NDS).*
  - microcrystalline wax, silica dimethyl silylate *(S).*

3. Vocabulary of cosmetic science

In addition to the different ingredient classifications presented in section 2, there is also a vocabulary of cosmetic science you need to be introduced to. Shortly, we'll be looking at how you make ingredient selections and put formulas together – but we'll use some of these words to describe certain ingredients, and differentiate between them.

Every trade has its own 'vocabulary' – its own special use of words or terminology that get used frequently to describe certain things. Here is the vocabulary of cosmetic science that you will need as a beginner – a list of common terminology you'll see us use in your beginner studies. If you continue on to more advanced studies with us, these will become even more common use terms for you.

You don't need to memorise this list – but it would be a good idea to flag it so that you can refer back to it when you need to, or see a word you're not so familiar with. This list is presented alphabetically to make it easy for you to find certain terms when you need to.

Some of these terms may not make complete sense right now either – don't panic, it's like learning a new language and these are its key terms. It's a vocabulary provided as a reference tool, so that when we start to discuss ingredient selection and formulation development in the next chapter, you'll know where to look to better understand any terms you don't already know.

Amphoteric: an amphoteric substance can be positively or negatively charged, depending on the pH environment. In cosmetic science, amphoteric substances are usually positively charged in an acidic pH ($pH < 7$) and negatively charged in an alkaline pH ($pH > 7$).

Anhydrous: without water. For example, powders and oils are completely anhydrous, as they do not contain any water.

Anionic: negatively charged. An anionic substance is always negatively charged whether it be a gum, emulsifier or surfactant. Anionic substances are not usually compatible with cationic substances, although exceptions do occur. Anionic substances are typically used in face and body care in lotions and creams. Anionic surfactants are very effective cleansing agents for the body and hair but should not be used in conditioning products, which usually carry a cationic (positive) charge.

Absorption: where a product is taken in through the pores of the skin.

Adsorption: the adhesion of a substance on the surface of another material.

Cationic: positively charged. A cationic substance is always positively charged whether it be a gum, emulsifier or surfactant. Cationic substances are not usually compatible with anionic substances, although exceptions do occur. Cationic substances are usually used in hair conditioners as they make the hair feel slippery and soft.

Chelating agent: chelating agents are used to sequester (bind to) metal ions that may be present in a product from water, manufacturing equipment or raw materials. They can also help boost preservative and antioxidant effectiveness.

Emulsifier: a chemical used to form an emulsion and/or help stabilise an emulsion from separating.

Emulsion: a suspension of droplets within a continuous phase; for example, an oil in water (o/w) emulsion is common in the personal care industry where oil droplets are suspended throughout a continuous phase. Since water is the continuous phase, this type of product would be water compatible (dispersible), would require hydrophilic emulsifiers and gums/polymers (water loving – see below) and would tend to feel non-greasy on the skin. Water in oil (w/o) emulsion means water droplets are suspended throughout an oil continuous phase. Since oil/lipid is the continuous phase, this type of product would not be water dispersible, requires specific emulsifiers and gums/polymers that suit an oil/lipid continuous phase and could feel greasy on the skin unless esters, mineral oils or silicones are used. Emulsion products, both o/w and w/o, look white and milky, like a lotion or cream.

Esterification: the formation of an ester through reaction of acid and alcohol functional groups in chemicals. Esters are commonly emollient lipids (oil like substance) but may also be emulsifiers.

Ethoxylation: treatment or reaction with ethylene oxide. This is done to make a substance more hydrophilic (water loving).

GMP: Good Manufacturing Practice. A set of rules that govern how cosmetic products should be made so as to ensure finished products contain their specified quantity and type of ingredients and meet quality requirements, without human, microbial or cross-contamination with non-specified inputs.

Hydrogenation: the reaction of hydrogen with another substance, usually under pressure and high temperatures in the presence of a catalyst. Oils are commonly hydrogenated to make them more butter-like.

Hydrolysis: a chemical reaction whereby a water molecule is added to a substance resulting in the split of that substance into two parts.

Hydrophilic: water loving/compatible with water. These substances are lipophobic; not compatible with oil.

Hydrophobic: water fearing/not compatible with water; means the same as lipophilic (oil loving).

Lipid: an oil like substance, can include oils, fats, waxes, mineral oil, esters and silicones. To be classified as a lipid, the substance would be lipophilic.

Lipophilic: oil loving/compatible with oil. These substances are hydrophobic; not compatible with water.

Lipophobic: lipid fearing/not compatible with lipids/oils; means the same as hydrophilic (water loving).

Non-ionic: no charge. A non-ionic substance never carries a charge and is not affected by charge whether it be a gum, emulsifier or surfactant.

Oxidation: a reaction where the atoms of an element lose electrons and become unstable. In personal care products, oxidation creates discolouration and/or rancid odours to develop in a product and can make a product unsaleable/have a short shelf life.

Petroleum derivatives: substances that are created by using the hydrocarbon backbone of crude oil. They are highly refined for personal care products and do not resemble the petroleum used to fuel vehicles.

Polymer: a large molecule that has many repeating sub-units.

Preservative: a substance that prevents or retards microbial growth in a product.

Propoxylation: the addition of a propyl functional group to a molecule.

Rancidity: a change in aroma to display off notes or undesirable characteristics in an oil.

Sequestrants: a compound that forms chelates (bonds) with metal compounds to prevent metal catalysed oxidation and/or formation of scum in hard water areas.

Shelf life: the period of time over which suitable performance characteristics of a personal care product are maintained.

Solvent: a liquid that dissolves a solid or liquid substance.

Stability: a measure of how well a formulation remains suitably unchanged over its shelf life.

Sulphonation/sulfonation: the addition of a sulfonic acid functional group to a molecule.

Superfatting agent: a lipid derivative that has been made partially hydrophilic, a superfatting agent is one which can help provide a more emollient/skin conditioning feel to a foaming product with its lipid portion whilst being able to be washed easily from the skin or hair due to its hydrophilic portion.

Surfactant: a substance with water loving and oil loving portions, making it surface active. Note: in Cosmetic Chemistry, 'Surfactant' is used to describe a surfactant substance that is used to cleanse the hair or body and creates foam. While an emulsifier is, chemically speaking, a surfactant, the term 'emulsifier' is used in Cosmetic Chemistry to describe substances which create lotions/creams compared to those which foam.

Synthetic: produced through chemical means using non-renewable sources.

Transesterification: the reaction of an ester with an alcohol functional group to create a new ester.

Viscosity: a measure of resistance to flow of a substance, commonly referred to as how readily a product will move when tipped.

%w/w – '% weight per weight' is a term used to describe how many grams of a substance has been added to make up a certain weight. For example, a 50% w/w solution would contain 50g of solid per 100g of final solution.

%w/v – '% weight per volume' is a term used to describe how many grams of a substance has been added to make up a certain volume of solution. For example, a 50% w/v solution would contain 50g of solid per 100mL of final solution.

%v/v – '% volume per volume' is a term used to describe how many milliliters of a liquid has been added to make up a certain volume of solution. For example, a 50% v/v solution would contain 50mL of a certain liquid per 100mL of final solution.

4. The role of pH in personal care science

pH is a measure of acidity or alkalinity of a solution, and is dependent on the concentration of hydrogen (H^+) or hydronium ions (H_3O^+).

The pH scale goes from 0 to 14; where 0 is the most acidic, and 14 the most basic (or alkaline). Water, which has an equal balance of hydrogen ions (H^+) and hydroxide ions (OH-), is neutral with a pH of 7.

The pH scale is a logarithmic scale, which means that each whole number change in pH is actually a 10-fold change in H^+ concentration. For example, a pH change from 5 to 6 represents a 10-fold decrease in H^+ concentration; while a pH change from 5 to 7 represents a 10 x 10 – fold (or 100-fold) decrease in H^+ concentration. This is compared to a linear scale, where a change from 5 to 6 would only represent a change of 1. The point to remember is that each whole number on the pH scale actually represents quite a large difference in the acidity or alkalinity of a solution.

Substances are defined as weak or strong acids or bases by the effect they have on a finished solution. For example, a weak acid is citric acid, commonly used in the personal care industry; and although it has a very acidic pH, it has only a weak effect on changing the pH of a solution, with small amounts adjusting the pH in decimal places rather than whole digits at a time.

The skin has a pH of around 5.5. Therefore, most personal care products should be pH balanced to 5.3 - 5.8, and rarely up to 7.0 (neutral). Exceptions do apply, and in some cases are necessary for stability. Some common examples include:

- naturally saponified solid and liquid soaps which have a pH around 9.5 and will separate into a fatty layer if adjusted much below this
- products containing zinc oxide which must be pH adjusted to around 7.0 - 8.0 to be stable
- hair conditioners which are generally pH adjusted to 4.0 – 4.5 to increase functionality and performance
- skin peel products which usually require a pH of around 3.5 – 4.0
- cosmeceutical actives which may have individual requirements to ensure efficacy and stability

Rarely does a formula yield a finished product at just the right pH, and adjustments are usually necessary to ensure it is safe to apply to the skin. You do not need to pH adjust formulas that do not contain water – pH is only relevant where water is present.

To adjust the pH of personal care products:

- to decrease the pH, that is, to make the finished product more acidic, (for example, from 9.0 to 5.5), a dilute concentration of citric acid (50%w/v solution) or lactic acid (88% w/v) is commonly added until the desired pH is reached.
- to increase the pH, that is, to make the finished product less acidic (for example, from 3.0 to 5.5), a dilute concentration of sodium hydroxide (NaOH, 10%w/v solution or tromethamine 30%w/v solution) is commonly added until the desired pH is reached.

In cosmetic science, we use pH buffer solutions to help us adjust this pH. Here is how to make buffer solutions:

NOTE: WHEN PREPARING BUFFER SOLUTIONS, ALWAYS ADD POWDERS **TO** WATER; **NEVER** water to powder. Wear safety glasses and gloves when preparing these solutions; if you get any powder or solution on your skin wash off thoroughly immediately. Observe all other safety precautions on the SDS.

To make 50 grams of a citric acid 50%w/v solution:

1. Measure out 25g purified water in a bowl.
2. Add 25g citric acid to the water.
3. Heat gently and stir to dissolve.
4. Allow to cool completely then pour off into container and cap.

To make 50 grams of a tromethamine 30%w/v solution:

1. Measure out 35g purified water in a bowl.
2. Add 15g tromethamine to the water.
3. Heat gently and stir to dissolve.
4. Allow to cool completely then pour off into container and cap.

To make 50 grams of a sodium hydroxide 10%w/v solution:

1. Measure out 45g purified water in a bowl.
2. Add 5g sodium hydroxide to the water.
3. Stir to dissolve – it will be warm enough just from adding the powder to the water.
4. Allow to cool completely then pour off into container and cap.

We do not recommend Beginners make anything stronger than these solutions.

When you make a formula with water as the continuous phase (so basically any formula containing water other than w/o emulsions) you will need to check and adjust the final pH. Sometimes you need a little pH adjuster, sometimes you need a lot – you can't ever know until you make that first sample how much impact your buffer solutions will have.

Watch how it's done!

Here is a great video on how to test and adjust pH: https://youtu.be/kwvLAK3KauM

Chapter 2: How cosmetic formulas get put together

Now that we've covered off on some essential terminology, let's take a look at how we put formulas together.

1. How to read (and write) cosmetic formulas

When you first start to read cosmetic formulas, you could liken them to following a recipe. When we make a formula, we have ingredients, just a like a recipe, and method to follow, just like a recipe. But there are some important differences when it comes to cosmetic formulas that you need to know about, right from the start.

When reading and writing cosmetic formulas, make sure you take note of the following 'rules' – you'll see an example of how this applies in a moment:

1. **Cosmetic formulas must be written by %w/w (weight for weight).** While some materials come as liquids, to ensure batch-to-batch consistency and ensure your formulas comply with rule number 2, you must use weight for all inputs in your formulas from this point forward.
2. **All formulas must total 100%w/w.** We write in %w/w rather than grams, because we need to be able to scale formulas up to larger batches. It is very difficult to do this if its written like a recipe, in grams; or a mixture of volume for liquids and grams for solids. But if you have a formula in %w/w, you can calculate how much of each ingredient to use in larger batches very easily, and accurately.
3. **Ingredients that should be processed together should be 'phased' together.** It helps make sense when the method is put together to refer to 'phases' rather than individual ingredients, just in case one gets missed!
4. **Formulas that contain water must have a 'q.s' pH adjustment at the end,** with statement of what that pH must be. 'q.s.' – translates to 'quantum sufficit' – it is a latin term that means 'as required'. You can't predict what the final pH of a formula will be, and whether it will need to go up, or down, until you've made a sample and can check the pH. So we write 'q.s' pH adjuster – and what it needs to be – so that we know we need to adjust it with whatever we need, and how ever much of it we need, to get the required final pH.
5. **The method must be written to suit the materials selected.** Even the best ingredient choices won't work together if the method doesn't suit the materials. We'll spend time explaining how to get this right later in this book.

Here is a really basic example of how a formula looks when put together:

Phase	% w/w	Material name
A	88.6	Water
A	5.0	Glycerin
B	5.0	Polysorbate 20
B	0.4	Lavender essential oil
B	0.1	Vitamin E natural
B	0.9	Phenoxyethanol, Ethylhexylglycerin (Euxyl PE9010)
	q.s	pH adjuster
	100.0%	Total

METHOD	1. Combine ingredients in phase A.
	2. Combine ingredients in phase B.
	3. Add phase B to phase A slowly while constantly stirring; if product starts turning milky slow down your addition of phase B until solution clears between additions.
	4. Check and adjust final pH to 5.0 – 5.5.
	Final pH required: 5.0 – 5.5

Notes on this formula:

Welcome to your first formula! There are a few things you will notice from the ‘rules’:

- Notice how everything is now measured by weight, NOT volume, even essential oils! This is so there is batch to batch consistency as only 1mL of water = 1 gram; every other material has its own volume:weight ratio, and that makes it practically impossible to convert a sample into a large scale production batch if some ingredients were written by weight, while others were written by volume. If you have been writing up formulas in drops or mL, they now need to be written to %w/w; and must ALWAYS total 100%.
- Materials are ‘phased’ and this same nomenclature is written into the method. This is so that materials are added in the correct order and nothing gets missed.
- pH adjuster is written as q.s. = ‘quantum sufficit’ = as much as needed. In this case, it is ‘as much as needed to achieve a final pH of 5.0 – 5.5’. You can’t ever know what pH a formula is going to come in at when writing it up; you can’t know how much you’ll need; and you also can’t know if you need citric acid, tromethamine or sodium hydroxide to adjust it! So, the pH adjuster is commonly written as ‘q.s. pH adjuster’ so that when you are in the lab, you can adjust your formula with the right material to achieve the required pH, as specified in the method, using however much you need to adjust it to the required pH without impacting your 100%w/w requirement.

Watch how it’s done!

Here is a great video to help you understand how to read a formula, prepare your pH buffer solutions and adjust final pH; our Beginners Cosmetic Science first workshop: https://youtu.be/s0I7ZsGqUhk

---

2. Formulation Development

How do chemists know what to put into a formula? How will YOU know what should go into a formula to make an actual product?

When we are formulating products, especially innovative or advanced product forms, we need to think in terms of the roles that different ingredients will play in the formula. Each ingredient has a specific role to play within a formulation. The four main categories are:

- **functional ingredients** – these ingredients are selected by the product type. For example, to make a shampoo, you need to use cleansing agents, classified as surfactants. The product may contain more than one functional ingredient, and may also include secondary functional ingredients to serve a secondary purpose. For example, a 2-in-1 shampoo first needs to clean the hair; and secondly provide a conditioning function. Another example is a foundation with sunscreen in it. Its primary function is to provide colour to the skin, while the secondary function is to protect the skin from UV light.

- **structural ingredients –** provide the structure for the product. Continuing with the shampoo example, structural ingredients such as viscosity increasing agents may be added to increase the ‘thickness’ of the product and help create the impression it is more concentrated and effective.
- **supportive ingredients –** added to improve the stability and shelf life of the product. In order to maintain the integrity of your shampoo, you will need to add preservatives and may choose to add a chelating agent to improve suitability in hard water conditions.
- **added extras –** these ingredients, usually added in small amounts, have no functional, structural or supportive role in the product but add to consumer acceptance. For instance, the smell and colour of your shampoo.

In addition, many ingredients may have more than one role in a formulation. For example, cetearyl alcohol is a common emulsifying agent enabling emulsions to form, making it a functional ingredient; however it can also alter the viscosity of a product making it a structural ingredient; and support long term stability of the emulsion, thereby also making it a supportive ingredient. In such instances, the most important role of the ingredient would be considered its primary role, while the other roles would be considered secondary.

So, how do different formulas come together? It relies on the answer to 4 key questions:

- **what do you need to create that type of product?** The answer will tell you what type of *functional* ingredients you need to use.

- **what ingredients do you need to get the desired form of the product?** The answer will tell you what type of *structural* ingredients you need to use.

- **what do you need to include in the formula to get a good shelf life?** The answer will tell you what *supportive* ingredients you need to use.

- **what ingredients do you need to use to attain good consumer aesthetics?** This also includes what you need to add to achieve required marketing claims. The answer will tell you what *added extras* you will need to include.

Here is a table to help you see how different products are put together using the different roles of ingredients. If you are continuing on to advanced or Diploma studies with IPCS, you will learn full formulation development in a lot more detail in later units.

Don’t worry - you do not need to memorise this table!

Institute of
Personal Care Science

To read the rest of this book please purchase

https://personalcarescience.com.au/Books/CosmeticFormulations:ABeginnersGuideBook-485/