Can hair be protected from oxidative damage during and after bleaching?

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Introduction

The purpose of bleaching human hair is to oxidise the naturally occurring pigment, melanin, in order to lighten the hair in preparation for further colour changes. Hydrogen peroxide (H_2O_2) is the principal oxidizing agent commonly used in conjunction with alkaliser(s) in order to boost the speed of the oxidative reaction.

In addition to the desirable oxidation of melanin, a host of undesirable reactions take place: Cell Membrane Complex degradation, disulphide bond oxidation and peptide bond hydrolysis [1,2,3,4]. Developing bleaching systems that cause minimal undesirable alterations to the hair fibre remains an important challenge to the industry .

The aim of this study was to assess *ex vivo* three different materials for their capacity to mitigate some of the above undesirable effects. The investigated actives were: **L-arginine, hydrolysed keratin and cystine-silanol copolymer.** They were selected on the basis of their affinity to hair proteins and their stability at high pH (pH≤10)

Materials and Methods

The tested actives are described in Table I. All actives were added at 0.75% w/w. Virgin Caucasian, brown hair tresses were used for testing (length=30cm, weight=5g, excluding the waxed top; Banbury Postiche, UK). A commercial system for hair bleaching was used, based on 40vol H_2O_2 and combined with Potassium persulfate-containing alkaliser.

Two different treatments for each active were tested: active mixed **with the bleach (WB)** and as a soaking solution for the tresses **after bleaching (AB)**

Table I. The formulation of the model semisolid emulsion

	L-Arginine	Aqua, Hydrolysed Keratin, Methylparaben, Propylparaben	Aqua, Cystine Bis-PG-Propyl Silanetriol
Derived from	Botanical sources	Animal sources	Synthetic
Active content	100%	25%	15%
Avg. MW (g/mol)	174.2	1,000	20,000
Amino acid present	Arginine	Cystine	Cystine
pH at 25°C	9.86 (0.75% sol)	5.40	9.76
pH compatibility	No information	Above pH 5.0	Stable in bleach
Physical properties	White crystalline powder	Brown transparent liquid	Yellow transparent liquid

Fig. 1 Examples of hair tresses at different degrees of bleaching

Colour measurements (dry): Spectrophotometer CM-2600D (Konika Minolta, Japan), illuminator D65, viewing angle 8°, five random measurements per tress. L-values (black to while scale) and *b*-values for (yellow to blue scale) were analysed.

Tensile measurements (wet and dry): TA XT Plus (Stable Micro Systems, UK), extension rate of 1% per second, T=22C°, RH=40. Each fibre was first viewed with Microscope CX40 and SC30 (Olympus, Japan), the width of the fibre was recorded in three places and averaged, and used to approximate the cross-sectional area of the fibre.

Combing ease (wet and dry): Texture Analyser – TA.XT with a hair combing rig A/HCR (Stable Micro Systems, UK), combed with medium plastic comb, width=8cm, 64 tines.

Sensory study protocols: The smoothness of dry hair tresses was evaluated by 12 blind-folded, trained volunteers

Results and Discussion

Colour measurements: L and *b* after **all** treatments changed to lighter and less yellow colour than bleached control (p<0.01); (Fig. 2a and 2b).

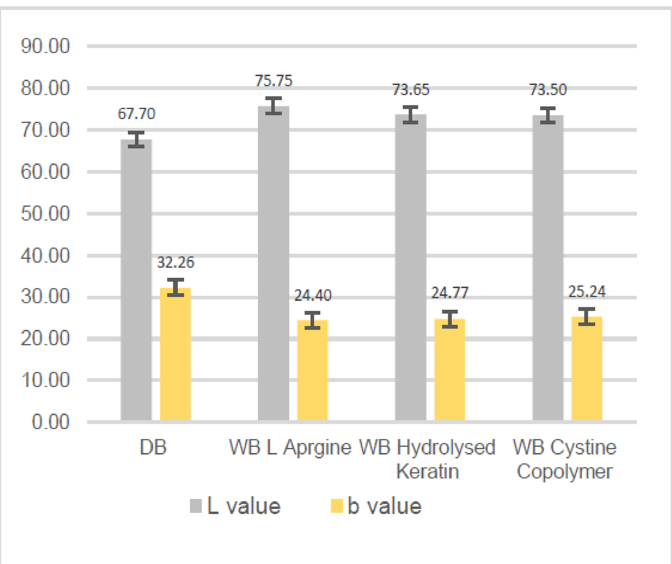

Fig. 2a L and *b* values for hair tresses treated using WB protocols

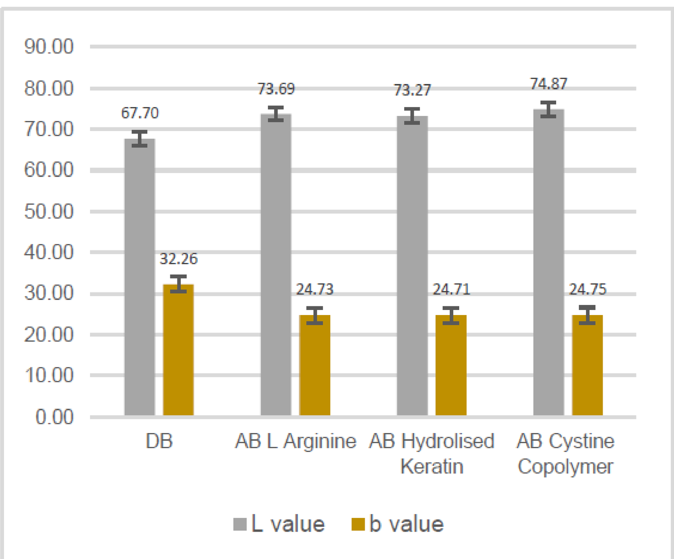

Fig. 2b L and *b* values for hair tresses treated using AB protocols

Tensile results (Fig 3):

- The cystine-silanol copolymer **showed potential to increase** single-fibre tensile strength, especially when applied as **AB**.
- It is hypothised that, as **AB,** the polymer adsorbs more effectively on the fibre and the heat of blow drying provides the activating energy for cross-linking and film formation.

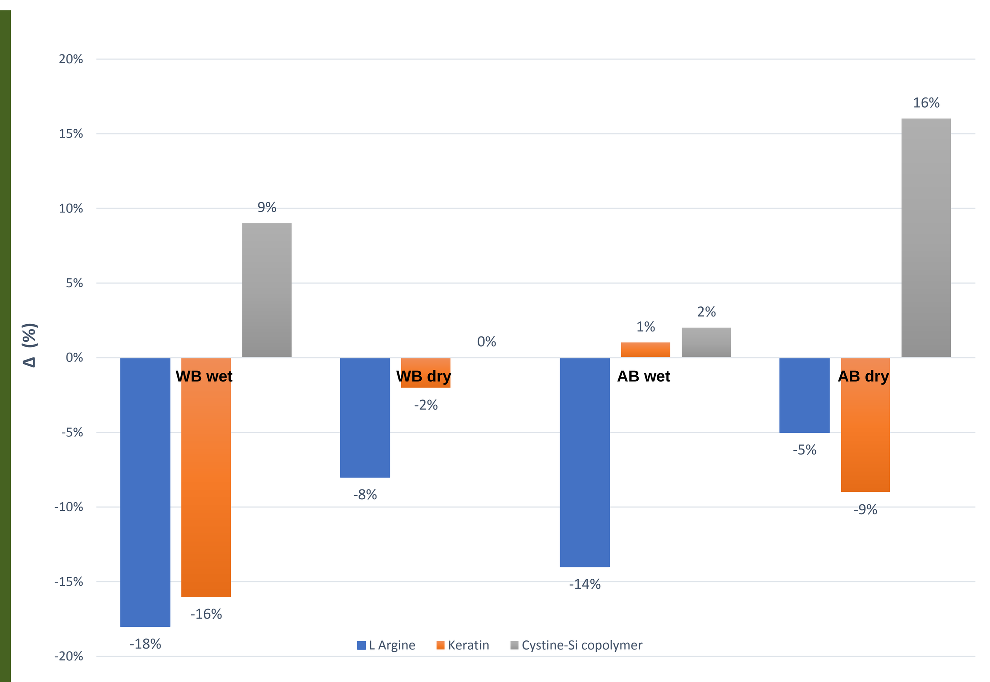

Figure 3: % change in the tensile stress between active treatments and double bleached hair, in wet and dry state

Combing ease results (Fig.4):

- The **cystine-silanol** copolymer reduced combing force as **WB** treatment.
- The **L-arginine** and **keratin AB** treatments appeared to increase combing force, especially in dry state.
- It is suggested that inter fibre friction has increased when using **L-arginine** and **keratin as AB**

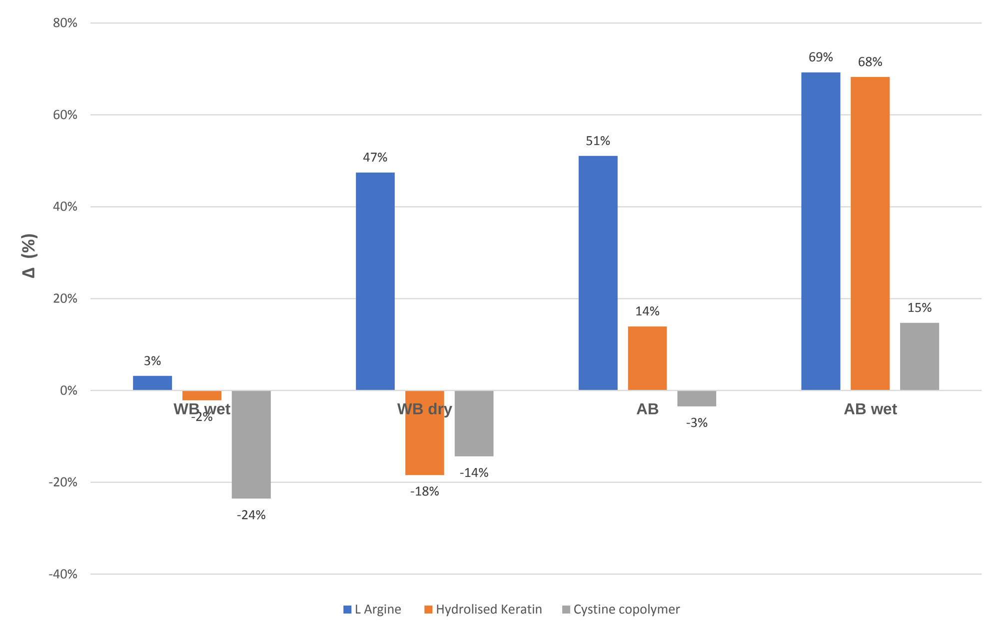

Figure 4: % change of combing work for various active treatments (wet and dry hair) in relation to double bleached hair

Sensory study protocols (Fig5):

- **WB** : the actives treatment eliciting smoothening effect with rating above double bleached hair were the **hydrolysed keratin and the copolymer treatments.**
- **AB:** all actives elicited improved smoothness, but there was no statistical difference between the active treatments.

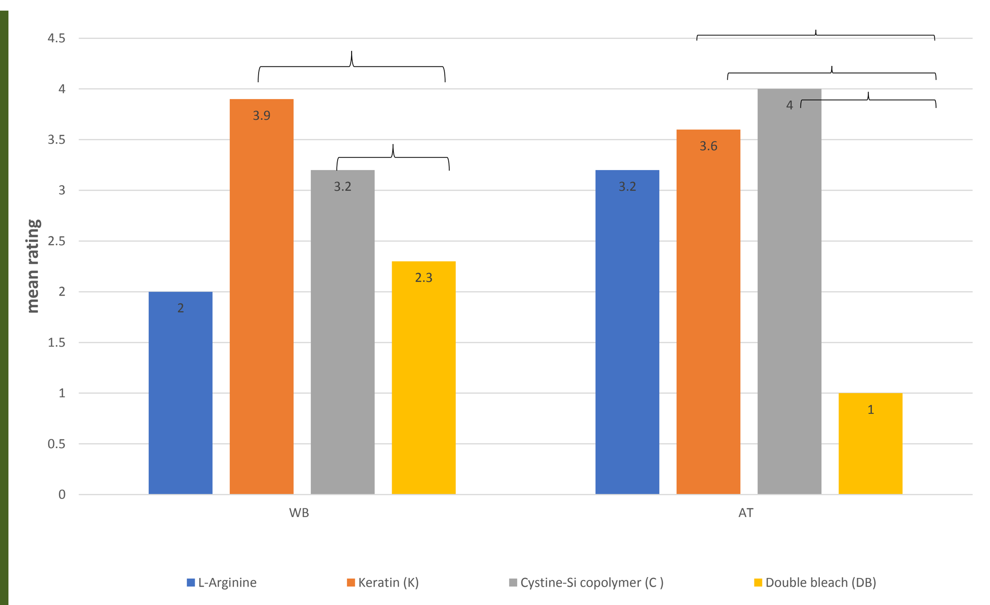

Figure 5: ratinging for smoothness of hair tresses by panellists (0=very rough, 5=very smooth)

Conclusion

- This study demonstrated that the actives with prevalent ionic affinity to hair, L Arginine and hydrolysed keratin, as tested at comparable concentrations, did not elicit consistent improvements across the instrumentally measured hair parameters.
- In contrast, the **cystine-silanol copolymer**, with its hydrophobic and chemical affinity, **provided more consistent benefits across the different test conditions**.
- Based on colour and sensory results, the actives improve the efficacy of bleaching and after-bleach products in two directions: lightening and smoothing the hair.

[1] Bushan, B. (2008) Nanoscale characterisation of human hair and hair conditioners, *Progress in Material Science*, 53, pp.585-710; [2]Evans, T. (2017) How damaged is hair? Part 2: Internal Damage, *Cosmetics and Toiletries*, 132, No 6, pp.36-45. [3] Kazagura A. (2006) Analysis of structural changes in bleached keratin fibers (black and white human hair) using Raman Spectroscopy, *Biopolymers*, 81, pp.506-514; Wortmann, F.J., Springob, C., Sendelbach, G. (2002) Investigation of cosmetically treated human hair by differential scanning calorimetry in water, [4] *Journal of Cosmetic Science*, 53, pp.219-228