An *ex vivo* comparison study: the effect of a fatty acid ester and a cationic silicone derivate on the protection of hair colour from washing and heat styling exposure

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Introduction

▪ Hair colour protection from shampoo related fading is becoming a popular claim on shampoos. The amount of fading depends on the structure of the dye, ultraviolet exposure, and the frequency of washing of the hair. It is also suggested that heat styling tools may play a negative role in the colour change (Santos et al., 2005).

▪ It is known that red colours especially rapidly fade with repeated washing. This results from the small molecular size of the red pigment, which makes it easier to travel through the hair cuticle (Bouillon & Wilkinson, 2005). This is more prominent when the hair suffers from high porosity through chemical colouring or bleaching (Marsh, 2012).

▪ Hair colour fading can be minimised by including e.g. milder primary surfactants, cationic conditioning agents, ultraviolet absorbers into shampoo formulations (Zhou et al,. 2008).

▪ We previously showed that colour fading can be reduced by using polyquaternium compounds within an amphotheric surfactant system in an acidic pH environment.

Aim

1. To find out whether a fatty acid ester (INCI: Triisostearyl Trilinoleate) on its own and in combination with a cationic silicone derivative compound (INCI: Silicone Quaternium-22) can provide improved colour retention properties when used within a shampoo.
2. To establish the impact of heat (different hair drying methods) on colour retention.

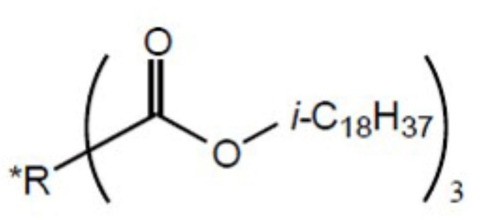
Materials and Methods

Hair. 13 Caucasian virgin natural brown hair tresses (Banbury, United Kingdom), length:29 cm, mass:1.18 grams.

Active ingredients

A) *Triisostearyl Trilinoleate* (Lubrizol, USA):

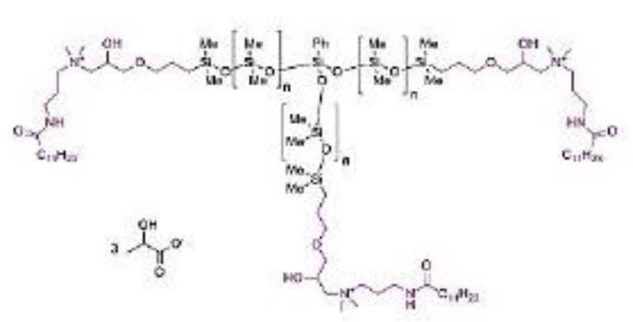
- Triester of Isostearyl Alcohol and Trilinoleic Acid.
- Claims: properties of lanolin oil, offering emolliency, viscosity and shine



*R: Trimer Acid Radical

B) *Silicone Quaternium-22* (Evonik, Germany):

- Has a T-structured silicone backbone that is end-capped with quaternary amine functionality and has three cationic charged sites.
- Claims: heat protection properties, improved colour retention of dyed hair and enhanced foam properties



Shampoo formulation

- Actives were incorporated individually at the level of 1.5% w/w (**A and B**), as well as in combination with each active at the level of 0.75% w/w (**C**), in a shampoo base formulation (**D**).
- Stable shampoo formulation (pH 5.3-5.4) was developed using a combination of Cocamide DEA, Sodium Chloride, PEG-150/Decyl Alcohol/SMDI Copolymer and PEG-120 Methyl Glucose Dioleate.
- *Ingredients*: Aqua, Sodium Laureth Sulphate, Polysorbate 20, Cocamidopropyl Betaine, Cocamide DEA, Sodium Chloride, PEG-150/Decyl Alcohol SMDI Copolymer, PEG-120 Methyl Glucose Dioleate, Triisostearyl Trilinoleate, Silicone Quaternium-22, Imidazolidinyl Urea, Citric Acid

Physicochemical characterisation of formulations

▪ Viscosity was measured with the Brookfield viscometer (sp4, RPM 12, 23°C) (Brookfield Viscometers Ltd, United Kingdom).
▪ Shampoo consistency was assessed using a texture analyser (Stable Microsystems, United Kingdom) by performing a backward extrusion test.
▪ Foam height and drainage were evaluated using the Hart-de George blender method (Klein,2004).

Experimental design

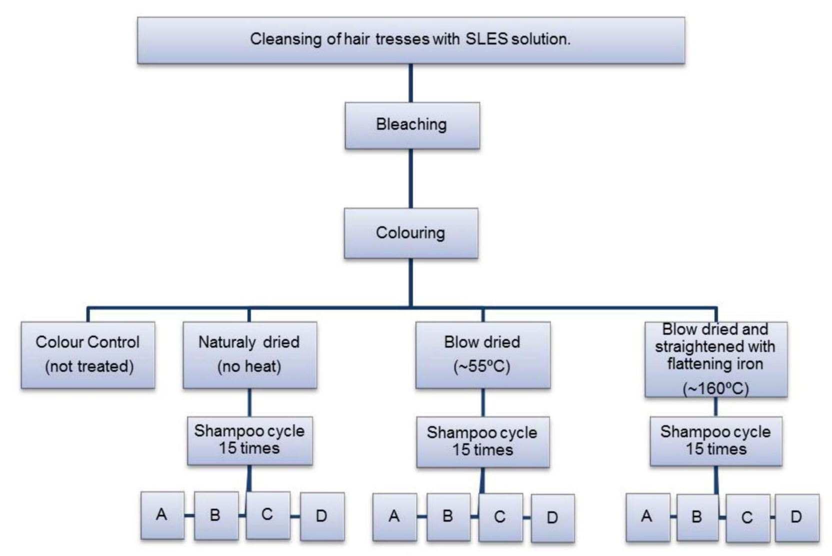


Figure 1. Set of 13 hair tresses were separated in 3 groups of 4 tresses, with one serving as a colour control. The groups were coded with a coloured label [white group: naturally dried using a hair stand and dried at room temperature; grey group: blow dried (~55°C) until dry to touch; and black group: blow dried and straightened with a flattening iron (~160°C)]. *SLES:* Sodium Laureth Sulphate.

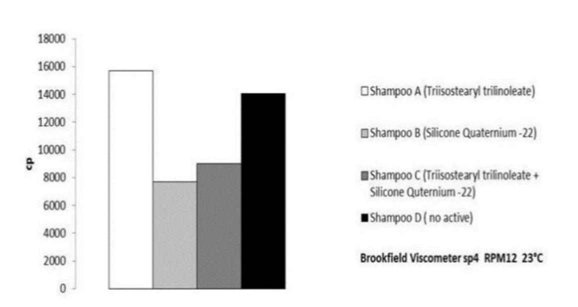
- Hair tresses were cleansed with a 10% w/w aqueous SLES solution, bleached, and dyed with a professional red oxidative dye.
- Each hair tress underwent 15 washing cycles.
- Colour measurements (L*C*h) were taken before and after bleaching, after colouring and after eaching washing cycle, using a spectrophotometer (Konica Minolta, United Kingdom).
- Deposition of active ingredients on the hair tresses was assessed using the Sebumeter® (Courage + Khazaka Instruments, Germany).

Results and Discussion

Physicochemical characterisation of the shampoo formulations

A) Viscosity and textural properties

Figure 2 (left panel) shows that Silicone Quaternium-22 had the highest impact on the viscosity of the formulation, while Triisostearyl Trilinoleate slightly increased the viscosity when compared to the control formulation. Silicone Quaternium-22 had a higher impact on the texture of the shampoo formulation than Triisostearyl Trilinoleate (right panel).



Test parameter	Firmness	Consistency	Cohesiveness	Index of Viscosity
	g	g sec	g	g sec
Test formulation	Force 1	Area F-T 1:2	Force 2	Area F-T 2:3
Shampoo A Triisostearyl Trilinoleate	12.973	125.169	-8.022	-11.997
Shampoo B Silicone Quaternium-22	11.443	124.122	-7.055	-9.152
Shampoo C Triisostearyl Trilinoleate and Silicone Quaternium-22	11.762	123.554	-7.235	-9.3
Shampoo D no active	12.739	125.454	-8.192	-12.851

Figure 2. Viscosity (spindle size 4, RPM 12, 23°C) (left panel) and textural properties (right panel).

B) Foam quality

Figure 3 (left panel) shows that both active ingredients (alone or combined) reduce the foam height. In comparison to the control formulation, the foam drained quicker.

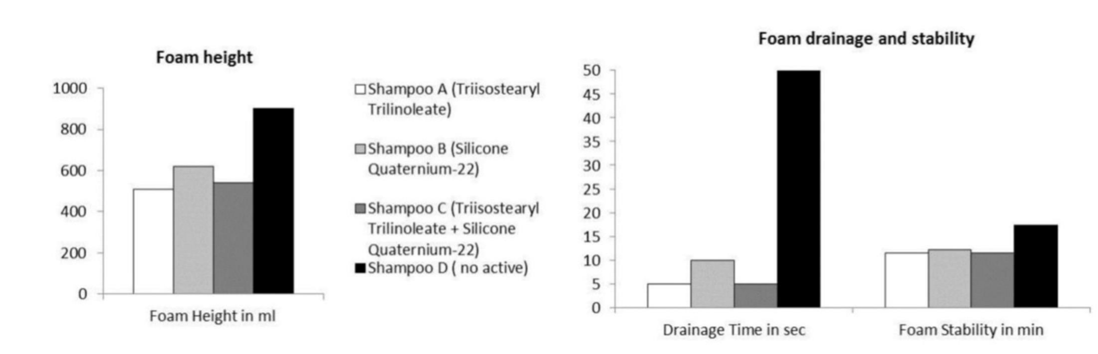


Figure 3. Foam height (left panel), drainage and stability (right panel).

The low performance of shampoos A, B, and C can be explained by the influence of hydrophobic liquids such as Triisostearyl Trilinoleate and Silicone Quaternium-22, which may act as antifoams.

Deposition of the actives on the hair

Figure 4 shows that the active Triisostearyl Trilinoleate is better deposited with shampoo C, suggesting that a better deposition on the hair fiber when combined with Silicone Quaternium-22.

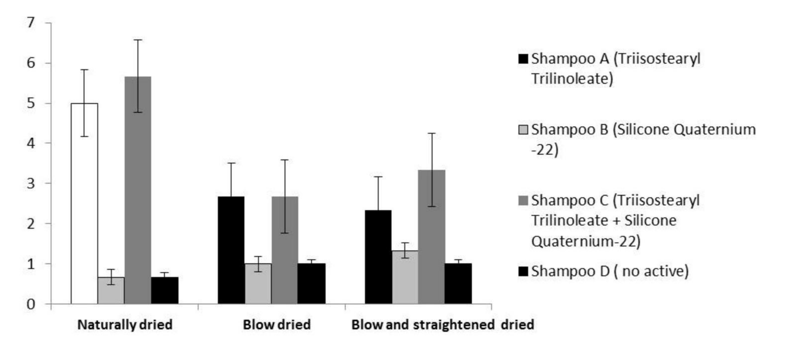


Figure 4. Deposition of active ingredients on the hair fibres and the impact of the drying method on their deposition.

Hair colour retention and the impact of drying method

Different drying methods have a significatn impact on colour fading. Moreover, a combination of drying and straigthening of the hair has imparted a greater colour loss compared to only blow dried or naturally dried hair tresses. Delta E (ΔE) measurements were used to compare the changes versus baseline of each hair tress (**Figure 5**).

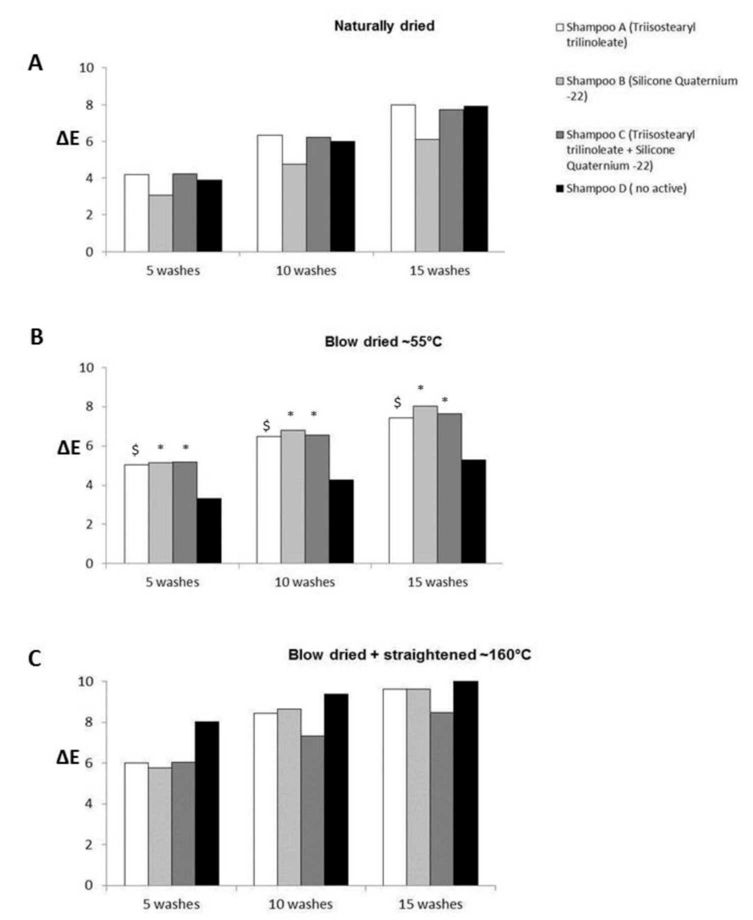


Figure 5. Impact of drying method on hair colour retention after 5,10 and 15 washes. A) Naturally dried, B) Blow dried, and C) Blow dried and straightened hair tresses. *Significantly different versus shampoo D, $Trend to significance

Results shown in **Figure 5A** suggest that in the naturally dried group, Silicone Quaternium-22 (shampoo B) has provided better protection than the other shampoos, although the effect was not statistically significant. **Figure 5B** demonstrates that the shampoo with no active has resulted in the lowest colour change, suggesting a better colour protection. From **Figure 5C**, it can be observed that shampoo C has provided the highest protection against colour fading when the hair was blow dried and straightened.

Conclusion

- The fatty acid ester (Triisostearyl Trilinoleate) and a silicone derivative (Silicone Quaternium-22) in a shampoo formulation did not show a significant effect on colour protection. However, a trend towards a significant difference was observed when both actives were combined and used on hair that has been blow dried and straightened.
- This study also demonstrates that different drying methods have a significant impact on hair colour retention.

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