WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.074
Volume 7, Issue 9, 510-515. Research Article ISSN 2277– 7105

FORMULATIONS OF SUNSCREEN LOTIONS USING *ACORUS CALAMUS* AND ZINC OXIDE NANOPARTICLES AND THEIR *IN VITRO* EVALUATION OF SUN PROTECTION FACTOR (SPF)

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Article Received on
24 March 2018,
Revised on 24 March 2018,
Accepted on 15 April 2018
DOI: 10.20959/wjpr20189-11562

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ABSTRACT

Objective: The present research work involves formulation of a sunscreen lotion using *Acorus calamus* extract and biogenically synthesized zinc oxide nanoparticles (ZnONPs). **Methods:** The prepared sunscreen lotion was evaluated for Sun Protection Factor (SPF) values by a facile UV-visible spectrophotometric method. **Results:** The SPF value of the *Acorus calamus* sunscreen lotion increased with the addition of ZnONPs. The SPF value of the combination product revealed a synergistic action between ZnONPs and the phytoconstituents present in the *A. calamus* extract. The prepared sunscreen lotion was compared for SPF with that of the commercially available formulations. The sunscreen lotion containing zinc oxide nanoparticles was found to have higher SPF compared to that of conventional one indicating the effect of reduction in particle size, from micro to nano, on the sun protection factor. **Conclusion:** The proposed UV-spectrophotometric method is simple, rapid, employs low cost reagents and can be used in the *in vitro* determination of SPF values in many cosmetic formulations.

KEYWORDS: Sunscreen lotion, *Acorus calamus*, SPF, Zinc oxide nanoparticles.

INTRODUCTION

It is a human nature to protect the skin against sunburn through the use of clothes and accessories or simply by avoiding sun exposure.[1,2] Because most of the skin cancer occurs

on the areas of the body which are frequently exposed to the sun, such as the face, neck, head and back of the hands. About one million people are diagnosed with skin cancer and about 10,000 die from malignant melanoma every year.[3,4] The rapid escalation of commercially available products containing sunscreens indicates that even though a suntan is still desired, people are conscious of the possible dangers of photoaging and skin cancer, occurring as a result of sun over exposure.

Due to these facts sunscreen substances are now incorporated into everyday products such as moistures, cream, lotion, shampoos, mousses, and other hair and skin preparations.[5,6] The regular use of these products may help to reduce the chance of the harmful effects of ultraviolet radiation. However, it is necessary that a very efficient sunscreen substance is used in the cosmetic formulation. Topical photoprotectors or sunblocks (or sunscreens) are cosmetic formulation that blocks UV rays. It has two purposes viz. (i) protects the skin against UVA and UVB rays and (ii) helps the skin to maintain moisture and its own natural oil which can be lost through exposure to the sun radiation.[7]

Sun protection factor reveals that protects the skin against harmful effects of the sun. *In vitro* determination of SPF values ten different commercially available samples of sunscreen emulsions of various manufactures were evaluated by spectrophotometric method.[4] A formulation of a sunscreen containing essential oil of *Ocimum basilicum* Linn as an active ingredient has been evaluated by in vitro experimental method for SPF determination.[8] Metal nanoparticles like zinc oxide and titanium dioxide are used in sunscreens because these block the UV 18 radiation and are opaque to light skin cream. Hence in the present work the biogenically synthesized zinc nanoparticles have been formulated into sunscreen lotions and its SPF determined spectrophometrically.

MATERIALS AND METHODS

Preparation of aqueous extract: The stem powder of *Acorus calamus* (1g) was weighed in a beaker and boiled with 50 ml of double distilled water for 30 min and filtered using Whatmann filter paper. The filterate was dried under vacuum and stored at -4 ^{o}C.

Preparation of zinc oxide nanoparticles: The zinc oxide nanoparticles were prepared by the procedure as reported earlier.[9] The aqueous plant extract (10 ml) of *Senna Auriculata* was added to 50 ml of zinc sulphate drop by drop under constant stirring at 80 ^{o}C followed by addition of NaOH (2 M) under continuous stirring for 4 h. A dark colored precipitate

obtained was kept in a muffle furnace at 600 ^{o}C. Then washed with methanol and dried at room temperature to get pure white zinc oxide nanoparticles.

Preparation of sunscreen lotions: The sunscreen lotions were prepared by the addition of aqueous phase to the oil phase with continuous stirring. Paraffin wax (10 mg) and emulsifying wax (10 mg) constituting the oil phase was heated up to 70±5 ^{o}C. Aqueous phase consisting of rosewater (10 ml) and aqueous extract of *Acorus calamus* (10 mg) was heated up to 80^{o}C and was added to the oil phase drop wise with continuous stirring and stored (ACL). Zinc oxide nanoparticles (5 mg) was then added and stirred until homogeneity (ACLZ). The prepared lotions (ACL) and (ACLZ) were stored in a refrigerator for further study.

***In vitro* determination of sun protection factor (SPF) using UV-visible spectrophotometer:** The SPF value of the prepared sunscreen lotions were calculated at different concentrations. A simple mathematical equation which substitutes the *in vitro* method proposed by Sayre[10] utilizing UV-visible spectrophotometer and the SPF was determined as per the procedure of Mansure[11] as given below

$$SPF_{spectrophotometer} = CF * \sum_{290}^{320} EE(\lambda) * I(\lambda) * Abs(\lambda)$$

Where EE(I)-erythermal effect spectrum; I(i)-Solar intensity spectrum; Abs(I)-absorbance of sun screen product's; CF-correction factor (=10). The value of EE*I are constant and are given in (**table 1).**

RESULTS AND DISCUSSION

Table. 1: Normalized product function used in the calculation of SPF.

Wavelength (λ nm)	EE*I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0187

20 mg prepared sunscreen lotions ACL and ACLZ were dissolved in 10ml of ethanol. 1ml was taken from 10 ml that is equal to 2 mg which was made up to 5 ml with the help of ethanol. The UV absorbance was measured at different wavelengths like 290, 295, 300, 305, 310, 315, 320 nm for the prepared sunscreen lotions (ACL and ACLZ). The recorded absorbance and the calculated SPF for the sunscreen lotions (ACL and ACLZ) are given in Table 2 and 3 respectively. The results (table 3) reveal that the calculated SPF value for ACLZ is higher compared to that of ACL (table 2). This may be due to the synergistic effect of zinc oxide nanoparticles incorporated into the sunscreen ACL. The results implies as we move from micro to nano, the SPF (ACLZ) become higher (32.92) which might be due to the interaction of ZnONPs in combination with the *Acorus calamus* extract. The SPF value, which reflects the protection against sunburn and erythema, is the only protection value requested for commercial sunscreen products. Excipients and other active ingredients can also produce UV absorption bands, thus interfering with those of UVA and UVB sunscreen. This effect is reflected in a finished formulation, especially for lotions with an SPF greater than 15. Dose response experiments of UVA or UV-SSR showed that the preparation with the highest PF-UVA provided a better protection with regard to dermal damage compared to the other formulation.[12]

Table. 2: Determination of SPF value for ACL.

Wavelength (λ nm)	Absorbance	EE(λ)*I(λ)	SPF= CF* $\sum_{290}^{390}$ EE (λ)* I(λ) * Abs(λ)
290	1.110	0.0150	0.1665
295	1.147	0.0817	0.9370
300	1.055	0.2874	3.0320
305	0.931	0.3278	3.0518
310	0.941	0.1864	1.7540
315	0.838	0.0837	0.7014
320	0.727	0.0187	0.1359
			9.7786

Table. 3: Determination of SPF value for ACLZ.

Wavelength (λ nm)	Absorbance	EE(λ)*I(λ)	SPF= CF* $\sum_{290}^{390}$ EE (λ)* I(λ) * Abs(λ)
290	4.000	0.0150	0.6
295	1.996	0.0817	1.6307
300	4.000	0.2874	11.496
305	4.000	0.3278	13.112
310	2.244	0.1864	4.1828

315	1.894	0.0837	1.5852
320	1.684	0.0187	0.3149
			32.9216

Data variation can be due to the use of non validated spectrophotometric methodology being used for the determination of the absorption characteristics of the different concentration of sunscreen lotions. Many factors viz. the use of different solvents, the combination and concentration of the sunscreens, type of emulsion, interaction of vehicle components, emulsifiers and pH used in the formulation affects the determination of SPF values.[13] Therefore to develop sunscreens with better safety and high SPF, the formulator must understand the physico-chemical principle. The proposed methodology may be useful as a rapid quality control method. It can be used during the production process, in the analysis of the final product and can give important information before proceeding to the *in vivo* tests.

CONCLUSION

Sunscreen lotions were formulated using the *Acorus calamus* extract and biogenically synthesized ZnONPs. The prepared sunscreens were evaluated for SPF values by UV-spectrophotometric method. The SPF values were found to be 9.77 for the lotion ACL but ACLZ containing 5mg ZnONPs in formulation possesses 32.92. The present research work affords an economical, eco-friendly method of synthesis of sunscreens which finds applications in cosmetic industry. A simple and rapid *in vitro* determination of SPF was also established. Therefore, the SPF value, which is still the only regulatory requested protection factor for sunscreen products.

ACKNOWLEDGEMENTS

The authors sincerely thank the Avinashilingam Institute for Home Science and Higher Education for Women University, Coimbatore, Tamil Nadu, for providing research facilities.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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