

# EMULSIFICATION OF COCONUT AND PALM-KERNEL OILS: I EFFECT OF SURFACTANT TYPE AND PHYSICO-CHEMICAL PROPERTIES OF THE OILS

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## Abstract

Liquid - liquid dispersions towards emulsions of cosmetic products have been adequately documented in respect of mineral oil like liquid paraffin, while the Nigerian vegetable oils, for example, palm-kernel and coconut oils still need adequate investigation for effective use in cosmetic products.

Primarily, oil-in-water emulsions are preferred hence the search for the effectiveness of different types of surfactants on liquid/liquid dispersions of the oils. Surfactants - Tween 40 (nonionic) Manoxol OT (anionic) and cetrimide (cationic) were each utilized at 5% w/w for the emulsification of palm-kernel and coconut oils.

The globule size, viscosity and percentage creaming were compared with those obtained from liquid paraffin. Finer globule sizes were obtained from the two vegetable oils than with liquid paraffin in the presence of all the surfactants. Liquid paraffin emulsions were less stable considering the percentage creaming and viscosity when compared with the two vegetable oils in the presence of the two ionic surfactants. The emulsion stability of the vegetable oils viz-a-viz the effects of the surfactants was Manoxol OT } Cetrimide } Tween 40 (ionic) } nonionic surfactants).

The physico-chemical properties of the oils could affect the properties of their emulsions. In fact, the chemical nature of the oils and their density difference with the dispersion medium, influenced the properties of the emulsions in the presence of the surfactant emulsifiers used.

## Introduction

Coconut and palm-kernel oils are locally available vegetable oils in Nigeria and have been found useful for cosmetic purposes. Liquid paraffin, a standard mineral oil is also widely used for its cosmetic purposes.

Liquid-liquid dispersion towards emulsions of cosmetic products have been adequately documented in respect of mineral oil like liquid paraffin adequate investigation for any effective use in

cosmetic products.

With the recent advances in the technology of surface-active agents, more synthetic emulsifying agents and fewer naturally occurring gums are being used in pharmaceutical emulsions. Nonionic surfactants have been continually investigated as emulsifiers in cosmetic emulsion formulation and so have the anionics (Lin, 1968; Lehne, 1972; Lin et al, 1974). Emulsions of quarternary ammonium compounds (cationic agents) have been found suitable for dermatological purposes and are used mainly for their disinfectant and preservative properties.

Some of these synthetic surfactants have been used in combination with certain oils or organic solvents for spontaneous emulsions or self-emulsifying systems. (Lee and Tadros, 1982; Iranloye et al, 1983).

Since oil-in-water emulsions are preferred for cosmetic purposes, the search for the effectiveness of different types of surfactants on liquid-liquid dispersions of the oils became appropriate.

Consequently, we have investigated the effects of surfactants on the separate emulsified products obtained under oil-in-water system for account oil, palm-kernel oil and liquid paraffin. A comparative evaluation of the emulsions was found relevant.

## MATERIALS AND METHODS

### Materials

The surfactants were the nonionic Tween 20, 40, 60, and 80 series (Honeywell Atlas Ltd., England), an anionic surfactant - Manoxol OT (MOT), and a cationic surfactant - cetrimide B.P. - CTAB (B.D.H. Ltd., England).

These were used as supplied.

Liquid paraffin, B.P. and two locally available oils - viz - palm-kernel and coconut oils were separately used as the internal phase. Freshly distilled water was used as the continuous phase.

Propylene glycol (Halewood Chem. Ltd., England) and glycerol (May and Baker Ltd., England) were used as the diluting fluids. The preservative was sorbic acid (BDH. Ltd., England).

## Methods

The emulsions (150g each) were prepared in identical 250ml pyrex beakers using the Silverson mixer. The surfactant (5%w/w) and 2.0%w/w sorbic acid as preservative where applicable, were dispersed in the freshly distilled water in a beaker. The water phase was then carefully poured into the oil phase in another beaker just before emulsification with the centrally place mixer.

The emulsion was mixed for 5 minutes and the experiments were carried out at 27<sup>o</sup>± 1<sup>o</sup>c. After mixing, the emulsions were homogenized two times with the Q.P. hand homogenizer.

The root-mean cube diameter (droplet size) of the emulsions was determined by the method of globule counting using the haemocytometer cell as used by Levius and Drommond (1953). The depth of the cell was 0.1mm. A 50%v/v aqueous propylene glycol was used as the dilution fluid for emulsions of the Tween and Manoxol OT., while 40%v/v aqueous glycerin solution was used for CTAB emulsions as this surfactant reacts with the commonly used propylene glycol (Levius and Drommond, 1953).

The prepared counting chamber was allowed to stand for 10 minutes before being examined to ensure uniform distribution of the droplets. After each count, the chamber and the cover-slips were washed with sodium lauryl sulphate solution, rinsed with distilled water and dried with a soft tissue.

The absolute viscosity of the emulsions was determined using the cup and bob viscometer (Haake RV 3), cup/bob MV<sub>1</sub>, using torque 50 Head or 500 head.

The percentage creaming of the emulsions was determined in a graduated 25ml measuring cylinder as the extent of percent separation observed after storing for a period of 30 days.

## RESULTS AND DISCUSSION

### Effect of nonionic surfactants:

A preliminary investigation was carried out on the effects of nonionic surfactants (the Tween series) on the properties of the

various emulsions produced in order to choose the best of surfactants. The results are given in Table 1.

Although, Tween 20 produced emulsions of relatively smaller droplet sizes throughout the series, the viscosity of Tweens 40 and 80. The rank order of the viscosity of the emulsions prepared with the various Tweens was Tween 40>80>20>60. Tween 40 also produced emulsions of considerably lower percentage creaming than any other Tween due to its viscous emulsions, while emulsions with Tween 60 were the least stable considering their percentage creaming (Table 1). Tween 40 was therefore chosen to represent the nonionic surfactants in the subsequent studies.

The HLB values of the Tween as given in Table 1 are in the order of Tween 20>40>60>80, and therefore cannot be used to explain the above trend of results.

Palm - kernel and coconut oils generally produced emulsions of smaller droplet sizes than liquid paraffin for all the Tweens. This may be due to the smaller density differences between these vegetable oils and the external phase (Table 2) which promotes ease of emulsification. However, the viscosity of the emulsions of the vegetable oils could not compare favourably with those of liquid paraffin emulsions even on storage, which accounted for the greater stability of the latter with these nonionic surfactants. Droplet sizes has been reported to have little effect on emulsions viscosity (Axon, 1956).

#### Effect of Surfactant type:

The result of the effects of surfactant type in the properties of the O/W emulsions of the various oils are given in Table 3.

Using ionic surfactants (MOT and CTAB) as emulsifiers, emulsions of both palm-kernel and coconut oils were generally more suitable than liquid paraffin emulsions and also more stable than liquid paraffin emulsions and also more stable than their emulsions containing Tween 40 considering the percentage creaming and absolute viscosity of the emulsions. In fact, the emulsion stability of the vegetable oils with regards to the surfactant emulsifiers was in the order of MOT>CTAB>> Tween 40, even on storage.

These results may be due to the chemical nature of the oils as well as the surfactants. The vegetable oils contain esters of fatty acids and are therefore more polar than liquid paraffin which consists mainly of saturated hydrocarbons. Thus there is a possibility that the polarity of the vegetable oil would enhance their emulsification by the ionic surfactants

rather than by the nonionics, hence the increased stability of their emulsions with the ionic surfactants. Also at that concentration of surfactant used, it was observed that as a result of the stirring action of the mixer, there was slight foaming during the emulsification of the vegetable oil emulsions containing the ionic surfactants, which later collapsed on standing. Shotton and white (1960) attributed the production of foams to the interaction of the internal phase components with the emulsifier films around the particles.

For all the surfactants studied, emulsions of the vegetable oils had smaller droplets sizes than liquid paraffin emulsions, as storage was to produce a fall in viscosity of the emulsions (fig.1) and an increase in their droplets sizes as expected (Table 3).

#### Effect of Physico - Chemical Properties of the oil:

The physico - chemical properties of the oils are given in Table 2. The viscosity of the selected oils is in the order of palm - kernel > liquid paraffin > coconut oil which does not correspond with the viscosity results of their emulsions (Table 3). Thus the internal phase viscosity is of little importance in determining the viscosity/ stability of its emulsions. Toms (1941) and Sherman (1964) found no correlation between emulsion viscosity and the viscosity of the internal phase.

The internal phase viscosity also has little or no influence on the droplets size distribution. The viscosity of the oils as given in Table 2 is in the order of palm-kernel > liquid paraffin > coconut oil, while the droplet size of their emulsions is in the order of liquid paraffin > coconut oil > palm-kernel oil.

However, small density - differences between the oils and the dispersion medium have been observed to promote the ease of emulsification. The densities of the oils are given in Table 2.

The differences in the droplet sizes of the emulsions of the vegetable oils which both had the same density, may due to the chemical nature of these oils. But factors other than density differences must be considered in comparing the stability (% creaming) of o/w emulsions as shown by the % creaming results of the emulsions with the Tweens as emulsifiers (Table 1).

The chemical nature of the oils affects the properties of their emulsions. The high polarity of the vegetable oils as confirmed by their acid and saponification values (Table 2) must have been responsible for their preference for the ionic surfactant emulsifiers for their emulsification into O/

W emulsions.

#### Conclusion

Emulsions of coconut and palm-kernel oils have been found to compare favourably with those of liquid paraffin. Finer globule sizes were obtained from emulsions of the two vegetable oils than those of liquid paraffin irrespective of the surfactant emulsifier.

The emulsions of the vegetable oils were more stable in the presence of ionic surfactants than liquid paraffin emulsions, and also more stable than their emulsions prepared with the nonionic surfactants. The emulsion stability of the vegetable oils viz-a viz the surfactant type effect was in the order of MOT>CTAB>> Tween 40.

The physico-chemical properties of these oils could also affect the properties of their emulsions. Small density differences between the oils and the dispersion medium were observed to promote ease of emulsification while the chemical nature of the oils influenced the properties of their emulsions.

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Table 1: Effect of 5% w/w selected nonionic surfactants on properties of o/w emulsions of the oil

A. Root-mean cube diameter (  $\mu$  ) of emulsion droplets.

Surfactant	HLB	Root - Mean Cube diameter ( $\mu$ )					
		At 24 hrs. of equilibration			At 30 days of equilibration		
		Liquid Paraffin	Palm-kernel oil	Coconut oil	Liquid Paraffin	Palm-kernel oil	Coconut oil
Tween 20	16.7	3.53	3.17	3.28	3.88	3.80	3.61
Tween 40	15.6	3.69	3.18	3.62	4.01	3.76	4.00
Tween 60	15.0	3.83	3.55	3.77	4.23	4.13	4.13
Tween 80	14.9	3.70	3.35	3.69	4.23	3.94	4.20

B. Absolute viscosity (cp)

Surfactant	At 24 hrs. of equilibration			At 30 days of equilibration.		
	Liquid paraffin	Palm-kernel oil	Coconut oil	Liquid paraffin	Palm-kernel oil	Coconut oil
Tween 20	15.86	13.44	17.46	14.54	13.10	15.22
Tween 40	20.87	14.44	18.14	15.74	13.68	15.70
Tween 60	14.88	13.01	17.40	14.33	12.84	15.05
Tween 80	17.54	14.40	18.06	15.53	13.35	15.39

C. Percentage Creaming (% v/v) at 30 days of equilibration.

Surfactant	Liquid paraffin	Palm-kernel oil	Coconut oil
Tween 20	50.66	56.63	55.56
Tween 40	46.08	56.51	55.01
Tween 60	52.46	60.48	59.55
Tween 80	53.31	56.57	55.53

**Table 2:**

The physico-chemical properties of the oils

Physico-chemical properties	Liquid paraffin BP	Palm-kernel oil	Coconut oil
Description	Transparent	Very dark	Clear, pale
	colourless, oily	brown liquid	yellow liquid
Odour	Almost odourless	Palm-kernel odour	Coconut odour
Acid value	-	20.14	8.275
Saponification value	-	227.06	247.375
Iodine value	-	6.51	1.648
Weight per millilitre at 27°C	0.8696	0.9091	0.9091
Refractive index at 50°C	-	1.455	1.450
Absolute viscosity (cp)	62.8	56.2	49.3

**Table 3: Effect of surfactant type on properties of emulsions prepared with different selected oils as the dispersed phase.**

Dispersed phase	Root-mean Cube diameter (μ)						Absolute viscosity (cp)						Percentage creaming (% v/v) at 30 days of equilibration		
	At 24 hrs of equilibration			At 30 days of equilibration			At 24 hrs. of equilibration			At 30 days of equilibration					
	T <sub>40</sub>	MOT	CTAB	T <sub>40</sub>	MOT	CTAB	T <sub>40</sub>	MOT	CTAB	T <sub>40</sub>	MOT	CTAB	T <sub>40</sub>	MOT	CTAB
Liquid Paraffin B.P	3.69	3.56	5.30	4.01	3.80	6.61	20.87	22.71	17.79	15.74	18.39	16.93	46.08	45.63	55.11
Palm-kernel oil	3.18	3.29	3.19	3.76	3.50	3.50	14.36	23.09	20.5	13.68	19.50	18.40	56.51	43.14	51.14
Coconut oil	3.62	3.25	4.37	4.00	3.51	4.50	18.14	22.50	19.86	15.70	18.60	17.50	55.01	45.06	50.73

T<sub>40</sub> = Tween 40

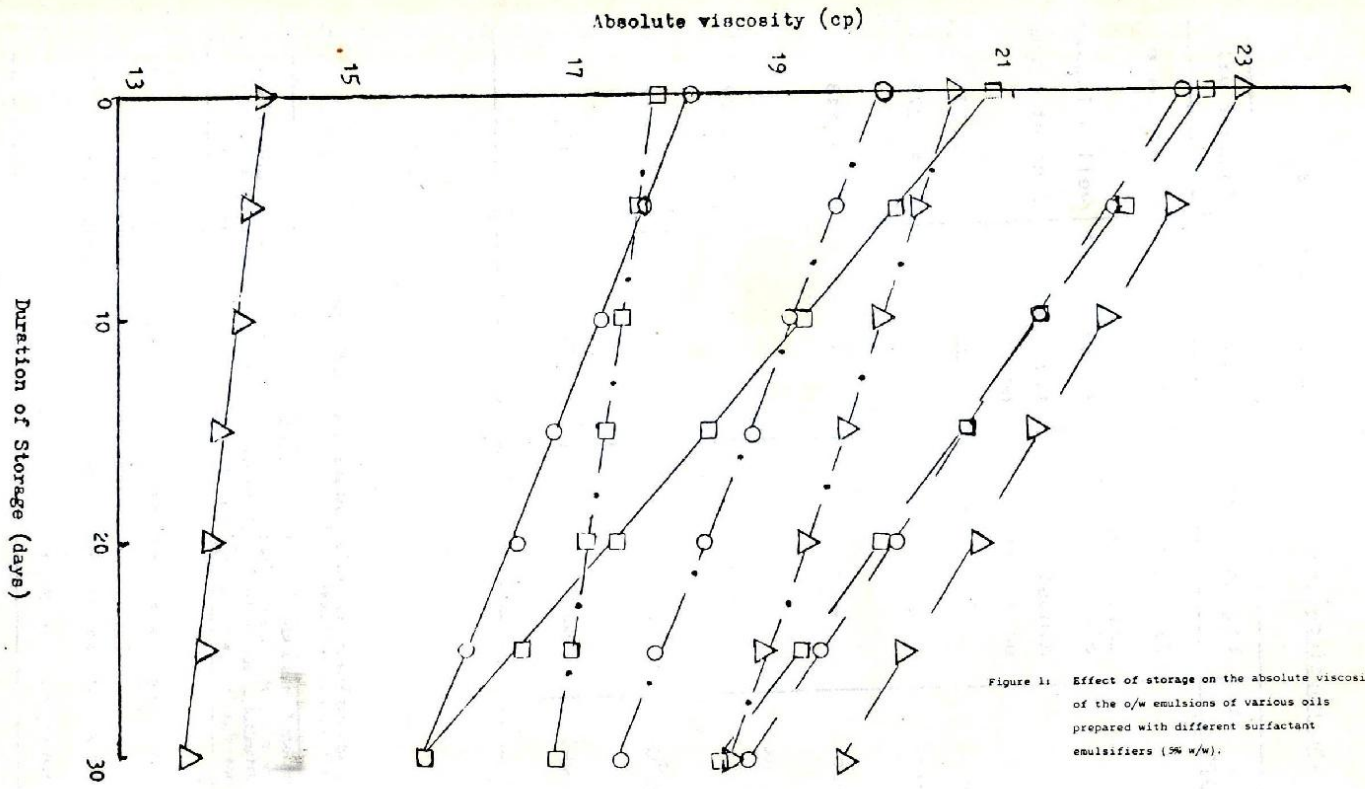


Figure 1: Effect of storage on the absolute viscosity of the o/w emulsions of various oils prepared with different surfactant emulsifiers (5% w/w).

- Liquid Paraffin
- △ Palm-kernel oil
- Coconut oil
- Tween 40
- - - MGT
- · - · CTAB