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An Environmentally Friendly UV High Absorption Lignin Sunscreen

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Abstract

Suncream prevents ultraviolet light from harming the skin, and it has been super competitive in recent years. Traditional sunscreens were not environmentally friendly, especially for marine animals. In contrast, suncream made from lignin is natural, which is highly connected with "environmental protection", sometimes, suncream may not be smooth enough for the skin. In this study, a functional suncream with robust UV absorption and environmental friendliness was achieved by regulating the quantity of lignin, which has an important prospect and market in cosmetics.

Keywords

Lignin, Suncream, Glycerine

1. Introduction

Exposure to the sun's ultraviolet (UV) radiation can cause skin aging (such as skin spots and wrinkles), sunburn, and skin cancer, the most common of all cancers [1] [2]. The US Food and Drug Administration (FDA) and the American Academy of Dermatology (AAD) recommend that they use broad-spectrum sunscreens even on cloudy days [1] [3]. At the same time, glycerine and urea showed significant skin hydration effects compared with other humectants [4]. Meanwhile, lignin is a phenolic biopolymer in the structure of woody plants and most other terrestrial plants, which lacks an organized 2˚ or 3˚ structure [5]-[7]. However, it is well known that lignin is a polymer of mainly three types of phenyl propanoid structures, including sinapyl alcohol (S type), coniferyl alcohol (G type), and para-coumaryl alcohol (H type) units [6] linked together primarily by arylglycerol ether linkages and other bonds to form the macromolecule structure [8]. The main function of lignin is to harden the cell wall by building interwoven

webs and playing a role in pressure resistance. Also, it explains the functions of avoiding biological invasion, water erosion, antibacterial, antioxidant, anti-UV absorption, and flame retardant. In suncream, lignin mainly functions as an anti-UV absorption. Meanwhile, the presence of lignin turns ligno-cellulosic fibers to a darker color (*i.e.*, photo-yellowing) after exposure to photo-irradiation [9]. Although this property has a negative effect on wood-based pulps (*i.e.*, mechanical pulps), it has a positive effect on lignin application as a UV blocker [8]. One of the main mechanisms for photo yellowing of lignin is light-catalyzed photo-reactions with lignin chromophores, ultimately resulting in the formation of quinones and other chromophoric bodies [9] [10]. This phenomenon can accelerate lignin UV blocking potential even after exposure to sunlight [8]. Additionally, the safety and cytotoxicity of lignin as a greener alternative to petroleum-based ingredients in the fabrication of these skincare products were reviewed.

2. Experimental Section

2.1. Laboratory Equipment and Materials

Equipment that is used in the experiment: beaker, spatula, magnetic force heating mixer, analytical balance, weighing paper, dropper, glass rod and timer.

Materials that are used in the experiment: stearic acid, glyceryl monostearate, cetyl alcohol, longli lignin, glycerine, propylene glycol, potassium hydroxide, Paraben, citric acid, essence, pure water.

2.2. Process of Experiment

During the experiment, 8 steps should be taken. First, weigh Sample A using the analytical balance and add it to a beaker [11]. Sample A contains five chemicals, including 10 g of Stearic acid, 1.5 g of Glyceryl monostearate, 3 g of cetyl alcohol, 10 g glycerine, and 4 g of propylene glycol. Second, start the magnetic force heating mixer, and while mixing the sample, heat it until the sample is 90˚C and keep the temperature. Third, add Sample B to the heater until it reaches 90˚C. Sample B contains two chemicals, including 80 ml of pure water, and 0.5 g of Potassium hydroxide. Fourth, with intense mixing of Sample B, slowly add it completely into Sample A, and keep the 90˚C for 45 min or more (Sample C). Fifth, after adding the preservative, mix in the beaker for 10 minutes, and then begin cooling. The preservative contains two chemicals, including 0.05 g of Paraben, and 0.1 g of citric acid. Sixth, in each experiment, take different amounts of lignin and stir it into Sample C. Seventh, once Sample C starts to form a gluey substance (approximately at 55˚C), add essence to Sample C and maintain the temperature for 10 minutes. Eighth, after cooling about 30˚C, take Sample C out of the magnetic force heating mixer and stay for 3h.

Recording and taking pictures of each suncream result in order to figure out the best formula for lignin-based suncream. For the first time, too much glycerol is added, which destroys the structure of the oil-in-water in the suncream. Therefore, for the second and later on, less glycerol is added to achieve the desired result.

3. Results and Discussion

For each experiment, there must be some problems that should be considered. Since suncream is an oil-in-water structure, it is essential to figure out a balanced amount for both oil and water.

Figure 1. Different representations of different amounts of oil.

Substance	Oil	Pure water	Result
1	8.5 g	80 g	Cannot wet skin
2	9.0 g	80 g	Perfectly wet
3	10.0	80 g	Demulsification

Figure 2. A table for the relation between water and oil and result.

From Figure 1 to Figure 2, it is easy to see the various states. However, for the first time, too little oil (glycerine) was put in here, so the skin could not absorb it. This also induces the wet ability to decrease, which has a bad look and experience. For the second time, a little more oil was put in, there was no deposit in the beaker, and it was much smoother than the first. Discovering a range for a base of sunscreen is difficult. For the third time, more oil was put in the cream, and emulsification happened. It will cause the material to be stratified and the wet ability to increase. The structure will be destroyed and turn to water-in-oil, unavailable to the skin. (The dark color is lignin and does not influence the result.)

The second problem that must be solved is the color of lignin. The colors of lignin suncream typically range from brown to black, which precludes lignin from the most commonly used white daily-use sunscreen lotions [12]. Based on the advantages of UV absorption and oxidation resistance [13], lignin has been evaluated as sunscreens, which pushes lignin into high-end field [14]-[16]. However, the dark color of industrial lignin causes staining on skin and the market promotion of lignin-based sunscreens is totally hindered [17]. Lignin color reduction has been attempted, but this process destroys lignin molecules, inevitably resulting in a decrease in UV absorption. The dark color formation can be accelerated under harsh conditions (*e.g.*, high temperature) [18].

In light of these studies, it is apparent that the UV absorbance of the usual types of technical lignins, in their standard microparticulate size, is not high enough for high-SPF (sun protection factor) broad-spectrum suncream [19].

The lignin that is used in the experiment is the chromophores group of lignin, which is responsible for the UV-shielding property of composites, but it brings an

undesirable dark color [20]. Interestingly, the sun protection factor and color difference (ΔE) of the lignin-based sunscreens were obtained to study the effect of the molecular weight of lignin on its UV-protecting property and color [21]. The goal was that while the sun protection effect is maximum, it also ensures the appearance.

Figure 3. Different amounts of lignin affect cream.

It is obvious that the one with lignin of 0.02 g has the best appearance (**Figure 3**). Nevertheless, it apparently has the worst UV protection. In order to fully know which suncream has the best UV protection performance, a light absorption test is needed (**Figure 4**).

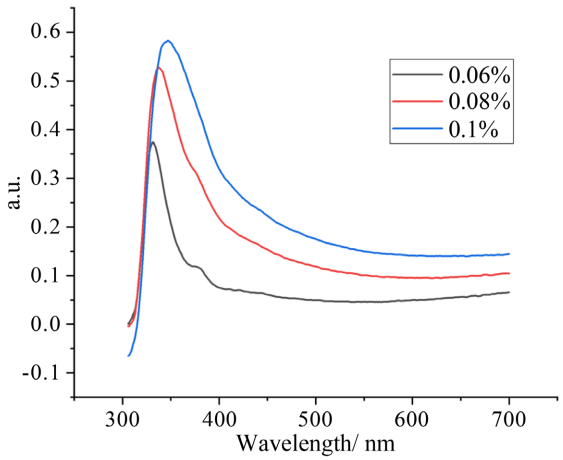

Figure 4. Wave absorption.

The overall light absorption test included three samples: 0.06%, 0.08%, and 0.1% of lignin. 0.1% has the best performance, while 0.06% has the worst performance at avoiding AV, apparently. By adding lignin inside the suncream for various percentages, the skill of blocking is different.

4. Conclusion

In this study, a special suncream is achieved with UV resistance. Suncream with lignin provides a new path of environmental protection, and it will contribute significantly to ocean sports lovers because of long-time exposure to the sun and seawater. As a result, suncream with 0.08% lignin is the formula for an environmentally sustainable alternative to the public, which maintains its unique characteristics as natural chemicals (lignin) and the best appearance of suncream.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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