

Physicochemical Analysis of Personal Care Products for Sensory Profiling

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Abstract

Personal care products consist of ingredients such as Rheological Modifiers, Emollients, and Humectants which can affect how consumers can perceive the product.

Sensory analysis is often subjective, time-consuming, and expensive to conduct. This project aims to understand the differences in the performance of various class of functional ingredients, and establish correlations between sensory attributes and instrument analysis.

From our findings, we can see that emollients and humectants have a significant impact on the colour of the formulated products and careful considerations should be taken when formulating with these types of raw materials.

In this project, we have also successfully developed test methods that allow us to reliability test the wet stage properties such as gloss and colour of our formulated samples. We have managed to obtain some relevant results from the texture tests conducted, though more investigations are needed to assess the validity and reliability of these tests.

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Chapter 1 Introduction

1.1 Background Information

1.1.1 Personal Care Product Market of Singapore

The personal care product market in Singapore is resilient, thriving and growing every year, however it does not necessarily mean that the consumer numbers are increasing every year. For beauty and cosmetics company to ensure their survival, they invest ever increasing amounts of funds into 'research and development' as well as marketing to entice the consumers into buying their products. This enticing could be possibly done by researching and marketing a product that consumers would like by satisfying their wants and needs. The product price must not be too expensive that it turns away consumers as well [1].

This Personal care product market is further separated into different market segments such as the 'High-end retail department stores' and the 'mass market brands,' 'E-commerce' and 'Beauty and Spa.' Each of the different market segments of the Personal care product market of Singapore is split to satisfy the needs of the wide range of consumers from all ages and both sexes.

Brief Introduction about the Study

Personal care products such as Gel, Serum, Cream, Spray, and lotion are commonly used in our daily lives. To ensure that the personal care products that we use so often meets rules, regulations and guidelines set by international bodies such as the Association of South East Asia Nations (ASEAN) Cosmetics Association (ACA) [2], European Union (EU), International Organization for Standardization (ISO), strict testing is done to make sure that the cosmetics and personal care products that we use do not cause us long term health effects.

ASEAN – ASEAN Cosmetics Directive [3]
EU - Regulation (EC) N° *1223/2009*[4]
ISO - ISO *22716:2007*[5]

As personal care products are created, sensory testing by a trained panel to ensure that there is consistency in the products which is usually time consuming and often inaccurate. This consistency testing has therefore improved over time due to development in instrumental analysis testing machines to map the sensory profile more easily and with improved accuracy.

This therefore would allow industry players, especially personal care formulation companies to make use of our research and potentially skip the Sensory testing which is not so accurate all the time.

1.1.2 Different types of Personal care products

Generally, there are five types of personal care products that we use most often in our daily routines. They are listed below.

1. Gel (1.1.2.1)
2. Serum (1.1.2.2)
3. Cream (1.1.2.3)
4. Spray (1.1.2.4)
5. Lotion (1.1.2.5)

This is a brief introduction about the five types of personal care products that we use most often.

1.1.2.1 Gel

What is a Gel?

A gel is a thick, clear, slightly sticky substance that is used in cosmetics (Hair gel, Aloe Vera Gel) [6] and in Medicine (Ultrasound gel). Gels do not contain oils as compared to Creams and Lotions which makes it suitable for those that have oily skin or are prone to acne.

What are the common uses for Gel in our daily lives?

Common uses for Gels include Hair gel which guys use to style their hair and Aloe Vera gel to moisturize skin by rubbing it on the surface of the skin to enable it to adsorb moisture from the gel fast.

What are the ingredients commonly found in Gel?

Common ingredients [7] found in Gel includes Deionized Water, Propylene Glycol, Paraben, Surfactants, Emulsifying agent, Polyacrylic acid (Carbomer).

1.1.2.2 Serum

What is a Serum?

A Serum [8] is an alternative to creams and lotion as they are light, fast-absorbing liquid that does not contains ingredients such as mineral oils which prevents water from evaporating. Most Serum in the markets are of mostly water content and does not contains oils, allowing it to evaporate faster.

What is a Serum designed to do?

Serums are skin care products that delivers high amounts of active ingredients into the skin to carry out different types of functions such as Hydration, Skin Brightening, Anti-ageing. This is because the active ingredients in Serums are of small molecular weight which allows it to penetrate deep into the skin where it is most needed [9].

What are the common ingredients found in a Serum?

Common ingredients [10] found in Serums includes Alpha Hydroxy Acid, Antioxidants, Niacinamide, Lipids and Retinol.

1.1.2.3 Cream

What is a Cream?

A cream is a mixture of oil and water at 50% ratio each. This high percentage weight of oil gives cream its unique properties which is the high grease level. Creams have thicker consistencies as compared to Lotions and Serums as the oil acts as a barrier to lock moister into the skin, allowing the skin to become hydrated [11].

What are the different types of Creams available in the market?

The different types of Creams that are available in the market includes vanishing creams, night creams, cleansing creams, moisturizing creams, foundation creams, cold creams, and eye creams [12]. Basically, the list given in the previous sentence is not exhaustive.

What are the common ingredients found in Creams?

Common ingredients found in Creams include Water, Emollients, Emulsifiers and Preservatives [12].

1.1.2.4 Spray

What is a spray?

A spray is a convenient way to keep our skins refreshed throughout the entire day by spraying the spray on our face to rehydrate our skins. This is done by pointing the bottle towards our faces and spraying it onto our face to let the mist from the bottle to be adsorbed onto our skins. Sprays are also mostly made of water which allows for the water to penetrate deep into our skins.

What are the different types of Spray available in the market?

The different types of Sprays that are available in the market are Face Mist, Thermal Water, Toner, Essences and Setting Spray [13].

In this study, we would be focusing just on Lotion instead of Gel, Serum, Cream and Spray as it would allow the study to be clear when analysing of the data obtained from instrumental analysis testing. This is because the formulations done are mainly only focused on Lotion in this final year project's study.

1.1.2.5 Lotion

What is a Lotion?

A Lotion is a thick, smooth liquid that is designed to be applied onto the skin for either Cosmetics (Moisturizer) or for Medical reasoning (Eczema, Mild Itchiness). This allows it to clean, protect or treat the skin as necessary according to the use the lotion is being used for [14].

What are the common types of Lotion used?

Personal Care	**Medical**
Moisturising Lotion	Calamine Lotion
Tanning Lotion	Cetaphil Lotion
Anti-ageing Lotion	Sunscreen Lotion

Table 1: Common Lotions Used

What are the common ingredients that are used to make Lotion?
Common ingredients [15] found in Lotions includes Deionized Water, Glycerine, Fragrance oils, Oils (Shear Butter, Mineral Oil, Coconut butter), Preservatives and Emollients.

How are Lotions Regulated?
Depending on how the Lotion is being categorized, Lotions might be Characterized as a Cosmetics, a Drug or as both Cosmetics and Drug. This is because lotions can be either used to beautify someone or for therapeutic purposes such as to treat or prevent disease [16].

An example of a Lotion used as a Drug would be SPF Sunscreen Lotions as they contain specific active ingredients such as Zinc Oxide, Sulisobenzone, Avobenzone SLZ and Bemotrizionol. Those Active ingredients present in the Lotion affects the functions of the body by absorbing, reflect or scatter Ultraviolet light. Therefore, preventing the body from adsorbing the Ultraviolet light that we normally adsorb without the application of Sunblock on our skins [16][17].

For Lotions that would fall under Cosmetics would be our daily Hand Lotion that we use to moisturize our skins to prevent our skins from drying out. The Active ingredients in those Lotions do not affect the structure or the functions of our body itself to be considered a Drug [16].

This means that the purpose and classification of the lotion depends on the active ingredients in the formulation Ingredients which therefore affects the classification of the lotion if it is a drug or just purely for cosmetics usage.

How can we possibly extend the lifetime of the Lotion?
By adding in Photo-stabilizer compounds into the formulation of the Lotion and quenching the excited energy states in the photo-sensitive ingredients, possible extension of the lifetime occurs [18]. The Photo-stabilizer compounds boost the photo-sensitive ingredients by preventing the formation of high energy chromophores which degrades when exposed to UV-light and to quench the excited chromophores to reduce the lifetime of excited state [18].

Therefore, being able to prevent UV light induced decomposition of the photo-sensitive ingredients as the Photo-stabilizer compounds are able to shield the photo-sensitive ingredients from degradation and as such last longer, giving the Lotion an overall longer shelf-life [18].

Besides adding in Photo-stabilizer compounds [18] and quenching the excited energy states, another possible way to ensure that lotions last longer would be to experiment with the shelf-life of a few batches of lotion inside a bottle that can block out UV-rays and observe on how long that specific batch of lotion last as compared to lotions that is not protected from UV-rays.

This, therefore, allows the possibility of exploring different ways to ensure that the product shelf-life of Lotion and other personal care products last even longer than their said expiry date. As such, promoting better usage of the Lotion beyond its expected lifespan as there are consumers that are not able to use up their lotion before the said expiry date.

1.1.3 Lotion Formulation

1.1.3.1 How a typical Lotion Formulation looks like

PEACH HAND LOTION

RAW MATERIALS	Parts by Weight
Water	568.0
Carbomer 934	2.0
Rosswax 573	4.0
GMS-SE	4.0
Almond Oil	16.0
Lipoval ALM	
Coconut Oil #76	16.0
Ross Jojoba Oil	4.0
TEA	4.0
Germaben II	6.0
Fragrance GK-16	q.s.

Procedure:
Heat the water to 60C under agitation and slowly add the Carbomer 934. When the water is fully mixed add the 573, GMS, Almond Oil, Coconut Oil, and Jojoba Oil that have been heated to 65C in a separate kettle. As soon as the Oil Phase has been mixed well, add the Germaben II, the Fragrance, and then the TEA under high agitation. Cool to 55C for filling.

SOURCE: Frank B. Ross Co., Inc.: Cosmetic Formulary: Formulas

Figure 1: Peach Hand Lotion Formulation [7]

Usually, when formulating of a Lotion is taking place, the Raw Materials are being added in Phases into the Distilled Water to ensure that there will be proper mixing of all of the Raw Materials, this is done instead of adding in all of the ingredients together in one go which would not lead to proper mixing.

1.1.3.2 Brief Introduction of Raw Ingredients and their Functions

Ingredient	**Purpose**
Deionized Water	Solvent
Rheological Modifier	Changes the viscosity of the Lotion
Emollient	Makes skin feels softer
Humectant	Provide Moisturizing agent
Additive	Biocide (Keep Lotion from spoiling)
Preservative	Prevent growth of Bacteria
Neutralizer	Adjust the pH Level to the desired pH Level

Table 2: Ingredients and their purpose

Some of the ingredients stated in the Table above is Hydrophilic (Water-Loving) molecule while some are hydrophobic (Water-hating) molecule.

A basic rule of thumb is that Hydrophilic and Hydrophobic substances are not able to mix no matter how much you try to shake or stir it to mix the liquids. However, it can mix both Hydrophilic and Hydrophobic substances together by Homogenizing the substances by adding them into a solution together.

1.1.4 Formulating of personal care products (Lotion)

Equipment used

S/N	Equipment	Purpose
1	Weighting Scale	To weigh out required amount of dry ingredients
2	Beaker	Contain Liquids
3	Magnetic Stirrer bar	To stir
4	Wash bottle	Rinse equipment
5	Weighing boat	To contain the dry ingredients in the weighing scale
6	Chemistry Spatula	To scope out the dry ingredients
7	Disposable Pipette	Transfer volumes of liquid
8	Hot-plate magnetic-stirrer device	Heat glassware and cause a stir bar to stir
9	Mixer	To ensure even mixing of all ingredients
10	Homogenizer	Ensure uniform distribution of all ingredients in solution
11	pH meter	Check for change in pH level
12	Sticker	Batch Label

Table 3: Equipment used and their purposes

1.1.5 Sensory Testing

What is Sensory Testing?

Sensory testing is described as a scientific method that is used to interpret the responses to a personal care product through the five senses namely, Sight, Smell, Taste, Hearing and Touch [19]. This is done by a trained sensory panel that evaluates the product according to a few criteria such as Stickiness, Oiliness, Moistness and Colour for example [19].

What is the purpose of Sensory evaluation?

When sensory evaluation occurs, it allows for the understanding of how the consumers would perceive the personal care product that they are using. This therefore allows the Research and Development (R&D) department and the marketing department to adjust accordingly [19].

For R&D, they would be able to make use of the information that they have obtained and therefore adjust the ingredient makeup accordingly to improve the sensory attributes to the desired levels by combining data that the R&D department has obtained from sensory test and instrumental testing to ensure that their personal care products that they have created are up to quality standards that are acceptable towards the consumers [19].

For a marketing's perspective for a company selling personal care products, companies can market ingredients that are popular in their products by proving claims such as 'Super hydrating towards the skin' with data obtained from the sensory and instrumental testing done. This therefore causes people to be attracted to their advertisements which carries catchy phrases that attracts attention [19].

Descriptive analysis by a trained panel of judges

Personal care products that has been approved by the instrumental testing done might be rejected by consumers as soon as they hit the shelfs due to the attributes of the product itself which may perhaps not appeal to the consumers. This makes it hard for the product developer to comprehend on why the products that they have made is a commercial flop [20]. This understanding on why the product developed is a commercial flop could be done by asking consumers on what they feel by asking them to fill up an open ended survey with

some closed ended questions to understand what the consumers are thinking and how to possibly improve.
Consequently, this calls for a need in having a group of highly trained personnel to test the product on the overall feels present to ensure that it meets consumers standards.
This is because this group of qualified personnel are able to understand the needs of the consumers and feedback accordingly to the product developer, therefore improving the chances of being a commercial success as they fill in the gap between the clinical testing and consumer data [20] by marketing the new and improved product under a new name.

Is there a standard in Descriptive Analysis of Lotion?
Yes. There is a Standard for Descriptive Analysis of Lotion. The Standard that is currently used now in the market is 'ASTM E1490 – 19' [21]. This Standard is a guide that guides its users on how to access the sensory traits [21] of both cream and lotion during the entire period of the testing to express the apparent sensory properties.

1.1.6 Testing of personal care products

In personal care products, testing is important to find out the attributes of the products and to improve it based on the data obtained from the results. They are listed below.

1. pH (*1.1.6.1*)
2. Viscosity (*1.1.6.2*)
3. Stability testing (*1.1.6.3*)
4. Texture testing (*1.1.6.4*)
5. Gloss testing (*1.1.6.5*)
6. Colour testing (*1.1.6.6*)

This is a brief introduction about the six types of testing that we do on personal care products and why they are important.

1.1.6.1 pH

Personal care products such as Lotions are applied onto the Stratum corneum (Skin). The skin is an Organ by itself and it covers an area of about 2 square meters [22] in adults. The pH Level of our skin deferrers from the anatomical sites such as the forehead and the cheeks varying from pH 4 to 6 [23].

Since Personal care products such as Lotions are being applied onto our skins, each of the individual Lotions would have a pH value, it is in our interest to be able to obtain the values of the Lotion so that we can adjust the amount of neutralizer added accordingly to ensure that it would not be too acidic or too alkaline as it will affect the "structure of the skin integrity, cohesion and desquamation" [24]. This measuring of the pH levels of the personal care product (Lotion) can be done by using a pH meter to obtain the pH level of the personal care product (Lotion).

An example of the Effect of change in pH levels is stated in 'Table 4.' [24].

Effect of change in pH levels

Decreased pH □ More Acidic □ Bacteria Growth □ Skin Disease/Irritation
Increased pH □ More Alkaline □ Bacteria Growth □ Skin Disease/Irritation

Table 4: Effect of change in pH Levels

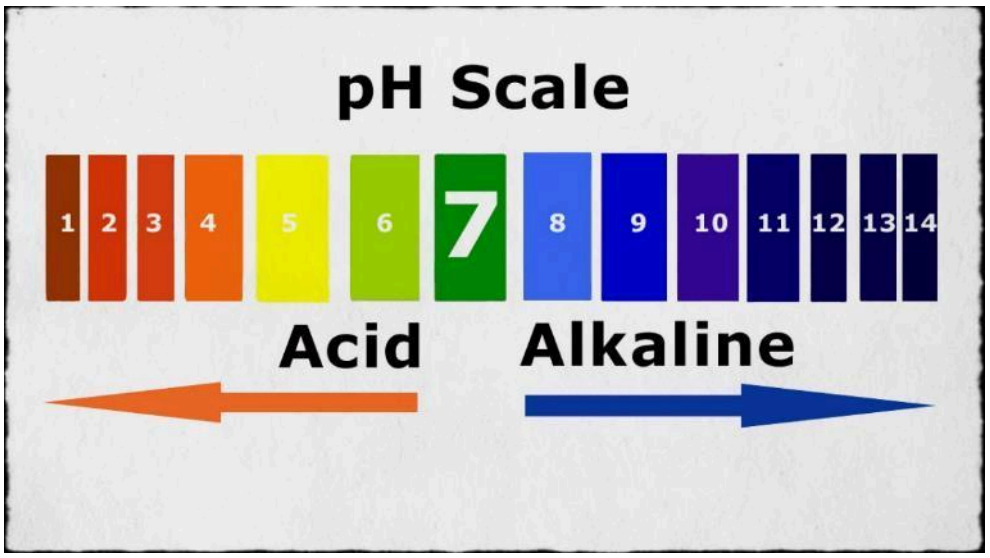


Figure 2: pH Scale [25]

1.1.6.2 Viscosity

The viscosity testing is a concern as it is used to measure the quality of the product by measuring the torque value by placing a spindle in the product sample and setting the test specifications accordingly by following a Standard Operating procedure (SOP) [26] of a Brookfield viscometer.

1.1.6.3 Stability testing

Personal care products such as Lotion are often used over a period of months or years. It is in our interest to therefore determine the shelf life of the product's stability [26]. Viscosity is used to measure the rheological changes in the product overtime as the chemical structures of the lotion changes over time due to a few external factors such as temperature and time. Those external factors would therefore lead to polymer degradation to occur and thus possibly changing the shelf life of the product dramatically.

As viscosity measurements are taken over a period, there might be visible changes in the viscosity of the product that a consumer might not be able to tell. This means that a possible change is being observed by the quality assurance team. Therefore, ensuring that all the batch of product is to be accepted or rejected as quality to a company is important.

Stability Testing is done during the quality control/analysis process to check if the product (Lotion) made meets the intended quality standards that are required to certify the product as stable.

This is due to the development phase of the product is quite short and requires a shorter duration due to the constant launch of new products every few months or even a shorter duration [27]. Due to the constant launch of new products, this calls for a need to design stability test that are short and gives valid yet reliable results.

Developers need to design an accelerated stability test with considerations such as being able to predict the shelf life of the product & predicting on how the product will be able to function under stress [27].

By designing a stability test according to the product tested, it will allow for specific data to be generated which will tell us about the properties of the product and how stable it will be under specific conditions.

1.1.6.4 Texture Testing

Texture testing is conducted in materials as a quality check to be used to tell the difference between the same samples at different durations. This is because the factory processes [12] such as packing, handling, and shipping for example can play a part in affecting the shelf-life and product acceptance by consumers.

From the start of formulation of the product to the end where the consumers get their hands on the product (Lotion), the product would have undergone mixing, shaking and even possibly has been dropped onto the concrete flooring.

Depending on the use of the Texture Analyser machine, it could be either used for 'Sensory or Instrumental analysis' as each of the analysis carries out a different purpose. Instrumental analysis for example is cheaper to conduct as compared to sensory analysis and is done under much stricter environmental conditions [12]. Sensory Analysis, however, is much more expensive and less strict environmental conditions as the sensory panel needs to be trained which requires both time and money.

Penetration Test

Penetration is done using a probe attached to the Texture Analyser machine and force is directly applied into the sample to deform it, creating a shear rate as penetration occurs. This penetration test allows for the measurement of properties such as "the work of cohesion and adhesion' that the sample feels which gives rise to trends such as firmness, cohesiveness, consistency, and index of viscosity [12].



Figure 3: Penetration

Spreadability

Spreadability is the study on how much a viscous sample can spread out with the application of a force applied. This can be done by using a Spreadability Rig which compromises of two parts. A male 90° cone probe and a perfectly matched female Perspex cone shape [28]. The testing is done by applying sample lotion into the female cone to around 2/3 of the height of the internal diameter and lowering the male cone forcing the sample to flow outwards at a 45° between both the male and female cone [28]. This therefore indicates its Spreadability [28].

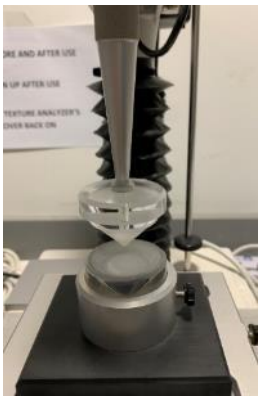


Figure 4: Spreadability

As force is being applied from the male cone, spreading is proportional to the weight applied and will eventually reach a constant as shear occurs giving rise to both shear stress and shear rate as shear thinning occurs [28][29].

1.1.6.5 Gloss Testing

A Glossmeter is an instrument that is used to measure the angle of reflectance on the surface of an object or solution by placing the glossmeter onto the surface that is to be tested.

Different types of Gloss angles that can be measured are 20°,45°,60°,75° and 85° [30]. Each of the different Gloss angles have different purposes as they are used in the different industry [31] such as automotive, paper, aerospace for different purposes.

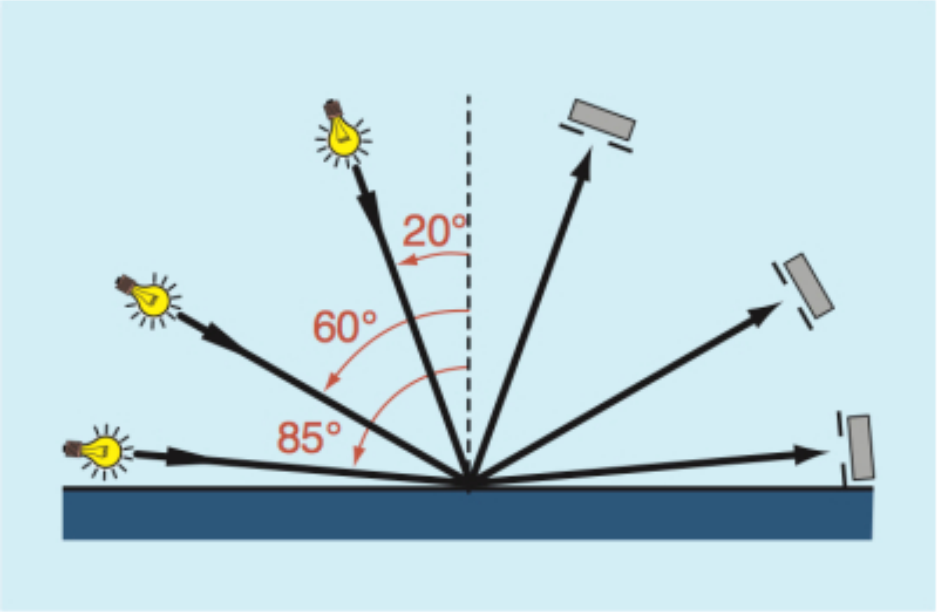


Figure 5: Gloss Range [32]

1.1.6.6 Colour

In Colour Testing, normally a Colorimeter is used calculate colour measurements while a spectrophotometer is used to analyse the full spectrum of colour [33].

Spectrophotometers have a wide range of application in many industries such as Chemicals, Cosmetics and Paint for example.[34] A Schematic diagram is shown below in Figure 6 [35].

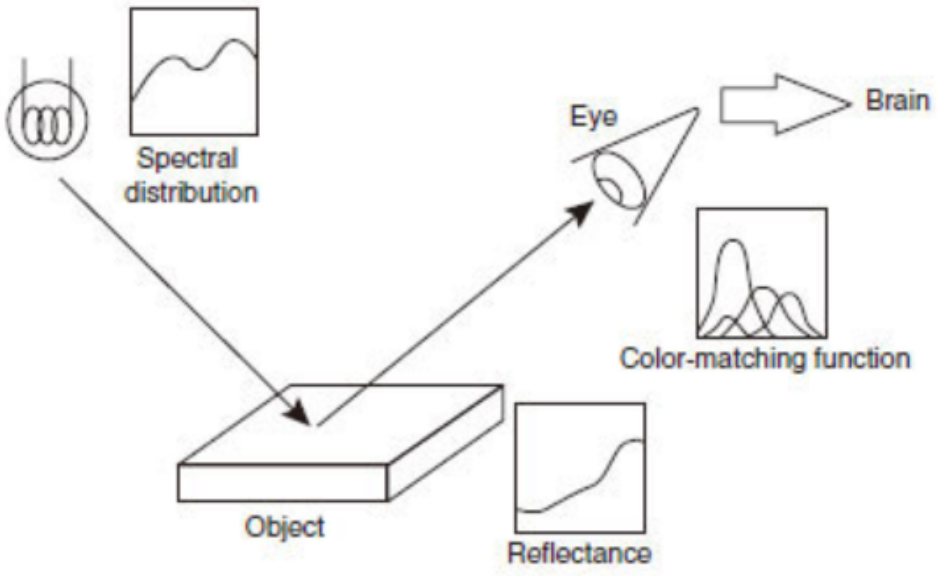


Figure 6: Schematic Diagram of a Spectrophotometer

Colour Measurement

- D65/10° - D65 Standard illuminate, 10 degrees viewing angle
- Whiteness (WI) and Yellowness Index (YI) ASTM E313
- CIE Lab

L represents the axis differences in dark colours versus lighter pastels, with **absolute white** at *100* and **absolute black** at *0* which is also known as Lightness

Positive a represents **Red**

Negative a represents **Green**

Positive b represents **Yellow**

Negative b represents **Blue**

The rectangular coordinates ***a*** and ***b*** represents the major colour axis [37].

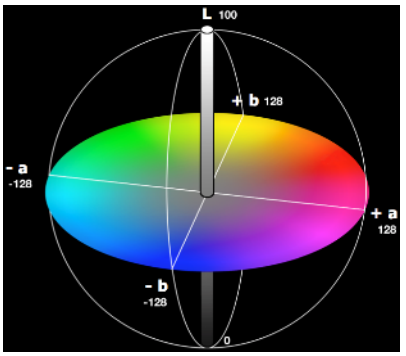


Figure 7: Colour Deviation

Colour Difference

In this Colour testing, a Spectrophotometer would be used as it is able to measure the individual wavelengths and calculate out the L×a×b values to give rise to the Delta E (ΔE) values which is always a positive. As the L×a×b is calculated, it can calculate the wavelength intensity in the product [34].

The ΔE^*_{ab} is used to calculate the difference between the L, a and b axis in the Formula as shown below [36].

$$\Delta E^*_{ab} = \sqrt{\left(L^*_2 - L^*_1\right)^2 + \left(a^*_2 - a^*_1\right)^2 + \left(b^*_2 - b^*_1\right)^2}$$

Difference	Explanation
0 < ΔE < 1	Observer does not notice the difference
1 < ΔE <2	Only experienced observer can notice the difference
2 < ΔE < 3.5	Unexperienced observer can notice the difference
3.5 < ΔE < 5	Clear difference in colour
5 < ΔE	Observer notices two different colours

Table 5: ΔE Scale

The ΔE^*_{00} [37] is used to measure the difference in colour.

$$\Delta E^*_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_c S_c}\right)^2 \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_r \left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

Where:

ΔE^*_{00} represents the difference in colour

L represents lightness

a and *b* represent the colour components

k_L, k_c and k_H are parametric weighting factors used as a constant value of *1*

S_L, S_C, and S_H are lightness, chromatic and hue-dependant scaling functions derived from the Commission Internationale de l'Eclairage (CIE) colour difference datasets

R_T is the additional scaling functions that depends on chroma and hue differences respectively

ΔL' represents the lightness differences

ΔC' represents the Chroma differences

ΔH' represents the hue differences

ΔE2000 allows for the better correlation of the human visual judgment of differences between two perceived colours.

ΔE_{min} (k)	ΔE_{max} (k)	Perception of colour differences
0.0	0.5	Hardly
0.5	1.5	Slight
1.5	3.0	Noticeable
3.0	6.0	Appreciable
6.0	12.0	Much
12.0	24.0	Very Much
24.0	∞	Strongly

Table 6: ΔE2000 Scale [38]

1.2 Objective and Scope

1.2.1 Objective

Sensory profiling of personal care products has a significant impact on the acceptance and purchase likelihood of the consumers. However, sensorial analysis is very time consuming and requires a trained panel. Results from obtained from the trained panel is often inconsistent and therefore limiting the consistency of the results.

With the advancement in technology in the field of instrumental analysis, modern and quick ways can be established to map the sensory profiles that is the same as the attribute used by the trained panel.

This project aims to use the different functional ingredients such as ‘Rheological modifiers, Emulsifiers and Emollients’ in Skin care product such as lotion to study and understand the impact of these ingredients on physical properties such as ‘Gloss’ for example and the stability of lightweight Lotion formulation.

As different functional ingredients are known to lead to different sensory results from the previous studies done, the project is able to validate if the instrumental test explored in the project is able to successfully correlate to those known differences in sensory results.

By doing this project, it would be possible to tell if there is any correlation between the ingredients that is added and what are the effects that the amount added has in our daily personal care products.

1.2.2 Scope and deliverables

1.2.2.1 Scope

Impact of the following physical properties and stability.

- Different types of Rheological Modifiers
- Different types of Emollients
- Different Levels of Humectants

1.2.2.2 Deliverables

Conclude whether each of the following instrumental test explored can successfully correlates to these known differences in sensory results.

- Gloss
- Colour
- Viscosity
- Texture Analysis (Penetration Test)
- Texture Analysis (Spreadability Test)

1.3 Experimental Plans

1. Overview of experimental work (1.3.1)
2. Formulation design (1.3.2)
3. Stability Testing (1.3.3)

1.3.1 Overview of experimental work

Preparation of formulation using the different functional ingredients for comparison, and characterization of formulated products using instrumental analysis.

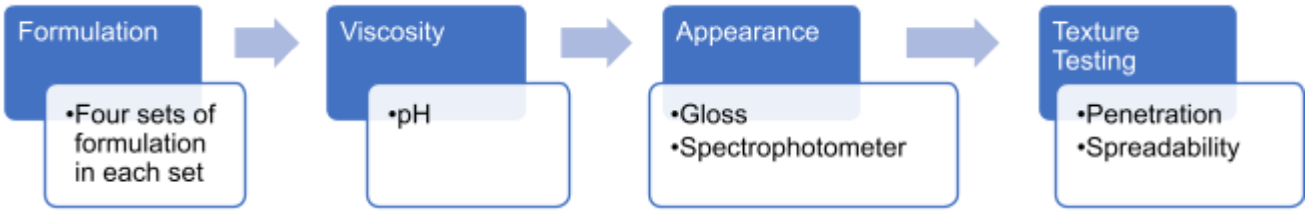


Table 7: Overview of experimental work

1.3.2 Formulation design

Samples are made accordingly to the following formulation design as listed in Table 7 below.

Experiemental design for Formulation			
Carbopol Ultrez 30		Carbopol Ultrez 20	
Schercemol 318 ester	Schercemol CO ester	Schercemol 318 ester	Schercemol CO ester
0% Propylene glycerol 0% Glycerin	0% Propylene glycerol 0% Glycerin	0% Propylene glycerol 0% Glycerin	0% Propylene glycerol 0% Glycerin
2% Propylene glycerol 2% Glycerin	2% Propylene glycerol 2% Glycerin	2% Propylene glycerol 2% Glycerin	2% Propylene glycerol 2% Glycerin
5% Propylene glycerol 5% Glycerin	5% Propylene glycerol 5% Glycerin	5% Propylene glycerol 5% Glycerin	5% Propylene glycerol 5% Glycerin
10% Propylene glycerol 10% Glycerin	10% Propylene glycerol 10% Glycerin	10% Propylene glycerol 10% Glycerin	10% Propylene glycerol 10% Glycerin

Table 8: Formulation design

1.3.3 Stability Testing

Stability testing conducted at both room and elevated temperature of 50°C which is done according to the following plans in Table 9 as listed below.

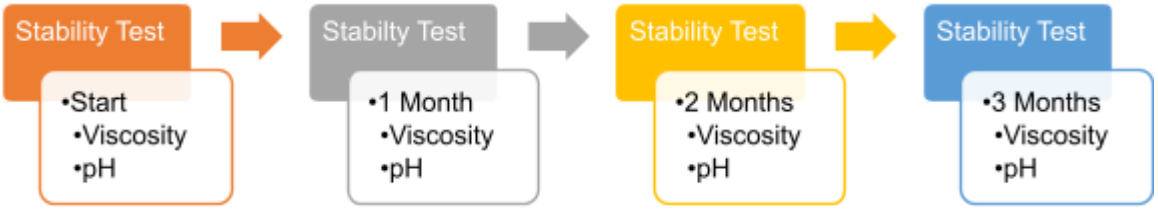


Table 9: Stability Testing

Chapter 2 Materials and Methods

2.1 Material Used

Ingredients used in the formulation of Lotion in this Project.

Types	Grade	INCI Names
Rheological Modifier	Carbopol Ultrez 30	Carbomer
Rheological Modifier	Carbopol Ultrez 20	Acrylates/C10-30AlkylAcrylate Cross-polymer
Emollient	Schercemol 318 ester	Isopropyl Isostearate
Emollient	Schercemol CO ester	Cetyl Ethylhexanoate
Humectant	Propylene Glycol	Propylene Glycol
Humectant	Glycerine	Glycerine
Additive	Disodium EDTA	Disodium EDTA
Preservative	Microcare PEHG	Phenoxyethanol and Ethylhexylglycerin
Neutralizer	Sodium Hydroxide (20% Solution)	Sodium Hydroxide

Table 10: Ingredients

In the project, there are a total of nine ingredients used to make the different formulations of Lotion used in the testing. Each of the ingredients is further separated into five different types of groups of ingredients. They are listed below.

1. Rheological Modifier (2.1.1)
2. Emollient (2.1.2)
3. Humectant (2.1.3)
4. Additive (2.1.4)
5. Preservative (2.1.5)
6. Neutralizer (2.1.6)

2.1.1 Rheological Modifier

In this Project, both Carbopol Ultrez 20 and 30 would be used. Carbopol is scientifically known as a Crosslinked Poly(acrylic) acid which has an Ultra-high molecular weight.

Carbopol is commonly used in the Cosmetics industry & Healthcare industry for its benefits such as Rheology properties, Stability, Ease to use and more.

Whenever Poly(acrylic) acid also known as Carbopol is being added into water in its dry form, it undergoes rapid absorption of water and changes from a white powder into a clear gel like substance floating on the surface of the water. This is due to the water neutralizing the polymer.

As time passes, dispersion would occur and the Carbopol would sink down into the beaker, producing a snowflake like effect as in snow is falling.

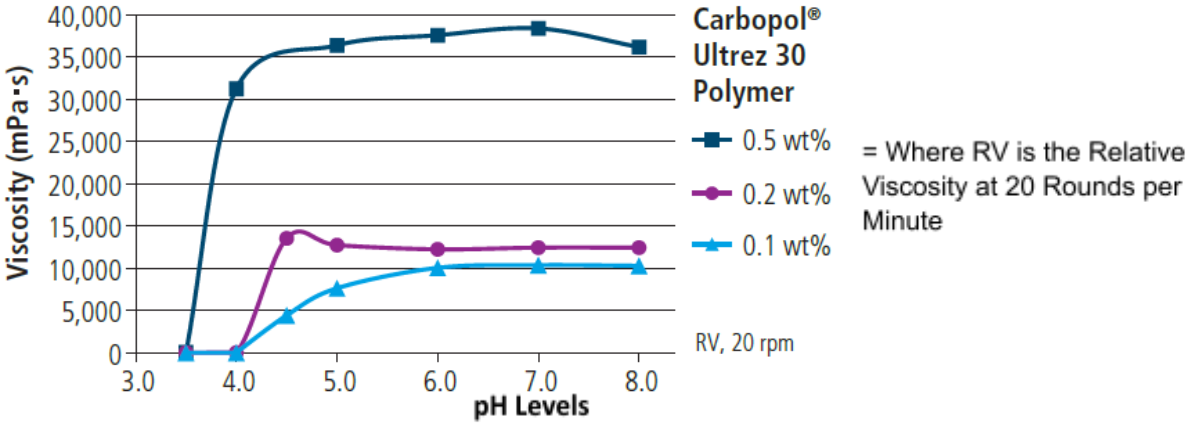
2.1.1.1 Carbopol Ultrez 30[39]

Typical Properties

INCI Designation	Carbomer
Appearance	White Powder
0.2 % Mucilage Viscosity (pH 5.5/mPa.s)	12000 – 24000
0.5 % Mucilage Viscosity (pH 5.5/mPa.s)	35000 – 50000
1 % Mucilage Viscosity (pH 5.5/mPa.s)	9500 – 12000
Dispersion Time (0.5 % Polymer in water)	Less than 15 Minutes

Table 11: Typical Properties of Carbopol Ultrez 30

This Carbopol has an excellent viscosity (mPa.s) at low weight percentage vs the pH at different levels in a formulation.



Graph 1: Viscosity vs pH at Different Weights Carbopol® Ultrez 30

This means that as the pH levels of the formulation increases as more NaOH weight percentage is being added into the formulation, the Viscosity will experience an exponential increase in the Viscosity levels. After a certain pH level, the viscosity level will remain relatively unchanged as the pH levels continue to increase due to the addition of NaOH. As such this shows that Carbopol Ultrez 30 can withstand High pH levels throughout the different Weight percentages.

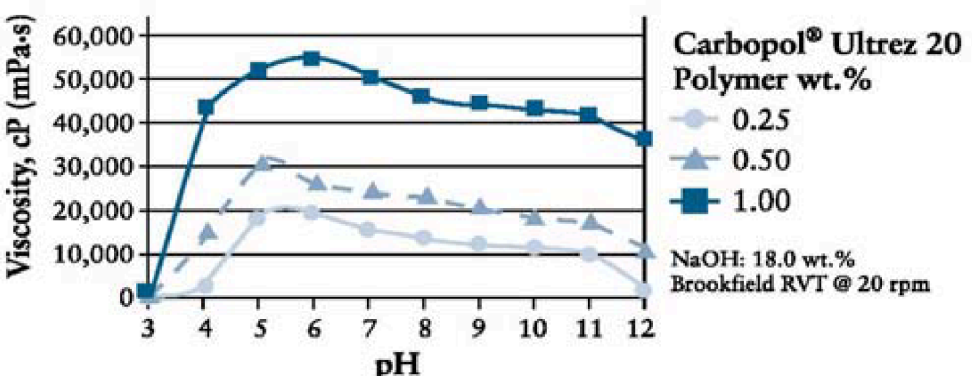
2.1.1.2 Carbopol Ultrez 20[40]

Typical Properties

Appearance	White Powder
Salt Viscosity* (1 % NaCl, mPa.s)	6 000
Mucilage Viscosity (mPa.s)	54 000
Clarity** (% Transmission)	More than 90%

Wetting Time (3.0 wt.%)	5 – 6 Minutes
Dispersion Viscosity*** (mPa.s)	More than 3 500
* 1% active polymer in water @ pH 7.3 – 7.8 ** 1% active polymer in water @ pH 5.8 – 6.3 *** 3% active polymer after 3 Hours	

Table 12: Typical Properties of Carbopol Ultrez 20



Graph 2: Viscosity vs pH at Different Polymer Weight Carbopol® Ultrez 20

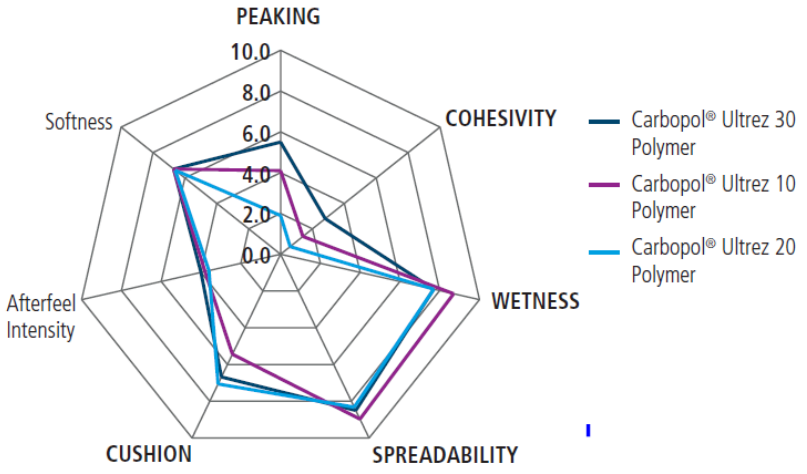
This means that as the pH levels of the formulation increases as more NaOH weight percentage is being added into the formulation, the Viscosity will experience an exponential increase in the Viscosity levels. After a certain pH level, the viscosity level will remain relatively unchanged as the pH levels continue to increase due to the addition of NaOH. As such this shows that Carbopol Ultrez 20 can withstand High pH levels throughout the different Weight percentages.

2.1.1.3 Comparison of Carbopol Ultrez 30 and Carbopol Ultrez 20[39][40]

Carbopol Ultrez 30 vs Carbopol Ultrez 20

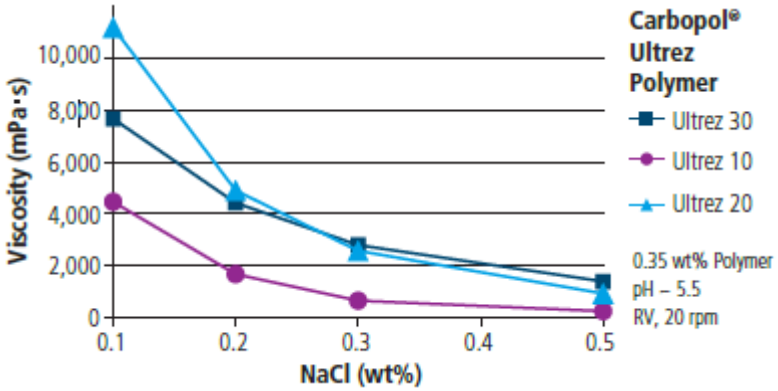
Grade name	INCI name
Carbopol® Ultrez 20 Polymer	C10-30 Alkyl Acrylate Cross-polymer
Carbopol® Ultrez 30 Polymer	Carbomer

Table 13: Carbopol Ultrez 30 vs Carbopol Ultrez 20



* Attributes highlighted in CAPS denote those in which significant differences resulted

Graph 3: Results of Rating Sensory Evaluation



Graph 4: Viscosity vs NaCl (Electrolyte Levels)

What causes the difference in Viscosity and Cohesiveness?
In Carbopol® Ultrez Polymer 20 and 30, the Molecular makeup is different. Carbopol® Ultrez Polymer 20 is a copolymer (Acrylates C10-c30 Alkyl Acrylate Cross-polymer while Carbopol® Ultrez Polymer 30 is a copolymer.

This means that the structure of both Carbopol® Ultrez Polymer 20 and 30 is different from one another which leads to a different profile sensory profile and viscosity effects. It also leads to a different tolerance level in pH levels and electrolyte levels.

Are there any other differences present besides Viscosity and Cohesiveness?
There are other differences present besides Viscosity and Cohesiveness such as playing time. This is because Carbopol® Ultrez Polymer 20 is supposed to break faster than Carbopol® Ultrez Polymer 30 when applied onto the skin.

2.1.2 Emollient
For this project, Emollients such as Schercemol™ 318 ester and Schercemol™ CO esters would be used in the ingredient's makeup. As for both the Emollients used in this experiment, they are both esters, the esterification equation is stated below.

Carboxylic acid + Alcohol □ Ester + Water

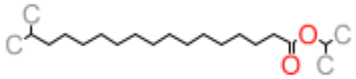
Emollients act as a Moisturizer to moisturize the skin and trap water inside the skin to prevent moisture loss from occurring to hydrate the skin. Depending on the type of Emollient used in the products in the market, it can either be left onto the skin or washed away. Lotion for example contains emollients that can be left on the skin while Soap contains emollients that needs to be washed away.

This is the working principle for moisturizing Lotions and Soap as the emollients trap the moisture in the skin and prevents it from leaving, therefore preventing dry skin.

When a pure concentrated emollient is directly applied onto your skin, it leaves behind an oily sensation and evaporates after a short while.

2.1.2.1 Schercemol™ 318 esters

INCI: Isopropyl Isostearate ($C_{21}H_{42}O_2$)



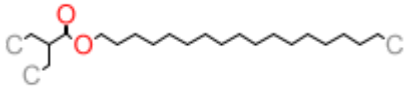
Schercemol™ 318 esters are made by the chemical reaction of Isopropyl Alcohol and Stearic Acid.

The recommended weight percentage of Schercemol™ 318 ester that should be added into solution should be from 1 wt.% to 15 wt.% [41]. If the weight percentage added is above 15%, there might be a slight irritation on the skin [42].

Schercemol™ 318 ester has a particularly good pigment dispersion and has a Hydrophilic-lipophilic balance of 11 ± 1 and can be used in colour cosmetics, Skin care and Sun care [41].

2.1.2.2 Schercemol™ CO ester

INCI: Cetyl Ethylhexnoate/ Hexadecyl 2-ethylhexanoate ($C_{24}H_{48}O_2$)



Schercemol™ CO ester is made by the chemical reaction of Cetyl Alcohol and 2-ethylhexanoic Acid.

The recommended weight percentage of Schercemol™ CO ester that should be added into solution should be from 1 wt.% to 20 wt.% [41].

Schercemol™ CO ester has a Light sensory texture and has a Hydrophilic-lipophilic balance of 10 ± 1 and can be used in only Skincare [41].

2.1.2.3 Difference between Schercemol™ 318 and CO ester

Schercemol™ 318 ester is Isopropyl Isostearate which is considered to be a medium level ester while Schercemol™ CO ester is considered to be a Light ester as it gives a lighter sensory feel as the after feel is generally dominated by the oil phase[41].

2.1.3 Humectant

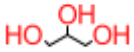
In this project, Glycerine and Propylene Glycol was used as a Humectant in the Lotion which are both water soluble and can act as a thickener.

A Humectant is a Hygroscopic substance that can adsorb moisture and hold it while acting as a plasticizer, giving the Lotion is Gel like properties. This is one of the unique properties present in Glycerine. Other commonly known properties of Glycerine are Viscosity, Low Volatility [43] and Anti-bacteria properties.

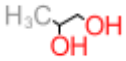
Glycerine is a polyol (Alcohol) which means that it has three hydrogen group attached to a carbon atom.

For Propylene Glycol, it is the derivative of Glycerine. As such, the properties are similar but not the same, for example, Glycerine is non-toxic while Propylene Glycol is toxic in high concentrations, hence it is important to clearly distinguish between the two.

Glycerine: $C_3H_8O_3$



Propylene Glycol: $C_3H_8O_2$



What leads to a difference in Viscosity besides temperature?
The difference in Viscosity is caused by the interaction between the polyols and the rheological modifiers (Carbopol Ultrez 20 and 30).

Besides the rheological modifiers, the higher the concentration, the higher the viscosity present as shown in the figure above.

2.2 Methods used

In this project, there quite a few methods used to either formulate the samples or to test the samples from the formulation. The table below contains the methods used in the formulation and testing of the lotion done in this project.

Formulation	Test
Formulating (2.2.1)	1. Hygiene Test (2.2.2) 2. Stability Test (2.2.3) 3. Gloss measurement (2.2.4) 4. Color measurement (2.2.5) 5. Texture testing (2.2.6)

Table 14: Formulation vs Test

2.2.1 Formulating

The formulation of Lotion would be split into four different parts to cover the different aspects in the formulation of Lotion in the list stated below.

1. Ingredients (2.2.1.1)
2. Equipment (2.2.1.2)
3. Formulation (2.2.1.3)
4. Decanting (2.2.1.4)

In this lotion formulation, the emulsion made would be Oil in Water (O/W).This means that the oil would be inside the Water phase as O/W means that there is a higher 'Hydrophilic-lipophilic balance' of a surfactant.

2.2.1.1 Ingredients

In this project, the focus of the project would be on the formulation of lotion to find out if the sensory profile have significant impact on the likelihood of the consumers to purchase and accept the product that that they are using through the usage of instrumental analysis in the test phase of the Methods used in the table above by using different functional ingredients such as rheological modifiers, emollients and emulsifiers.

Stated below in the Tables are the ingredients used in the formulation of the lotion samples to create only one Master batch, namely, **20_CO**. Since there are 4 Master batch, there is too many to cover and as such, the remaining 3 Master batch is listed in **Appendix A**.

Each of the Masterbatch is coded according to the Rheological Modifier code followed by the Emollient code used in the following sequence as stated below.

Rheological Modifier Code_Emollient Code

Master batch Code Names:
1. 20_CO
2. 20_318
3. 30_CO
4. 30_318

The Master batch codes, and the individual batch codes are found in **Appendix** B.

To create a batch of Lotion, four distinct phases of both dry and wet ingredients must be added at the right steps and at the right amount to produce the desired properties of lotion.

Clear separation of the Ingredients is required as the mixing of ingredients together will allow for the proper homogenization, mixing and dispersion of the ingredients in the Lotion.

By ensuring that all the different phases are added at the right time, it would lower the chance of formulation failing within 24 hours. The 24 hours is the most crucial as it will tell if the formulation is a success or a failure.

The four phases of ingredients are listed in the table below.

Phase	Ingredients
Phase A	1. Carbopol Ultrez 20 (Rheological Modifier) 2. Carbopol Ultrez 30 (Rheological Modifier) 3. Glycerine (Humectant) 4. Propylene Glycol (Humectant) 5. Disodium EDTA (Additive)
Phase B	1. Schercemol 318 ester (Emollient) 2. Schercemol CO ester (Emollient)
Phase C	Microcare PEHG (Preservative)
Phase D	20% Sodium Hydroxide Stock Solution

Table 15: Different phases of ingredients

20_CO Master batch (Theoretical Weight makeup Percentage)		
Ingredients		
Phase A	**Theoretical Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.25%
Disodium EDTA	1 gram	0.05%
Carbopol Ultrez 20	4 grams	0.2%
Phase B	**Theoretical Weight**	**Weight Percentage**
Schercemol Emollient CO	100 grams	5%
Phase C	**Theoretical Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%
Total	**1600 grams**	**80%**

Table 16: Theoretical weight of 20_CO

20_CO Master batch (Actual Weight makeup Percentage)		
Ingredients		
Phase A	**Actual Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.244%
Disodium EDTA	1.047 grams	0.052%
Carbopol® Ultrez 20	4.019 grams	0.200%
Phase B	**Actual Weight**	**Weight Percentage**
Schercemol Emollient CO	100.007 grams	4.99%
Phase C	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10.043 grams	0.502%
Total	**1600.116 grams**	**79.988%**
pH Level		**5.2**

Table 17: Actual weight of 20_CO

When a Master batch is being completed, fine tuning is required to ensure that the pH level is within the acceptable pH range of 5.95 ~ 6.15 and the final total Theoretical weight to be at around 2000 grams. This is the specific limit that must reached to ensure that the formulation of Lotion would not fail by breaking up into two specific and distinct phases, clearly showing the oil phase above the oil phase.

To achieve the final theoretical weight of around 2000 grams, additional ingredients such as Propylene glycol, Glycerin and Distilled Water that was left out on purpose was added together only after the lotion has been separated into its Individual batches to raise the theoretical weight to around 2000 grams.

As for the pH level to reach the acceptable pH range of 5.95 ~ 6.15, Sodium Hydroxide Stock Solution was added into formulation containing Phase A, B, C and the additional ingredients added into the formulation drop by drop to slowly increase the pH levels to the acceptable pH range.

Each of the Master batch created will then further be divided into four individual batch for easier handling and will be given batch codes accordingly. The individual batch codes are as stated below.

Individual Batch Code Name and weight:
1. 20_CO_1 (320.202 grams)
2. 20_CO_2 (320.037 grams)
3. 20_CO_3 (320.145 grams)
4. 20_CO_4 (320.677 grams)

Master batch:
$1600.116 - 320.202 - 320.037 - 320.145 - 320.677 = 319.055\ grams\ remainder$

The remainder amount of Master batch lotion calculated is not accurate as there was some lotion that could not be salvaged and therefore the weight of lotion is estimated to be below 319.055 grams.

20_CO Individual Batch Actual Weight

Batch	20_CO_1	20_CO_2
20_CO Master Batch	320.202 grams (80% Weight)	320.037 grams (80% Weight)
Propylene Glycol	-	8.051 grams (2% Weight)
Glycerine	-	8.004 grams (2% Weight)
Deionized Water	80.075 grams (20% Weight)	64.272 grams (16% Weight)
Obtained pH Level	5.95	5.95
Total weight of Propylene Glycol, Glycerine and Deionized water to be added	80.075 grams	80.327 grams
Total Weight	**400.277 grams (100% Weight)**	**400.364 grams (100% Weight)**

Table 18: 20_CO Actual weight part 1

Batch	20_CO_3	20_CO_4
20_CO Master Batch	320.145 grams (80% Weight)	320.677 grams (80% Weight)
Propylene Glycol	20.019 grams (5% Weight)	40.787 grams (10% Weight)
Glycerine	20.029 grams (5% Weight)	40.022 grams (10% Weight)
Deionized Water	40.206 grams (10% Weight)	-
Obtained pH Level	6.28	5.98
Total weight of Propylene Glycol, Glycerine and Deionized water to be added	80.254 grams	80.809 grams
Total Weight	**400.399 grams (100% Weight)**	**401.486 grams (100% Weight)**

Table 19: 20_CO Actual weight part 2

Total additional weight added:
$80.075 + 80.327 + 80.254 + 80.809 = 321.465\ grams$

As for Phase D, it needs to be made separately before the formulation of the Master batch. The ingredients to make Phase D is as stated in the table below.

Phase D (20% Sodium Hydroxide Stock Solution)		
Ingredients	**Actual Weight**	**Weight Percentage**
Sodium Hydroxide Pellets	20 grams	20%
Deionized Water	100 grams	80%

Table 20: Phase D

Steps required to make the Stock Solution:
Step 1: Weight out 20 grams of Dry NaOH Pellets in a weighing boat
Step 2: Weight out 100 grams of Deionized Water in a beaker
Step 3: Add both the Sodium Hydroxide Pellet and Deionized Water together in a beaker
Step 4: Stir till the Sodium Hydroxide Pellets has completely dissolve
Step 5: Transfer Sodium Hydroxide Stock Solution into a Glass bottle for storage.

2.2.1.2 **Equipment and Ingredients used**

S/N	Equipment	Amount
1	Deionization Water System Machine	1
2	Deionized Water Tank	1
3	Squeeze Bottle	4
4	Weighing Scale	1
5	500 mL beaker	8
6	2000 mL beaker	2
7	Packets of Weighing boat of different sizes	-
8	Disposable Pipette	-
9	Magnetic stirrer	4
10	Hot-plate magnetic stirrer	1
11	T25 Ultra-Turrax Disperser (IKA) Mixer	1
12	Homogenizer	1
13	pH meter	1
14	Disposable kitchen roll	1
15	Scissors	1
16	Metal spatula	5

Table 21: Equipment used

The amount is not stated for the weighing boat and Disposable pipettes are not mentioned in the table above as we kept changing every time the equipment was dirty. Besides that, they were of disposables. Therefore, there was no record on the amount used. The amount required to add are in the table below or is present in **Appendix A**.

S/N	Ingredient
1	EDTA Disodium Salt
2	Glycerin
3	Microcare PEHG
4	Propylene Glycol
5	Sodium Hydroxide Pellets
6	Deionized Water
7	Schercemol Emollient CO
8	Schercemol Emollient 318
9	Carbopol Ultrez 20
10	Carbopol Ultrez 30

Table 22: Ingredients used

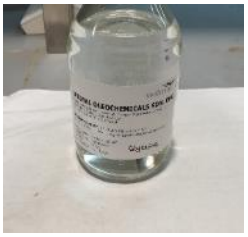


Figure 8: Glycerin



Figure 9: Propylene Glycol



Figure 10: Microcare PEHG



Figure 11: Carbopol Ultrez 20 and 30



Figure 12: EDTA Disodium Salt



Figure 13: Emollients

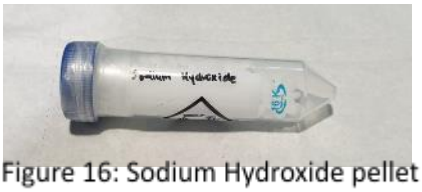


Figure 16: Sodium Hydroxide pellet

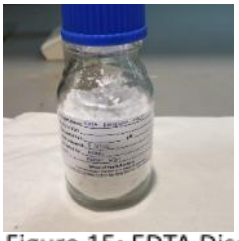


Figure 15: EDTA Disodium Salt



Figure 14: Deionized Water

2.2.1.3 **Formulation Steps for Lotion**

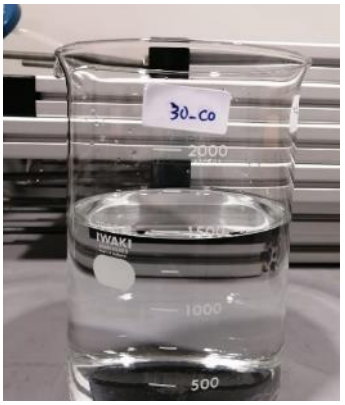


Figure 17: 1485 grams of Deionized water

Step 1: Measure and add water from a squeeze bottle and add 1485 grams of water using a weighing scale into a 2000mL beaker and label the Master batch code.

The weighting scale can only measure up to 600 grams. The weighing can be done by adding in a small amount of water at a time.

Divide the required weight of 1485 grams into four batches of different weights by following the formula below.

1485 grams = 400 grams + 400 grams + 400 grams + 285 grams

Step 2: Measuring dry ingredients required.

20_CO Master batch (Theoretical Weight makeup Percentage)		
Ingredients		
Phase A	**Theoretical Weight**	**Weight Percentage**
Disodium EDTA	1 gram	0.05%
Carbopol® Ultrez 20	4 grams	0.2%
20_CO Master batch (Actual Weight makeup)		
Ingredients		
Phase A	**Actual Weight**	**Weight Percentage**
Disodium EDTA	1.047 grams	0.052%
Carbopol® Ultrez 20	4.019 grams	0.200%

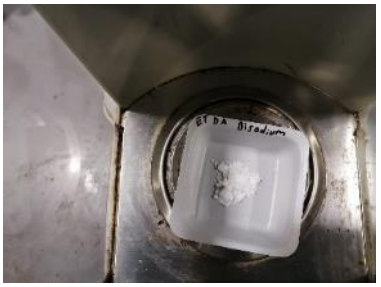
Use a weighing boat and a metal spatula to measure out the required amount of ingredients in the table below.

Table 23: 20_CO Theoretical and Actual weight



Figure 18: 4.019 gram of Ultrez 20


Figure 19: 400 grams of Deionized Water


Figure 20: 1.047 gram of EDTA Disodium

Step 3:
Measure and add 10 grams of Microcare PEHG using a disposable pipette into the 2L beaker containing 1485 grams of Deionized Water and add both Disodium EDTA and Carbopol® Ultrez 20 by scattering it from the weighing boat into the 2000mL beaker.

Wait 10 minutes for the Dry Ingredients to fully adsorb the Deionized Water and become clumpy.

Gentle stirring might be required for the Dry ingredients to hydrate.

Clumps of Dry ingredients forming can clearly be seen on the surface of the Deionized Water, the dry ingredients will sink onto the bottom, giving off a snowflake effect.


Figure 21: Hydrating Dry ingredients


Figure 22: Snowflake effect

20_CO Master batch (Theoretical Weight makeup Percentage)		
Ingredients		
Phase C	**Theoretical Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%
20_CO Master batch (Actual Weight makeup Percentage)		
Ingredients		
Phase C	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10.043 grams	0.502%

Table 24: 20_CO Theoretical and Actual weight Percentage

Step 4: Mixing of Phase A and C

Place a magnetic stirrer inside the 2000mL beaker then place the beaker on the Hot-plate magnetic stirrer device and stir under 200 rpm. Slowly increase the speed until there is a vortex form created by the magnetic stirrer till it reaches 400 rpm.

Once the solution is translucent and there is an absence of clumps, Phase A and C is mixed and dispersed thoroughly.


Figure 23: Mixing of Phase A & C

Step 5: Addition of Phase Bin Solution containing Phase A and C

20_CO Master batch (Theoretical Weight makeup Percentage)		
Ingredients		
Phase B	**Theoretical Weight**	**Weight Percentage**
Schercemol Emollient CO	100 grams	5%
20_CO Master batch (Actual Weight makeup)		
Ingredients		

Phase B	Actual Weight	Weight Percentage
Schercemol Emollient CO	100.007 grams	4.99%

Table 25: Addition of Phase B in Phase A and C solution

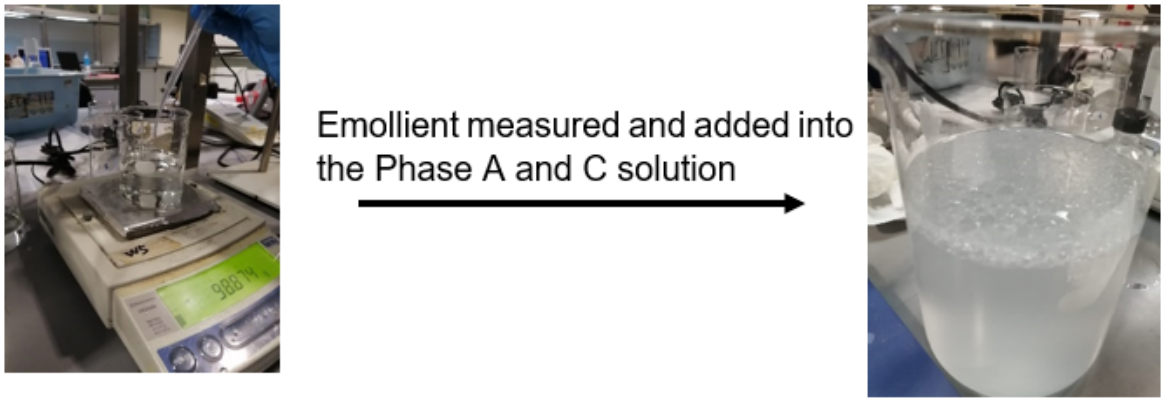


Figure 24: Addition of Emollients

Notice that there is a clear distinct difference in the layers observed in Figure 24 as both the oil and water phases are not mixed thoroughly as it has not been properly emulsified.

Step 6: Mixing of Oil and Water Phase.

Place the 2000 mL beaker back onto the hot plate magnetic-stirrer and stir Phase 'A and C' and B together for 5 minutes, ensure that there is a vortex formed by increasing the speed accordingly.

Measure the pH level using a pH meter and record it down for references.

Step 7: Neutralizing and Mixing.

The neutralization process is carried out by adding in 20% Sodium Hydroxide Stock Solution into the 2000mL beaker till close to the defined pH level. To ensure even mixing, increase the speed whenever there is a vortex observed, as the pH level increases to become more alkaline, the viscosity increases, and turns white.

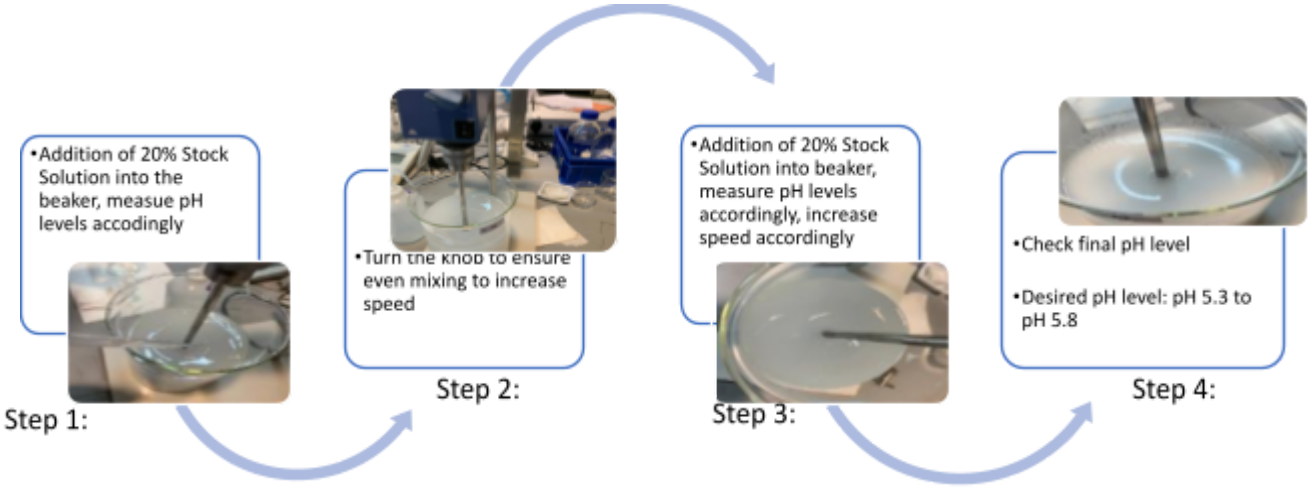


Figure 25: Steps to ensure even mixing and proper neutralization

Check pH levels regularly with a pH meter and add in more 20% Sodium Hydroxide Stock Solution if necessary.

Step 8: Separation into individual batches.

Measure 320 grams of Lotion from the Master batch and pour it into a 500 mL beaker, using a weighing scale to measure the weight.

Add a sticker to label the individual batch code.


Figure 26: Measuring Lotion

Theoretical weight of Individual batch			
20_CO_1	**20_CO_2**	**20_CO_3**	**20_CO_4**
320.000 grams	320.000 grams	320.000 grams	320.000 grams
Actual Weight of Individual batch			
20_CO_1	**20_CO_2**	**20_CO_3**	**20_CO_4**
320.202 grams	320.037 grams	320.145 grams	320.677 grams

Table 26: Weight of 20_CO individual batches

Leftover from Master batch:
1600.116 - 320.202 - 320.037 - 320.145 - 320.677 = 319.055 grams

Step 9: Fine tuning of pH level and increase weight to 100%.

Since each of the individual batches are of 80% weight, a further 20% weight would be added in to complete the formulation of the individual lotion batch inside the 500 mL beaker. This 20% consist of additional ingredients such as Propylene Glycol, Glycerine, and deionized water.


Figure 27: Ingredients required

The amount of ingredients to be added into the individual batches would be based on the table below.

20_CO Theoretical weight of Individual Lotion				
Batch	**20_CO_1**	**20_CO_2**	**20_CO_3**	**20_CO_4**
20_CO Master Batch	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)
Propylene Glycol	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Glycerine	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Deionized Water	80 grams (20% Weight)	64 grams (16% Weight)	40 grams (10% Weight)	-
Obtained pH Level	5.95	5.95	6.28	5.98
Total Weight	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)
20_CO Actual weight of Individual Lotion				
Batch	**20_CO_1**	**20_CO_2**	**20_CO_3**	**20_CO_4**
20_CO Master Batch	320.088 grams (80% Weight)	320.088 grams (80% Weight)	320.059 grams (80% Weight)	320.065 grams (80% Weight)
Propylene Glycol	-	8.04 grams (2% Weight)	19.998 grams (5% Weight)	40.07 grams (10% Weight)
Glycerine	-	8.019 grams (2% Weight)	20.027 grams (5% Weight)	40.103 grams (10% Weight)
Deionized Water	80.015 grams (20% Weight)	64.01 grams (16% Weight)	40.028 grams (10% Weight)	-
Obtained pH Level	5.95	5.95	6.28	5.98
Total Weight	400.103 grams (100% Weight)	400.157 grams (100% Weight)	400.112 grams (100% Weight)	400.238 grams (100% Weight)

Table 27: 20_CO Theoretical and Actual weight

As for the other formulations of Lotions, it is available in **Appendix A**.

Step 10: Homogenizing of the Individual Lotion.

Add in 20% Sodium Hydroxide Stock Solution and check the pH level using a pH meter regularly. Add accordingly till the defined pH level to neutralize the Lotion while homogenizing.

Desired pH level: pH 5.95 to pH 6.15

Use either a Normal Household kitchen Homogenizer or T25 Ultra-Turrax® disperser (IKA) to homogenize the lotion.

As for the Homogenizing speed, increase the speed slowly to ensure even mixing and to prevent the spillage of lotion.
For T25 Ultra-Turrax® disperser (IKA), homogenize with a starting speed of 100 rpm to around 6000 rpms or more for at least 3 minutes.

To see if the Lotion is properly homogenized, the Lotion should thicken to form a gel like consistency and turn whiter and there should not be a clear distinct separation of the phases.

Remember to constantly check the pH value and add in 20% Sodium Hydroxide Stock Solution if necessary.

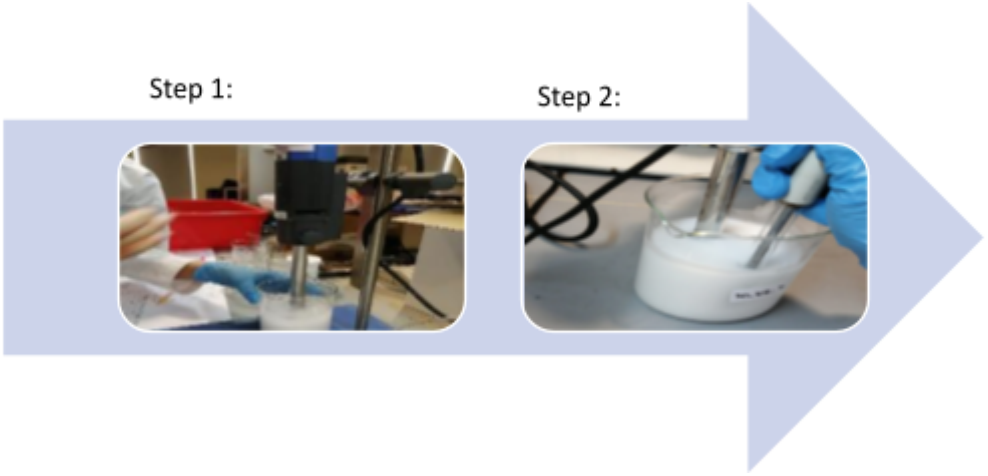


Figure 28: Homogenizing process

2.2.1.4 Decanting

Decanting is the process of pouring the lotion into smaller batches for testing.

Step 1: Label the stickers accordingly to the batch number in the table as shown below.

Step 2: Assemble all the bottles accordingly to size and batch code.

Step 3: Paste the stickers onto the bottle.

Step 4: Pour into the bottles for storage.



Figure 29: Bottles of different size

Each Individual batch of Lotion would be divided into five bottles, each of different sizes.



Figure 30: Bottled up

1. 1 30 mL bottle to be send to Lubrizol for testing
2. 2 60 mL bottle for Testing
3. 2 120 mL bottle leftovers

The biggest sized bottle is 120 mL, the middle-sized bottle is 60 mL and the smallest sized bottle is 30 mL.

Total volume of sample expected to be obtained would be a total of 390 mL from each batch of individual batches with an estimated 10 mL loss of Lotion.

The other 3 Sets, set 2, set 3, set 4 are in **Appendix B**.

Set 1	**Left over**	20_CO_1	20_CO_2	20_CO_3	20_CO_4
	Left over	20_CO_1	20_CO_2	20_CO_3	20_CO_4
	_L*	20_CO_1_L	20_CO_2_L	20_CO_3_L	20_CO_4_L
	_RT**	20_CO_1_RT	20_CO_2_RT	20_CO_3_RT	20_CO_4_RT
	_Ov***	20_CO_1_Ov	20_CO_2_Ov	20_CO_3_Ov	20_CO_4_Ov

Table 28: Set 1 abbreviations

_L* stands for send to Lubrizol for further test.
_RT** stands for Room temperature stability test.
_Ov*** stands for Oven stability test.

Leave all the bottles of Lotion to rest for at least 24 hours to observe if there is any separation of the oil and water phases.

If there is a separation of phases, the Lotion formulation has failed.

2.2.2 Hygiene Test

In the Hygiene test, the pH of the Lotion would be taken using a pH Meter and the viscosity of the Lotion will also be measured using a Brookfield viscometer. This is the initial reading for Stability test.

1. pH meter (2.2.2.1)
2. Viscometer (2.2.2.2)

2.2.2.1 pH meter

The purpose of this test was to measure the amount of change in the pH levels before and after the stability test in the oven at 50°C and at room temperature after 1 month, 2 months and 3 months and at the start.

Step 1: Calibrate pH meter using buffer solutions.

Step 2: Open any bottle from each of the 20_CO individual batch.

Step 3: Wash the pH probe with a squeeze bottle containing deionized water and dry the pH probe using a kitchen roll.

Step 4: Insert pH probe into the Lotion bottle of the 20_CO individual batches.

Step 5: Wait for pH reading to stabilise and record pH value.

Step 6: Remove pH probe and wash with deionized water and wipe dry the pH probe using a kitchen roll.

Step 7: Repeat on other individual batches and repeat **Step 5** and **Step 6**.

Step 8: Repeat **Step 2** to **Step 7** on the other batches from 30_CO, 20_318 and 30_318 to obtain pH level.

2.2.2.2 Viscometer

Model of the Viscometer used: Brookfield DV1 Digital Viscometer

Settings of the Viscometer

Rounds per minute (rpm)	20 rpm
Temperature (°C)	25°C
Spindle size	Spindle 4 (RV-04)
Time	30 Seconds

Table 29: Viscometer settings

Parameters for % torque reading according to the settings in Table 29 would be from 10% to 100%.

If the % torque is below 10%, a higher speed or a different spindle should be used to increase % torque reading.

If the % torque is above 100%, a lower speed or a different spindle should be used to decrease % torque reading.

Spindle 4 is used in the Hygiene test as it gives a % torque reading of 31.9% which is within the parameter range. As for the other Spindles, they either give a % torque below 10% or above 100% and therefore is not suitable.

Step 1: Ensure that the Brookfield Viscometer's Leveller is centred to ensure accurate readings.

Step 2: Open the Spindle box and attach Spindle 4 (RV-04) into the Spindle holder and tighten the spindle.

Step 3: Switch on the Brookfield Viscometer and press the option button to configure the settings accordingly in Table 29 above.

Step 4: Place the 20_CO Individual bottle below Spindle 4 and adjust the height accordingly. The Spindle must be at least 1 cm from the top of the Lotion.

Step 5: Run Spindle and record results, results are in centipoise (cp).

Step 6: Remove Spindle.

Step 7: Scrap off the excess lotion using a metal spatula and wash the Spindle with deionized water and wipe dry using a kitchen roll.

Step 8: Attach Spindle back on and ensure that the Spindle is tighten.

Step 9: Repeat **Step 4** to **Step 8** for the other Individual Samples of Lotion.



Figure 31: Viscometer process

2.2.3 Stability Test Oven Model: Memmert

Temperature	50°C
Duration	3 Months

Table 30: Settings of oven



Figure 32: Oven

Step 1: Conduct initial pH and viscosity readings.

Step 2: Set oven temperature at 50°C.

Step 3: Place samples inside oven for storage, leave sample inside for 1 month.

Step 4: Repeat **Step 1** to **Step 3** every month to obtain 1st month, 2nd month and 3rd month pH and viscosity readings.

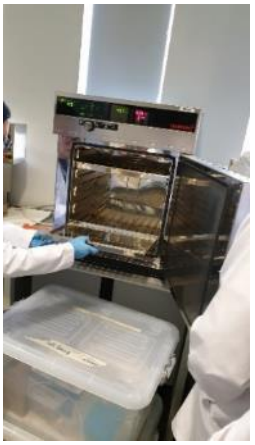


Figure 33: Empty Oven

The 3rd month reading will only be recorded due to the 2019 Covid-19 Situation in which caused us to miss the readings of the 1st month and 2nd month of the stability testing.

Appearance of Lotion during the Initial and 3rd month interval

	Initial	**Third month**
Appearance	White and gel like.	White and gel like

Table 31: Appearance of Lotion between intervals



Figure 34: Samples inside Oven

2.2.4 Gloss measurement
Glossmeter Model: Horiba IG-331

Before the Glossmeter is used, calibrate it to ensure an accurate reading is obtained.

Calibration Steps:
Step 1: Press the on button and attach the protection cap to cover to sensor.

Step 2: Place the sensor on a flat surface.

Step 3: Press the Cal button (Glossmeter will automatically calibrate) and will show 20° and 60° values.

Step 4: Check the 20° and 60° values against the label on the protective cap.

The values shown during the calibration should be ± 1 of the values shown on the label on the protective cap.

Measurement Steps:
Step 1: Wash and dry Casting knife.

Step 2: Place the Casting paper on a flat surface for smooth casting and secure it with a masking tape to prevent it from moving around.

Step 3: Take all the Lotion bottles ending with _1, _2, _3 or _4 and shake for 10 seconds.

Step 4: Open the Lotion bottles.

Step 5: Using a metal spatula, scoop out 1 and a half spoonful of lotion and place it in the centre of the Casting paper.

Step 6: Using the Casting knife, flip to the caster of 200 µm gap and place it at the top of the Casting paper.

Step 7: Hold down the Casting knife on both sides and slide downwards. A Lotion film will be formed due to the sliding action.

Step 8: Place glossmeter on the casting paper and measure the 20° and 60° values by clicking on the 20° and 60° button.

Step 9: Wait for the readings to stabilize and record it down.

Step 10: For each bottle of Lotion, repeat the readings in triplicates by repeating **Step 1** to **Step 9**.

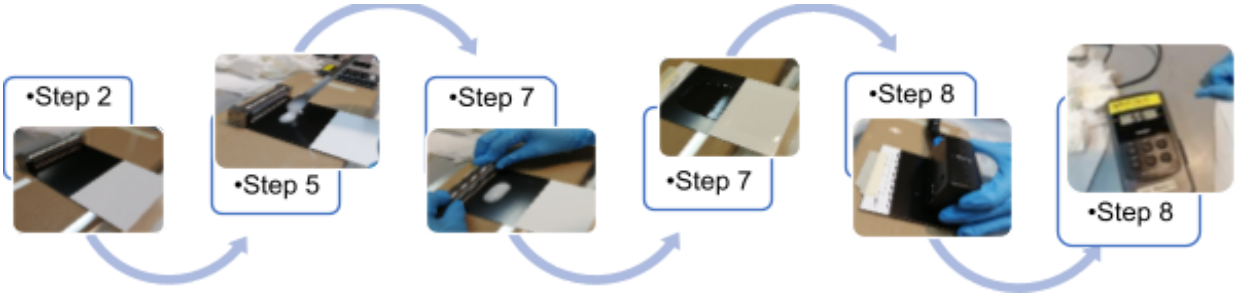


Figure 35: Gloss measurement

2.2.5 Colour Measurement
Spectrophotometer model: Hunter Lab Ultra-Scan® Pro “USP1289”

Mode Steps:
Step 1: Open the relevant job file “200326 Test.jsd”.

Step 2: Set mode.

Mode Name	Mode #1
Mode Type	RSIN – Reflectance Specular Included
Area View	0.790 inches
UV Filter Position	Nominal
Standardization Status	Standardized

Table 32: Modes

Calibration Steps:
Step 1: Click ‘Sensor’ and click ‘Standardize F4’.

Step 2: Place black light trap at the port and click ‘Next’.

Step 3: Place white light trap at the port and click ‘Next’.

Step 4: Click ‘Finish’.

Reading of Samples Steps:
Step 1: Click ‘Option’ and click ‘Read method’.

Step 2: Click ‘Normal’ at the arrow button and click ‘OK’.

Step 3: Using the Lotion bottles ending with _1, _2, _3 and _4, shake the Lotion bottles for 10 seconds.

Step 4: Ensure that the Quartz cell is Clean and Dry without any fingerprint smudges by cleaning with Ethanol, Deionized Water and dry using a Kitchen roll.

Step 4: Pour the bottle of Lotion into the Quartz Cell and ensure that the “Clear and Smooth Side” is free of bubbles. If there is presence of bubbles, use a “Ice Cream stick” to pop the bubbles.

Step 5: Place the Quartz cell onto the sample platform and place the black cover on top of the Quartz cell.

Step 6: Click ‘Measurement’ and Click ‘Read Sample F3’ and ensure that the ‘ ’ button is ticked.

Step 7: Click ‘Read’, remove the Black cover, and flip the Quartz Cell and put the Black cover back on and Click ‘Read’ again.

Step 8: Click ‘ ’ and enter the Lotion Sample ID name and Click ‘OK’.

Standard ID:	White tile
Sample ID:	Lotion Sample ID
Product Name:	Blank
Extra ID:	Blank

Table 33: Read Sample

Step 9: Remove the Quartz Cell for cleaning.

Step 10: Repeat **Step 3** to **Step 9** for the rest of the samples.

Export data Steps:

Step 1: Click ‘Option’, click ‘ASCII Export’ and click ‘Export Data’.

Step 2: Configure Data according to the table below and click ‘OK’.

Scale	CIELAB
Delta Scale	dL*
Indices	457nm Brightness
Spectral Data	5nm
Text Fields	Measurement ID
Procedure	Haze
Illuminate/Observer	A/2
MI Illuminate	A/2
Delimited	Tab
ASCII Code	44
Quotes around Text Fields	Tick
Include Column Labels	Tick

Table 34: CIE Configuration

Step 3: Click ‘Export’, click ‘ASCII Export’ and click ‘Export Data’.

Step 5: Save as “200326 Export Raw Data”.

Step 6: Convert text to excel file by following the steps below.

Step 1: Open Text File

Step 2: Control A

Step 3: Control C

Step 4: Control V into excel file

Step 5: Add the sample names in the first column of the excel file

For further References, Refer to SOP for Spectrophotometer in **Appendix C.**

2.2.6 Texture Testing
Texture analyser Model: SMS TA. XTplus Texture Analyzer

Penetration Test:
Configuration Steps:
Step 1: Open relevant project file “Lotion Project 4.PRJ”.

Step 2: Calibrate Force
Step 1: Click ‘T.A.’, Click ‘Calibrate’ and Click ‘Calibrate Force’.
Step 2: Follow the instructions on the windows pop out and Press ‘NEXT’.
Step 3: Calibration Weight: Key in ‘2000’ (g) and press next and click ‘Finish’.

Step 3: Calibrate Height
Step 1: Click ‘T.A.’, Click ‘Calibrate’ and Click ‘Calibrate Height’.
Step 2: Use the buttons to move the probe close to the base.
Step 3: Click ‘OK’ and enter the settings accordingly in the table below.

Return Distance (mm)	10
Return Speed (mm/Sec)	10
Contact Force (g)	1

Table 35: Penetration Configuration

Step 4: Click ‘OK’ and Click ‘OK’.

Step 4: Check Force.
Step 1: Click ‘T.A.’, Click ‘Calibrate’ and Click ‘Check Force’.
Step 2: Place Calibration Weight of 2000 grams onto the Calibration Platform and check reading. The measured force should be 1999.9 g and click ‘OK’.

Step 5: Click ‘Reset Project’ and Click ‘T.A. Settings’ and Key in the Parameters in the table below and click ‘OK’.

Test Mode	Compression
Pre-Test Speed	1.00 mm/sec
Test Speed	1.00 mm/sec
Post-Test Speed	1.00 mm/sec
Target Mode	Distance
Distance	8.000 mm
Trigger Type	Auto (Force)
Trigger Force	1.0 g
Break Mode	Off
Stop Plot At	Start Position
Tare Mode	Auto
Advance Options	On
Distance	mm
Force	g
Time	sec

Table 36: Penetration Configuration 2

Step 6: Test Configuration

Step 1: Fill in the following settings in the table below

Archive Information Tab
Fill in File ID with Sample Name
Probe Selection Tab
p/0.5R;1/2 DIA CYLINDER DELRIN RADIUSED
Post Tab
Step 1: Click 'Run Macro' Step 2: Click '…after Autosave'

Table 37: Penetration Configuration 3

Step 2: Click 'Apply'

Reading Sample Steps:

Step 1: Place Sample bottom on the Test Platform.

Step 2: Use the buttons to lower the probe into eh sample Lotion bottle at around 1cm above the Lotion sample.

Step 3: Click 'Run a Test'.

Step 4: Results will be autogenerated.

Step 5: Repeat **Step 2** and **Step 3** 2 more times, as Results should be in Triplicates.

Step 6: Remove Lotion Sample Bottle.

Step 7: Gently wipe probe clean.

Step 8: Proceed with next sample and repeat **Step 1** to **Step 7**.

Data Extraction into Excel

Step 1: For Copying Processed 'Results' Tab to excel

Step 1: Control A and Select all Columns

Step 2: Control C

Step 3: Control V in Excel

Export of Raw Data

Step 1: Select relevant sample (Needs to be done one by one)

Step 2: Follow the steps twice

Step 1: Click 'File'

Step 2: Click 'Export'

Step 3: Click 'Spreadsheet'

Step 4: Save excel file according to sample name

For further References, Refer to SOP for Penetration in Appendix C.

Spreadability Test:

Configuration Steps:

Step 1: Open relevant project file “Lotion Project 3.PRJ”

Step 2: Calibrate Force

Step 1: Click ‘T.A.’, Click ‘Calibrate’ and Click ‘Calibrate Force’

Step 2: Follow the instructions on the windows pop out and Press ‘NEXT’

Step 3: Calibration Weight: Key in ‘2000’ (g), and press next and click ‘Finish’

Step 3: Check Force

Step 1: Click ‘T.A.’, Click ‘Calibrate’ and Click ‘Check Force’

Step 2: Place Calibration Weight of 2000 grams onto the Calibration Platform and check reading. The measured force should be 1999.9 g and click ‘OK’

Step 4: Click ‘Reset Project’ and Click ‘T.A. Settings’ and Key in the Parameters in the table below and click ‘OK’

Test Mode	Compression
Test Speed	3.00 mm/sec
Target Mode	Distance
Distance	23.000 mm
Advance Options	Off
Distance	mm
Force	g
Time	sec

Table 38: Spreadability Configuration 1

Step 5: Test Configuration

Step 1: Fill in the following settings in the table below

Archive Information Tab
Fill in File ID with Sample Name
Probe Selection Tab
HDP/SR: SPREADABILITY RIG
Post Tab
Step 1: Click ‘Run Macro’ Step 2: Click ‘…after Autosave’

Table 39: Spreadability Configuration 2

Step 2: Click ‘Apply’

Reading Sample Steps:

Step 1: Place Sample Lotion in the bottom cone by squeezing from a pipette

Step 2: Fill the bottom cone to around ¾ full of lotion

Step 3: Click ‘Run a Test’

Step 4: Results will be autogenerated

Step 5: Repeat **Step 2** and **Step 3** 2 more times, as Results should be in Triplicates

Step 6: Remove Lotion Sample

Step 7: Gently cone probe clean

Step 8: Proceed with next sample and repeat **Step 1** to **Step 7**

Data Extraction into Excel

Step 1: For Copying Processed ‘Results’ Tab to excel

- **Step 1**: Control A and Select all Columns
- **Step 2**: Control C
- **Step 3**: Control V in Excel

Export of Raw Data

Step 1: Select relevant sample (Needs to be done one by one)

Step 2: Follow the steps twice

- **Step 1**: Click ‘File’
- **Step 2**: Click ‘Export’
- **Step 3**: Click ‘Spreadsheet’
- **Step 4**: Save excel file according to sample name

Chapter 3 Results and Discussions

3.1 Observations during formulating

As formulation took place, the general changes during the formulation was to the viscosity, colour, and pH levels. This were the few parameters that could be easily observed without instrumental testing.

This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Self-wetting properties of Carbopol thickeners (3.1.1)
2. Thickening of Carbomers under the right pH conditions (3.1.2)
3. Formation of Emulsion with homogenization (3.1.3)
4. Change in Viscosity (3.1.4)
5. Change in Colour (3.1.5)
6. Change in pH Level (3.1.6)

3.1.1 Self-wetting properties of Carbopol thickeners:
Observation:

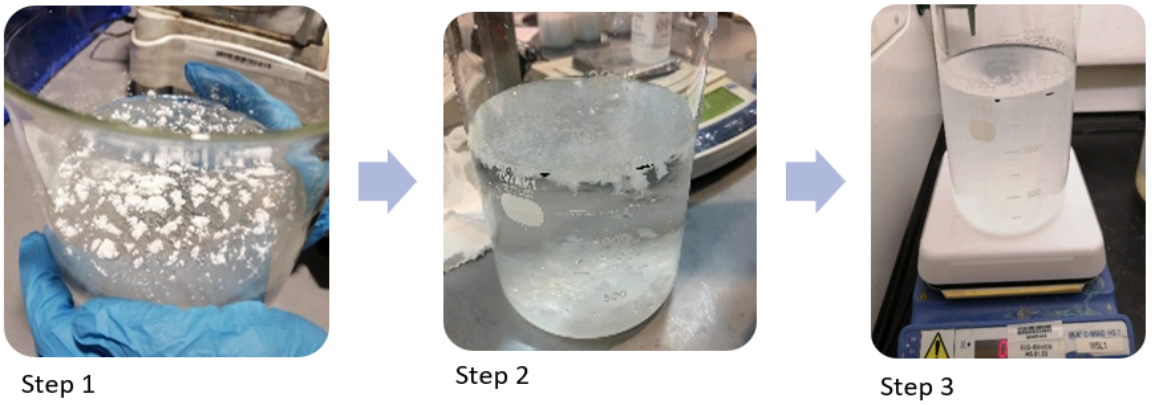


Figure 36: Self-wetting of Carbomer

Observations seen during the Self-wetting of Carbomers:
In Step 2, after 10 minutes of adding in the Carbomer thickener powder in the water containing the different phases required for the formulation of lotion, the Carbomer thickener powder has rapidly adsorbed water and is completely "self-wetted" [44] without the help of external agitation.

Besides that, it is observed that the Carbomer thickener powder has changed from white to translucent in colour.

In Step 3, the Carbomer thickener powder can be easily dispersed into the water containing the different phases using a magnetic stirrer to stir to ensure homogenised mixing and does not requires aggressive dispersion.

Discussion:
From the observations seen during the Self-wetting of Carbomers, due to the properties of the Carbopol family, which is present in the Carbomer thickener powder used [44]. This has allowed for the ease of Carbomer thickener powder dispersion easily, which reduces the amount of time required for complete self-wetting to occur.

3.1.2 Thickening of Carbomers under the right pH conditions
Observations:

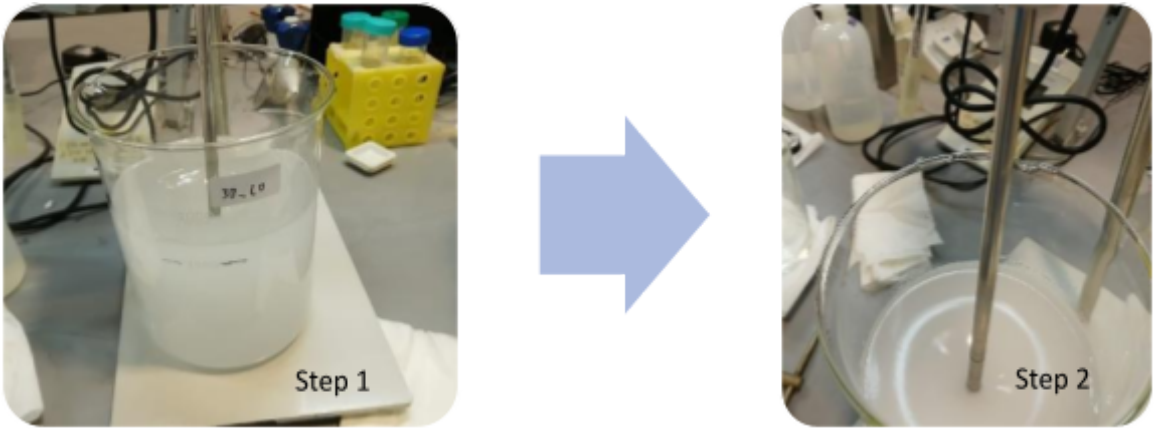


Figure 37: Thickening of Carbomers

As observed in Step 2 of the thickening of Carbomer, the formulation thickens as more pH adjuster (20% Sodium Hydroxide Stock Solution) is added.

Discussion:

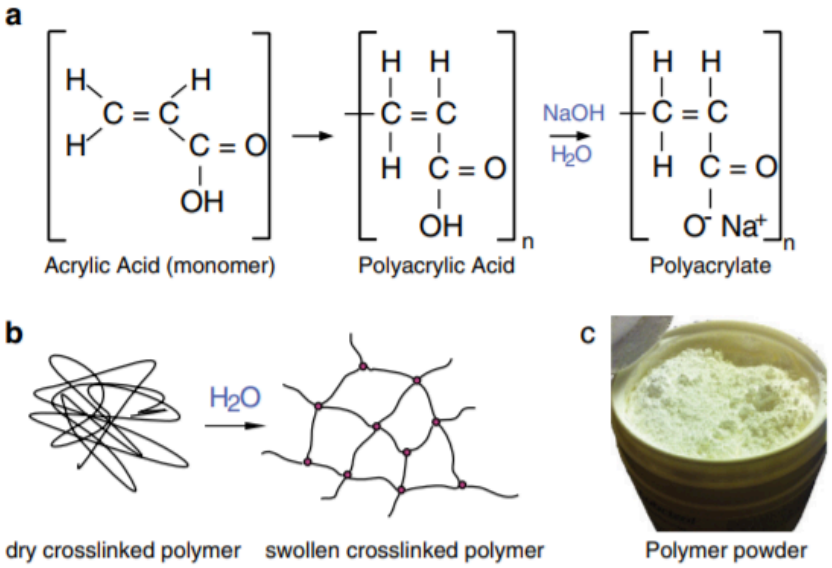


Figure 38: Process of Neutralization to obtain required viscosity [45]

For Part A of the image, the Acrylic Acid would undergo polymerization to become Polyacrylic Acid and dried to obtain Part C which is a Polymer powder [45].

During the process of formulation, dry Polymer powder is added into water and undergoes "self-wetting" with the addition of Water to swell. Afterwards, pH adjuster (20% Sodium Hydroxide Stock Solution) is added to increase the pH levels of the formulation to thicken the formulation to form Polyacrylate [45]. This is because the Rheological modifier (Polymer powder also known as Carbomer)'s properties behaviour will affect the final formulation product formed.

3.1.3 Formation of emulsion with homogenization
Observations:

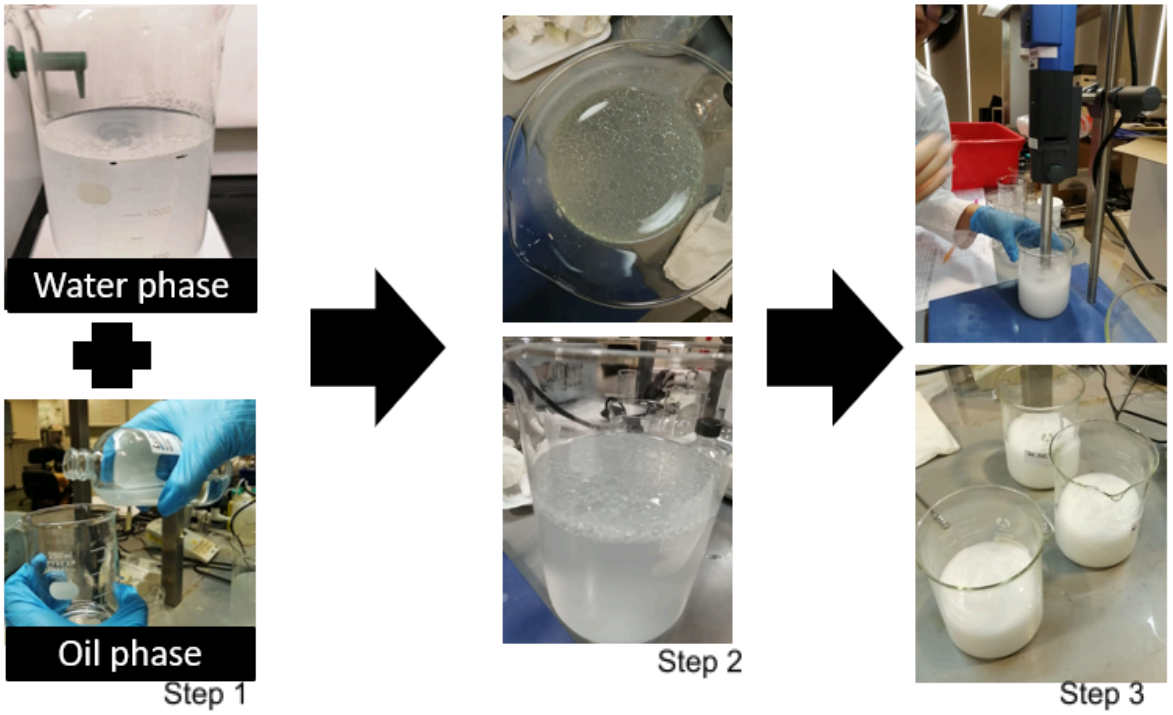


Figure 39: Formulation of emulsion with homogenization

Observations seen during the formation of emulsion with homogenization:

- In Step 2, it can clearly be seen that there are two different distinct phases that looks immiscible (Not able to mix). On the surface, oil (Humectant) is observed to be floating on the surface of the water.
- In Step 3, the homogenous mixture formulation is further homogenized using a homogenizer.

Discussion:

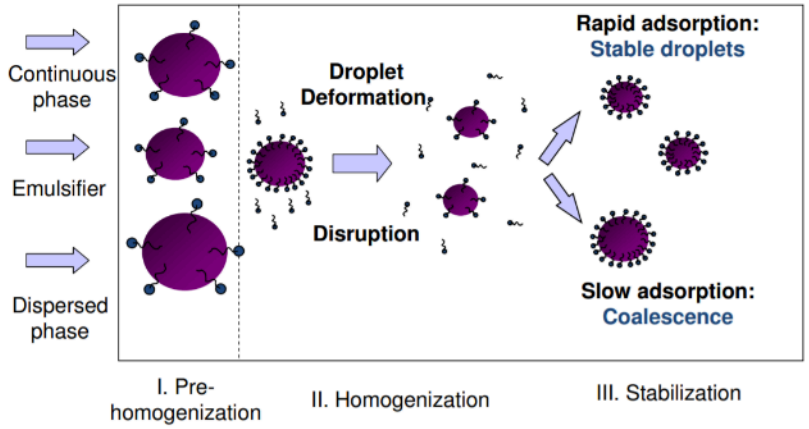


Figure 40: Homogenization process [45]

The homogenization process breaks down large oil droplets as seen in Step 2 into submicron sized oil droplets to produce an oil-in-water emulsion.

3.1.4 Change in Viscosity:
After Rheological Modifiers were added into the Water together with the other Phase A, B & C ingredients and was mixed using the T25 Ultra-Turrax Disperser (IKA) Mixer. It shows the clear transition from a Viscous liquid to a Viscoelastic Solid due to the addition of 20% Sodium Hydroxide Stock Solution.

As 20% Sodium Hydroxide Stock Solution is a Neutralizer. Besides being a Neutralizer, it acts as a thickener to thicken up the lotion from a viscous liquid to a Viscoelastic solid overtime which had a paste like consistency.

3.1.5 Change in Color:
At the start of the formulation, the main ingredient, Water, which would be the emulsion base, also known as the solvent, was clear (Can see through). As the Phase A ingredients were added and mixed using a Magnetic stirrer and Hot-plate magnetic stirrer, the solution become milky white.

As we proceed with further steps, and with the addition of 20% Sodium Hydroxide Stock Solution, the Lotion become white in color.

3.1.6 Change in pH Level:
The pH level of pure deionized water is usually at around pH 7, this pH level is affected by several factors such as atmospheric composition, temperature, and time. In the case for the deionized water used in the formulation of lotion, the pH level is assumed to be pH 7.

As we start the formulation and add in both phase A & C ingredients together, the pH levels dropped to around pH 5.85 to pH 5.20 which was a drop of a minimum of pH 1.15 and a maximum of pH 1.8. This change in the pH levels were due to the different percentage weight ingredients that were added into the pure deionized water and mixed. The pH readings of pH 5.85 to pH 5.20 are readings from each of the individual Master batch before the addition of ingredients as stated in the paragraph below.

When around ± 80 grams of ingredients (deionized water, propylene glycol, glycerine & 20% Sodium Hydroxide Stock Solution) was added to increase the final weight to ±400 grams, the pH level increased. This was partially due to the addition of 20% Sodium Hydroxide Stock Solution which was alkaline in nature that lead to the increase in pH levels to around pH 5.93 to pH 6.43. The pH readings of pH 5.85 to pH 5.20 are readings from each of the individual batches that came from the division of the Master batch.

The amount of 20% Sodium Hydroxide Stock Solution added throughout the entire formulation process was not calculated, as such, it led to the addition of ± 80 grams of ingredients to be approximated.

3.2 Observations after overnight storage at room temperature

This observation occurs directly after 24 hours of formulation of the Lotion. This is done by film wrapping the individual Master batch of Lotions and leaving it alone under specific conditions. The specific conditions set in this observation is stated in the table below.

Temperature	23 – 25.5°C
Pressure	1 atm
Time	≥ 24 hours

Table 40: Specific Conditions

This observation is important as it allows for any possible separation of phases to clearly show and to allow for any particulates in the lotion to settle to the bottom. As we follow the specific conditions, we can see if the Lotion has failed by separating into a clear and distinct layer of oil floating on the surface.



Figure 41: After overnight storage

After the lotion has been left alone for more than 24 hours, the first observation of the lotion through visual observations was that the Lotion had no noticeable changes in the in-can appearances and properties after overnight storage at room temperature and that the formulation is stable after the overnight storage.

3.3 Impact of Rheological Modifiers

From the Rheological Modifiers graphs obtained from data analysis, only the graphs that provides a clear trend would be shown due to the meaningful results. Graphs with no clear trend would not be shown, due to the lack of meaning in the results. Note that this is at 0 months.

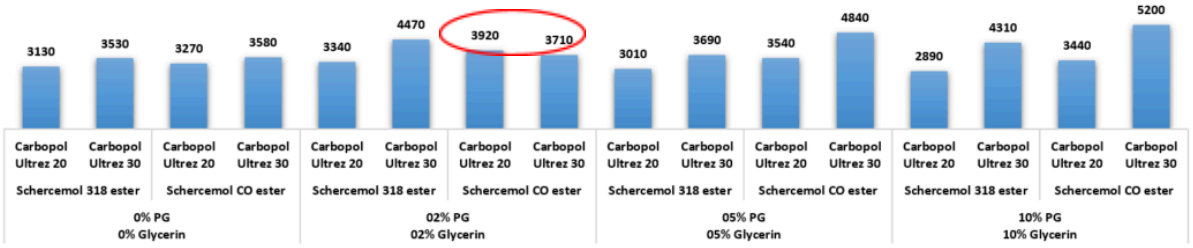
Parameters	Graphs
Viscosity	Impact of RM of Brookfield Viscosity – spindle 4 at 0 mth (cP) (Stability @ rtp)
Texture	Impact of RM of Firmness (g) Impact of RM of Cohesiveness (g) Impact of RM of Stickiness (g) Impact of RM of Stringiness (mm)
Gloss	Impact of RM of Gloss @ 60-degree
Colour	Impact of RM of WI E313 [D65/10]

Table 41: Parameters of Rheology Modifier

This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Viscosity (3.3.1)
2. Texture (3.3.2)
3. Gloss (3.3.3)
4. Colour (3.3.4)
5. Impact of Rheological Modifier Summary (3.3.5)
6. Discussion (3.3.6)

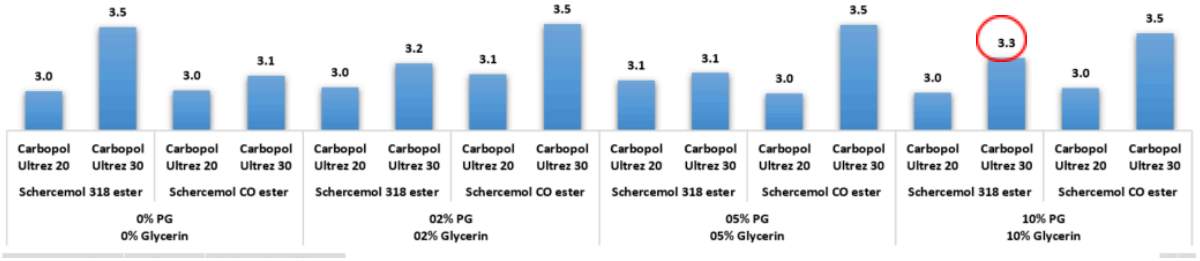
3.3.1 Viscosity



Graph 5: Impact of RM of Brookfield Viscosity

From observations, in both Schercemol 318 ester and Schercemol CO ester, Carbopol Ultrez 30 is seen to give rise to higher Viscosity value in most of the data obtained as the Emollient levels increases from 0% to 10% for both Propylene Glycol and Glycerine with the exception at 02% Schercemol CO ester in red which shows a decrease in Viscosity value.

3.3.2 Texture



Graph 6: Impact of RM of Firmness (g)

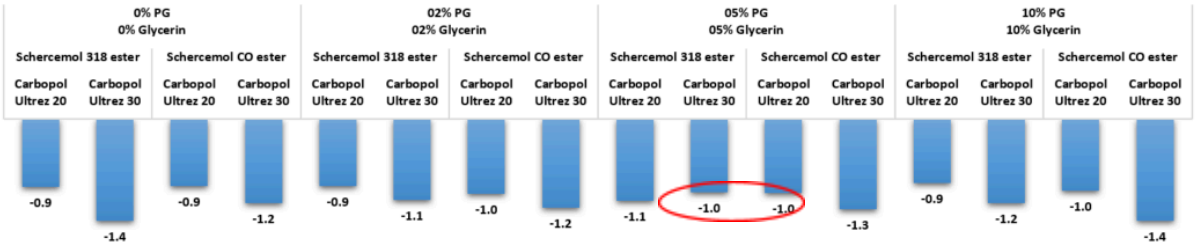
From observations, we can see that in both Schercemol 318 ester and Schercemol CO ester, Carbopol Ultrez 30 gives rise to higher Firmness in all of the data obtained as the Emollient levels increases from 0% to 10% for both Propylene Glycol and Glycerine.

The Firmness experiences a decrease in Schercemol 318 ester in Carbopol Ultrez 30 as the Emollient levels increases from 0% to 05% in both Propylene Glycol and Glycerine, however at 10% there is a sudden decrease in the firmness value which shows the presence of an abnormally, this abnormally is circled in red.

In Schercemol CO ester's 'Carbopol Ultrez 30', as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10%, leads to the increase in firmness value. Therefore, showing a clear trend that as the Humectants levels increase, the Firmness for Rheological Modifier increases as well.

However, from Schercemol 318 ester's 'Carbopol Ultrez 20' and Schercemol CO ester's 'Carbopol Ultrez 20', the Firmness value remained relatively constant as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10% with a sudden increase in Firmness values which indicates that there are abnormally present.

In conclusion, Firmness is observed through the entire graph. In both Schercemol 318 and CO ester, Carbopol Ultrez 30 is clearly shown to give rise to a higher Firmness level compared to Carbopol Ultrez 20 as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10%.



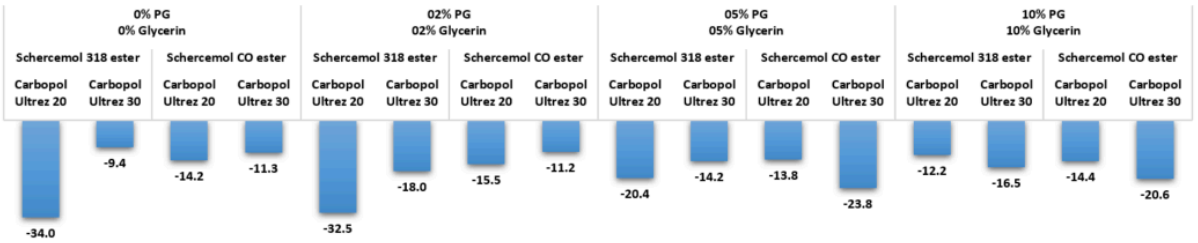
Graph 7: Impact of RM of Cohesiveness (g)

From observations, we can see that in both Schercemol 318 ester and Schercemol CO ester, Carbopol Ultrez 30 gives rise to higher Cohesiveness in most sets of data obtained as the Emollient levels increases from 0% to 10% for both Propylene Glycol and Glycerine. However, there is a presence of an Anomaly, circled in red.

In Schercemol 318 ester's 'Carbopol Ultrez 20 and Carbopol Ultrez 30', as the Propylene Glycol and Glycerine levels increase from 0% to 10% consistently. It is shown that Carbopol Ultrez 30 will give rise to higher Cohesiveness value throughout the graph with the exception at 05% Humectant levels which shows that Carbopol Ultrez 20 has a higher Cohesiveness value.

In Schercemol CO ester's 'Carbopol Ultrez 20 and Carbopol Ultrez 30', as the Propylene Glycol and Glycerine levels increase from 0% to 10% consistently, there is a clear consistent decrease in Cohesiveness value. Therefore, it shows a clear trend in the Cohesiveness value for Rheological Modifier.

In conclusion, Cohesiveness is observed through the entire graph. In both Schercemol 318 and CO ester, Carbopol Ultrez 30 is clearly shown to give rise to a higher Firmness level compared to Carbopol Ultrez 20 as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10%.



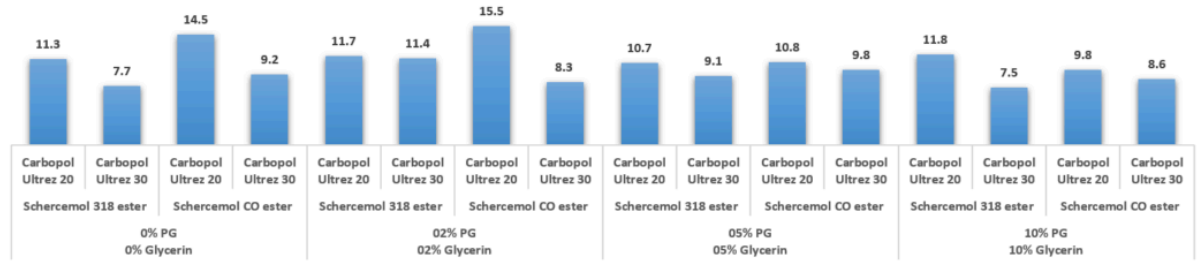
Graph 8: Impact of RM of Stickiness (g)

No clear trend can be observed. Although Carbopol is known to give rise to a higher Stickiness level as compared to Carbopol Ultrez 20.

From 0% to 02%, in both Schercemol 318 and CO ester, Carbopol Ultrez 20 is shown in the graph to give rise to a higher Stickiness level compared to Carbopol Ultrez 20.

At 05%, in Schercemol 318 ester, Carbopol Ultrez 20 is shown in the graph to give rise to a higher Stickiness level compared to Carbopol Ultrez 20. However, in Schercemol CO ester, Carbopol Ultrez 30 is shown to give rise to a higher Stickiness level as compared to Carbopol Ultrez 20.

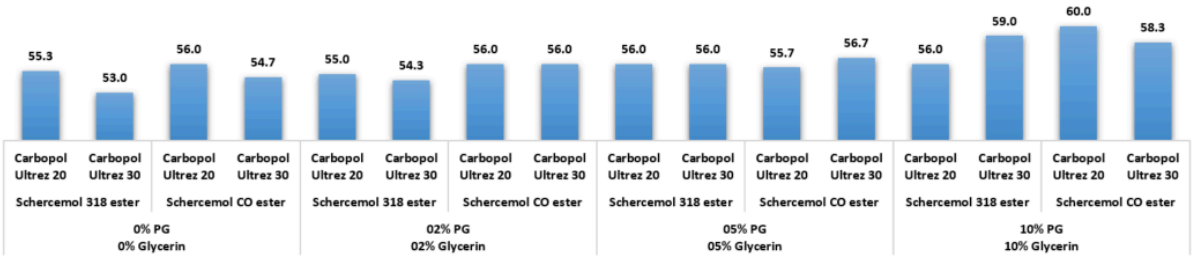
At 10%, in Schercemol CO ester, Carbopol Ultrez 30 is shown to give rise to a higher Stickiness level as compared to Carbopol Ultrez 20.



Graph 9: Impact of RM of Stringiness (mm)

From observations, we can see that in both Schercemol 318 ester and Schercemol CO ester, Carbopol Ultrez 30 gives rise to higher Stringiness in all of the data obtained as the Emollient levels increases from 0% to 10% for both Propylene Glycol and Glycerine.

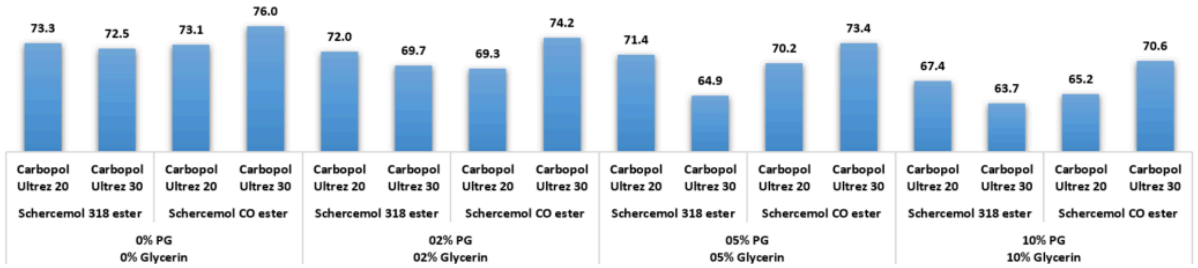
3.3.3 Gloss



Graph 10: Impact of RM of Gloss @ 60-degree

No clear trend that can be observed.

3.3.4 Colour



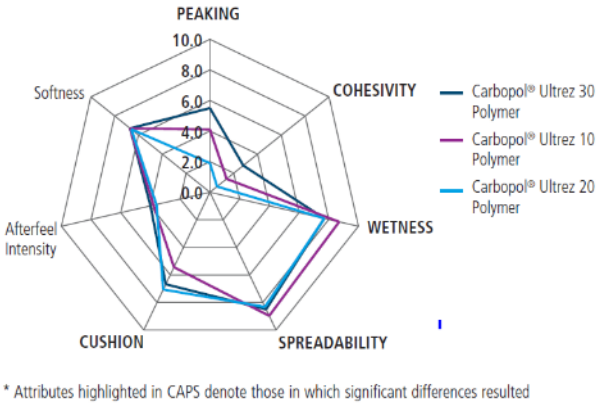
Graph 11: Impact of RM of WI E313 [D65/10]

No clear trend that can be observed.

3.3.5 Overview of results and discussion

Properties		Carbopol Ultrez 20	Carbopol Ultrez 30
Viscosity		Lower	Higher
Texture	**Firmness**	Lower	Higher
	Cohesiveness	Lower	Higher
	Stringiness	Higher	Lower
Gloss		No obvious trend	
Colour		No obvious trend	

Table 42: Rheological Modifier Properties Summary



Graph 12: Attributes of different Rheological Modifier [39]

From the Graph 13 observed above extracted from Carbopol® Ultrez 30 Polymer Product Data, it is clearly observed that the Cohesiveness obtained in the test conducted is accurate

and reliable as the data obtained shows that Carbopol® Ultrez 30 Polymer is of higher Cohesiveness compared to Carbopol® Ultrez 20 Polymer.

From the results obtained, it is shown that Carbopol Ultrez 30 will give rise to clearer readings in specific parameters such as Viscosity, and Firmness from tests such as Texture analysis's Spreadability and Brookfield Viscometer. This means that, up to 10% Propylene Glycol and 10% Glycerine, Carbopol Ultrez 30 will give rise to higher values in the specific parameters present in the Spreadability test and Viscosity.

However, for Stringiness, Carbopol® Ultrez 20 Polymer has a higher value as compared to Carbopol® Ultrez 30 Polymer.

In the Gloss and Colour parameters, the results between Carbopol Ultrez 20 and Carbopol Ultrez 20 is not clear due to the lack of clear trend present.

Discussions

Carbopol® Ultrez 30 Polymer gives rise to a higher Cohesiveness value compared to Carbopol® Ultrez 20 Polymer which is supported with known performances as shown in previous studies conducted on both Carbopol® Ultrez 30 Polymer and Carbopol® Ultrez 20 Polymer's grade.

From the Stickiness* results obtained from the Spreadability texture test, no clear trend is observed, although it is known that Carbopol Ultrez 30 will give rise to a higher Stickiness value as compared to Carbopol Ultrez 20. This could mean that the Spreadability Texture test conducted is either not appropriate or inadequate and as such might require further testing to be done to confirm that the increase in stickiness is compensated by the effects of rheological modifier used.

Stickiness refers to Cohesiveness. Cohesiveness is the tendency of a product to stick together or cohere. This is because the intermolecular attraction by which the elements of a body or mass of materials are held together to determine its Cohesiveness. It is related to the internal Stickiness of a product such as Cheese, Honey, or any Viscoelastic materials. This is usually determined by the measurement of the amount of force that is applied to remove an item from the product mass. [46]

3.4 Impact of Emollient

From the Emollient graphs obtained from data analysis, only the graphs that provides a clear trend would be shown due to the meaningful results. Graphs with no clear trend would not be shown, due to the lack of meaning in the results. The rest of the graphs can be found in the appendix. Note that this is at 0 months.

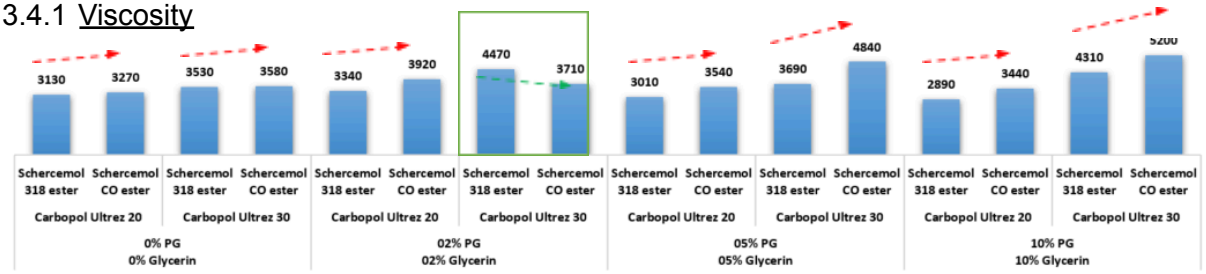
Parameters	Graphs
Viscosity	Impact of Emollient of Brookfield Viscosity – spindle 4 at 0 mth (cP) (Stability @ rtp)
Texture	Impact of Emollient of Firmness (g) Impact of Emollient of Cohesiveness (g)
Gloss	Impact of Emollient of Gloss @ 20-degree Impact of Emollient of Gloss @ 60-degree
Colour	Impact of Emollient of YI E313 [D65/10] Impact of Emollient of WI E313 [D65/10] Impact of Emollient of dE2000

Table 43: Parameters of Emollient

This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Viscosity (3.4.1)
2. Texture (3.4.2)
3. Gloss (3.4.3)
4. Colour (3.4.4)
5. Impact of Impact of Emollient (3.4.5)
6. Discussion (3.4.6)

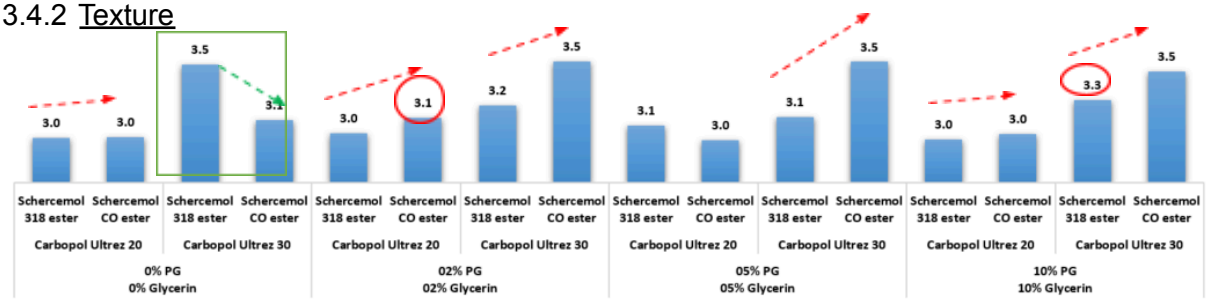
3.4.1 Viscosity



Graph 13: Impact of Emollient of Brookfield Viscosity

From Observations, it is seen that Schercemol CO will give rise to a slightly higher Viscosity reading as compared to Schercemol 318 throughout most sets of data. However, there is a presence of an Anomaly that can be clearly observed in the graph.

3.4.2 Texture



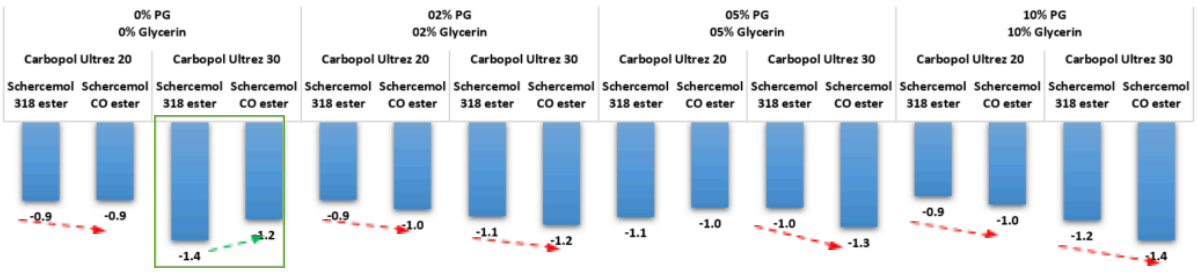
Graph 14: Impact of Emollient of Firmness (g)

From Observations, it is seen that Schercemol CO will give rise to a higher Firmness reading as compared to Schercemol 318 throughout most sets of data. However, there is a presence of an Anomaly that can be clearly observed in the graph.

Consistency seen in Schercemol 318 ester's 'Carbopol Ultrez 30' as the Humectant Propylene Glycol and Glycerine increased from 0% to 10%, the Firmness decreases constantly. However, there is a sudden increase in the Firmness level at 10% Humectant levels which suggest that there is an abnormally present circled in red. Therefore, the Firmness data shows a clear trend in the Firmness for Rheological Modifier.

In Schercemol CO ester's 'Carbopol Ultrez 30', as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10%, leads to the increase in firmness value. Therefore, showing a clear trend that as the Humectants levels increase, the Firmness for Rheological Modifier increases as well.

However, from Schercemol 318 ester's 'Carbopol Ultrez 20' and Schercemol CO ester's 'Carbopol Ultrez 20', the Firmness value remained relatively constant as the Humectant, Propylene Glycol and Glycerine increased from 0% to 10% with a sudden increase in Firmness values which indicates that there are abnormally present.

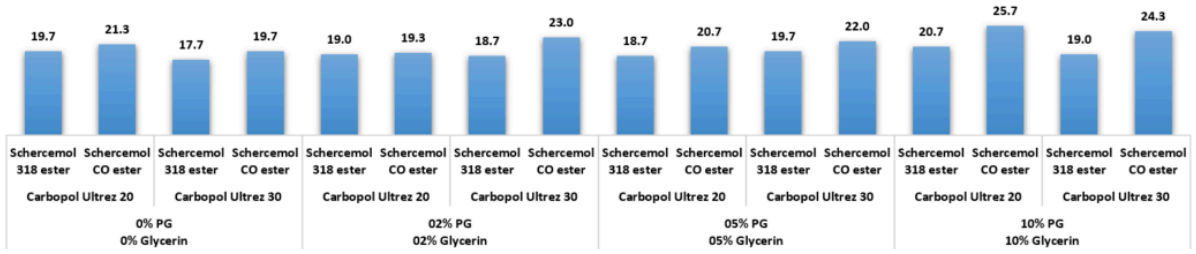


Graph 15: Impact of Emollient of Cohesiveness (g)

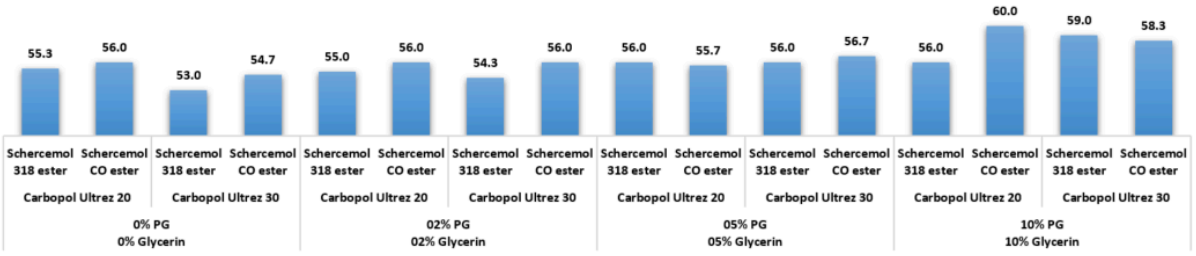
From Observations, it is seen that Schercemol CO will give rise to a higher Cohesiveness reading as compared to Schercemol 318 throughout most sets of data. However, there is a presence of an Anomaly that can be clearly observed in the graph.

In Carbopol Ultrez 20's 'Schercemol 318 ester', as the Propylene Glycol and Glycerine levels increase from 0% to 10% consistently, there is a clear increase in Consistency. There is a constant increase in the Consistency values. Therefore, it shows a clear trend in the Consistency for Humectant.

3.4.3 Gloss



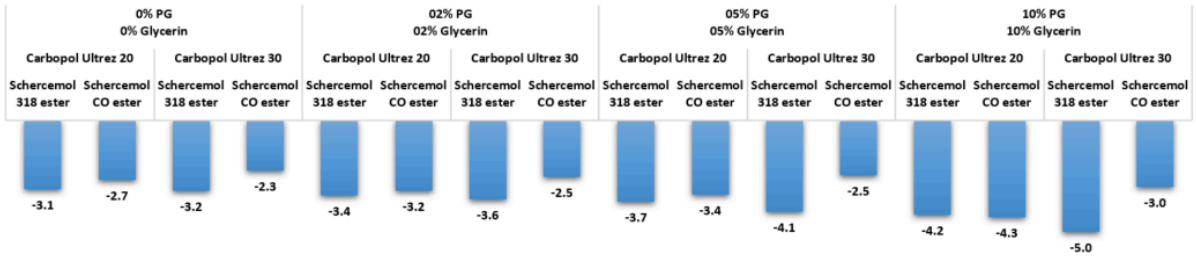
Graph 16: Impact of Emollient of Gloss @ 20-degree



Graph 17: Impact of Emollient of Gloss @ 60-degree

From Observations of both the Stability Gloss @ 20-degree and 60-degree graph, it is shown that Schercemol CO ester gives rise to a comparable higher gloss level as compared to Schercemol 318 ester. This means that Schercemol CO ester has a higher shininess as compared to Schercemol 318 ester.

3.4.4 Colour



Graph 18: Impact of Emollient of YI E313 [D65/10]

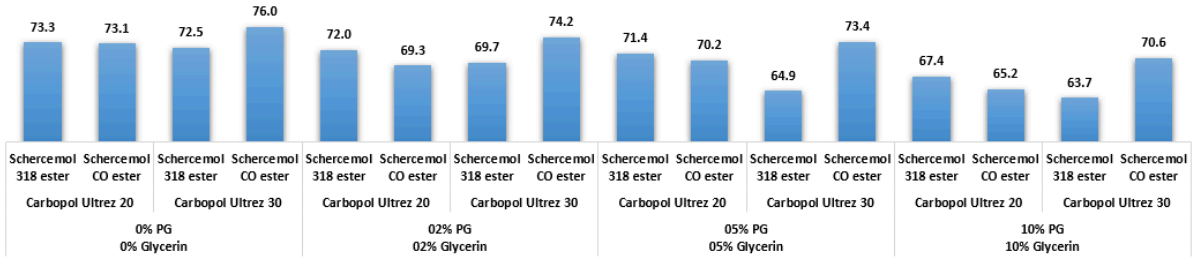
As seen in the graph for Stability Yellowness, Schercemol 318 ester's inherent pale-yellow colour has an impact on the finished Lotion product. This is because it gives rise to a slightly higher Yellowness value compared to Schercemol CO ester.

As the percentage of Propylene Glycol and Glycerine increases, the Yellowness for Carbopol Ultrez 20 and Carbopol Ultrez 30's Schercemol 318 ester and Schercemol CO ester generally decreases from 0% Propylene glycerol and 0% Glycerine to a lower Yellowness value at 10% Propylene glycerol and 10% Glycerine. Therefore, the Yellowness level is decreasing in a downwards trend.

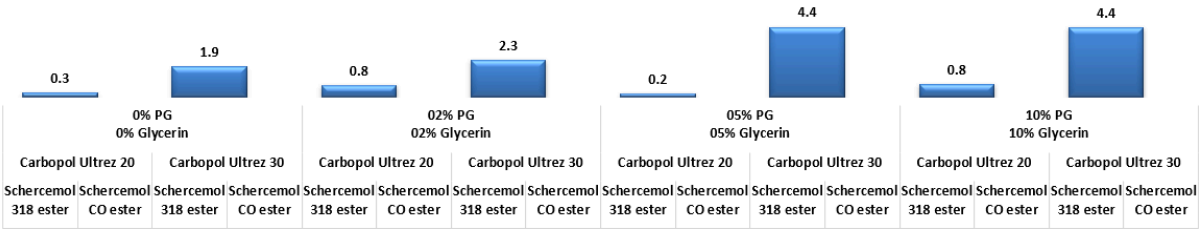


Figure 42: 318 ester and CO ester

From observations, we can see that Schercemol™ 318 esters are comparatively more 'Yellow' as compared Schercemol™ CO ester. This has therefore led the final product to be of a more 'Yellow' colour that was clearly detected by the Spectrophotometer. This in turn has produced the same effect in both the Whiteness value and the dE2000 values obtained as shown in the graphs below.



Graph 19: Impact of Emollient of WI E313 [D65/10]



Graph 20: Impact of Emollient of dE2000*

*Direct comparison of Schercemol 318 ester and Schercemol CO ester while the rest of the formulation remains.

3.4.5 Overview of results and discussion

In the Impact of Emollient, the three parameters that showed the best results were Viscosity, Gloss and Yellowness. Each of the three parameters provided a clear trend that was easily observed, as for the other parameters from the test done, it was not able to provide a clear and specific trend which lead to the omission as it was not able to provide any clear understanding.

Properties		Carbopol Ultrez 20	Carbopol Ultrez 30
Viscosity		Lower	Higher
Texture	**Firmness**	Lower	Higher
	Cohesiveness	Lower	Higher
Gloss		Slightly Lower	Slightly Higher
Colour (Yellowness)		Higher	Lower

Table 44: Emollient Properties Summary

From the results obtained, we can see that Schercemol CO ester will give rise to a higher Viscosity, Firmness, Cohesiveness and Gloss reading as compared to Schercemol 318 ester. Both Viscosity and Gloss readings are not related to each other and therefore, do not affect each other as they are independent of each other.

As for the Yellowness, Schercemol 318 ester has a higher Yellowness value as shown in the table above as compared to Schercemol CO ester. This is further supported by Figure 45 which showed that Schercemol 318 ester is more ‘Yellow’ in its original form compared to Schercemol CO ester. This natural pale-Yellow present, therefore affected the final product’s Yellowness that was detected by the spectrophotometer.

The colour differences between the samples with Schercemol 318 ester and Schercemol CO ester seems to be more pronounced when samples formulated with Carbopol Ultrez 30 than Carbopol Ultrez 20. This could mean that there is a synergy effect between the Carbopol Ultrez 30 thickener and the emollients, further investigation can be done to confirm this.

Discussion

As seen in Figure 45, Schercemol 318 ester is of a pale-Yellow colour which had an impact on the final product that contained Schercemol 318 ester in its composition by giving rise to a slight increase in Yellowness compared to Schercemol CO ester which is further supported by results obtained from the spectrophotometer which is displayed in the Yellowness graph. As such, further considerations are required on the possible impact on colour that Schercemol 318 ester will have on the formulation itself.

From Observations of the Yellowness, Viscosity and Gloss graphs, it is observed that only the Yellowness graph will experience a slight increase in Yellowness value throughout all sets of data as the Humectant levels increases. This 'increasing' trend is not seen in the rest of the other parameters. From the results of the Yellowness graph, it shows that even though the Emollient added remained the same, the Humectant levels increased. This might mean that as the Humectant levels increases, the Yellowness will also increase. This therefore could be further investigated, therefore allowing the study of the relationship between Humectant and Emollient and the impact on colour during formulation.

Schercemol 318's INCI name is known as Isopropyl Isostearate and Schercemol CO's INCI name is known as Cetyl Ethlhexanoate. Schercemol 318 is known to be a medium ester while Schercemol CO is known to be a light ester. Due to Schercemol 318 ester being used in the formulation, formulated samples containing Schercemol 318 ester is expected to result in higher viscosity, however, this is inconsistent with our findings. This could be because of the droplet size present in the sample, which therefore calls for further investigations.

Both Viscosity and Gloss readings in Schercemol CO ester will give rise to higher values as compared to Schercemol 318 ester throughout all sets of data, it is not clear if the amount of Emollient would have a significant impact on the Gloss or Viscosity, and as such, this calls for the need for future investigations.

Both Schercemol 318 ester and Schercemol CO ester used in the formulation both have similar reflective index, which likely caused the difference in the Gloss results due to the level of humectant added during the formulation process.

3.5 Impact of the level of Humectant

From the Humectant graphs obtained from data analysis, only the graphs that provides a clear trend would be shown due to the meaningful results. Graphs with no clear trend would not be shown, due to the lack of meaning in the results. The rest of the graphs can be found in the appendix. Note that this is at 0 months.

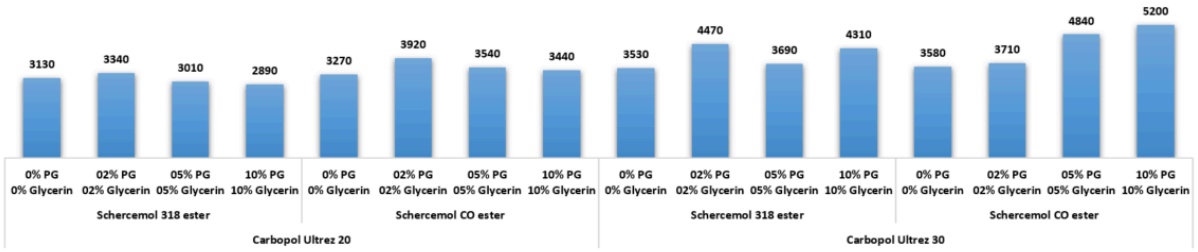
Parameters	Graphs
Viscosity	Impact of Humectant of Brookfield Viscosity – spindle 4 at 0 mth (cP) (Stability @ rtp)
Texture	Impact of Humectant of Cohesiveness (g) Impact of Humectant of Stickiness (g)
Gloss	Impact of Humectant of Gloss @ 20-degree Impact of Humectant of Gloss @ 60-degree
Colour	Impact of Humectant of WI E313 [D65/10] Impact of Humectant of YI E313 [D65/10] Impact of Humectant of dE2000

Table 45: Parameters of Humectant

This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Viscosity (3.5.1)
2. Texture (3.5.2)
3. Gloss (3.5.3)
4. Colour (3.5.4)
5. Impact of Impact of Humectant (3.5.5)
6. Measuring of Purity of Humectant (3.5.6)
7. Discussion (3.5.7)

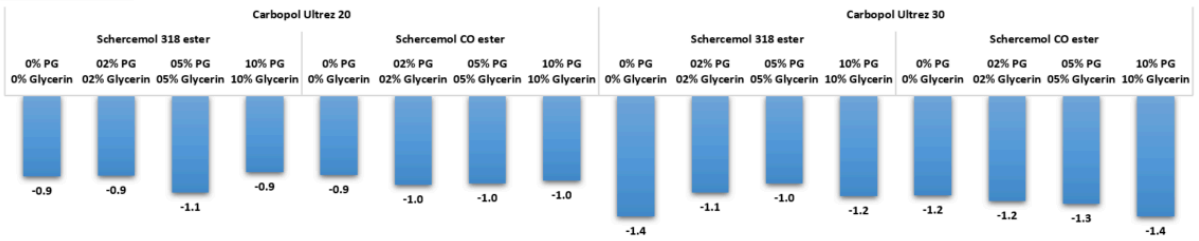
3.5.1 Viscosity



Graph 21: Impact of Humectant of Brookfield Viscosity

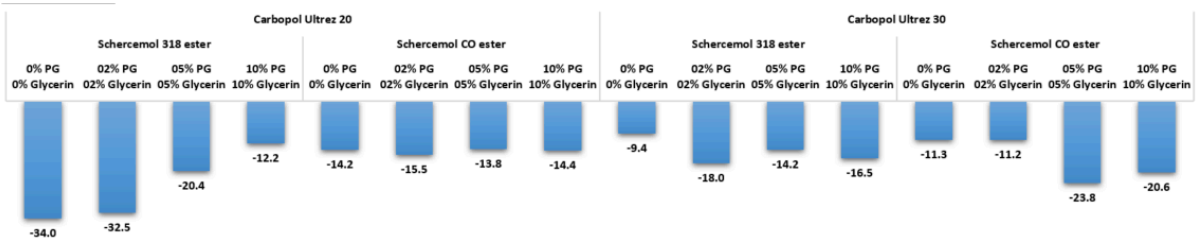
No clear trend observed. The increase in the Humectant does not shows any impact on the viscosity of the final product.

3.5.2 Texture



Graph 22: Impact of Humectant of Cohesiveness (g)

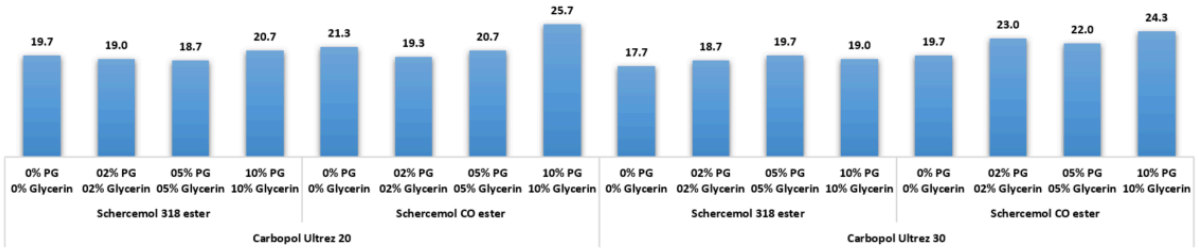
No clear trend observed. This could be because the test methods used are not good enough to differentiate the formulations as the ingredients in each formulation are similar.



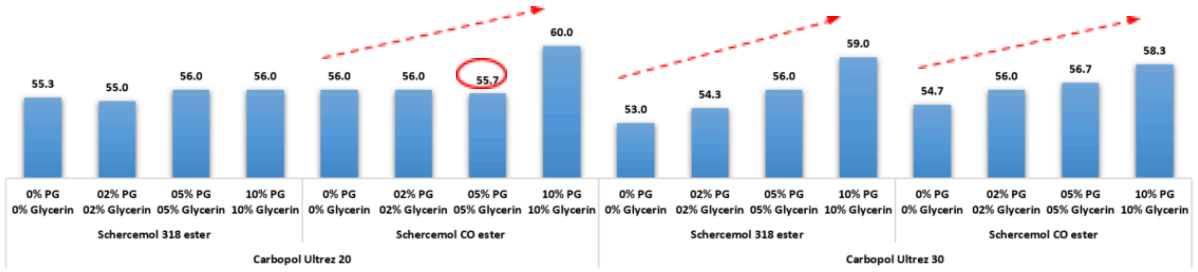
Graph 23: Impact of Humectant of Stickiness (g)

No clear trend observed. This could be because the test methods used are not good enough to differentiate the formulations as the ingredients in each formulation are similar.

3.5.3 Gloss



Graph 24: Impact of Humectant of Gloss @ 20-degree



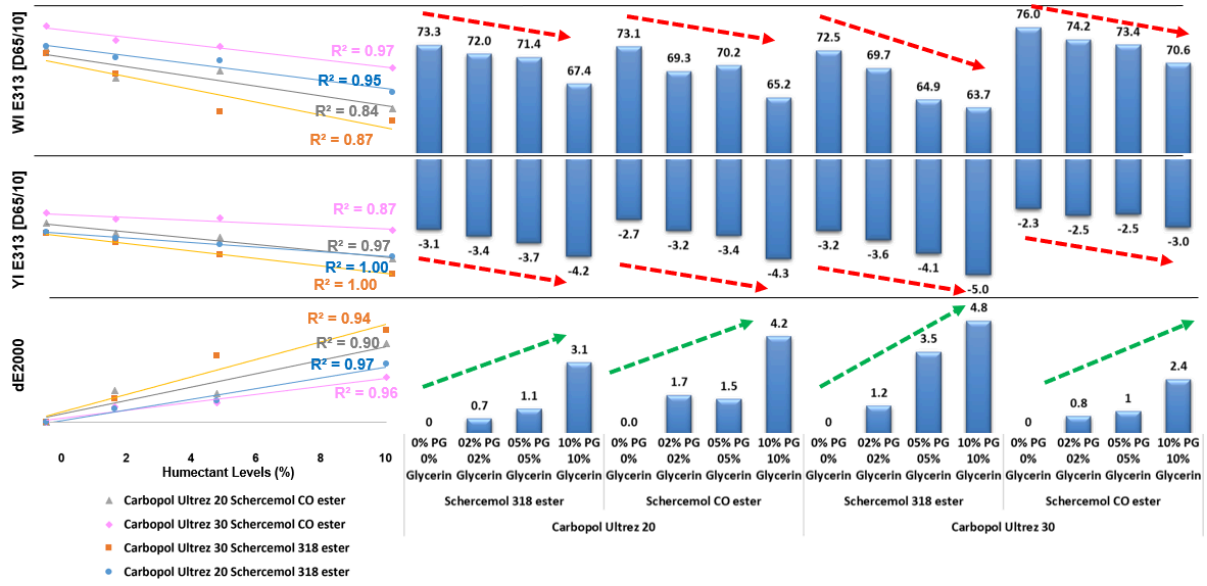
Graph 25: Impact of Humectant of Gloss @ 60-degree

From the 20-degree and 60-degree Gloss readings, clear results are only present in the 60-degree Gloss readings that as the Humectant levels increases, the Gloss increases slightly.

At 60-degree Gloss reading, there is an anomaly which should have been an increase or constant reading which is circled in red.

However, as for the 20-degree Gloss reading, there is no evidence to say that as the Humectant levels increase, the Gloss reading will also increase. Therefore, it is only clear in 60-degree Gloss reading that as the Humectant level increases, Gloss increases slightly.

3.5.4 Colour



Graph 26: Humectant WI, YI, and dE graphs

As the level of Whiteness decreases while the Yellowness increases. This could be due to the slight Yellowness of the grade of Propylene Glycol or Glycerine that was used. At 2% Humectant levels and above, there was a noticeable colour difference present as compared to having no Humectant added.

Whiteness:
The Whiteness level in 'Carbopol Ultrez 20's Schercemol 318 ester' and 'Carbopol Ultrez 30's Schercemol 318 ester and Schercemol CO ester' generally decreases as the percentage of Propylene Glycol and Glycerine increases from 0% to 10%. Therefore, the Whiteness level is decreasing in a downwards trend.

However, in Carbopol Ultrez 20's Schercemol CO ester, the Whiteness level decreased as the Humectant percentage increased from 0% to 02% Propylene glycerol and 0% to 02% Glycerine, followed by an increase in Whiteness level at 05% Propylene glycerol and 05% Glycerine before the Whiteness level decreased again at 10% Propylene glycerol and 10% Glycerine. Therefore, showing an abnormally in the Whiteness level.

Yellowness:
As the percentage of Propylene Glycol and Glycerine increases, the Yellowness for Carbopol Ultrez 20 and Carbopol Ultrez 30's Schercemol 318 ester and Schercemol CO ester generally decreases from 0% Propylene glycerol and 0% Glycerine to a lower Yellowness value at 10% Propylene glycerol and 10% Glycerine. Therefore, the Yellowness level is decreasing in a downwards trend.

dE2000:
The dE2000 value increases in Carbopol Ultrez 20's 'Schercemol 318 ester' and in Carbopol Ultrez 30's 'Schercemol 318 ester and Schercemol CO ester' as the percentage of Propylene Glycol and Glycerine increases from 0% to 10%. Therefore, the dE2000 value is increasing in an upwards trend.

However, in Carbopol Ultrez 20's Schercemol CO ester, the dE2000 value increase as the Humectant percentage increased from 0% to 02% Propylene glycerol and 0% to 02% Glycerine, followed by an decrease in dE2000 value at 05% Propylene glycerol and 05% Glycerine before the dE2000 value increased again at 10% Propylene glycerol and 10% Glycerine. Therefore, showing an abnormally in the dE2000 value for Carbopol Ultrez 20's Schercemol CO ester.

Overview of results and discussion

In the Impact of Impact of Humectant, the three parameters that showed the best results were Viscosity, Gloss and Yellowness. Each of the three parameters provided a clear trend that was easily observed, as for the other parameters from the test done, it was not able to provide a clear and specific trend which lead to the omission as it was not able to provide any clear understanding.

Properties		Increasing level of Humectant
Viscosity		No clear trend
Texture	**Firmness**	No clear trend
	Cohesiveness	Slight increase
Gloss		Slight increase
Colour	**Whiteness**	Increase
	Yellowness	Increase
	dE2000 (Colour difference as compared samples with no Humectants added)	Addition of just 2% of Propylene Glycol and Glycerine starts to lead to slight noticeable change in colour

Table 46: Humectant Properties Summary

Material	Refractive index
Propylene Glycol (100%)	1.433
Glycerol (Glycerine)	1.4729

Table 47: Refractive index of Humectants [47]

The measurement of purity of humectants follows the APHA colour scale, which is also known as the Hazen scale, the Platinum Cobalt (Pt/Co) Scale [48], and ASTM D1209 [49].



Figure 43: APHA Standard Liquid [50]

Some properties of Glycerine are listed in the Table as below.

Specification	Typical Values
Appearance	Transparent
Glycerine Content (%)	99.7 min

Moisture (%)	0.3 max
Colour (APHA)	10 Max
Colour (mL $FeCl_3$)	0.4 Max

Table 48: Properties of Glycerine

Discussion

The increase in Glycerine levels is known to increase the level of Stickiness in the final product, however, the change in the level of Stickiness is not reflected in the results even though Penetration and Spreadability Texture test were conducted. This shows that the Texture test method used in the study is not appropriate and therefore inadequate in the measurement of the level of Stickiness in the final product which therefore means that better Texture test methods could be possibly be developed so as to show the change in the level of Stickiness.

Although both Propylene Glycol and Glycerine have APHA values of maximum 10, this means that they generally appear colourless towards the human eyes as seen in our study. However, a dosage of about 2% weight in the formulation can have a visible and significant effect on the in-can appearances of the formulation products which could be detected using a spectrophotometer.

Humectants can adsorb water and prevent moisture loss. This unique property of Humectants allow it to act as a moisturizer when added into personal care products and therefore it is important to be aware of the potential consequences that might affect both the Whiteness and Yellowness of the final product. This is because other ingredients in the formulation such as titanium dioxide could also potential affect the final colour values detected, as such, requiring further investigations necessary.

The increase in humectant levels in the samples has higher gloss levels, this observation could be because glycerine has a higher refractive index.

3.6 Results and Observations after stability test

This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Visual Observations (3.6.1)
2. Observation during drawdown for wet stage gloss testing (3.6.2)
3. Viscosity (3.6.3)
4. pH (3.6.4)
5. Colour (3.6.5)
6. Colour for Carbopol Ultrez 30, 3rd month at rtp (3.6.6)
7. Colour for Carbopol Ultrez 30, 3rd month at Oven (3.6.7)
8. Overview of results (3.6.8)
9. Discussion (3.6.9)

From the Stability test graphs obtained from data analysis after 3 months for both Oven and Room temperature, only the graphs that provides a clear trend would be shown due to the meaningful results. Graphs with no clear trend would not be shown, due to the lack of meaning in the results. The rest of the graphs can be found in the appendix. Note that this is at 3 months.

Parameters	Graphs
Viscosity	Stability Brookfield Viscosity – spindle 4 0 mth to 3 mth (cP) Stability Change in Viscosity – spindle 4 (cP) Stability Brookfield Viscosity – spindle 4 at 3 mth Oven (cP) Stability Brookfield Viscosity % change – spindle 4 at 3mth
pH	Stability pH – from 0 mth to 3 mth Stability Change in pH – 3 mth Oven and rtp
Colour	Stability WI E313 [D65/10] – from 0 mth to 3 mth Stability Change in WI E313 [D65/10] – 3 mth Ultrez 30 Stability YI E313 [D65/10] – from 0 mth to 3 mth Stability Change in YI E313 [D65/10] – 3 mth Ultrez 30 Stability dE2000 – 3 mth Carbopol Ultrez 30
Colour for Carbopol Ultrez 30, 3rd month at rtp	Stability WI E313 [D65/10] – 3 mth at rtp Stability Change in WI E313 [D65/10] – 3 mth at rtp Stability YI E313 [D65/10] – 3 mth at rtp Stability Change in YI E313 [D65/10] – 3 mth at rtp Stability dE2000 – 3 mth at rtp Stability Change in dE2000 – 3 mth at rtp
Colour for Carbopol Ultrez 30, 3rd month at rtp	Stability WI E313 [D65/10] – 3 mth at Oven Stability Change in WI E313 [D65/10] – 3 mth at Oven Stability YI E313 [D65/10] – 3 mth at Oven Stability Change in YI E313 [D65/10] – 3 mth at Oven Stability dE2000 – 3 mth at Oven Stability Change in dE2000 – 3 mth at Oven

Table 49: Parameters after Stability test

3.6.1 Visual Observations:

1. Samples appear slightly darker in Oven and room temperature samples.
2. No clear separation is observed in all samples, no obvious sign of stability issue.
3. Presence of some tiny specks of oil on the surface of some samples.
4. Sample seems less viscous compared to 3 months ago before stability test.

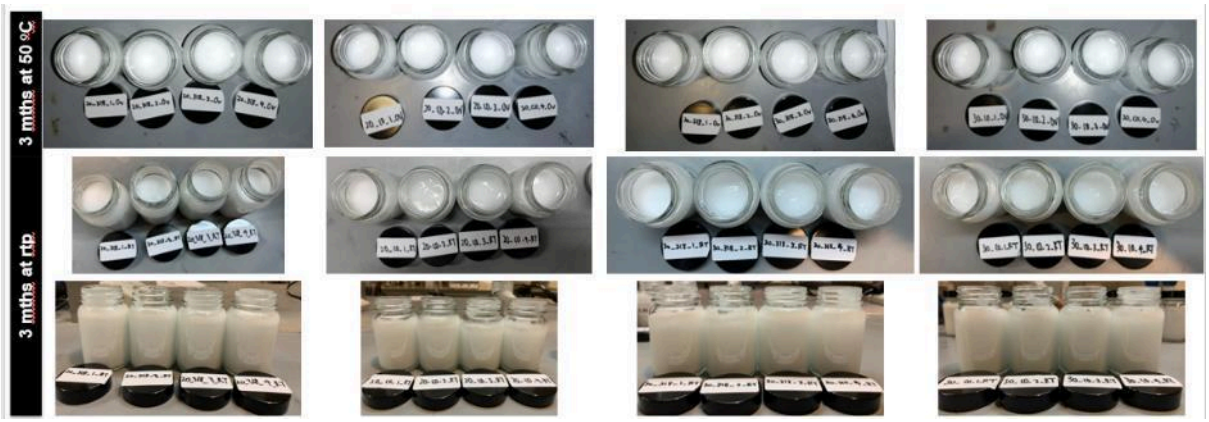
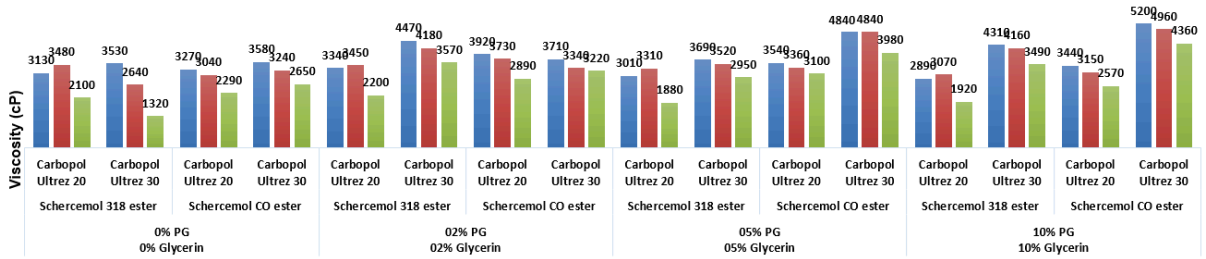


Figure 44: Visual Observations of all Samples

3.6.2 Observation during drawdown for wet stage gloss testing:

1. Films shrinks fast as compared to at 0 months
2. Lotion Samples at 3 months seems to be less viscous as compared to at 0 months for both Oven and at Room temperature.

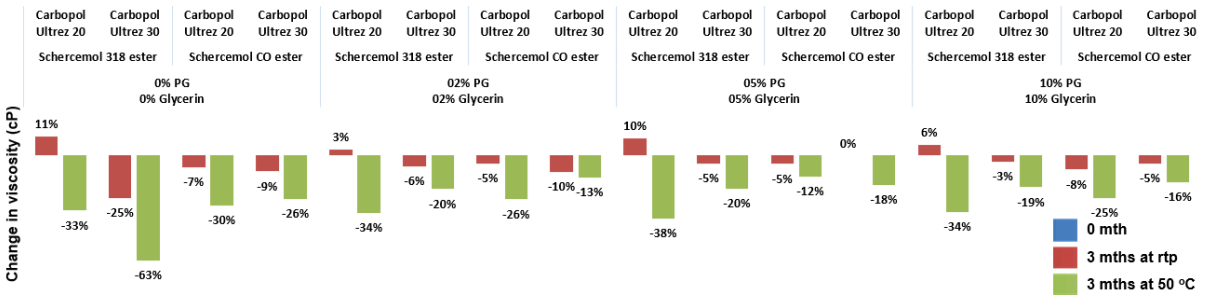
3.6.3 Viscosity



Graph 27: Stability Brookfield Viscosity – spindle 4 0 mth to 3 mth (cP)

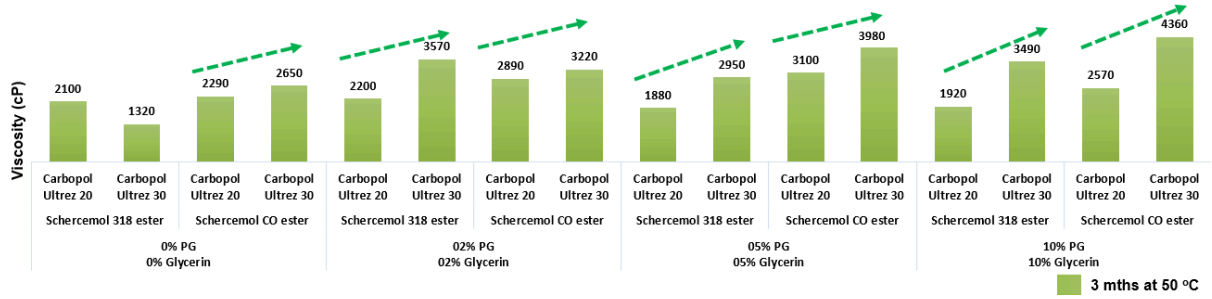
In the 'Stability Brookfield Viscosity – spindle 4 from 0 mth to 3 mth (cP)' graphs above, each of the graphs are all similar in terms of the minimum number of parameters present, which are 0 mth, and 3 mth at 50°C.

In most samples, after 3 months of stability in the oven at 50°C, most of the viscosity of the samples experienced an obvious drop in Viscosity which is aligned to the observations made during the drawdown during the wet stage gloss testing where some samples appears to be less viscous compared to at 0 months.



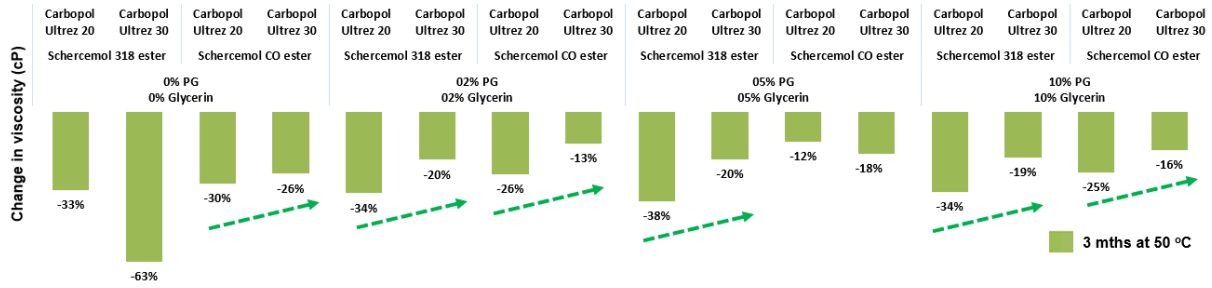
Graph 28: Stability Change in Viscosity – spindle 4 (cP)

Absence of obvious change in viscosity after 3 months stability test at room temperature in most of the samples.



Graph 29: Stability Brookfield Viscosity – spindle 4 at 3 mth Oven (cP)

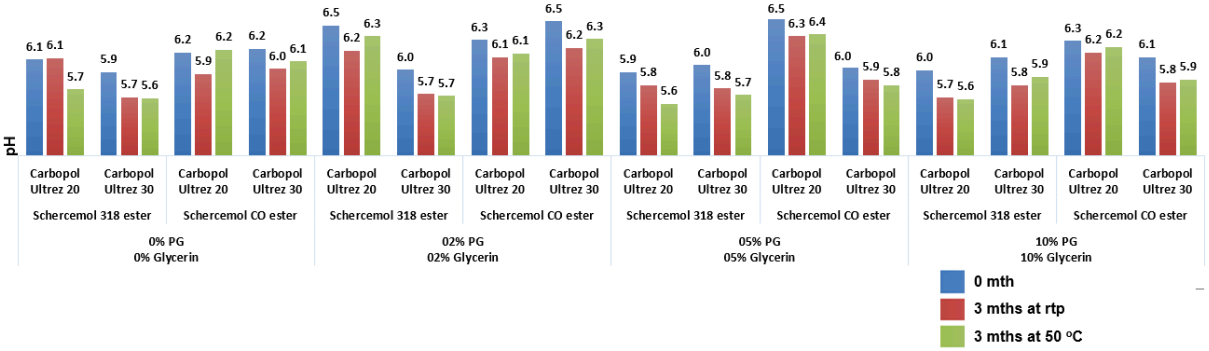
For the stability test after 3 months at 50°C, Carbopol Ultrez 30 is shown to have a higher viscosity in general as compared to Carbopol Ultrez 20 throughout as the levels of humectants increases from 0% to 10% Propylene glycol and Glycerine.



Graph 30: Stability Brookfield Viscosity % change – spindle 4 at 3mth

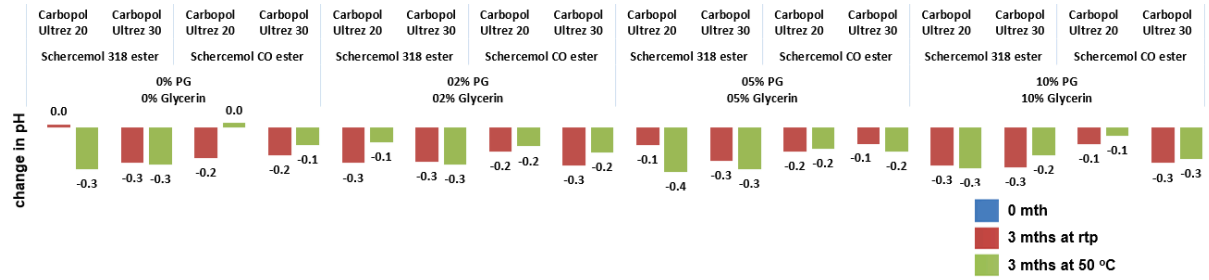
As seen in the ‘Stability Brookfield Viscosity change in percent – spindle 4 at 3 mth Oven (cP) graph’, Carbopol Ultrez 20 is shown to experience a higher drop in viscosity as compared to Carbopol Ultrez 30 in most of the formulated samples.

3.6.4 pH



Graph 31: Stability pH values – from 0 mth to 3 mth

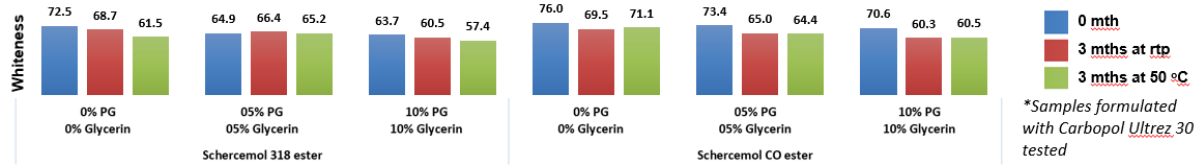
No clear trend can be observed from the 'Stability pH values – from 0mth to 3 mth' graphs above. However, it is observed that the pH values remain relatively unchanged after 3 months of stability test at room temperature and elevated temperature at 50°C.



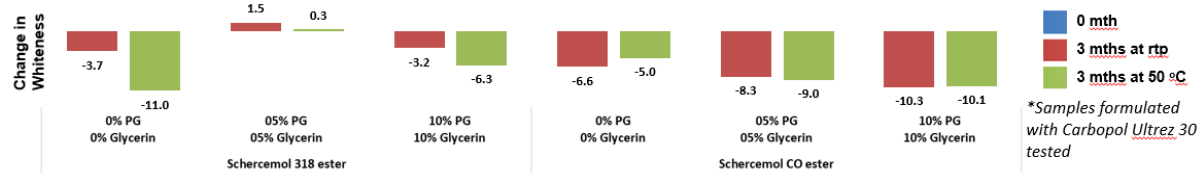
Graph 32: Stability Change in pH – 3 mth Oven and rtp

No clear trend can be observed from the 'Stability pH change in percent – at 3 mth' graphs above. However, it is observed that the pH values remain relatively unchanged after 3 months of stability test at room temperature and elevated temperature at 50°C.

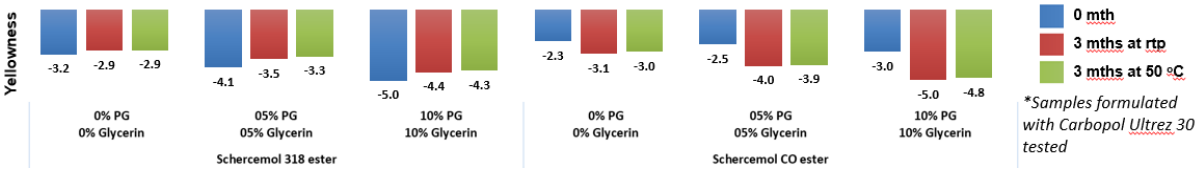
3.6.5 Colour



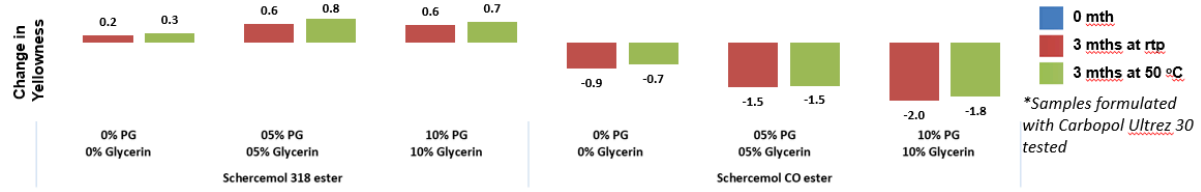
Graph 33: Stability WI E313 [D65/10] – from 0 mth to 3 mth



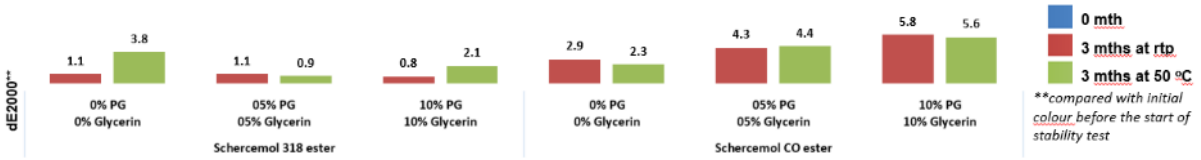
Graph 34: Stability Change in WI E313 [D65/10] – 3 mth Ultrez 30



Graph 35: Stability YI E313 [D65/10] – from 0 mth to 3 mth



Graph 36: Stability Change in YI E313 [D65/10] – 3 mth Ultrez 30

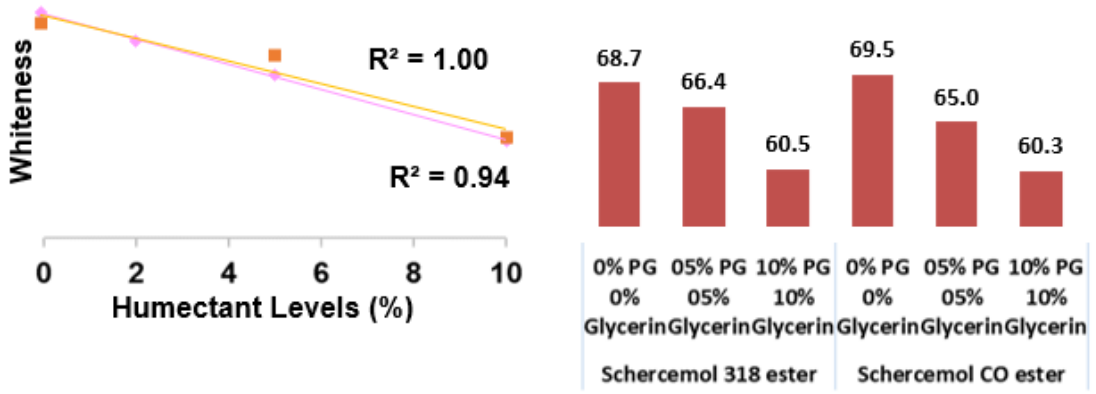


Graph 37: Stability dE2000 – 3 mth Carbopol Ultrez 30

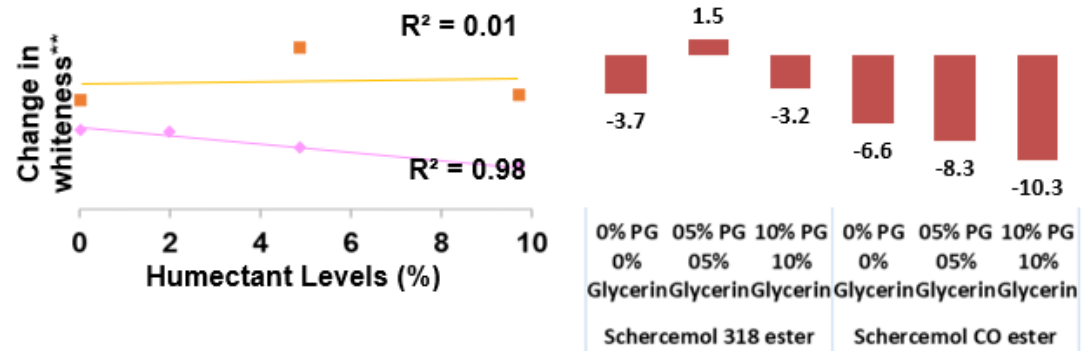
Generally, from Graph 34 to 38, the Whiteness and Yellowness values increases after 3 months of stability test over time conducted at room temperature and at 50°C while independent of each's temperature condition subjected.

From both the esters used in the formulated samples, Schercemol CO ester is shown to give rise to an increase in the Whiteness and Yellowness values as clearly shown in Graphs no (Stability Change in YI E313 [D65/10] – 3 mth Carbopol Ultrez 30, Stability dE2000 – 3 mth Carbopol Ultrez 30, Stability Change in WI E313 [D65/10] – 3 mth Carbopol Ultrez 30). This means that Schercemol CO ester will give rise to a higher colour change as compared to Schercemol 318 ester. This colour tone shift seems to be different between both the emollient grades used as shown in the samples.

3.6.6 Colour for Carbopol Ultrez 30, 3rd month at rtp

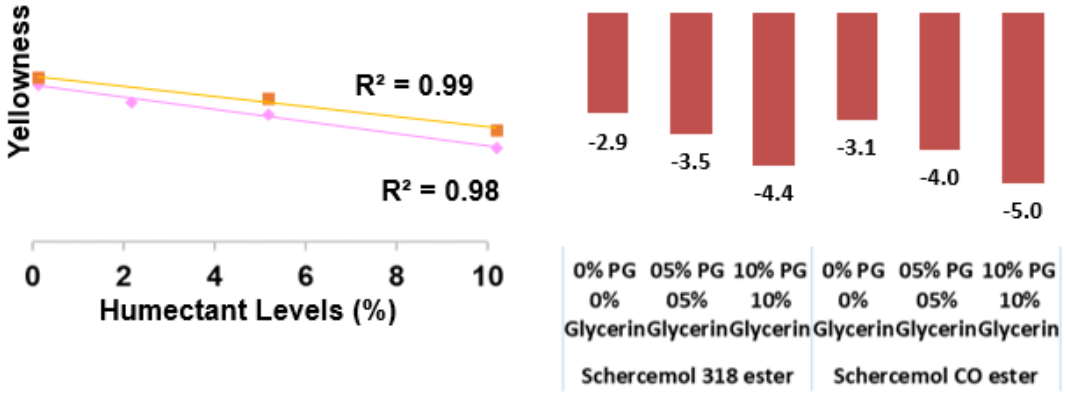


Graph 38: Stability WI E313 [D65/10] – 3 mth at rtp

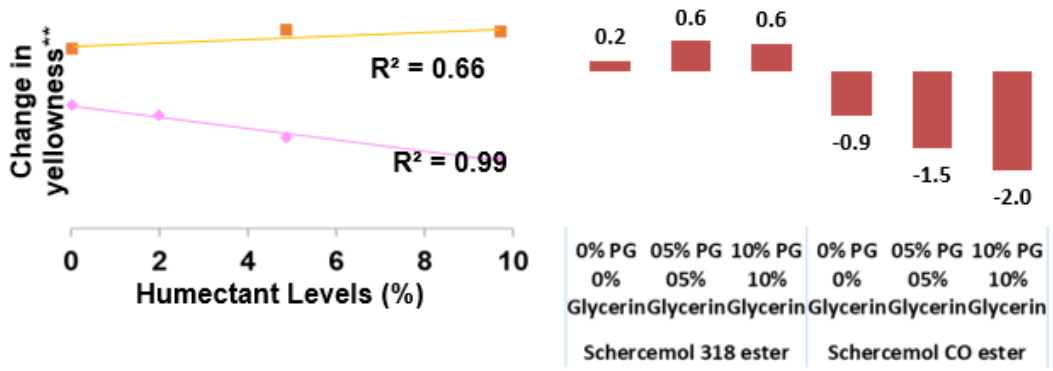


Graph 39: Stability Change in WI E313 [D65/10] – 3 mth at rtp

**Compared with initial colour before the start of the stability test.

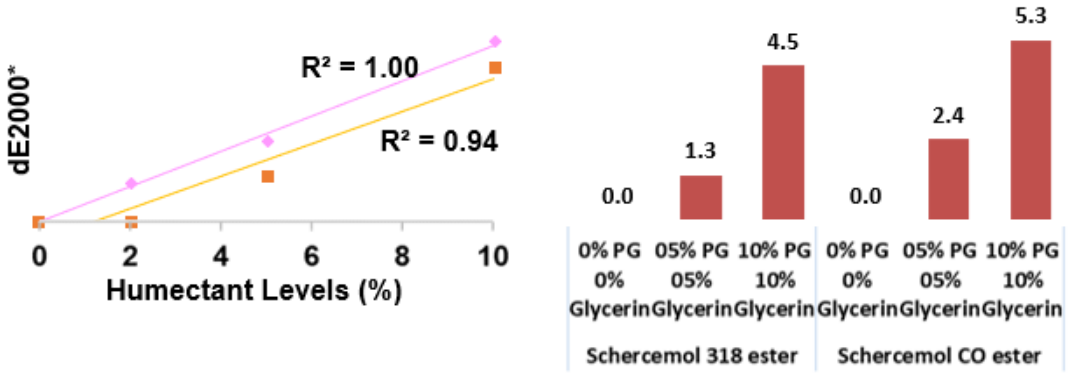


Graph 40: Stability YI E313 [D65/10] – 3 mth at rtp



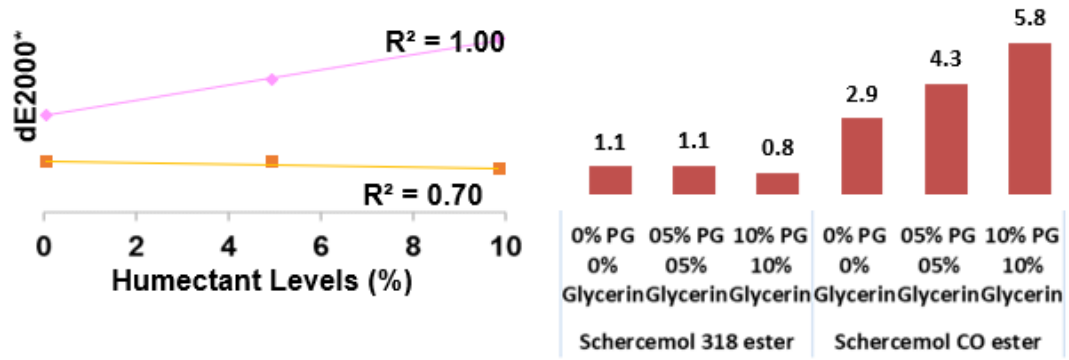
Graph 41: Stability Change in YI E313 [D65/10] – 3 mth at rtp

**Compared with initial colour before the start of the stability test.



Graph 42: Stability dE2000 – 3 mth at rtp

*Formulation at 0% Humectant levels is set as the standard for the same set.



Graph 43: Stability Change in dE2000 – 3 mth at rtp

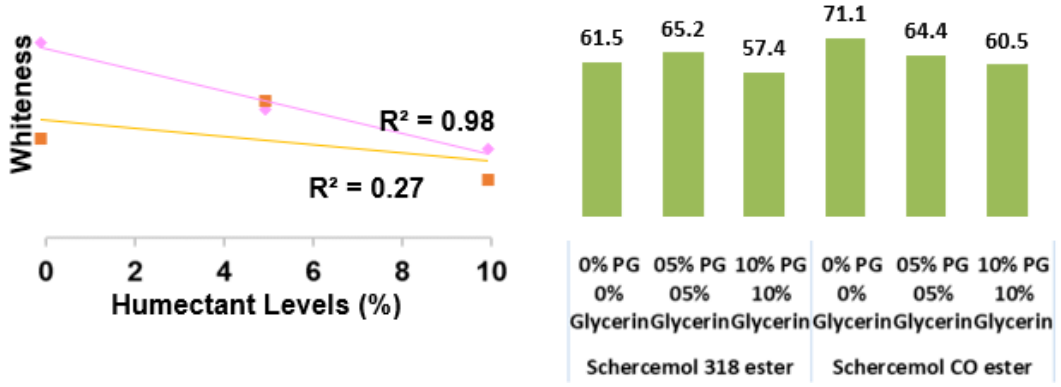
*Formulation at 0% Humectant levels is set as the standard for the same set.

Generally, as observed from Graph 39 to 44 for 3 months at room temperature. The increase in the level of humectant will lead to a decrease in Whiteness value and an increase in Yellowness value.

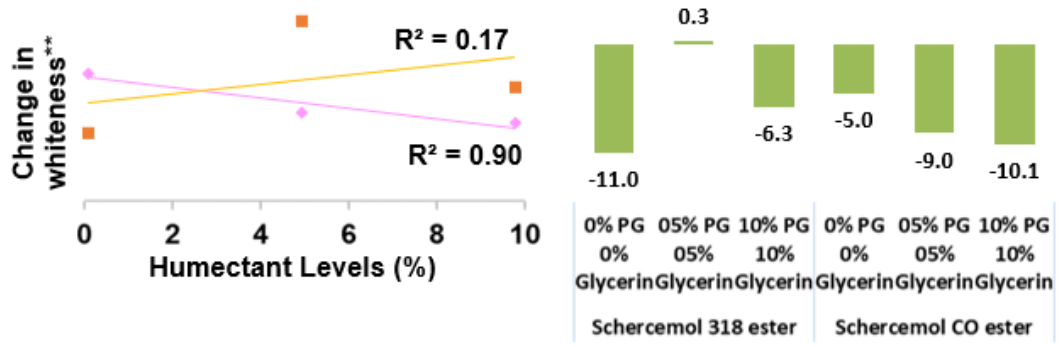
When 5% Humectant levels are being added into the formulated products, noticeable colour change can be observed compared to without the addition of Humectants inside the formulated products.

As for the samples that were formulated using Schercemol CO ester, as the amount of Humectants added increases, the higher the change in colour observed in both the Whiteness and Yellowness values compared to the initial colour before the stability test.

3.6.7 Colour for Carbopol Ultrez 30, 3rd month at Oven

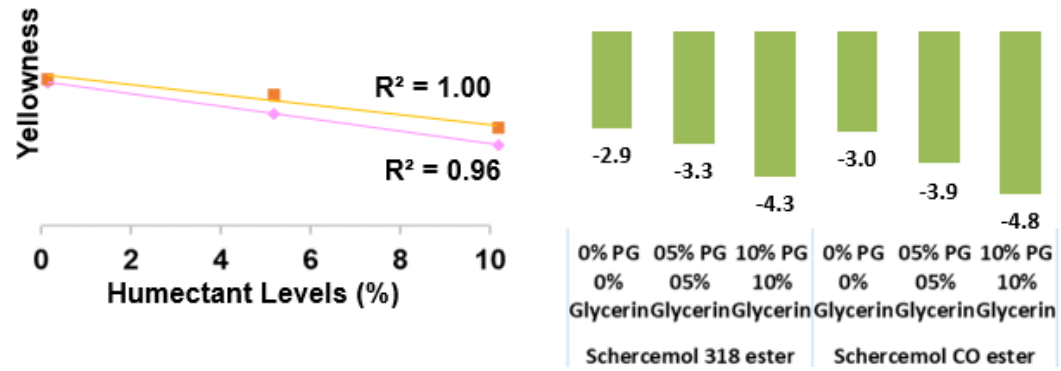


Graph 44: Stability WI E313 [D65/10] – 3 mth at Oven

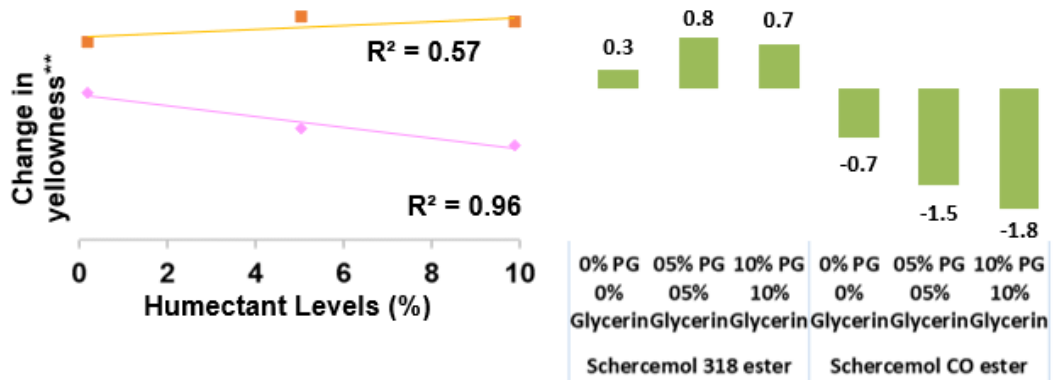


Graph 45: Stability Change in WI E313 [D65/10] – 3 mth at Oven

** Compared with initial colour before the start of the stability test.

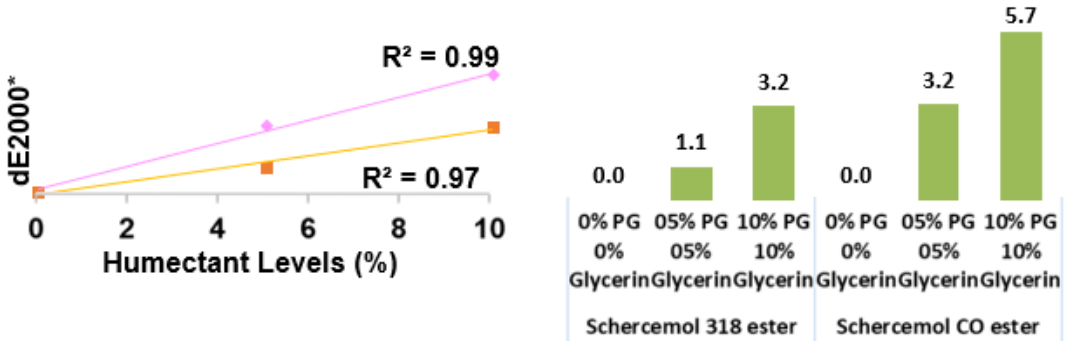


Graph 46: Stability YI E313 [D65/10] – 3 mth at Oven



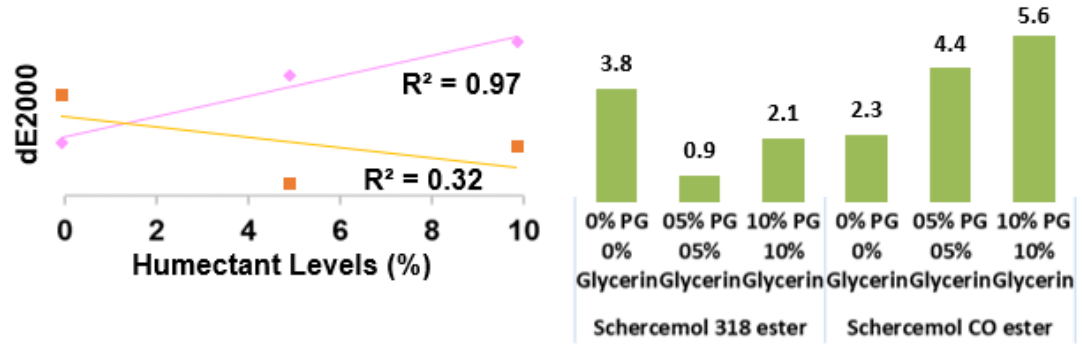
Graph 47: Stability Change in YI E313 [D65/10] – 3 mth at Oven

**Compared with initial colour before the start of the stability test.



Graph 48: Stability dE2000 – 3 mth at Oven

* Formulation at 0% Humectant levels is set as the standard for the same set.



Graph 49: Stability Change in dE2000 – 3 mth at Oven

Generally, as observed from Graph X to X for 3 months at room temperature. The increase in the level of humectant will lead to a decrease in Whiteness value and an increase in Yellowness value.

When 5% Humectant levels are being added into the formulated products, noticeable colour change can be observed compared to without the addition of Humectants inside the formulated products.

As for the samples that were formulated using Schercemol CO ester, as the amount of Humectants added increases, the higher the change in colour observed in both the Whiteness and Yellowness values compared to the initial colour before the stability test. This is the same trend that was observed in “3.6.6 Appearance for Carbopol Ultrez 30, 3rd month at rtp”.

3.6.8 Overview of results and discussion

General trends after Stability Test

	Observations
Viscosity	Decreases
pH	Remains relatively unchanged
Colour	Whiteness decreases and yellowness increases in both temperature conditions. More prominent colour change in the set with Schercemol CO ester. Colour tone shift seems to be different between samples between 2 emollient grades.

Table 50: General trend after stability test

Properties		**Trends observed before start of stability tests**		**Trend still true after stability**
		Carbopol Ultrez 20	**Carbopol Ultrez 30**	
Viscosity		Lower	Higher	Yes
Texture	**Firmness**	Lower	Higher	Yes
	Cohesiveness	Lower	Higher	Yes
	Stringiness	Higher	Lower	Yes

Table 51: Rheological Modifier performance after stability

Properties		**Schercemol 318 ester**	**Schercemol 318 ester**	**Trend still true after stability**
Viscosity		Lower	Higher	Yes
Texture	**Firmness**	Lower	Higher	Yes
	Cohesiveness	Lower	Higher	Yes
Colour (Yellowness)		Higher	Lower	Yes, in Schercemol 318 and no for Schercemol CO ester.

Table 52: Emollient Trend after stability

Properties		**Increasing level of Humectant**	**Trend still true after stability**
Gloss		Slight increase	Yes
Colour	**Whiteness**	Increase	Yes
	Yellowness	Increase	Yes
	dE2000 (Colour difference as compared samples	Addition of just 2% of Propylene Glycol and Glycerine starts to lead	Yes

	with no Humectants added	to slight noticeable change in colour	

Table 53: Humectant Trend after stability

Discussion

As observed from the Overview of results, most of the trends and differentiations observed on raw materials used before the stability test are still true after the stability test.

When the Stability Brookfield viscosity was placed together, clear observations can be seen that the viscosity of the samples placed at 50°C for stability testing had a significant decrease in viscosity levels as compared to the 0 months viscosity readings. This is further supported by the Graphs which clearly shows the drop in viscosity. However, for most of the sample stored at room temperature, there was no obvious change in the viscosity levels.

As seen in above, (pH and change in pH), the pH levels after stability at room temperature and at 50°C remain relatively unchanged, however, the pH values did drop in most of the samples as seen in graph (change in pH). This might mean that stability testing for a longer period might decrease the pH levels.

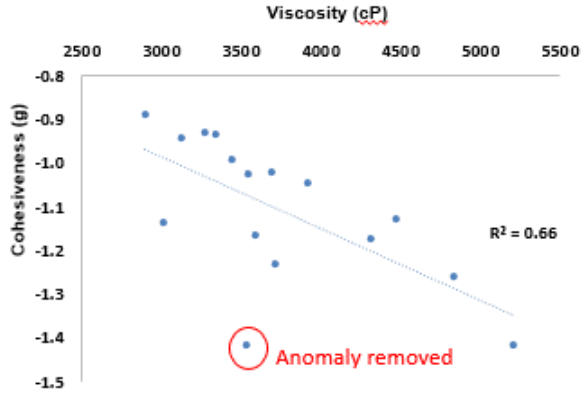
During the results analysis for the colour of the samples, it is observed that Schercemol Co ester experiences a drop in Whiteness and increase in Yellowness as seen more clearly in Schercemol CO ester formulated samples.

3.7 Correlation between results

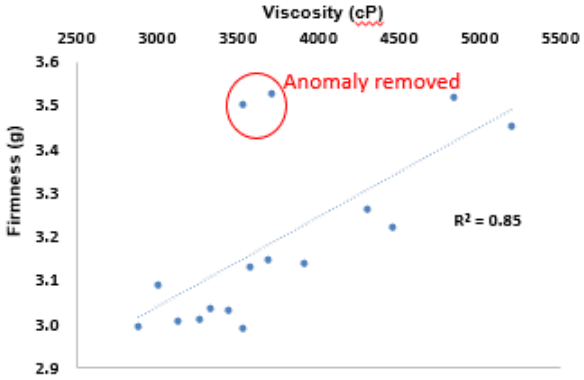
This part of the chapter will be split into sub-parts to properly cover all the different graphs and the summary and discussion points mentioned as listed below.

1. Viscosity vs Texture (3.7.1)
2. Viscosity vs pH (3.7.2)
3. Gloss vs Colour (3.7.3)
4. Overview of results (3.7.4)
5. Discussion (3.7.5)

3.7.1 Viscosity vs Texture



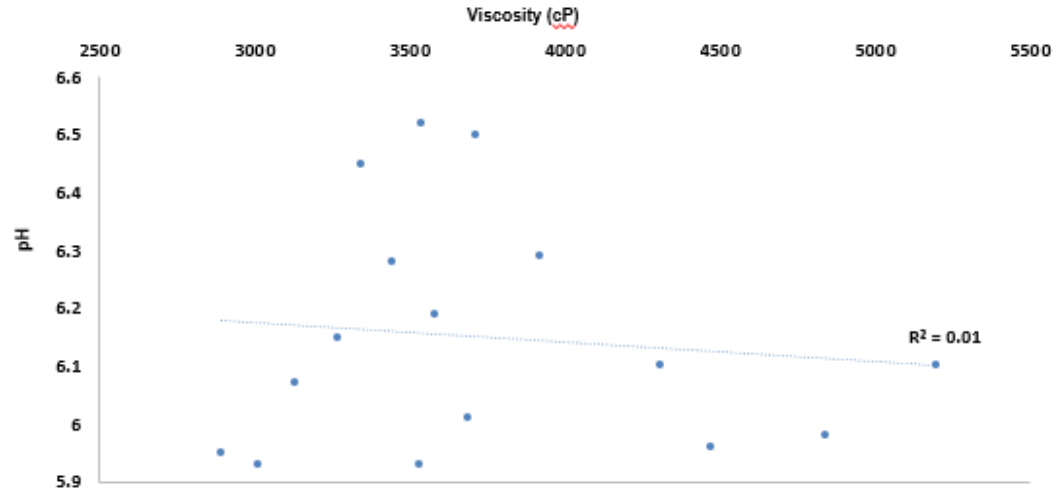
Graph 50: Viscosity vs Cohesiveness



Graph 51: Viscosity vs Firmness

When both Graph 51 and 52 are being compared against texture properties, ignoring the anomalies, it is observed that as the Viscosity increases, the Cohesiveness and the Firmness increases accordingly.

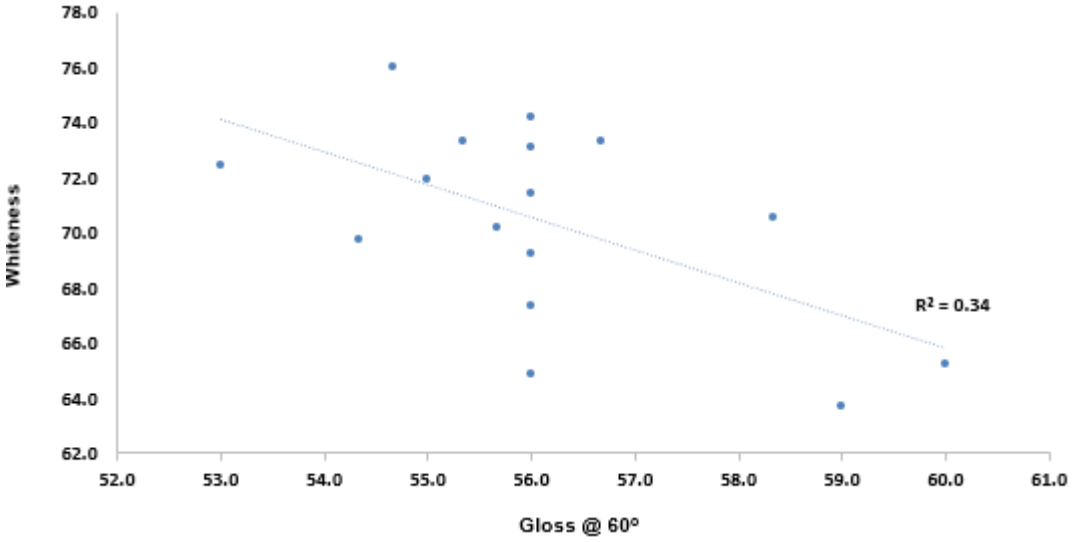
3.7.2 Viscosity vs pH



Graph 52: Viscosity vs pH

No clear correlation can be observed between Viscosity and pH.

3.7.3 Gloss vs Colour



Graph 53: Gloss vs Colour

No clear correlation can be observed between Gloss and Colour.

3.7.4 Overview of results and discussion

Properties	R^2	Correlation
Viscosity vs Cohesiveness	0.66	Strong Correlation observed
Viscosity vs Firmness	0.85	Strong Correlation observed
Viscosity vs pH	0.01	No Correlation observed
Gloss vs Colour	0.34	No Correlation observed

Table 54: Correlation between results

Discussion

From the Correlation between results as obtained as above, the R^2 for Viscosity with Cohesiveness and Firmness is well correlated with each other when the anomalies are being ignored.

Cohesion refer to the sticking of particles of the Lotion together that is placed under stress. The cohesion of the particles itself leads to the development of surface tension to occur when stress is being applied to the Lotion[]. Due to the decreasing cohesiveness present, leading to lower surface tension present in the formulated product which in turns decreases the bond strengths of each of the particles present, leading to a higher viscosity level observed.

There is very little evidence to relate both firmness and viscosity together, this means that the correlation between firmness and viscosity is not clearly understood. From the results obtained, it is clearly seen that the increase in viscosity leads to the increase in firmness. This is because, as the viscosity increases, the formulated product becomes more ‘solid’ in nature and as such thicker, this leads to the firmness of the formulated product to increase as well due to the ‘thicker’ formulation which in turn shows up.

Chapter 4 Conclusion

From the test results obtained from the test conducted, the following conclusions can be drawn. Each of different “raw material” and “Methodology” contributes to the conclusion drawn.

1. Impact of raw materials (4.1)
2. Methodology (4.2)

2.1 Impact of raw materials

Rheological Modifier:

When Texture analysis is conducted on Rheological Modifier sets, clear observations is seen in that Rheological Modifier Carbopol Ultrez 30 will give rise to a higher Firmness and Cohesiveness value as compared to Rheological Modifier Carbopol Ultrez 20.

As for the Stringiness measured in the Rheological Modifier set, it is observed that Rheological Modifier Carbopol Ultrez 20 gives rise to a higher Stringiness value as compared to Rheological Modifier Carbopol Ultrez 30 which is opposite of both Firmness and Cohesiveness obtained during the Texture analysis.

Similar trends are observed after the stability tests, this could be due to the differences in the network structures form between the 2 polymers.

From the stability test, we have observed that all samples dropped in viscosity after 3 months of heating aging in oven, for samples formulated with Carbopol Ultrez 20 generally experienced a bigger drop in viscosity. Further investigation can be done to understand the reason behind this observation.

Emollient:

The Emollient used in the formulated products affects the final Yellowness value obtained during the Colour measurement (Spectrophotometer), and formulations with Schercemol 318 ester have a higher yellowness, and this is due to the intrinsic yellowness of Schercemol 318 ester.

When both Emollient Schercemol CO ester and Schercemol 318 ester, is used in the formulated products, Schercemol CO ester is shown to give rise to a higher viscosity compared to Schercemol 318 ester. This is also supported by data obtained conducted by the Texture analysis which shows that Schercemol CO ester will give rise to a higher Firmness and Cohesiveness value compared to Schercemol 318 ester.

In general, most of the earlier observed trends remains true both before and after the three months stability test except for the Emollient for Colour as Schercemol 318 remains true while Schercemol CO does not remains true.

Humectant:
As the amount of Humectants Propylene Glycol and Glycerine increases from 0% to 10%, there is a slight increase in the Gloss level which can be clearly seen across all sets of formulated products. This is because, humectants have higher refractive index as compared to the rest of the raw materials in the formulation. This can clearly be seen with the addition of Humectants from 0% to 10% can be clearly correlated to the increase in Whiteness, decrease in Yellowness and the dE2000 values. This could be due to the slight yellowness of the humectant grade used. Similar trends are also observed after stability tests.

Conclusion on the use of raw materials:
Both the Emollients and Humectants used in the formulated products affects the yellowness obtained during the colour measurement (Spectrophotometer). Thus, careful consideration should be taken during the formulation with these types of raw materials to avoid the negative impacts on colour.

There is a presence of a clear trend in viscosity to indicate that Rheological Modifier Carbopol Ultrez 30 and Emollient Schercemol CO ester used in the formulated products gives rise to a higher viscosity as compared to the other Rheological Modifier Carbopol Ultrez 20 and Emollient Schercemol 318 ester used during the formulation process to formulate the product.

4.2 Methodology

From the test results and analysis of “Wet Stage” Gloss and Colour of formulated products, we can confidently say that as the dosage of Humectant used increases during the formulation, the “Wet Stage” Gloss and Colour of formulated products experienced a positive correlated increase as supported with evidence. Hence, we can confidently conclude that we have developed reliable ways to evaluate wet stage gloss and colour samples.

In both the Cohesiveness and Firmness results obtained from the Texture Analysis Spreadability, it provides a clear differentiation between both Rheological Modifier Carbopol Ultrez 30 and Carbopol Ultrez 20 that were used in the formulation and hence tested. This is well-correlated with the already known performances. However, the methodology itself has not provided any evidence on the increase in Cohesiveness due to the increase in the Glycerine content which is also another known performance, indicating that the increase in Stickiness could be compensated by the effects of both the Rheological Modifier Carbopol Ultrez 30 and Carbopol Ultrez 20.

This could also mean that the test method is not reliable enough and requires more study to be conducted.

Chapter 5 Directions for Future Studies

In sensory profiling of a personal care product, there are many functional ingredients that play a role in sensory attributes of personal care products used in our daily lives such as Rheological modifiers, emulsifiers, and emollients.

Listed in this chapter are the further possible studies that can be conducted to find out more about the sensory attributes such as Gloss, Whiteness, Yellowness, Stickiness etc. If there is a success in the correlation are established between instrumental characterization and sensory attributes, the personal care industry could potentially save time and resources required to conduct labour-intensive and subjective sensory testing.

1. Impact of Rheological Modifier: (5.1)
2. Impact of Emollients (5.2)
3. Impact of the level of Humectant (5.3)
4. Correlating instrumental analysis and sensory attributes (5.4)

5.1 Impact of Emollients

Further investigation can be done to understand the reason for the drop in viscosity after 3 months of stability test in oven.

The potential synergy effect of Carbopol Ultrez 30 and the emollients should also be further investigated.

5.2 Impact of Emollients

More work could be done to investigate the possible reasons for difference in viscosity results from known performances of the grades tested. A possible direction that could be further investigated would be the droplet size of both the Emollients used during the formulation process.

Schercemol CO ester should undergo stability testing in the oven at 50°C, to check if Schercemol CO ester has caused the shift in colour that was observed in the samples that were formulated with Schercemol CO ester.

It is not clear if the amount of Emollient used during the formulation process would affect the final Gloss and Viscosity readings, as such requiring more investigation to be conducted.

5.3 Impact of the level of Humectant

Both the Humectant Glycerine and Propylene Glycol could have different impacts on the formulated product such as Stickiness. As the dosage of Humectants used is increased simultaneously during the formulation, it makes it impossible for the analysis of the impact of each type of humectant. Therefore, it may be worthwhile to conduct a separate study to study the analysis of the impact of the Humectants.

Further investigations could be conducted to ensure the validity of the stickiness and cohesiveness results that are obtained from the texture tests conducted. We can then understand, the potential benefits of the rheology modifier on the control of stickiness even as the glycerine level is increased. Stickiness is an undesirable attribute with the addition of glycerine. Possible ways to help in the control the undesirable attribute leads to much flexibility in formulation.

5.4 Correlating instrumental analysis and sensory attributes

For this project, we assess the relevance and reliable of our instrumental test methods by drawing comparison with known performances of the raw materials tested.

Sensory testing should also be conducted to ensure that the conclusions drawn from the testing conducted on the formulated products are consistent with the consumers' perceptions.

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Appendix A

Ingredients used in the Formulation of a Masterbatch

20_CO Masterbatch Formulation

20_CO Master batch (Theoretical Weight makeup Percentage)			**20_CO Master batch (Actual Weight makeup)**		
Ingredients			**Ingredients**		
Phase A	**Theoretical Weight**	**Weight Percentage**	**Phase A**	**Actual Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.25%	Deionized Water	1485 grams	74.244%
Disodium EDTA	1 gram	0.05%	Disodium EDTA	1.047 grams	0.052%
Carbopol® Ultrez 20	4 grams	0.002%	Carbopol® Ultrez 20	4.019 grams	0.002%
Phase B	**Theoretical Weight**	**Weight Percentage**	**Phase B**	**Actual Weight**	**Weight Percentage**
Schercemol Emollient CO	100 grams	5%	Schercemol Emollient CO	100.007 grams	4.99%
Phase C	**Theoretical Weight**	**Weight Percentage**	**Phase C**	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%	Microcare PEHG	10.043 grams	0.502%
Total	**1600 grams**	**80%**	**Total**	**1600.116 grams**	**79.988%**
Acceptable pH range	**5.3 ~ 5.8**		**pH Level**		**5.2**

Table : 20_CO Masterbatch Formulation

20_318 Masterbatch Formulation

20_318 Master batch (Theoretical Weight makeup Percentage)			**20_318 Master batch (Actual Weight makeup)**		
Ingredients			**Ingredients**		
Phase A	**Theoretical Weight**	**Weight Percentage**	**Phase A**	**Actual Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.25%	Deionized Water	1485 grams	74.25%
Disodium EDTA	1 gram	0.05%	Disodium EDTA	1.009 grams	0.05%
Carbopol® Ultrez 20	4 grams	0.002%	Carbopol® Ultrez 20	4.105 grams	0.002%
Phase B	**Theoretical Weight**	**Weight Percentage**	**Phase B**	**Actual Weight**	**Weight Percentage**
Schercemol Emollient 318	100 grams	5%	Schercemol Emollient 318	100.066 grams	5.00%
Phase C	**Theoretical Weight**	**Weight Percentage**	**Phase C**	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%	Microcare PEHG	10.401 grams	0.502%
Total	**1600 grams**	**80%**	**Total**	**1600.581 grams**	**79.804%**
Acceptable pH range	**5.3 ~ 5.8**		**pH Level**		**5.72**

Table : 20_318 Masterbatch Formulation

30_CO Masterbatch Formulation

30_CO Master batch (Theoretical Weight makeup Percentage)			**30_CO Master batch (Actual Weight makeup)**		
Ingredients			**Ingredients**		
Phase A	**Theoretical Weight**	**Weight Percentage**	**Phase A**	**Actual Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.25%	Deionized Water	1485 grams	74.244%
Disodium EDTA	1 gram	0.05%	Disodium EDTA	1.07 grams	0.0534%
Carbopol® Ultrez 30	4 grams	0.002%	Carbopol® Ultrez 30	3.95 grams	0.0019%
Phase B	**Theoretical Weight**	**Weight Percentage**	**Phase B**	**Actual Weight**	**Weight Percentage**
Schercemol Emollient CO	100 grams	5%	Schercemol Emollient CO	100.346 grams	5.01%
Phase C	**Theoretical Weight**	**Weight Percentage**	**Phase C**	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%	Microcare PEHG	10.00 grams	0.5%
Total	**1600 grams**	**80%**	**Total**	**1600.116 grams**	**80.2899%**
Acceptable pH range	**5.3 ~ 5.8**		**pH Level**		**5.42**

Table : 30_CO Masterbatch Formulation

30_318 Masterbatch Formulation

30_318 Master batch (Theoretical Weight makeup Percentage)			**30_318 Master batch (Actual Weight makeup)**		
Ingredients			**Ingredients**		
Phase A	**Theoretical Weight**	**Weight Percentage**	**Phase A**	**Actual Weight**	**Weight Percentage**
Deionized Water	1485 grams	74.25%	Deionized Water	1453 grams	72.62%
Disodium EDTA	1 gram	0.05%	Disodium EDTA	1.00 grams	0.05%
Carbopol® Ultrez 30	4 grams	0.002%	Carbopol® Ultrez 30	4.05 grams	0.002%
Phase B	**Theoretical Weight**	**Weight Percentage**	**Phase B**	**Actual Weight**	**Weight Percentage**
Schercemol Emollient 318	100 grams	5%	Schercemol Emollient 318	100.00 grams	5.00%
Phase C	**Theoretical Weight**	**Weight Percentage**	**Phase C**	**Actual Weight**	**Weight Percentage**
Microcare PEHG	10 grams	0.5%	Microcare PEHG	10.038 grams	0.501%
Total	**1600 grams**	**80%**	**Total**	**1600.581 grams**	**78.173%**
Acceptable pH range	**5.3 ~ 5.8**		**pH Level**		**5.86**

Table : 30_318 Masterbatch Formulation

Phase A + B + C Ingredients Weight

Phase A + B + C Ingredients Theoretical Weight								
Master Batch	**Deionised Water**	**EDTA Disodium Salt**	**Ultrez 20**	**Ultrez 30**	**Microcare PEHG**	**Schercemol CO ester**	**Schercemol 318 ester**	**Total Weight**
20_CO	1485 grams	1 gram	4 grams	-	10 grams	100	-	1600 grams
30_CO	1485 grams	1 gram	-	4 grams	10 grams	100	-	1600 grams
20_318	1485 grams	1 gram	4 grams	-	10 grams	-	100	1600 grams
30_318	1485 grams	1 gram	-	4 grams	10 grams	-	100	1600 grams
Phase A + B + C Ingredients Actual Weight								
Master Batch	**Deionised Water**	**EDTA Disodium Salt**	**Ultrez 20**	**Ultrez 30**	**Microcare PEHG**	**Schercemol CO ester**	**Schercemol 318 ester**	**Total Weight**
20_CO	1485 grams	1.047 gram	4.019 grams	-	10.043 grams	100.007 grams	-	1600.116 grams
30_CO	1485 grams	1.07 gram	-	3.95 grams	10 grams	100.346 grams	-	1600.116 grams
20_318	1485 grams	1.009 gram	4.105 grams	-	10.401 grams	-	100.066 grams	1600.581 grams
30_318	1485.3 grams	1.00 gram	-	4.05 grams	10.038 grams	-	100.000 grams	1600.581 grams

Table : Master batch Phase A + B + C Ingredients Weight

Ingredients used in the Formulation of the Individual batches

20_CO Individual Batch

20_CO Individual Batch Theoretical Weight				
Batch	**20_CO_1**	**20_CO_2**	**20_CO_3**	**20_CO_4**
20_CO Master Batch	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)
Propylene Glycol	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Glycerine	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Deionized Water	80 grams (20% Weight)	64 grams (16% Weight)	40 grams (10% Weight)	-
Total Weight	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)
20_CO Individual Batch Actual Weight				
Batch	**20_CO_1**	**20_CO_2**	**20_CO_3**	**20_CO_4**
20_CO Master Batch	320.088 grams (80% Weight)	320.088 grams (80% Weight)	320.059 grams (80% Weight)	320.065 grams (80% Weight)
Propylene Glycol	-	8.04 grams (2% Weight)	19.998 grams (5% Weight)	40.07 grams (10% Weight)
Glycerine	-	8.019 grams (2% Weight)	20.027 grams (5% Weight)	40.103 grams (10% Weight)
Deionized Water	80.015 grams (20% Weight)	64.01 grams (16% Weight)	40.028 grams (10% Weight)	-
Obtained pH Level	5.95	5.95	6.28	5.98
Total Weight	400.103 grams (100% Weight)	400.157 grams (100% Weight)	400.112 grams (100% Weight)	400.238 grams (100% Weight)

Table : 20_CO Individual Batch

30_CO Individual Batch

30_CO Individual Batch Theoretical Weight				
Batch	**30_CO_1**	**30_CO_2**	**30_CO_3**	**30__CO_4**
30_CO Master Batch	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)
Propylene Glycol	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Glycerine	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Deionized Water	80 grams (20% Weight)	64 grams (16% Weight)	40 grams (10% Weight)	-
Total Weight	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)
30_CO Individual Batch Actual Weight				
Batch	**30_CO_1**	**30_CO_2**	**30_CO_3**	**30_CO_4**
30_CO Master Batch	320.05 grams (80% Weight)	320.190 grams (80% Weight)	320.213 grams (80% Weight)	320.246 grams (80% Weight)
Propylene Glycol	-	8.281 grams (2% Weight)	20.039 grams (5% Weight)	39.834 grams (10% Weight)
Glycerine	-	8.557 grams (2% Weight)	20.034 grams (5% Weight)	40.093 grams (10% Weight)
Deionized Water	79.982 grams (20% Weight)	64.178 grams (16% Weight)	40.220 grams (10% Weight)	-
Obtained pH Level	6.13	6.35	5.93	6.02
Total Weight	400.032 grams (100% Weight)	401.206 grams (100% Weight)	400.506 grams (100% Weight)	400.173 grams (100% Weight)

Table : 30_CO Individual Batch

20_318 Individual Batch

20_318 Individual Batch Theoretical Weight				
Batch	**20_318_1**	**20_318_2**	**20_318_3**	**20_318_4**
20_318 Master Batch	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)
Propylene Glycol	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Glycerine	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Deionized Water	80 grams (20% Weight)	64 grams (16% Weight)	40 grams (10% Weight)	-
Total Weight	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)
20_318 Individual Batch Actual Weight				
Batch	**20_318_1**	**20_318_2**	**20_318_3**	**20_318_4**
20_318 Master Batch	320.085 grams (80% Weight)	320.032 grams (80% Weight)	320.083 grams (80% Weight)	320.058 grams (80% Weight)
Propylene Glycol	-	8.013 grams (2% Weight)	20.111 grams (5% Weight)	40.002 grams (10% Weight)
Glycerine	-	8.019 grams (2% Weight)	20.059 grams (5% Weight)	40.023 grams (10% Weight)
Deionized Water	80.026 grams (20% Weight)	64.011 grams (16% Weight)	40.053 grams (10% Weight)	-
Obtained pH Level	6.05	6.43	5.93	6.01
Total Weight	400.111 grams (100% Weight)	400.075 grams (100% Weight)	400.306 grams (100% Weight)	400.083 grams (100% Weight)

Table : 20_318 Individual Batch

30_318 Individual Batch

30_318 Individual Batch Theoretical Weight				
Batch	**30_318_1**	**30_318_2**	**30_318_3**	**30_318_4**
30_318 Master Batch	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)	320 grams (80% Weight)
Propylene Glycol	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Glycerine	-	8 grams (2% Weight)	20 grams (5% Weight)	40 grams (10% Weight)
Deionized Water	80 grams (20% Weight)	64 grams (16% Weight)	40 grams (10% Weight)	-
Total Weight	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)	400 grams (100% Weight)
30_CO Individual Batch Actual Weight				
Batch	**30_318_1**	**30_318_2**	**30_318_3**	**30_318_4**
30_318 Master Batch	320.085 grams (80% Weight)	320.032 grams (80% Weight)	320.083 grams (80% Weight)	320.058 grams (80% Weight)
Propylene Glycol	-	8.013 grams (2% Weight)	20.111 grams (5% Weight)	40.002 grams (10% Weight)
Glycerine	-	8.019 grams (2% Weight)	20.059 grams (5% Weight)	40.023 grams (10% Weight)
Deionized Water	80.026 grams (20% Weight)	64.011 grams (16% Weight)	40.053 grams (10% Weight)	-
Obtained pH Level	6.05	6.43	5.93	6.01
Total Weight	400.111 grams (100% Weight)	400.075 grams (100% Weight)	400.306 grams (100% Weight)	400.083 grams (100% Weight)

Table : 30_318 Individual Batch

Appendix B

Set Number	Set 1	Set 2	Set 3	Set 4
Individual batch codes	**20_CO**	**30_CO**	**20_318**	**30_318**
	20_CO_1	30_CO_1	20_318_1	30_318_1
	20_CO_2	30_CO_2	20_318_2	30_318_2
	20_CO_3	30_CO_3	20_318_3	30_318_3
	20_CO_4	30_CO_4	20_318_4	30_318_4

Table : Batch codes

Set 1	Left over	20_CO_1	20_CO_2	20_CO_3	20_CO_4
	Left over	20_CO_1	20_CO_2	20_CO_3	20_CO_4
	_L	20_CO_1_L	20_CO_2_L	20_CO_3_L	20_CO_4_L
	_RT	20_CO_1_RT	20_CO_2_RT	20_CO_3_RT	20_CO_4_RT
	_Ov	20_CO_1_Ov	20_CO_2_Ov	20_CO_3_Ov	20_CO_4_Ov

Table : Set 1 abbreviations

Set 2	Left over	30_CO_1	30_CO_2	30_CO_3	30_CO_4
	Left over	30_CO_1	30_CO_2	30_CO_3	30_CO_4
	_L	30_CO_1_L	30_CO_2_L	30_CO_3_L	30_CO_4_L
	_RT	30_CO_1_RT	30_CO_2_RT	30_CO_3_RT	30_CO_4_RT
	_Ov	30_CO_1_Ov	30_CO_2_Ov	30_CO_3_Ov	30_CO_4_Ov

Table : Set 2 abbreviations

Set 3	Left over	20_318_1	20_318_2	20_318_3	20_318_4
	Left over	20_318_1	20_318_2	20_318_3	20_318_4
	_L	20_318_1_L	20_318_2_L	20_318_3_L	20_318_4_L
	_RT	20_318_1_RT	20_318_2_RT	20_318_3_RT	20_318_4_RT
	_Ov	20_318_1_Ov	20_318_2_Ov	20_318_3_Ov	20_318_4_Ov

Table : Set 3 abbreviations

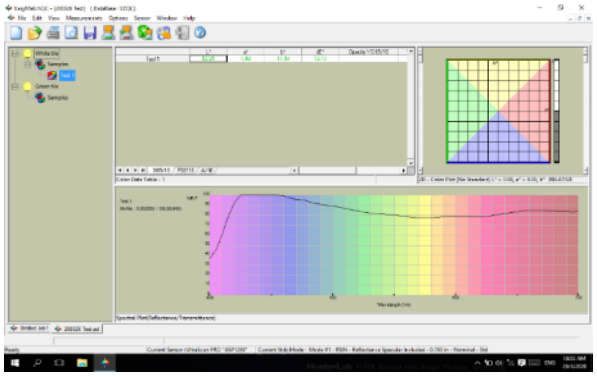
Set 4	Left over	30_318_1	30_318_2	30_318_3	30_318_4
	Left over	30_318_1	30_318_2	30_318_3	30_318_4
	_L	30_318_1_L	30_318_2_L	30_318_3_L	30_318_4_L
	_RT	30_318_1_RT	30_318_2_RT	30_318_3_RT	30_318_4_RT
	_Ov	30_318_1_Ov	30_318_2_Ov	30_318_3_Ov	30_318_4_Ov

Table : Set 4 abbreviation

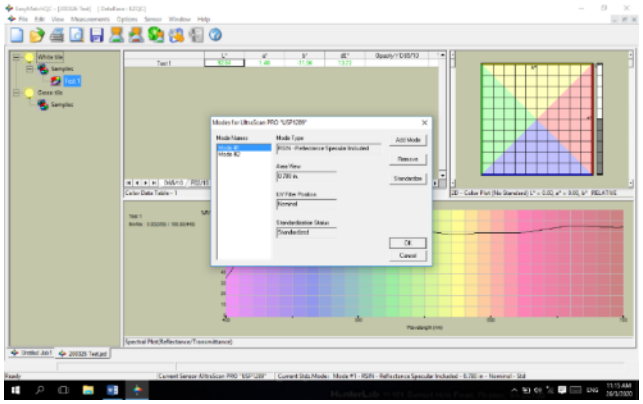
Appendix C

Sprectrophotometer test

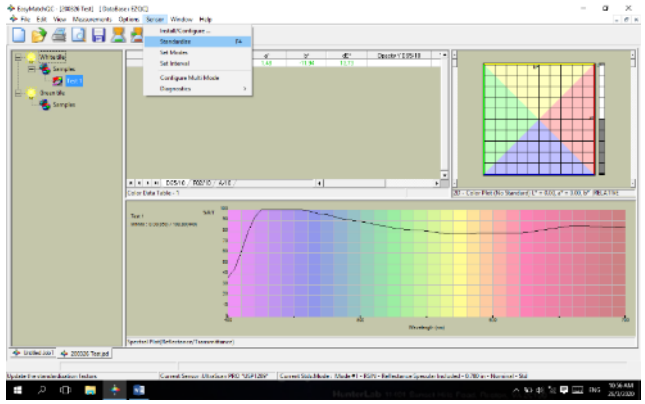
1. Open the relevant job file “200326 Test.jsd”



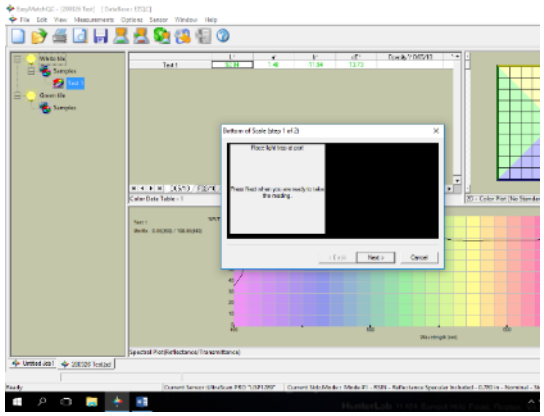
2. Set Mode



3. Calibrate
    1) Sensor
    2) Standardize



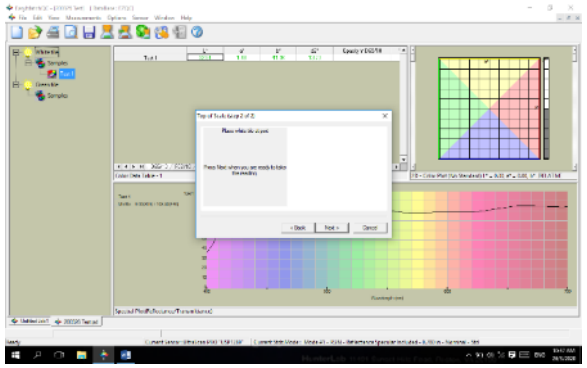
    1) Place black light trap at port
    2) Next





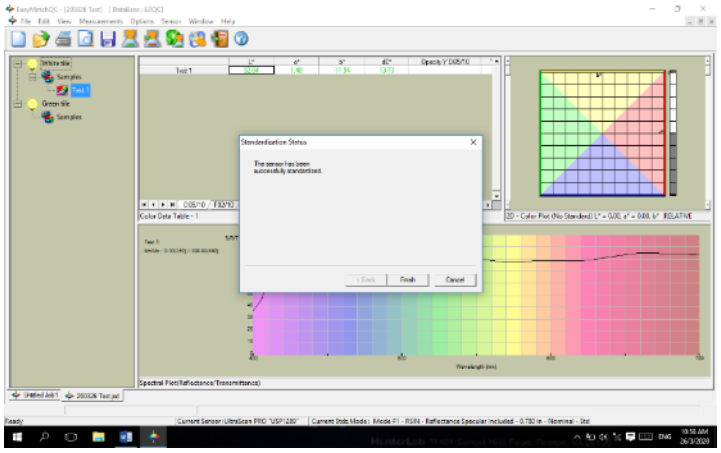
Place white light trap at port

3) Next

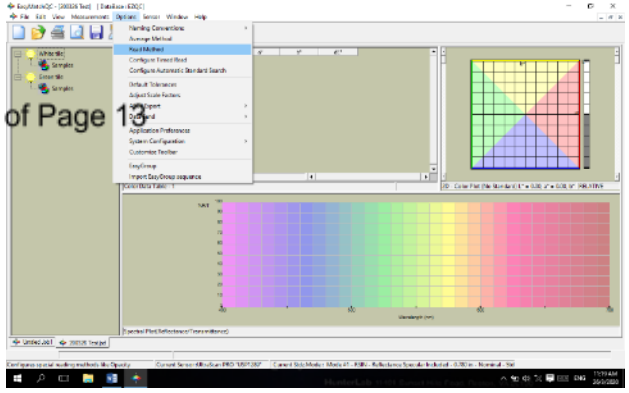




1) Finish

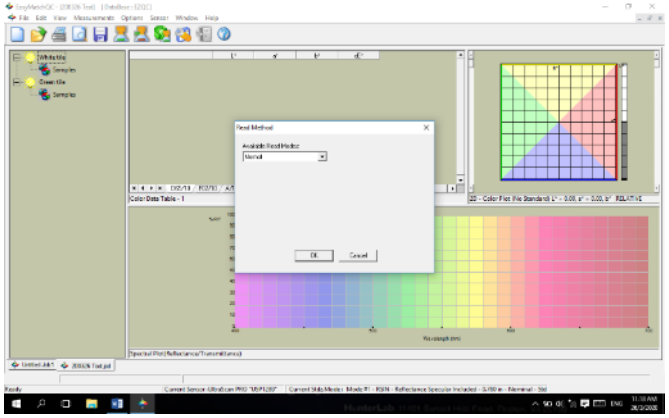


4. Read method
    1) Option
    2) Read method



Appendix C: Page 2 of Page 13

3) Normal
4) Ok



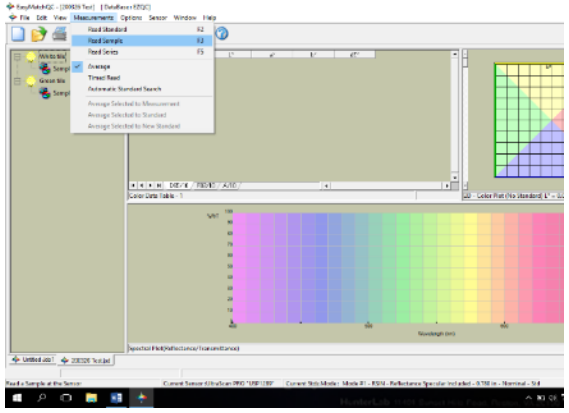
5. Fill up the Quarz Cell with the sample, make sure both clear sides are free of bubbles



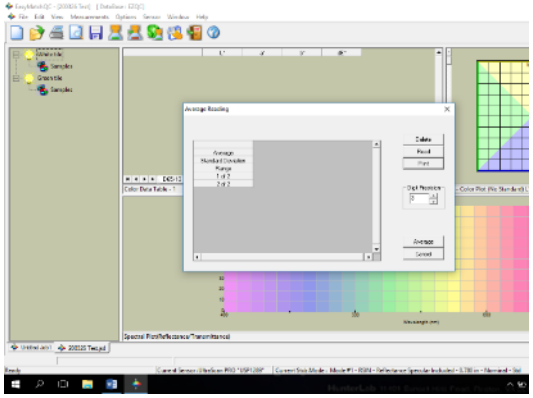
6. Place the Quarz cell on the sample platform and place the black cover on top of the cell



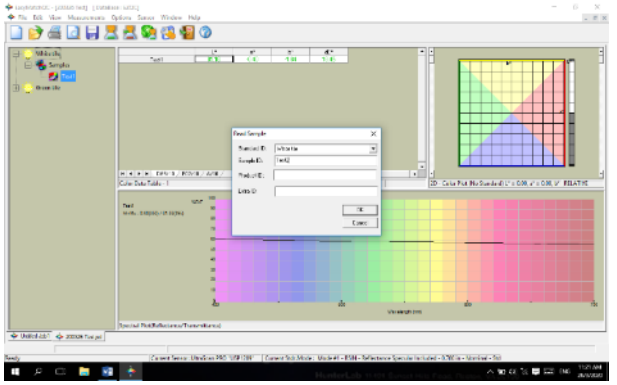

7. Measurement
    1) Measurment
    2) Read Sample



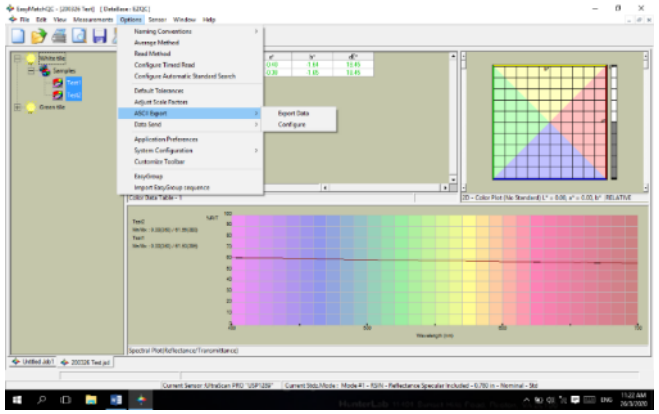
    3) Click Read
    4) Remove the black cover and flip the Quarz Cell
    5) Put the black cover back on
    6) Click Read again



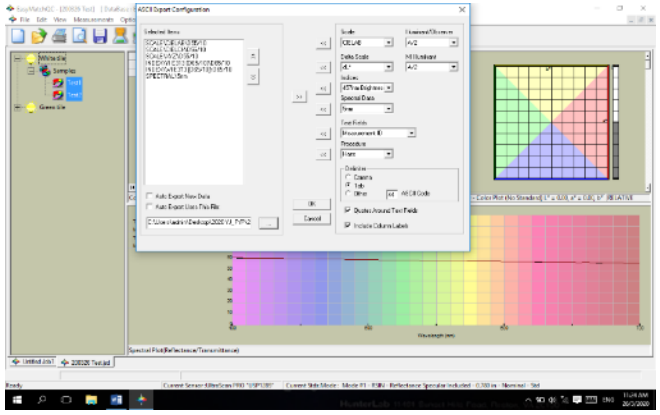
    7) Click
    7) Enter Sample ID e.g. 20_CO_1
    8) Ok



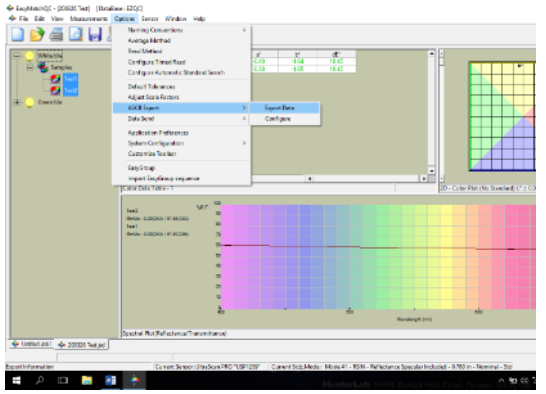
8. Remove the Quartz cell for cleaning
9. Repeat the test for the rest of the samples
10. Export data
    1) Option
    2) ASCII Export



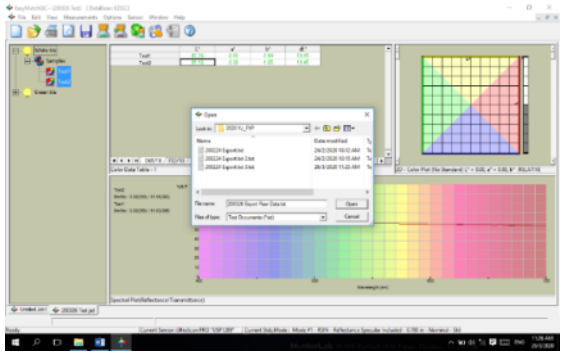
1) Configure



3) Export



4) Save as “200326 Export Raw Data”

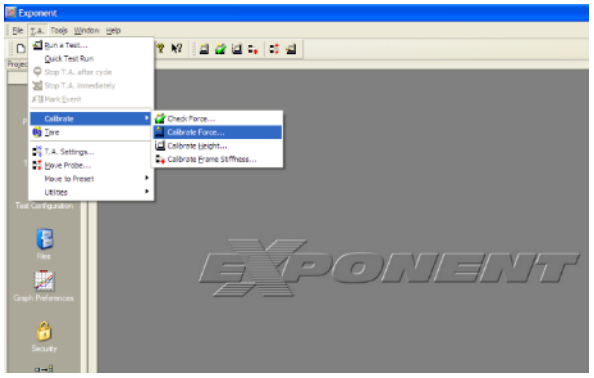


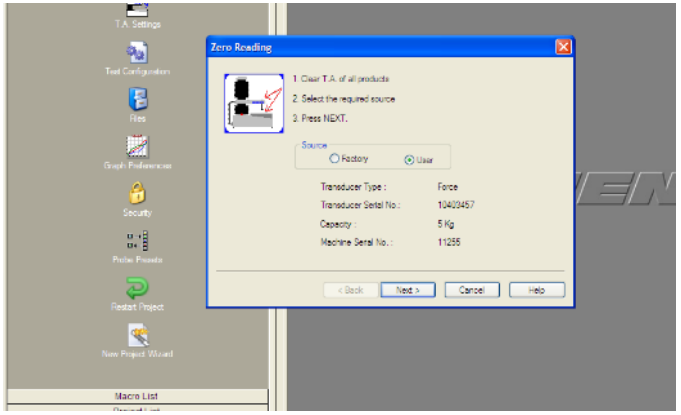
11. Convert txt to excel file
    1) Open txt file
    2) Ctrl a
    3) Ctrl c
    4) Ctrl v into excel file
    5) Add the sample names in the first column of the excel file

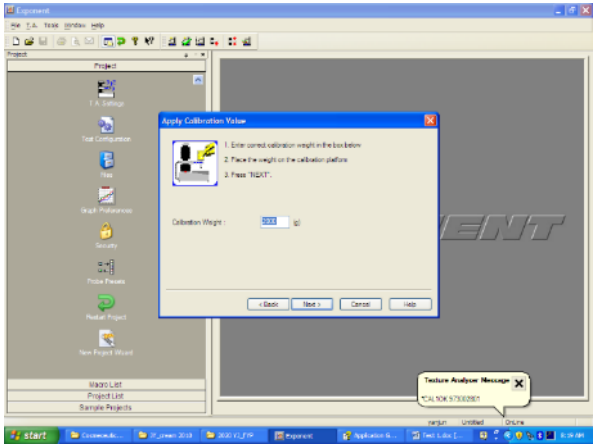
L* D55/10	a* D55/10	b* D55/10	L* D55/10	C* D55/10	h D55/10	X D55/10	Y D55/10	Z D55/10	YI E313 [D65/10]	WI E313 [D65/10]	350nm	355nm	360nm	365nm	370nm	375nm	380nm	385nm	390nm	395nm
81.14	-0.54	-1.66	81.14	1.75	252.09	56.03	58.72	54.99	-4.03	67.24	0	58.75	60.22	60.71	60.98	61.2	61.33	61.39	61.45	61.53
81.14	-0.52	-1.67	81.14	1.75	252.68	56.04	58.72	55	-4.04	67.28	0	59.24	60.36	60.83	61.41	61.5	61.55	61.44	61.47	61.43

Penetration test

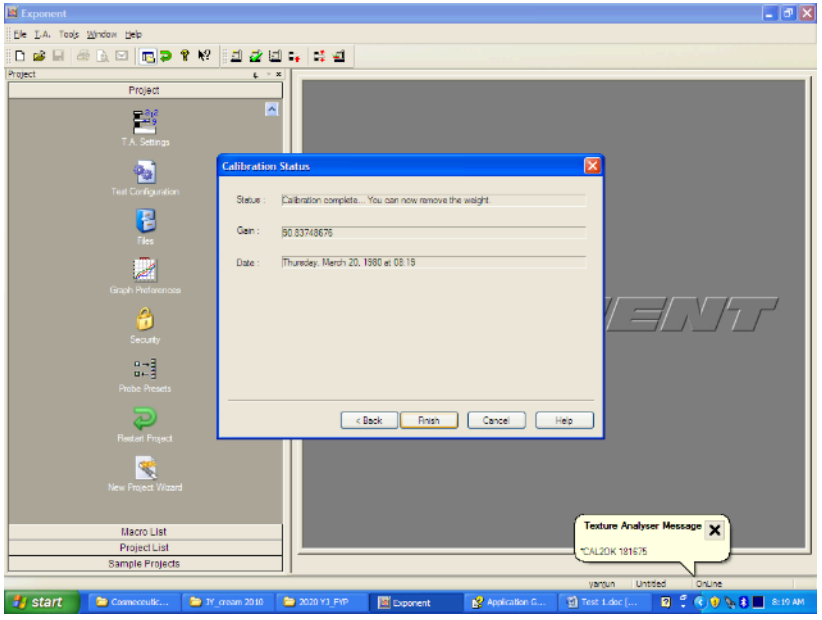
1. Open the relevant project file “Lotion Project 4.PRJ”
2. Calibration Force
   1) T.A.
   2) Calibrate
   3) Calibrate Force





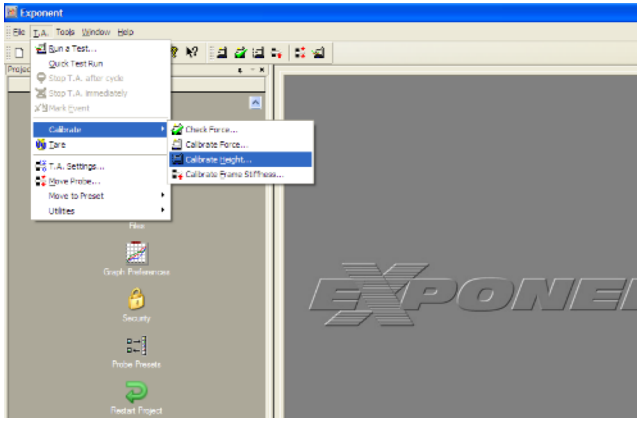






3. Calibration Height

1) T.A.
2) Calibrate
3) Calibrate Height



4) Use the following buttons to move the probe close to the base

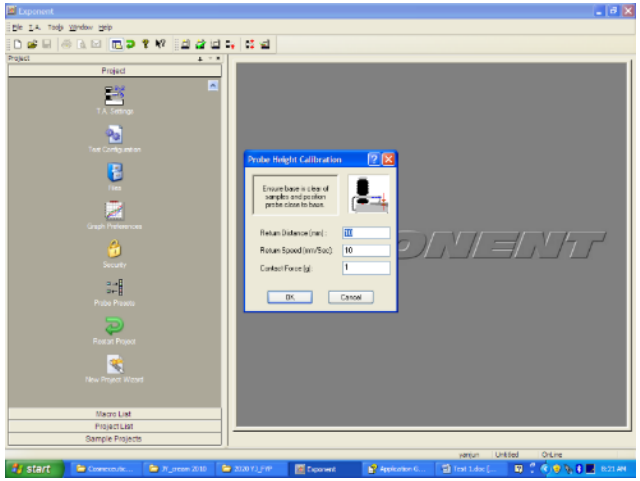


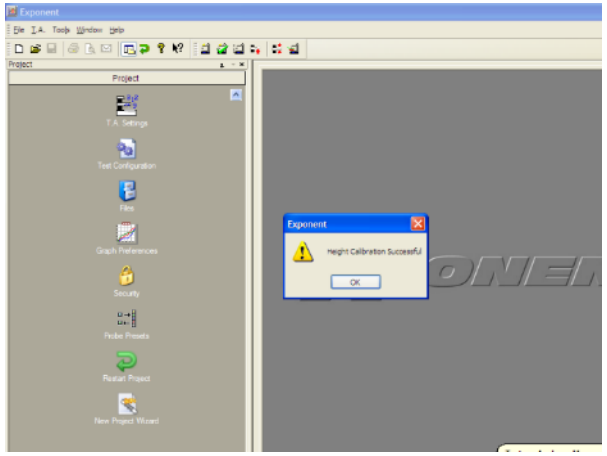




5) Click Ok

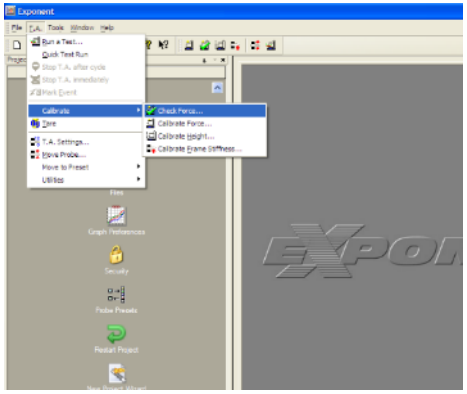
The probe will be lowered until it touches the plate and returns.



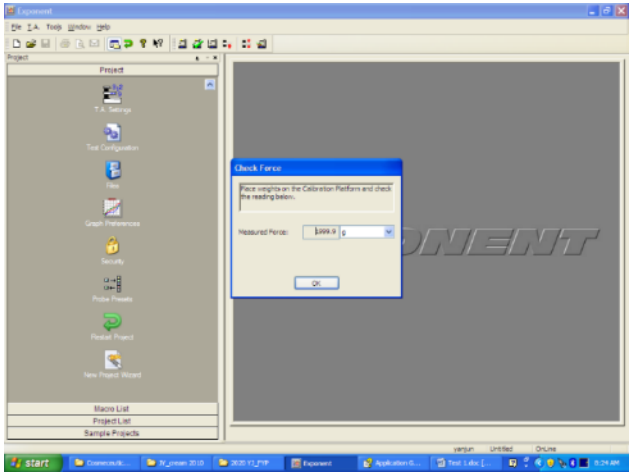


4. Check Force

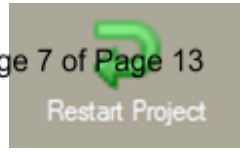
1) T.A.
2) Calibrate
3) Check force

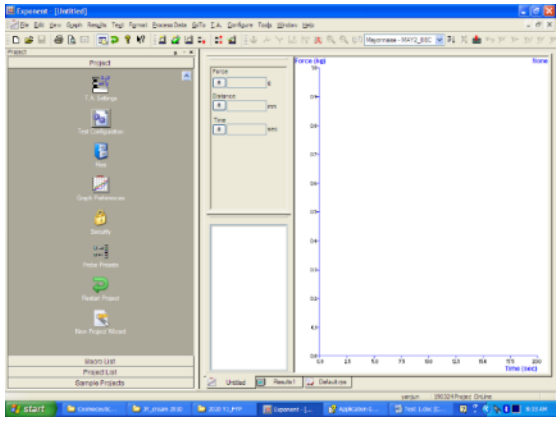




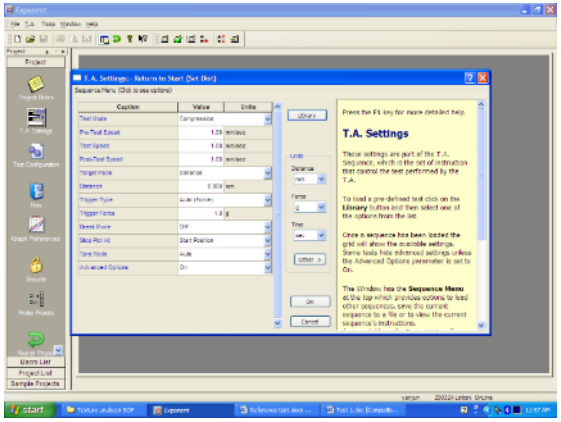


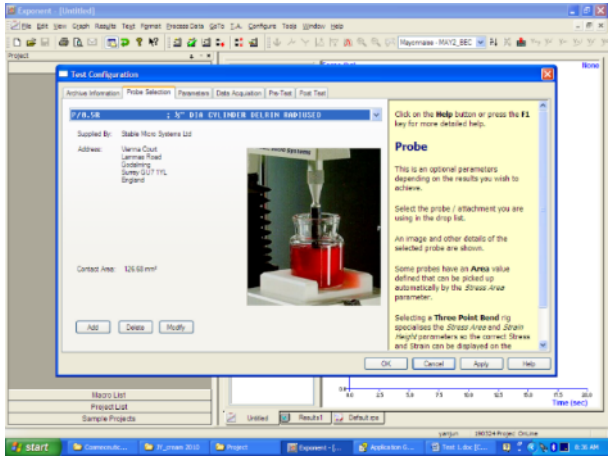
5. Select restart project





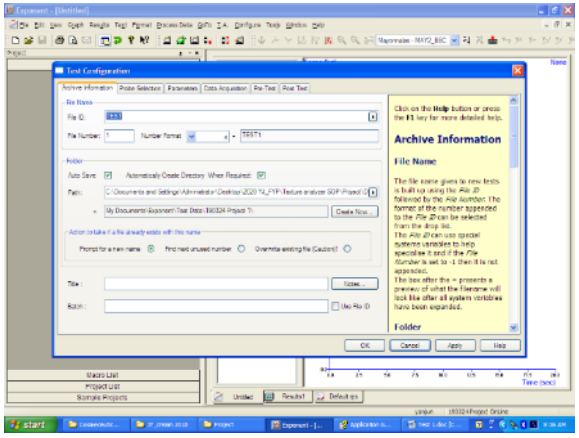
6. Select T.A. Settings

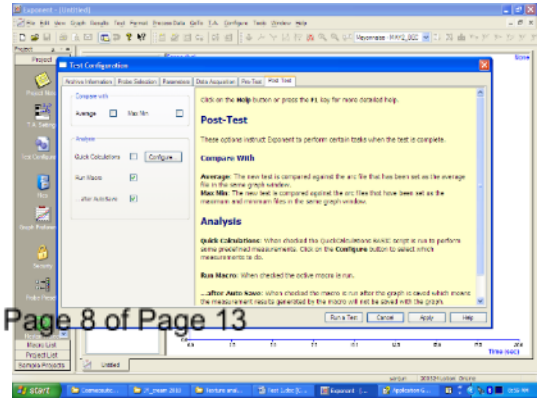




. Test configuration

File ID: sample name e.g. 20_CO_1





C: Page 8 of Page 13

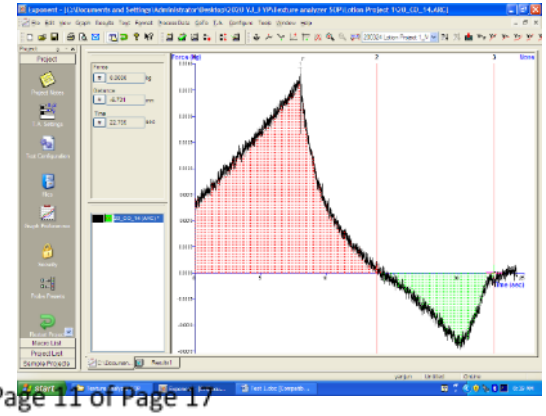
2) Click “Apply”
3) Place your sample bottom on the test platform
4) Use the following bottons to lower the probe into the sample container so that the probe is just above the surface of the lotion.



5) Use the following button to “Run a test”



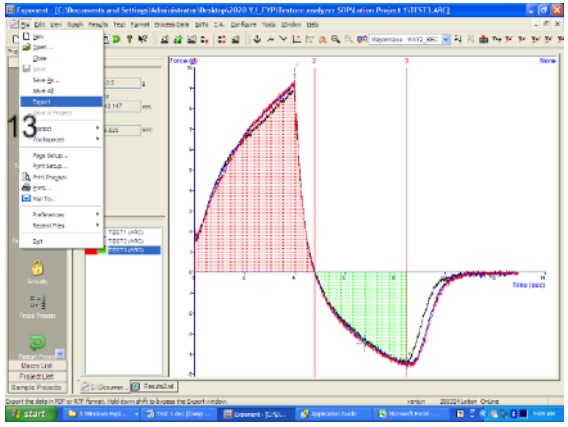
The results will be auto-generated once the test is completed.

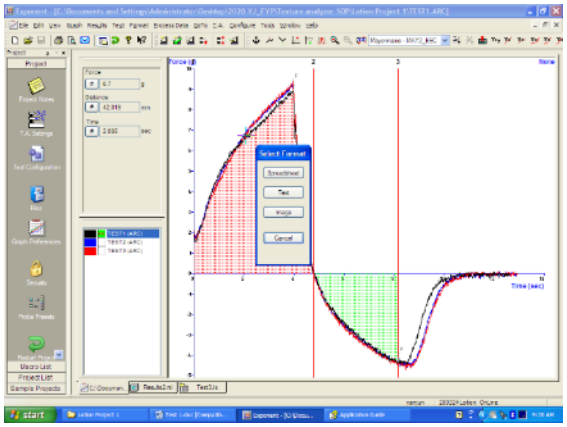


8. Data extraction
    1) To copy processed “Results” tab to excel
        - Ctrl a / select all columns
        - Ctrl c
        - Ctrl v in excel

Test ID	Batch		Firmness	Consistency	Cohesiveness	Index of Viscosity
			g	gsec	g	gsec
			Force 1	Area F-T 1:2	Force 2	Area F-T 2:3
Start Batch Unknown	Unknown					
TEST1	Unknown		8.939	26.832	-4.459	-9.42
TEST2	Unknown		9.291	27.465	-4.635	-11.162
TEST3	Unknown		9.412	27.295	-4.734	-11.193
End Batch Unknown	Unknown					
Average	Unknown (F)	AVERAGE("BATCH")	9.214	27.197	-4.609	-10.592
S.D.	Unknown (F)	STDEVP("BATCH")	0.201	0.267	0.114	0.829
C.V.	Unknown (F)	STDEVP("BATCH")/AVERAGE("BATCH")*100	2.179	0.983	-2.469	-7.822
End of Test Data						

2) To export raw data
    - Select the relevant sample (you will have to do this one by one)
    - Follow the following steps (twice)
        - File
        - Export
        - Spreadsheet
        - Save the excel file according to your sample name 20_CO_11

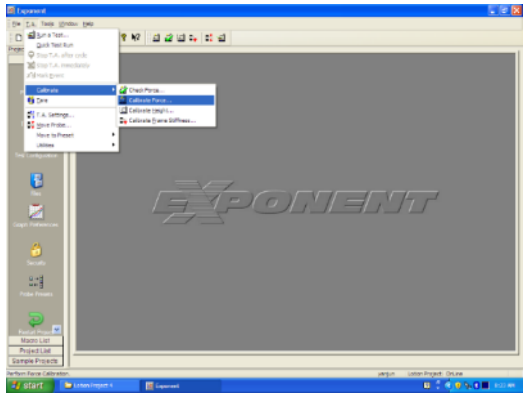


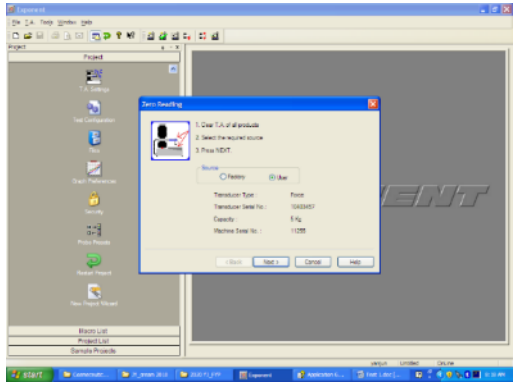


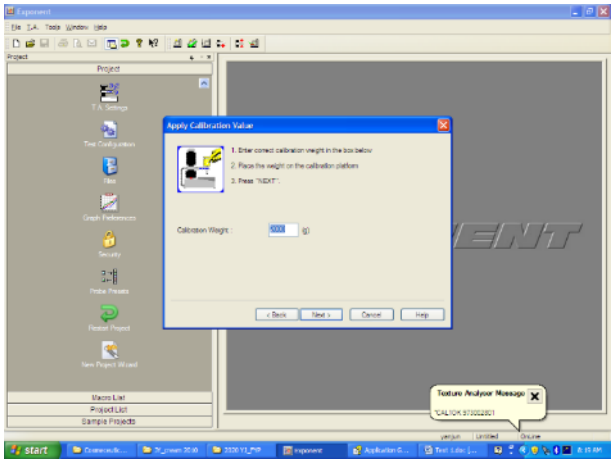
9. “Run 3 test” 3 times
10. Remove the sample bottle
11. Gently wipe the probe clean
12. Proceed with the next sample

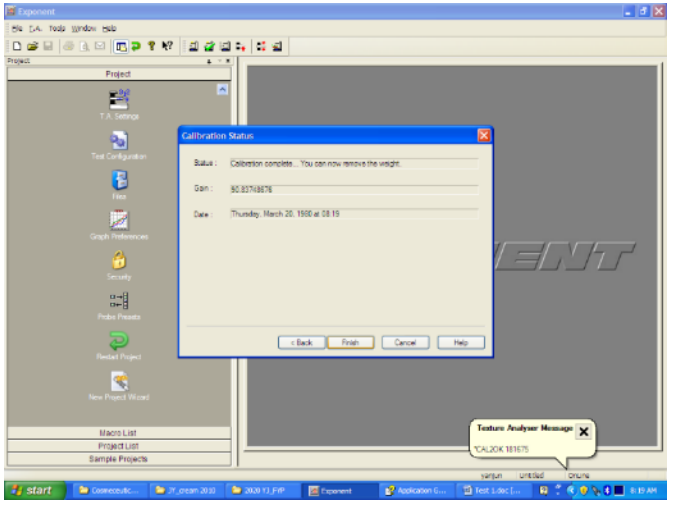
Spreadability test

1. Open the relevant project file “Lotion Project 3.PRJ”
2. Calibration Force
    1) T.A.
    2) Calibrate
    3) Calibrate Force

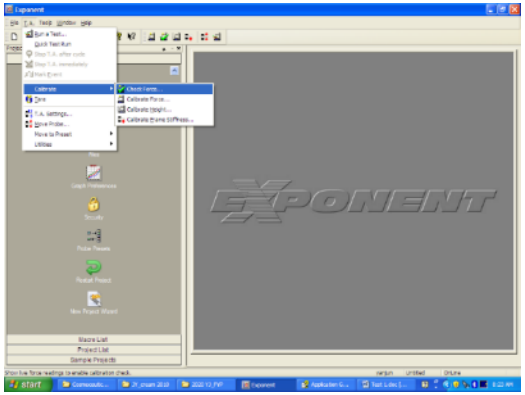




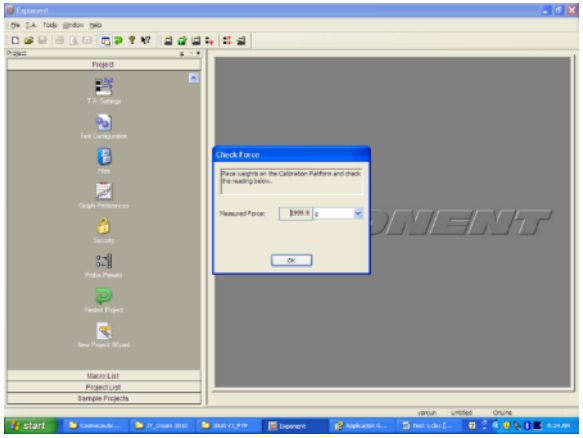




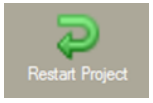
3. Check Force
    1) T.A.
    2) Calibrate
    3) Check force

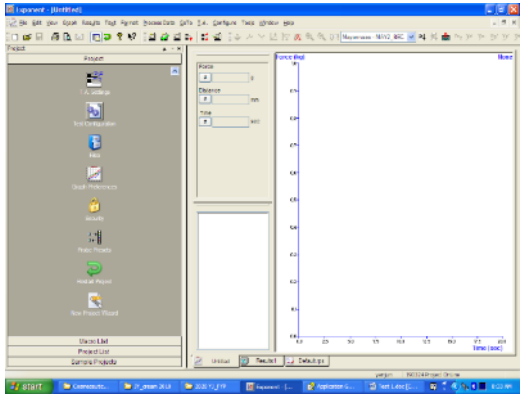




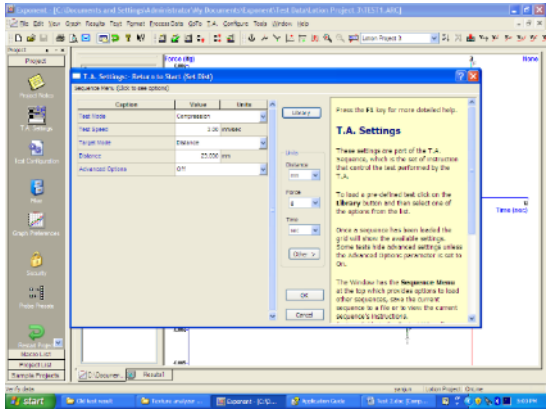


4. Select restart project

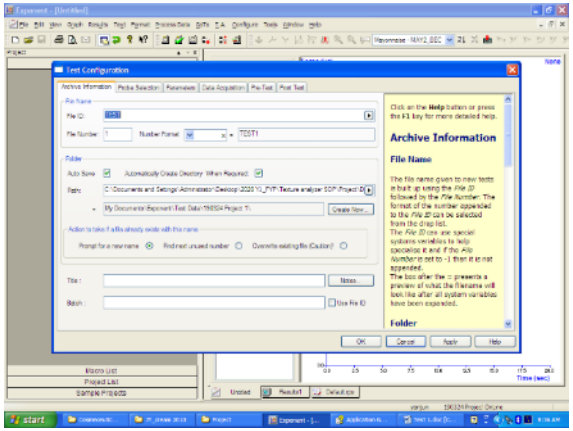


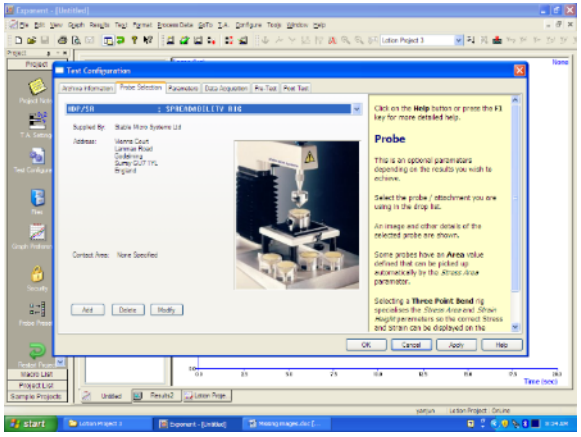


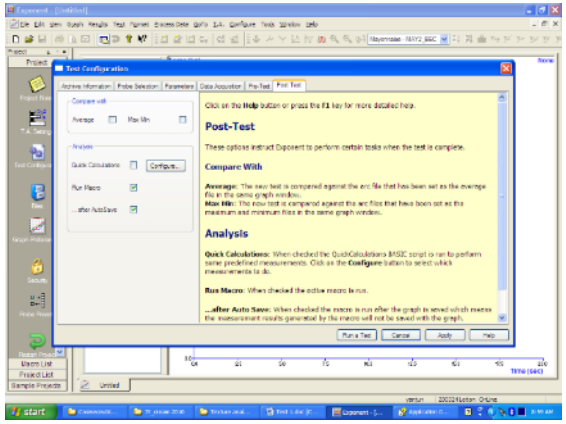
5. Select T.A. Settings



6. Test configuration
   1) File ID: sample name e.g. 20_CO_1







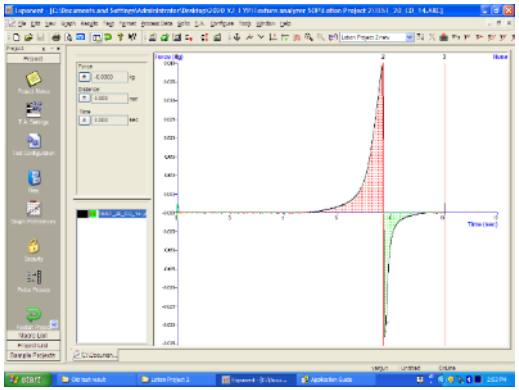
2) Click “Apply”
3) Squeeze your sample in the bottom cone



4) Use the following button to “Run a test”



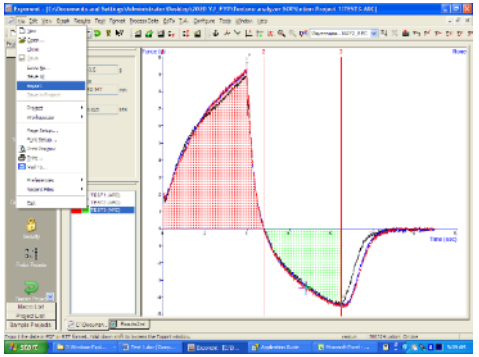
6) The results will be auto-generated once the test is completed

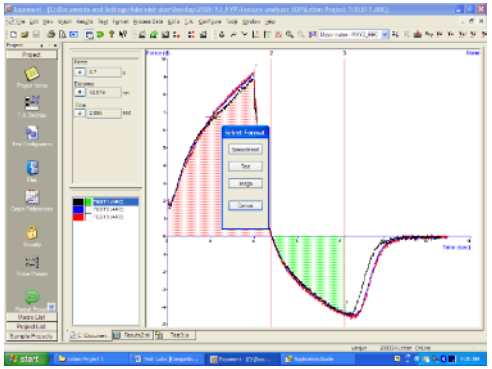


7. Data extraction
    1) To copy processed “Results” tab to excel
        - Ctrl a / select all columns
        - Ctrl c
        - Ctrl v in excel

Test ID	Batch		Firmness	Work of Shear	Stickiness	Work of Adhesion
			g	gsec	g	gsec
			Force 1	Area F-T 1:2	Force 2	Area F-T 2:3
Start Batch Unknown	Unknown					
TEST_20_CO_14	Unknown		40.006	21.006	-33.334	-7.627
End Batch Unknown	Unknown					
Average:	Unknown (F)	AVERAGE("BATCH")	40.006	21.006	-33.334	-7.627
S.D.	Unknown (F)	STDEV("BATCH")	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Coef. of Variation	Unknown (F)	STDEV("BATCH") / AVERAGE("BATCH") * 100	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
End of Test Data						

    2) To export raw data (twice)
    - Select the relevant sample (you will have to do this one by one)
    - Follow the following steps (twice)
        - File
        - Export
        - Spreadsheet
        - Save the excel file according to your sample name 20_CO_11





8. “Run 3 test” 3 times
9. Remove the sample bottle
10. To clean up between runs
    - remove the transparent top part
    - Gently remove the bottom transparent part
11. Proceed with the next sample