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COMPARATIVE AND EXPERIMENTAL STUDY ON THE PROPERTIES AND POTENCY OF SYNTHESIZED ORGANIC AND MINERAL SUNSCREEN MOISTURIZER

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ABSTRACT

This research work aims at synthesizing two different types of moisturizers: a body butter and a lotion. Based on the methodology, three samples of the body butter and lotion was produced, by varying the percentage of zinc oxide and Shea butter, the samples were analyzed with a UV- spectrophotometer to determine the transmittance and absorbance strength which was in turn used to determine the SPF. Vaseline which is a standard organic lotion was also analyzed to determine the transmittance, absorbance strength and SPF. The results were compared. Of all the moisturizers synthesized in this research, the lotion which had 10% zinc oxide had the highest absorbance strength, and hence the highest SPF. Therefore, it was concluded that a minimum of 10% zinc oxide should be used in the production of sunscreen moisturizers to provide moderate sun protection.

Keywords: Absorbance Strength, Body Butter, Lotion, transmittance, Sun Protection Factor (SPF)

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1. INTRODUCTION

The ancient Greeks used olive oil to protect the skin from sun damage. Over the years, the South Americans use rice jasmine and lupine plants extracts by, as skin care to help protects their skin from sun damage [6]. Sunscreen, otherwise called sunblock, is a gel like moisturizer that absorbs, reflects, or scatters a portion of the sun's (UV) radiation and subsequently prevent sunburn. The first sunscreen moisturizer ever known was produced in France by Eugene sculler in 1935. In 1946, sunscreen produced by Franz Greiter was commercially introduced into the market [16]. Schulze was credited with introducing the idea of SPF in 1956, thereby approximately estimating the effectiveness of sunscreen when applied to the skin evenly at $3mg/cm^2$, and the first Greiter's cream was appraised later to have SPF of 2. However, sunscreens have become a very essential skincare product worldwide. In 1990, $525 million was spent on sun protection products in USA and the figure increased yearly [14] in a bid to reduce the damaging effect of the (UV) radiation on the skin, [1and 4] reports that solar radiation is the combination of visible light and ultraviolet radiation that reaches the earth from the sun. A small portion of this spectrum is composed of short-wave length in the region 200nm-400nm high energy ultra violet (UV) radiation harmful to life on earth. [17]. The application of sunscreen prevents the absorption of UV radiation thereby reducing skin photo-damage and the carcinogenic effects of solar irradiation [9 and 15]. There are two types of sunscreens actives in use today: Organic sunscreen and Mineral based sunscreen. Both the organic and mineral based sunscreens contain UV-filters. UV- filters are compounds or mixtures that block or absorb ultraviolet (UV) light. [10 and 13]

1.1. Organic Sunscreen

These are known to as chemical filters. They are mostly aromatic compounds conjugated with C=C double bonds, which have the electronic excitation energy in the UV range [10,15]. This general structure allows the molecule to absorb high-energy UV rays and give out lower-energy rays, which in turn prevents UV rays from getting to the skin [8]. Organic UV filters are made up different classes (functional groups), which can be classified as UVA filters (benzophenones, anthranilates and dibenzoylmethanes) and/or UVB filters (PABA derivatives, salicylates, camphor derivatives and cinnamates) according to their specific absorption characteristics [18].

1.2. Mineral Sunscreen

Mineral sunscreens are made with inorganic UV filters. The most common types are TiO_2 and ZnO particles [15]. A maximum concentration of 25% UV filter are widely used in sunscreen lotions as active broadband sunscreens that blocks both UVB (260–350 nm) and UVA (300–450 nm) sunlight radiation with high SPF. Microfine particles, which make physical sunscreens virtually invisible have been developed [3]. They are transparent to visible radiation, reflection from the particle surface is minimal, and occasionally (TiO_2 and ZnO) absorption are maximized.

1.3. Testing of Sunscreen Products

Sun protection factor (SPF) is a measure of quantity of UV radiation required to produce sunburn on protected skin (i.e. in the presence of sunscreen) [19]. As SPF value increases, sunburn protection increases.

i. There are two methods of measuring the sun protection factors:

(i) **In vivo method**: In this method, SPF is measured on human by applying 2 mg/cm^2 of a sunscreen formula to a portion on the skin, allowing dryness for 10minutes, and administering a series of five increasing doses of UV radiation, to skin sites treated with the sunscreen. After 15hours, the irradiated skin sites are examined for SPF. The SPF is the lowest dose of UV that causes mild sunburn in the sunscreen area divided by the lowest dose of UV that causes mild sunburn in the area without sunscreen [5].

(ii) In vitro method: This method is cost-effective and rapid. It can be used as a formulation tool to identify new filters and optimize combinations of old ones. This method is of two types:

- **i.** the measurement of absorption of UV radiation through sunscreen product films in quartz plates.
- **ii.** the absorption characteristics of the sunscreens based on spectrophotometric analysis of solutions [2, 12 and 18].

2. CREATIVE METHODOLOGY

Stearic Acid, Ethanol (99.5%), Zinc oxide obtained from Drug House (DBH), Poole, England, Carrot seed oil *(Daucus Carota)*, Red raspberry seed oil (*Rubus Idaeus*), Vitamin E oil (*α-tocapherol*), Almond oil (*Prunus Dulcis*), Beeswax (*Cera Alba*), Coconut oil *(Copra oil)*, Jojoba oil *(Simmondsia Chinensis)*, Shea butter *(Vitellaria Paradoxa)*, Lavender oil *(Lavandula Angustifolia)*, Glycerine, and Emulsifying wax all obtained from Amazons in United States.

2.1. Preparation of Body Butter

A known quantity of water is heated in a double boiler to a temperature of 90^{o}C. Plants' flowers, roots, leaves and seeds contain some active ingredients which are known as base or Essential oil [11]. The base oils used in this study consist of 35% Coconut seed oil, 15% Almond seed oil, 5% Jojoba seed oil and 22% of Shea butter are added to the upper portion of the double boiler. The mixture is stirred continuously for 10 minutes.

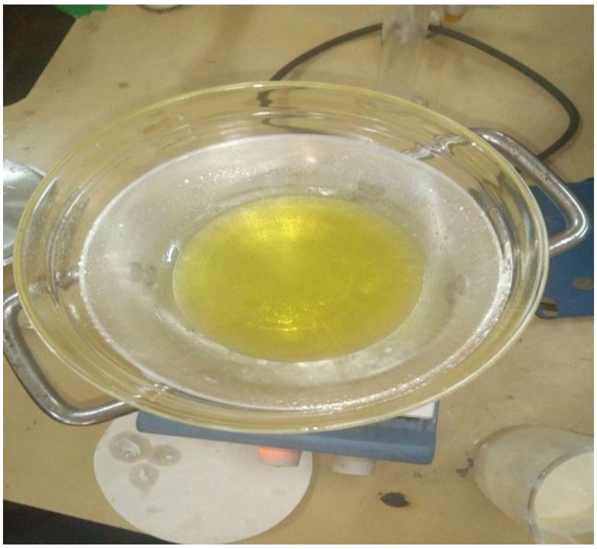

Figure 2.1 Blending of the base oils over a double boiler

2.2 Blending of the Viscosifier, antioxidants and zinc oxide

4% of melted beeswax was added to the base oil in the double boiler, the mixture is stirred continuously and allowed to cool to 40^{o}C, 10% of zinc oxide was added and whisked for 15 minutes. 1% of the antioxidant and essential oils comprising of carrot seed oil *(Daucus Carota)*, red raspberry seed oil (*Rubus Idaeus*) were added to the mixture. The sunscreen moisturizer produced is poured into a container and left to cool completely.

Figure 2.2 Melted beeswax pellets

2.3. Production of different samples with varied Percentages of Zinc Oxide

The procedure above is repeated with varying percentages of zinc oxide with Shea butter to produce three different samples.

(i) 2.3a Sample 2

- 23.5% of Shea butter is used in the production of the base oils.
- 7.5 % of Zinc oxide is added to the mixture

(ii) 2.3b Sample 3

- 25% of Shea butter is used in the production of the base oils.
- 5% of Zinc oxide is added to the mixture

2.4. Preparation of Lotion

4% of emulsifying wax is melted completely, 50% of zinc oxide was dispersed in 46% of jojoba oil, and Zinc Oxide is blended with the melted emulsifying wax. 2% of beeswax emulsifying wax are melted completely, 1.5% jojoba oil, 1.5% almond oil and 2% coconut oil are blended together, the melted waxes are mixed with the oil. 68.7% of distilled water is added to 4% glycerin and heated to 70^{o}C, the mixture is stirred continuously for 20 minutes, and 0.5% vitamin E oil, red raspberry oil, coconut oil, fragrance and 1% protein preservative are added to the mixture at 40^{o}C and allowed to cool.

3. RESULT AND DISCUSSION

The (SPF) is obtained using “in vitro” analysis with a UV-Spectrometer

i. The absorption of samples in the solution were obtained using a 1cm quartz cell and ethanol as a blank which was in the range of 280 to 470nm.
ii. The absorption data were obtained in the range of 290 to 320nm, every 5nm, and three determinations were made at each point followed by the application of Manseur equation.

Sample 1: Vaseline

Table 1 Spectrometric Analysis of dilute Sunscreen Solution

Ii x ee(λ)	Wavelength(nm)	Absorbance(λ)	Transmittance	Ee x ii x abs (λ)

0.015	290	0.104	78.70%	0.00156
0.0817	295	0.107	78%	0.0087419
0.28817	300	0.112	77%	0.032275
0.3278	305	0.107	78%	0.0350746
0.1864	310	0.105	79%	0.019572
0.0839	315	0.102	79%	0.0085578
0.018	320	0.091	81%	0.001638

Calculated SPF= 10.1

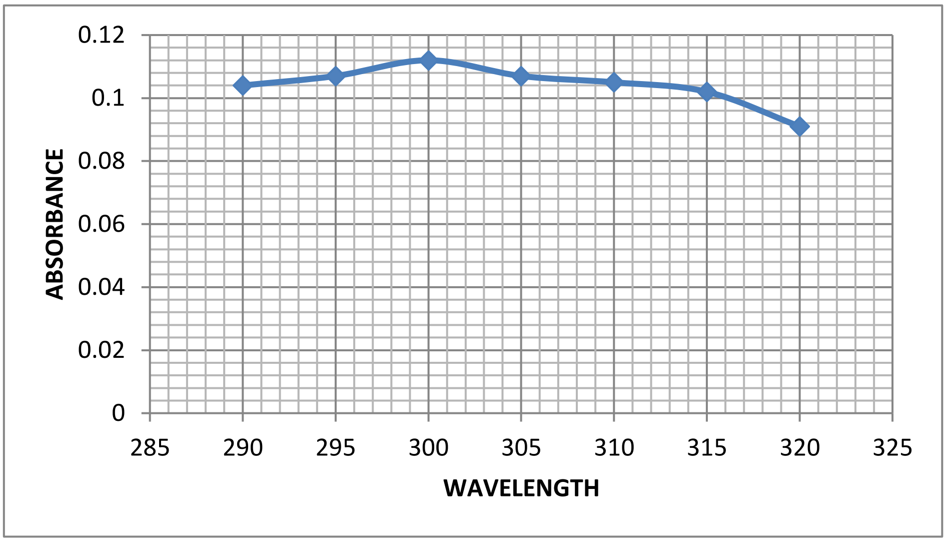

Figure 3.1 Absorbance against wavelength

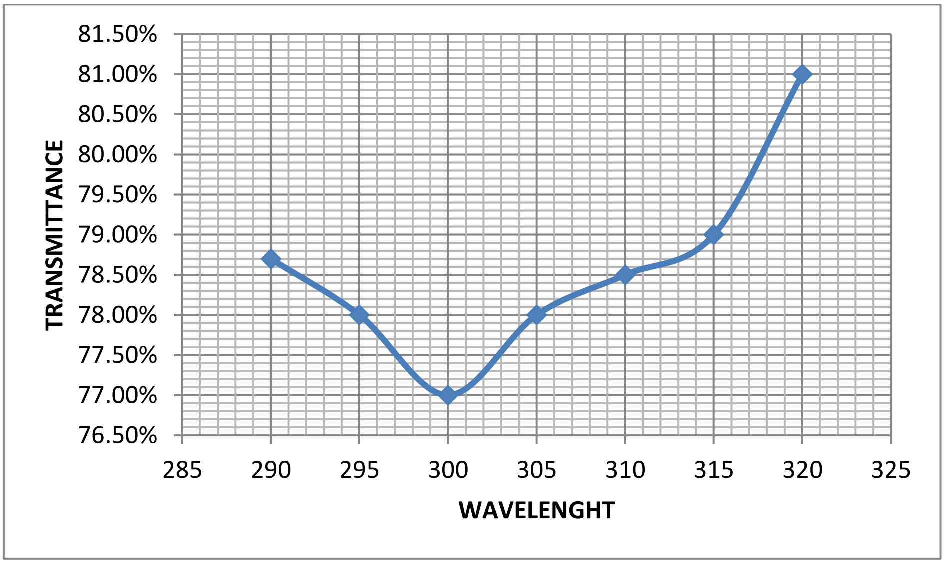

Figure 3.2 Transmittance against wavelength

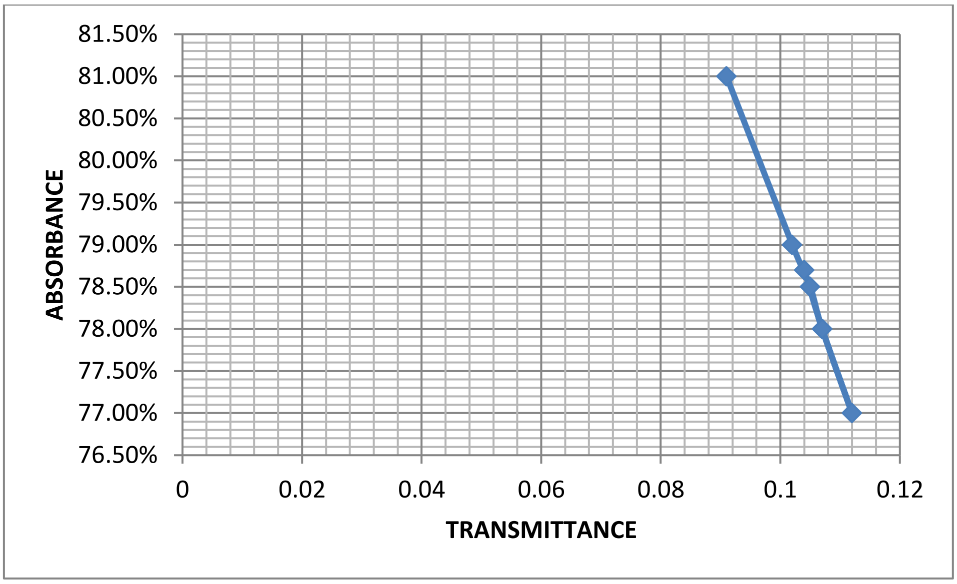

Figure 3.3 Absorbance against transmittance

SAMPLE 2: Body butter containing 10 % Zinc Oxide

Table 2 Spectrometric Analysis of Dilute Sunscreen Solution

Ii x ee(**λ**)	Wavelength(nm)	Absorbance(**λ**)	Transmittance	Ee x ii x abs (**λ**)
0.015	290	0.063	86.50%	0.000945
0.0817	295	0.067	85.70%	0.0054739
0.28817	300	0.072	84.70%	0.02074824
0.3278	305	0.076	83.90%	0.0249128
0.1864	310	0.07	85.11%	0.013048
0.0839	315	0.063	86.50%	0.0052857
0.018	320	0.052	88.70%	0.000936

Calculated SPF = 7.1

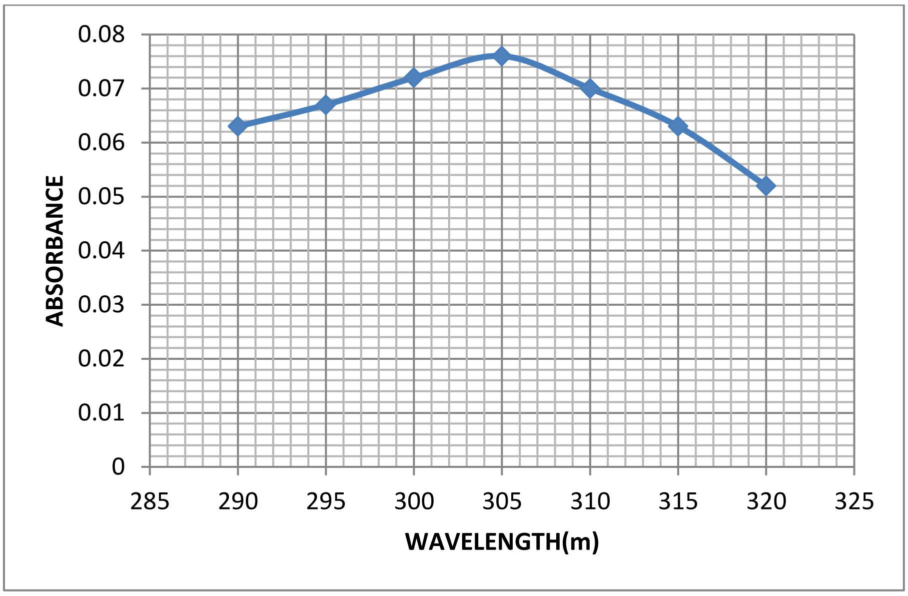

Figure 3.4 Absorbance against wavelength

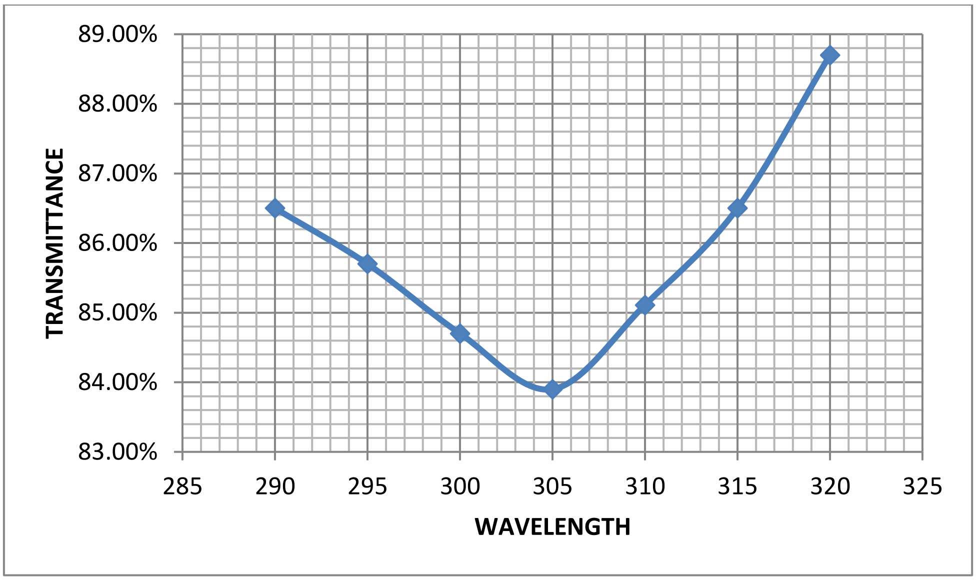

Figure 3.5 Transmittance against wavelength

SAMPLE 3: Body Butter Containing 7.5% Zinc Oxide

Table 3 Spectrometric analysis of Dilute Sunscreen Solution

Ii x ee($\boldsymbol{\lambda}$)	Wavelength(nm)	Absorbance($\boldsymbol{\lambda}$)	Transmittance	Ee x ii x abs ($\boldsymbol{\lambda}$)
0.015	290	0.051	88.90%	0.000765
0.0817	295	0.053	88.50%	0.0043301
0.28817	300	0.055	88.10%	0.0158494
0.3278	305	0.063	86.50%	0.0206514

0.1864	310	0.057	87.70%	0.0106248
0.0839	315	0.039	91.40%	0.0032721
0.018	320	0.036	92.04%	0.000648

Calculated SPF = 5.6

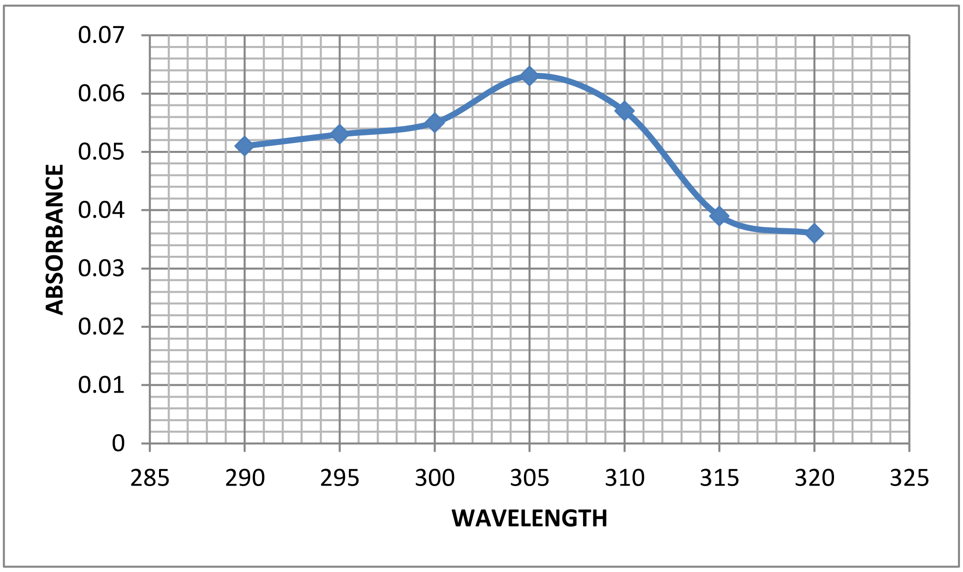

Figure 3.6 Absorbance against wavelength

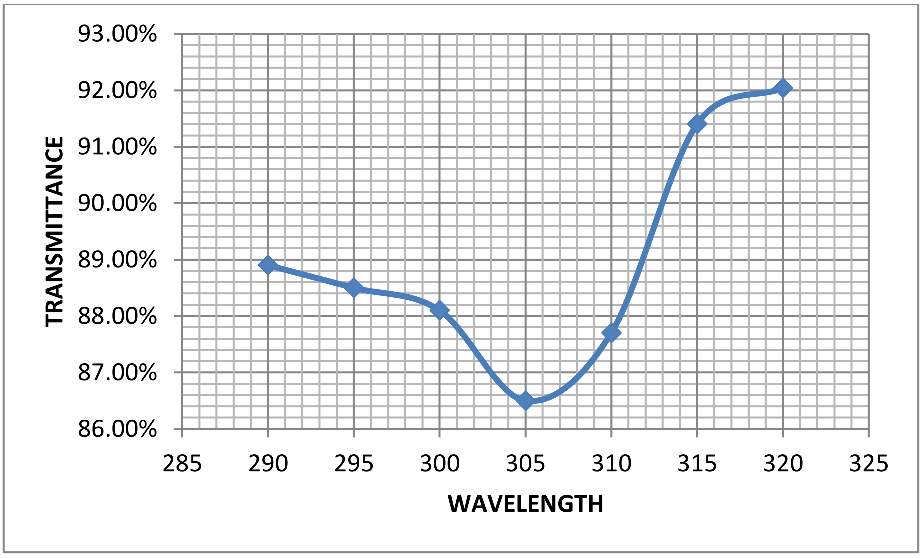

Figure 3.7 Transmittance against wavelength

SAMPLE 4: Body Butter Containing 5% Zinc Oxide

Table 4 Spectrometric Analysis of Dilute Sunscreen Solution

Ii X Ee(𝝀)	**Absorbance(𝝀)**	**Wavelength (Nm)**	**Transmittance**	**Ee X Ii X Abs (𝝀)**
0.015	0.027	290	93.90%	0.000405
0.0817	0.032	295	93%	0.002614
0.28817	0.035	300	92.30%	0.010086
0.3278	0.04	305	91.20%	0.013112
0.1864	0.037	310	92%	0.006897
0.0839	0.035	315	92.30%	0.002937
0.018	0.023	320	94.80%	0.000414

Calculated SPF = 3.6

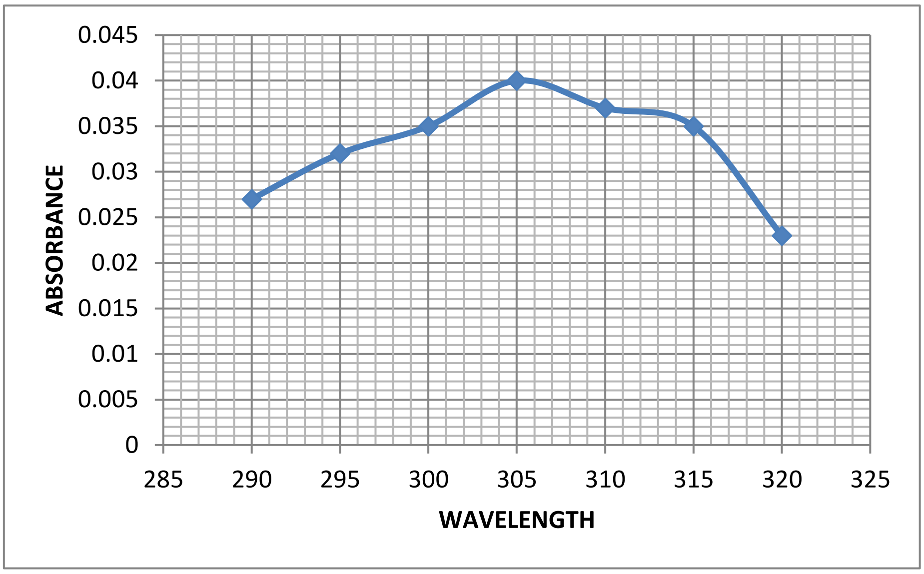

Figure 3.8 Absorbance against wavelength

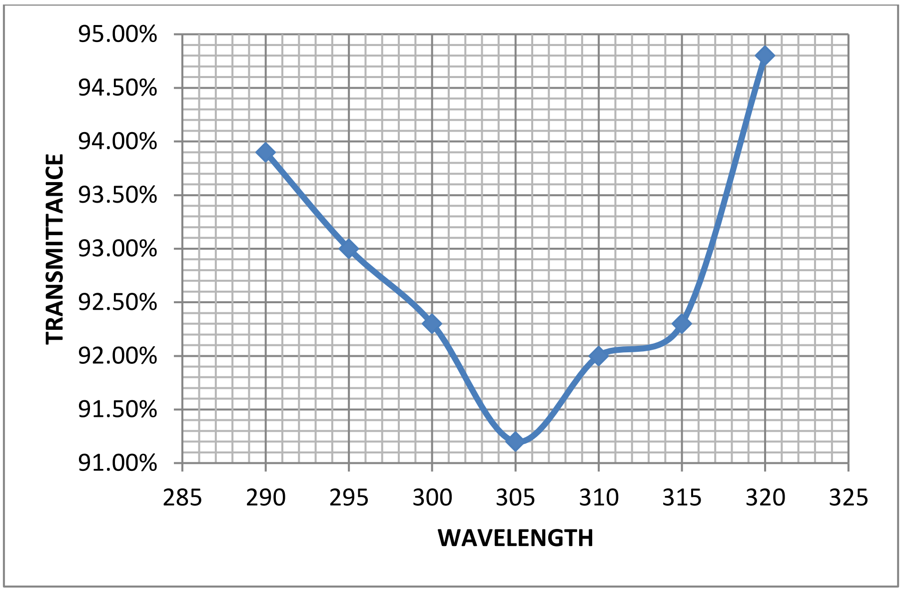

Figure 3.9 Transmittance against wavelength

SAMPLE 5: Body Lotion Containing 10% Zinc Oxide

Table 5 Spectrometric Analysis of Dilute Sunscreen Solution

Ii X Ee(𝝀)	Wavelength (Nm)	Absorbance(𝝀)	Transmittance	Ee X Ii X Abs (𝝀)
0.015	290	0.072	84.70%	0.00108
0.0817	295	0.075	84.10%	0.006128
0.28817	300	0.078	83.60%	0.022477
0.3278	305	0.085	82.20%	0.027863
0.1864	310	0.082	82.80%	0.015285
0.0839	315	0.073	84.50%	0.006125
0.018	320	0.057	87.70%	0.001026

Calculated SPF = 8.1

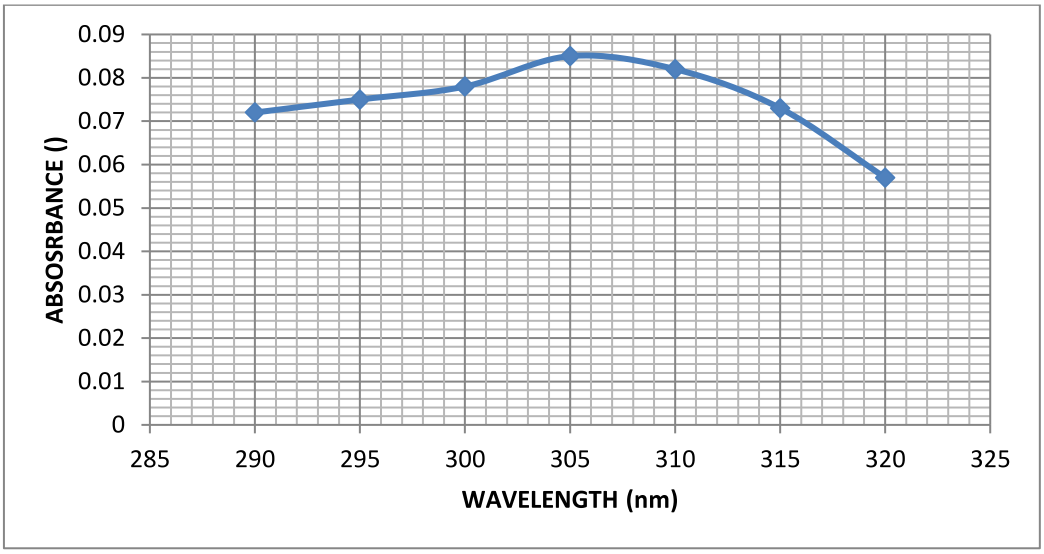

Figure 3.10 Absorbance against wavelength

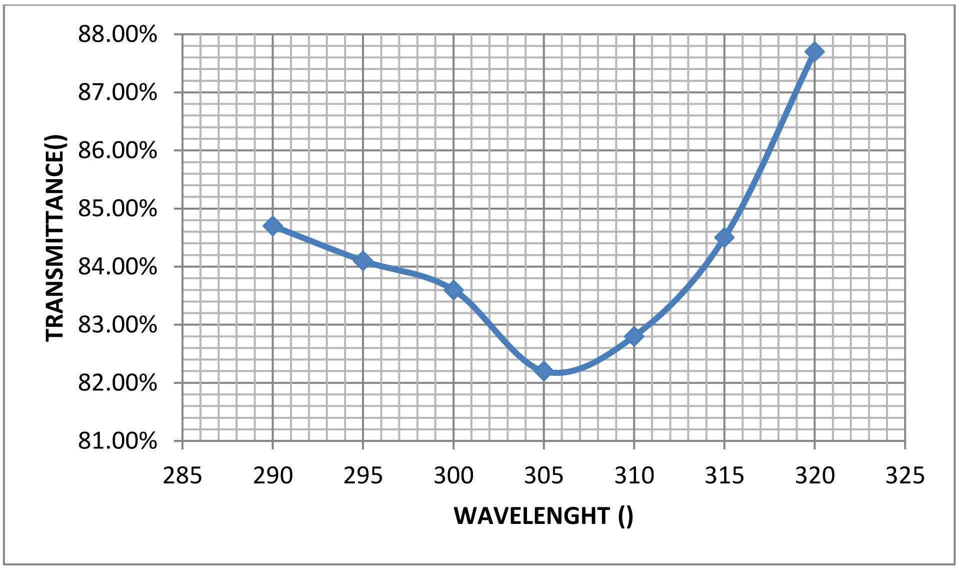

Figure 3.11 Transmittance against wavelength

Table 6 Summary of Absorbance Strength at Different Wavelength

ABSORBANCE					
Wavelength	**Sample 1 (Vaseline)**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**
290	0.104	0.063	0.051	0.027	0.072
295	0.107	0.067	0.053	0.032	0.075
300	0.112	0.072	0.055	0.035	0.078
305	0.107	0.076	0.063	0.04	0.085
310	0.105	0.07	0.057	0.037	0.082

315	0.102	0.063	0.039	0.035	0.073
320	0.091	0.052	0.036	0.023	0.057

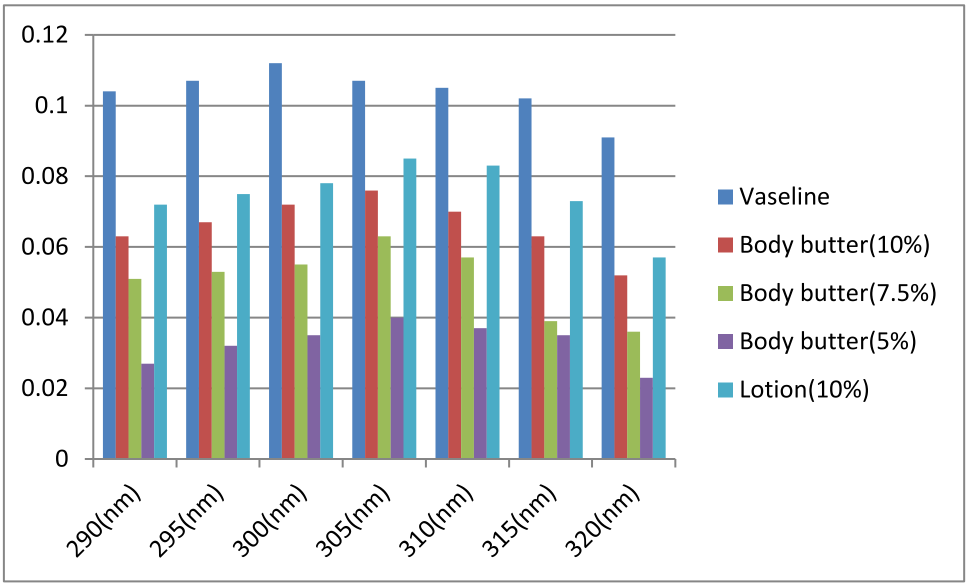

Figure 3.12 Comparison of the absorbance strength of samples at different wavelength

The result obtained from this research work, shows that the absorbance increased as the wave length increases from 290nm, at 305nm the absorbance value began to reduce. The absorbance values at different wavelengths between 290nm-3210nm with 5nm interval was obtained for each of sample. The standard Vaseline lotion with an organic UV filter had the highest absorption values among all sunscreens tested. Of all the sunscreens creams synthesized for this research work, with mineral UV filters sample 4, lotion containing 10% of zinc oxide had the highest absorption values for the different wavelength. Sample 1, a body butter containing 10% zinc oxide had the second highest absorption range, this was followed by sample 2 which contained 7.5% of Zinc Oxide and sample 3 which contained 5% Zinc oxide. The results show that increasing the quantity of the UV filter increased the absorption strength of the sunscreen. It was observed that sample 1 and sample 4 which contained the same quantity of zinc oxide had different absorption values, the difference was due to the variation in the production method. The transmittance, which is the measure of amount of light radiation allowed to pass through the solution of the different samples were determined through the UV spectrophotometer and the values obtained were observed to be inversely proportional to the absorbance. The graphs obtained from the results shows that transmittance is not linearly proportional to the SPF. Despite its relationship with the SPF, it provides quantitative information on the percentage of UVB rays filtered out by the sunscreen. The higher the SPF, the lower the transmittance which meant more light absorbed by the sunscreen as also reported by [5]. It was observed that the Vaseline had the highest absorption range and the lowest transmission range among all the sunscreens tested. The transmittance range of sample 4 was less than that of sample 1 which was in turn less those of sample 2 and 3 respectively. Comparing the absorption and transmission range of the tested sunscreens it can be observed that they are both inversely proportional because as the absorption increased the percentage transmission reduced. This shows that the more UV- light is absorbed the less is transmitted to the skin. Therefore, UV filters with high absorption characteristics are the preferred choice when formulating a product. Vaseline lotion which is a standard organic UV filter having Butyl

Methoxydibenzonylmethane and methoxycinnamate as the active UV filter, was tested through in vitro method of analysis and SPF 10 was obtained and this was found to correlate with the labeled SPF on the product. Therefore, this shows that the Vaseline lotion provides 90% of UVB protection on the human skin. However, this result shows that the quantity of zinc oxide increases as the SPF of the cream increases, but the final SPF is also a function of the particle size and the quality when dealing with mineral UV filters.

4. CONCLUSION

The use of non- Nano Zinc oxide as a UV filter produces a sunscreen that provides moderate sun protection. The quantity of zinc oxide used in production, determines the absorption strength and hence the sun protection factor of the sunscreen. A minimum of 10% of Zinc oxide should be used in formulations to provide moderate sun protection.

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AUTHOR’S CONTRIBUTIONS

Corresponding Author: Co-ordination of experimental work, editing, write- up.

Modupe E. Ojewumi: Checking the antiplaigairism and similarity test.

Ayodeji A. Ayoola: Soucing for more information, brainstorming.

Oladele J. Omodara: involved in experimental work and equipment handling.

Funmi Y. Falope: Funding for the research work.

Olaitan H. Gbadamosi: Sourcing for raw materials and reagents used.

ETHICS

This paper has neither been published nor submitted in any domestic or abroad journals.

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