Plastic Free Sunscreens

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Introduction:

Recent years have seen plenty of sun care ingredients studied frequently due to its detrimental influences on the environment, mainly affected by their organic counterparts, zinc oxide and titanium dioxide. A recent study of the eight most commonly used sunscreen actives approved by the U.S. Food and Drug Administration, all of them have environmental and health concerns.[1]

Prettypaul et al. raised the mechanism that polymer affect the water resistance and water proofing of sunscreen formulations. [2] After assessing how polymers deposit onto the skin, the study found that plastics in the formulation would get washed off of the skin，creating plastic debris in the environment, while those that are less than five millimeters will cause “microplastics”. Plastics have become widespread in cosmetic and personal care formulations since their appearance in cosmetics 50 years ago. Spherical or amorphic plastic particulates are used as ingredients in personal care and cosmetic products (PCCPs) for many purposes such as sorbent phase for delivery of active ingredients. Most of the plastic ingredients in PCCPs contain nondegradable polymers. These plastics may take hundreds of years to completely degrade. Most of microbeads (also called microplastics) on the market for PCCP formulations are about 1 μm, nearly impossible to be seen by naked eyes. However, they are applied in a variety of leave-on and rinse-off formulations like sunscreen. Plastic ingredients in PCCPs do not decompose in wastewater treatment systems, therefore cannot be recycled after being poured down the drain.

The purpose of this study was therefore to research the replacement of a traditional plastic film former with a liquid naturally derived bis-octyldodecyl dimer dilinoleate / propane diol copolymer and to study the aesthetics of sunscreen formulations and their biodegradability. [3]

Materials & Methods:

Raw Materials

Film Formers

Bis-octyldodecyl dimer dilinoleate / propane diol copolymer (CosmoSurf® DDG 20) was obtained from SurfaTech Corporation USA and used as recieved. Acrylates/Octylacrylamide Copolymer (CAS 129702-02-9 was obtained from Nouryon Corporation (CAS 129702-02-9) and used as received. VP/Eicosene Copolymer was obtained from Ashland Corporation (CAS 28211-18-9) (Ganex V-220) was obtained by and used as received.

Sunscreen Actives

All organic actives were obtained from -- and used as received.

Method for preparing Plastic Free Continuous Spray Sunscreen Formulation

Continuous spray formulation: Placing organic sunscreen actives (42.50 g) into a flask and heated to -- and allowed to stir until being homogenous. Added Bis-octyldodecyl dimer dilinoleate / propane diol copolymer (5.00 g) and sorbeth-2 hexaoleate (12.50 g) to the flask and allowed to stir until being homogenous. The mixture was allowed to cool down to room temperature and slowly added a specific amount of ethanol (165.00 g) to the mixture and allowed them to stir until being homogenous. The formulation was tested as is.

Method for preparing Plastic Continuous Spray Sunscreen Formulation

Continuous spray formulation: Placed organic sunscreen actives (42.50 g) into a flask and heated to -- and allowed to stir until being homogenous. Added Sorbeth-2 hexaoleate (12.50 g) to the flask and allowed to stir until being homogenous. The mixture was allowed to cool down to room temperature. After room temperature was achieved, then slowly added a mixture of Acrylates/Octylacrylamide Copolymer (5.00 g) in ethanol (165.00 g) to the mixture, and allowed them to stir until being homogenous. The formulation was tested as prepared.

SPF Testing

To measure the Static Sun Protection Factor (SPF) value for a sunscreen formula and the Static SPF value of the FDA standard sunscreen product using FDA, 21 CFR Sec. 201.327, subpart (i), SPF Test Procedure, Sunscreen Drug Products for Over-the-Counter Human Use, Final Monograph, Federal Register, Vol. 76, No. 117, June 18, 2011. The light source is a Xenon Arc Solar Simulator lamp, which provides a continuous emission spectrum from 290 to 400 nanometers (nm) with a limit of 1,500 watts per square meter (W/m2) of total irradiance for all wavelengths between 250 and 1,400 nm. The spectral output of the solar simulator will be filtered so that it meets the spectral output requirements for testing Sunscreen Drug Products for over-the-counter human use; FDA Final Monograph, 21 CFR Part 201.327 (i)(1) UV Source, Federal Register, Vol. 76, No. 117, June 18, 2011 and the International Sun Protection Factor (SPF) Test Method, May 2006.

Results & Discussion:

Results

The film forming ability of bis-octyldodecyl dimer dilinoleate / propane diol copolymer was tested in both a continuous spray and an emulsion formulation.

Material	A (%)	B (%)
Avobenzone	3.00	3.00
Octocrylene	5.00	5.00
Octyl Salicylate	5.00	5.00
Oxybenzone	4.00	4.00
Homosalate	10.00	10.00
Sorbeth-2 hexaoleate	5.00	5.0
bis-octyldodecyl dimer dilinoleate / propane diol copolymer	2.00	-
Acrylates/Octylacrylamide Copolymer	-	2.00
Ethanol	66.00	66.00
80 min SPF	34.60	34.73

Table 1. Continuous spray formulation containing bis-octyldodecyl dimer dilinoleate / propane diol copolymer

As seen in Table 1, the formulation containing bis-octyldodecyl dimer dilinoleate / propane diol copolymer had an 80 minute water immersion SPF of 34.60. This result was similar to the formulation that contained acrylates/octylacrylamide copolymer which recorded a 34.73. In this test, both formulations were very water resistant (VWR). Bis-octyldodecyl dimer dilinoleate / propane diol copolymer was then placed into an emulsion formulation and tested against VP/eicosane copolymer.The formulation is shown in Table 2.

Material	A (%)	B (%)
Water	59.25	59.25
Acrylates/C_{10-30} Alkyl Acrylate Crosspolymer	0.20	0.20
Ethylenediaminetetraacetic Acid	0.05	0.05
Triethylamine	0.05	0.05
Avobenzone	3.00	3.00
Octocrylene	5.00	5.00
Octyl Salicylate	5.00	5.00
Oxybenzone	4.00	4.00
Homosalate	10.00	10.00
Stearic Acid	2.50	2.50
Glycerin Monostearate	2.50	2.50
Sorbeth-2 hexaoleate	5.00	5.0
bis-octyldodecyl dimer dilinoleate / propane diol copolymer	2.00	-
VP/Eicosene Copolymer	-	2.00
Germaben II	1.00	1.00
80 min SPF	34.78	34.73

Table 2. Emulsion formulations containing (A) bis-octyldodecyl dimer dilinoleate / propane diol copolymer and (B) VP/eicosene copolymer.

As seen in Table 2, both formulations were very water resistant and obtained an SPF after the 80 min water immersion of 34.78 and 34.73 respectively.

Discussion

Sun-protection products are designed to be used in everyday activities and outdoor watersports. Water resistant properties are significant for these products, avoiding the actives being washed off of the skin, leaving the skin exposed to harmful UV rays. The most common way of embarking water resistance into sun-protection products is to utilize a polymer, which sometimes can be classified as plastics. Oxford Dictionary defines a plastic as: a synthetic material made from a wide range of organic polymers such as polyethylene, PVC and nylon that can be molded into shape while soft and then set into a rigid or slightly elastic form. In general, these plastics are solid phase, water insoluble ingredients that can flake off of the skin and be washed directly into the surrounding environment. However, Bis-octyldodecyl dimer dilinoleate / propane diol copolymer is a non-plastic, liquid polymer that has been shown to be inherently biodegradable in an OECD 301B test. [4] It is also soluble with the organic sunscreen filters, so it can be incorporated into both a continuous spray and emulsion product and provide water resistance producing SPFs of 34.60 and 34.78 respectively. This provides the flexibility to design an oil phase that has a desired SPF and esthetics that can be incorporated in a variety of product types without modifying the oil phase.

Conclusions:

A non-plastic biodegradable film former bis-octyldodecyl dimer dilinoleate / propane diol copolymer has been shown to provide water resistance in both ethanol and emulsion formulations. And through our experiment, we can clearly see that bis-octyldodecyl dimer dilinoleate / propane diol copolymer indeed can replace the traditional plastic sunscreens and this material has a strong power of biodegradability and solubility, which provides a better opportunity for the formation of the aesthetics of sunscreen formulations.

References:

[1]Environmental Working Group, *15th Annual Guide to Sunscreens*, **2021.**
[2] Prettypaul, D.; Fares, H.; *J. Cosmet. Sci.*, *63*, 213 -221, **2012**.
[3] www.surfatech.com
[4] SurfaTech CosmoSurf DDG 20 Technical Data Sheet