

PALM-BASED ESTOLIDE AS AN INGREDIENT IN SHAMPOO: A PRELIMINARY STUDY

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ABSTRACT

Estolides produced from dihydroxystearic acid (DHSA-estolides) were evaluated as ingredients in shampoos. Adding DHSA-estolides to a shampoo formulation improved its detergency and combability. The compounds can also be used as a viscosity builder.

Keywords: dihydroxystearic acid, estolides, formulation, shampoo.

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INTRODUCTION

Estolides are natural compounds (Plattner *et al.*, 1979) which can also be synthesized by homopolymerization of hydroxy fatty acids (Modak and Kane, 1965; Raynor *et al.*, 1990; Delafield *et al.*, 1965) or unsaturated fatty acids (Burg *et al.*, 1995; Erhan *et al.*, 1993; Isbell and Kleiman, 1994). Estolides have high viscosity, good oxidative stabilities and are biodegradable (Erhan and Kleiman, 1995). They have shown promise as an ingredient in cosmetics, coatings and lubricants. Estolides from meadowfoam were reported to improve the intrafibre moisture retention of hair and thereby protect it from thermal damage, restore its elasticity and reduce the friction of the cuticle surface to prevent mechanical damage (www.fancrop.com). In another work, Isbell *et al.* (2000) found that oleic estolides significantly improved rinseability, wet feel as well as detangling in shampoo. We have synthesized and characterized estolides from DHSA as starting material (Awang *et al.*, 2005). In this paper, we report the use of DHSA-estolides as an ingredient in shampoo. Characteristics such as foamability, detergency and combability of the shampoos were evaluated.

MATERIALS AND METHODS

DHSA-estolides were prepared as described by Nor Azizan (2006) to be an ingredient in a test formulation of shampoo as shown in Table 1. The most stable DHSA-estolides formulated shampoo was subjected to further tests.

TABLE 1. TEST SHAMPOO FORMULATION

Ingredient	% Weight
Sodium laureth sulphate	8.0
Cocamide DEA	5.0
PEG-7 glyceryl cocoate	1.0
EDTA	0.05
Sodium laureth	2.0
DHSA-estolides	2.0
Perfume	0.1
Preservative	0.1
Citric acid/NaOH	To pH5.5
Deionized water	To 100

Foaming Power and Stability

A solution of the test shampoo (1 g shampoo/ 200 ml deionized water) was poured into a 500 ml measuring cylinder. A foam was whipped up with 30 vigorous strokes of a perforated plunger. The foam volume was noted after 30 s and 5.5 min. The foam stability was expressed as the ratio of the foam volume at 5.5 min to that at 30 s (V_5/V_0).

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Detergency

Preparation of hard water: A stock solution of hard water (equivalent to 5000 ppm CaCO_3) was prepared by dissolving 4.41g $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ and 4.93 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in 1000 ml deionized water. Water of other hardness (50 ppm, 150 ppm and 350 ppm CaCO_3), were prepared by dilution of the appropriate aliquots of the stock solution with deionized water.

Detergency test. The detergency of the shampoo in water of various hardness as well as in deionized water, at room temperature on soiled cloth, (70C, silk soiled with sebum), was determined by a Terg-o-tometer. Before washing, the reflectance of the 70C cloth was measured using the Minolta CM-3600d spectrometer. Washing as per the procedure described by Ahmad *et al.* (1998), was then carried out. The detergency, or % soil removal, was calculated using the formula:

$$\text{Soil removal, \%} = [(\text{AW}-\text{BW})/(\text{OC}-\text{BW})] \times 100$$

where,

AW = reflectance of the soiled cloth after washing.
 BW = reflectance of the soiled cloth before washing.
 OC = reflectance of original cloth.

Combability Test

The combability measured is based on the reduction in combing force required. Wet and dry combability were tested for self-bleached swatches of European hair using a Diastron 756 Fibre Dimensional Analyser. The hair samples were immersed in bleaching solution (25% ammonium solution and 35% hydrogen peroxide) for 30 min, after which, the swatches were dried at room temperature. The bleached swatches were washed using the shampoos tested. After shampooing for 1 min, the hair was rinsed with water for another 1 min. This test was carried out in triplicate for each shampoo. The combing force was measured in Joules, calculated by

$$\text{Combing force, \%} = [(\text{JB}-\text{JA})/ \text{JB}] \times 100$$

where

JA = combing force of hair after shampooing.
 JB = combing force of hair before shampooing.

RESULTS AND DISCUSSION

Compatibility and Properties of DHSA-estolides in Shampoo

The DHSA-estolides prepared were used to formulate shampoo and the stability of the various

formulations observed at room temperature. Only the formulation containing DHSA monoestolide and diestolide were stable after 24 hr storage at room temperature (Table 2). Therefore, they were chosen for further evaluation, the results of which are presented in Table 3.

TABLE 2. COMPATIBILITY OF SHAMPOOS FORMULATED WITH DHSA-ESTOLIDES

Shampoo containing	Stability after 24 hr storage at RT
DHSA-monoestolide	Stable
DHSA-diestolide	Stable
DHSA-triestolide	Separated into 2 layers
DHSA-pentaestolide	Separated into 2 layers
Control	Stable

TABLE 3. FURTHER EVALUATION OF STABLE SHAMPOOS

Test	Control	DHSA-estolides formulated shampoos	Commercial shampoo
Clarity	Clear	Opaque, pearly	Opaque, pearly
Foam Volume, (ml)	330	345-365	315
Foam Type	Loose, airy	Rich, dense, creamy	Rich, dense, creamy
Surface tension, (mN m^{-1})	37.1	35.8-36.2	36.5
Wetting time, (s)	140	138-141	140
pH	5.5	5.5-5.7	5.6

Viscosity and Foaming Properties

A good shampoo must have adequate viscosity-low enough for easy pouring from the bottle and yet high enough to cling and not drip from hair during use (Mainkar and Jolly, 2001). The shampoo formulated with DHSA-estolides had a higher viscosity than the control and commercial samples (Figure 1). This suggested that DHSA-estolides can be used as a viscosity builder in shampoo.

DHSA-estolides exhibited higher foaming power and foam stability (Figure 2) than commercial sample. This was because the foams generated by DHSA-estolides formulated shampoos were more compact and uniform, leading to nicer, richer and denser foams than the commercial and control samples. Therefore, adding these compounds in shampoo

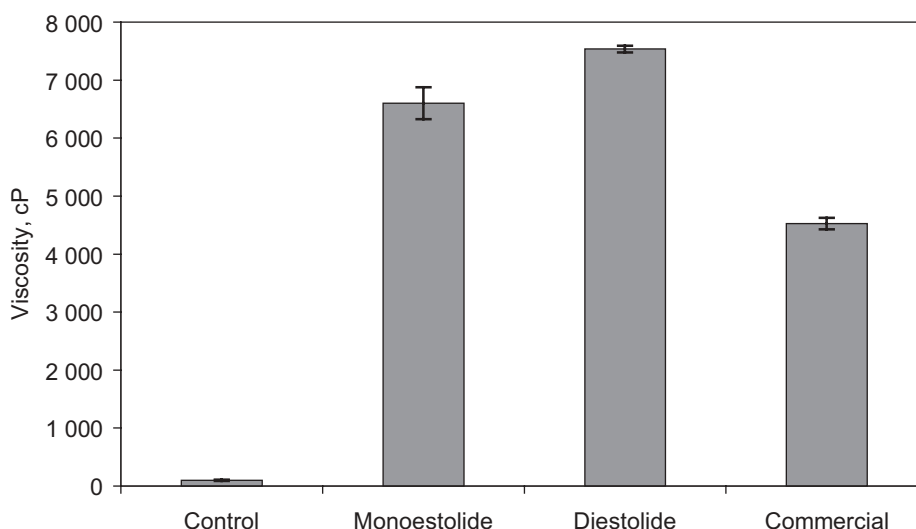


Figure 1. Viscosity of DHSA-estolides formulated, control and commercial shampoos.

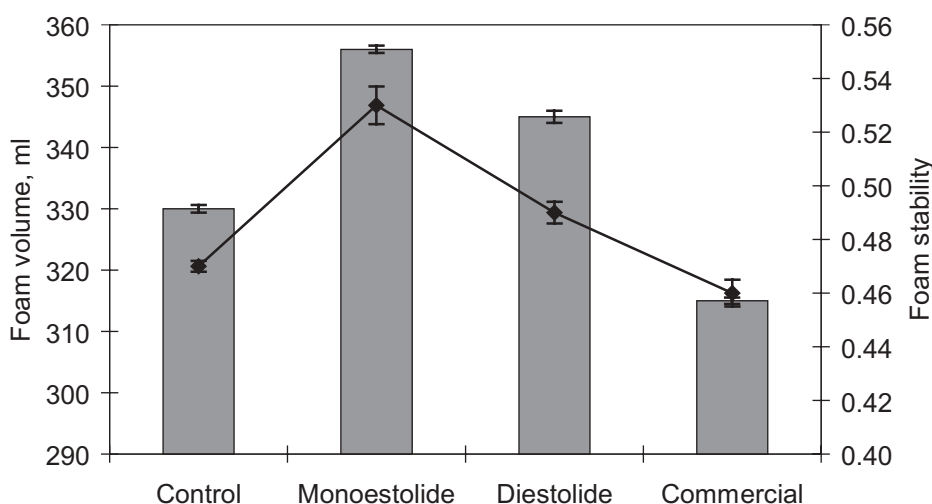


Figure 2. Foaming power and foam stability of DHSA-estolides formulated, control and commercial shampoos.

causes slower coalescence of the foam by strengthening the film at the air/water interface in the matrix of bubbles.

Detergency of Shampoos

The best method to evaluate shampoo performance is to test it on clients in a salon but this is costly and time consuming. In this preliminary study, human hair was replaced with a standard fabric coated with synthetic sebum to simulate the presence of soil. The performances of the shampoos were evaluated in water of different hardness at room temperature (Figure 3). In distilled water, the shampoos containing DHSA-estolides showed higher detergency than the control sample. However, only the shampoo containing DHSA-monoestolide had a higher detergency than the commercial one.

The DHSA-estolide-formulated shampoos had higher detergency than the commercial one in water

of 50 ppm to 350 ppm CaCO₃ hardness. However, the detergencies of all the shampoos decreased gradually as the water hardness increased. Hard water interferes with detergency because the ions form insoluble precipitates with a variety of detergent ingredients and soil, thus making the detergent less effective (Fujimoto, 1985; Kauro, 1998).

Combability

The combability of a shampoo is based on the reduction in combing force. In this study, no other conditioning agents were added into the control and DHSA-estolide-formulated shampoos in order to ensure that only the effects of the DHSA-estolides were measured. Under wet conditions, the formulation containing DHSA-monoestolides as well as the control did not improve the combability of the hair samples, while under dry conditions, the shampoos containing DHSA-estolides showed

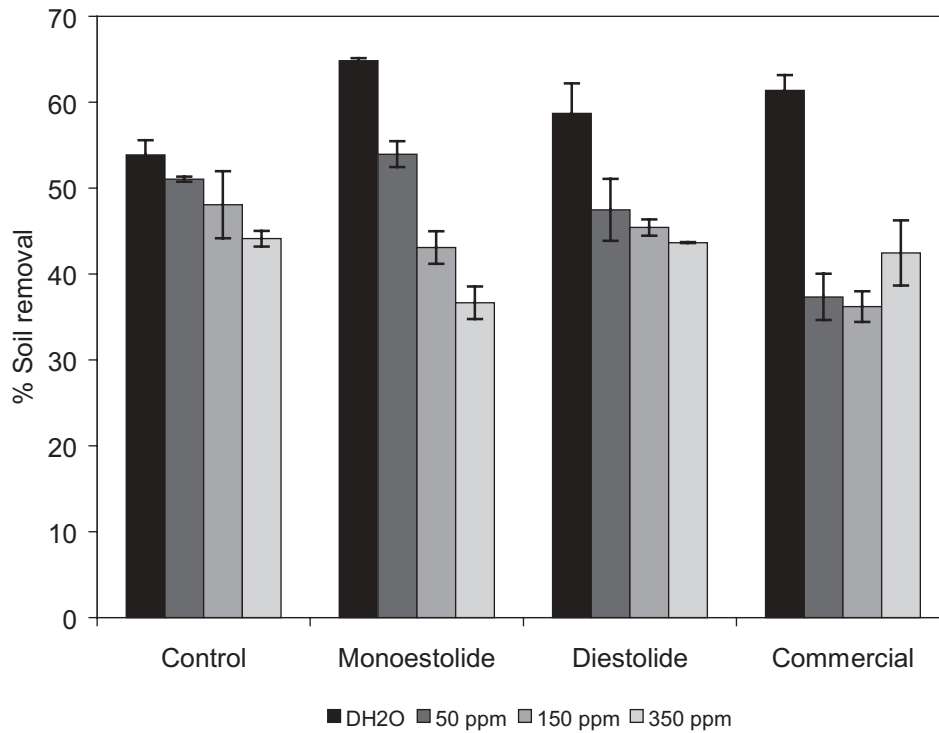


Figure 3. Detergency of DHSA-estolides formulated, control and commercial shampoos in various water hardness at RT.

comparable combability property to the commercial one (Figure 4). This result indicated that DHSA-estolides can be used as a conditioning agent in shampoo formulation.

CONCLUSION

Shampoos containing DHSA-estolides were formulated. The addition of these compounds in the

formulations improved the detergency and combability of the shampoos.

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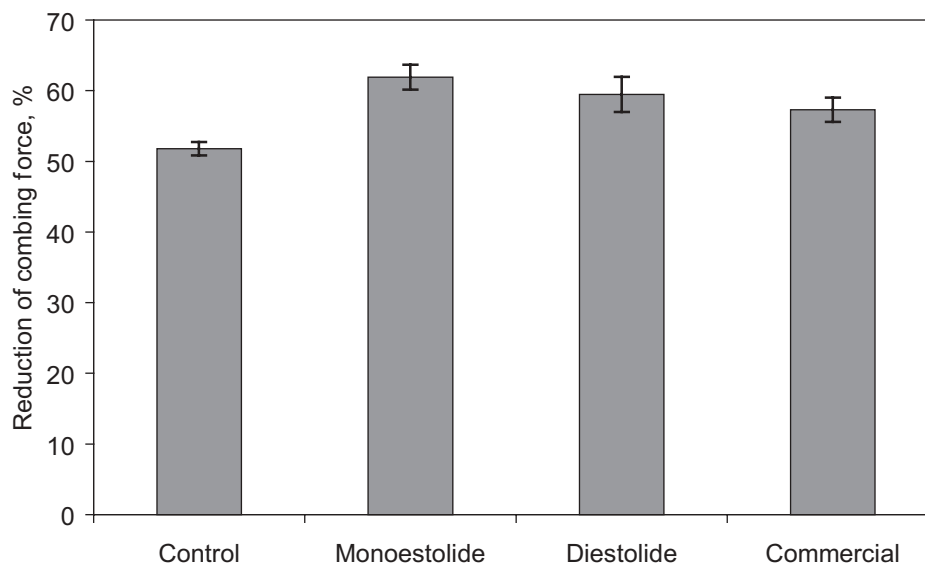


Figure 4. Reduction in combing force for dry hair using DHSA-estolide formulated, control and commercial shampoos.

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