St. Paul's Convent School

Dyeing Hair, Dying Hair? (「髮」證先鋒)

Introduction

Hair dyeing is the norm in this era but are we letting our hair turn into dying hair in the process?

Objectives

In Part I, the content of bleaching agent H_2O_2 of 9 commercial hair dyes was determined through titration. In Part IIA, we investigated the chemical, temperature and time effect on hair bleaching. In Part IIB, we compared the damaging effects of different bleaching conditions on hair. In Part IIIA, we used lemon juice with tea to bleach hair. In Part IIIB, we compared the dyeing effects of commercial and natural dyes. In Part IV, we investigated the effect of the 7 natural dyes on white hair.

Chemical Principles

Part I Determination of H_2O_2 Content in Commercial Hair Dyes

The content of active ingredient, H_2O_2, was determined through titration against acidified $KMnO_4$.

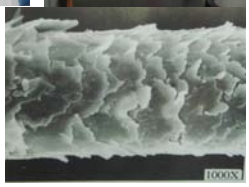
$2\ MnO_4^-{}_{(aq)} + 5\ H_2O_2{}_{(aq)} + 6\ H^+{}_{(aq)} \rightarrow 2\ Mn^{2+}{}_{(aq)} + 5\ O_2{}_{(g)} + 8\ H_2O_{(l)}$

Under heating, the rate of decomposition of H_2O_2 increases.

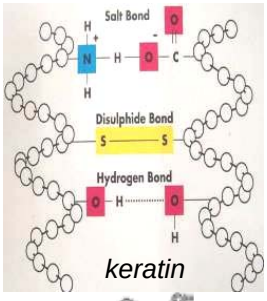
$2\ H_2O_2{}_{(aq)} \rightarrow 2H_2O_{(l)} + O_2{}_{(g)}$

Part IIA Chemical, Temperature and Time Effect on Hair Bleaching

Hair bleaching involves the dissolution of melanin pigment granules and subsequent depolymerisation of pigment chromophore into carboxylated derivatives which are soluble in alkaline medium and can be eliminated by rinsing. A typical bleaching includes a bleaching agent, usually H_2O_2, a NH_3 base, which raises the cuticle scales for the penetration of bleaching chemicals and a booster like $S_2O_8^{2-}$, which provides an additional source of oxygen for bleaching.



raise hair cuticle

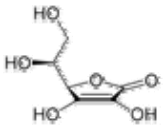


keratin

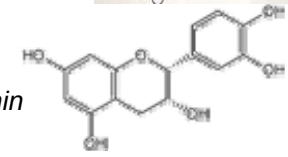
Part IIB Damaging Effects of Different Bleaching Conditions

During bleaching, H_2O_2 attacks keratin protein in the hair cortex by oxidizing the amino acid cystine to cysteic acid and breaking the disulphide linkages. As bleaching compositions are usually formulated between pH 9 to 11, the hydrolysis of peptide bond during bleaching could also reduce the tensile strength of hair.

ascorbic acid



catechin



Part IIIA Hair Bleaching with Lemon Juice and Tea

Ascorbic acid in lemon juice and catechins in tea are antioxidants which convert the double bonds of the conjugated π system of melanin chromophoric units into single bonds, thus the chromophore is unable to absorb visible light and hair is said to be bleached. Sunlight is required for significant bleaching results as it opens the cuticle by altering the amino acids by photochemical degradation.

Part IIIB Comparison of Dyeing Effects of Commercial and Natural Dyes

Permanent commercial hair dyes generally consist of p-diamines and p-aminophenols that are oxidized by H_2O_2 to active intermediates, which react inside the hair with colour couplers to provide shampoo-resistant hair dyes. The natural sources chosen cover a wide range of colours and all contained high concentrations of colour pigments, which are anthocyanins, chlorophyll, curcumin, beta-carotene and caffetannin respectively. Addition of binding agents like egg yolk enhances the molecular interactions between keratin and pigments. Egg yolk and soya flour

contains lecithin, a phospholipid which increases the adhesion of natural dyes to the hair. Egg white is an albumin solution which gives shine and transparency to colours. Gelatin has an amphoteric and hydrophobic character which gives it emulsifying properties.

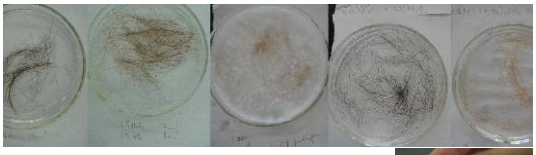
10-point scale

☺ lowest bleaching power ☺☺☺☺☺☺☺☺☺☺ greatest bleaching power

Experiments

Part I Determination of H_2O_2 Content in Commercial Hair Dyes

Known volumes of H_2O_2 developers were acidified and titrated against standard $KMnO_4$ solution until a permanent pink colour was observed. Titration was carried out at different temperature to investigate the effect of temperature on the H_2O_2 content in the developers.



Part IIA Chemical, Temperature and Time Effect on Hair Bleaching

All the black hair used is from a 12 year old girl whose hair has never received any treatment. Hair bleached with different combinations of bleaching agent, base and booster for 1 hour, 3 hours, 24 hours and at 25°C, 40 °C and 60 °C, were rated according to a ten point scale.

Part IIB Damaging Effects of Different Bleaching Conditions

A spring balance was used to measure the average force required to snap a piece of hair taped to the tabletop in which a larger force implied a stronger tensile strength of the hair.

Part IIIA Hair Bleaching with Lemon Juice and Tea

Lemon juice was freshly squeezed and added to 11 different types of tea in the volume ratio 1:3 for 24 hours under sunlight to observe the bleaching effects.

Part IIIB Comparison of Dyeing Effects of Commercial and Natural Dyes

Pigments were extracted from 7 natural sources: strawberries, blueberries, cherries, spinach, ginger, carrot and coffee for hair dyeing. Ripen fruits were squashed with a glass rod in a beaker of heated vinegar and water mixed in the volume ratio of 1:7. Suction filtration was then carried out to obtain the dye extract. Part of the hair samples was dipped into one of the 4 binding agents before dyeing and dyeing effect was observed for commercially and naturally dyed hair. Hair samples were washed with shampoo to test for the permanence of the natural dyes.

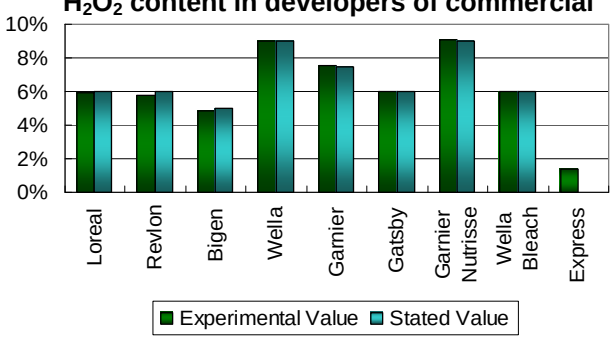
bleaching cream, 6% H_2O_2 developer

Part IV Effect of Natural Dyes on White Hair

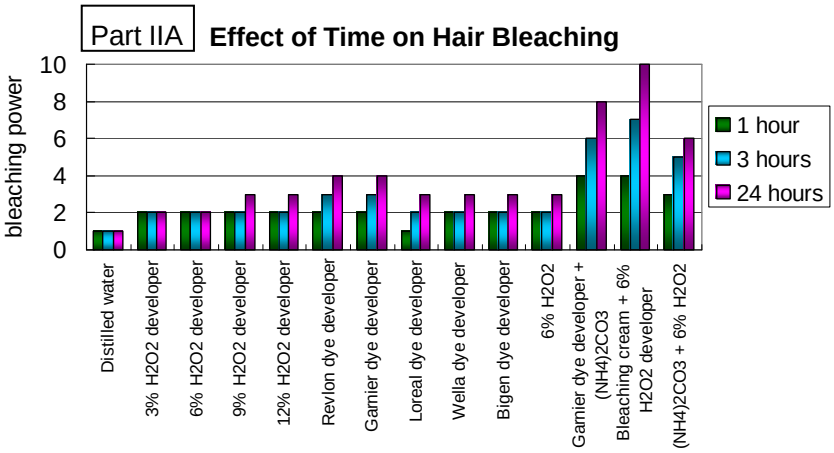
White hair samples were taken from a 65 years old lady. Hair was bleached with bleaching cream and 6% H_2O_2 developer at 40°C for 1 hour, 1.5 hours and 2 hours and then dyed with blueberry dye extract for 3 hours, 6 hours, 9 hours and 12 hours respectively to investigate the effect of duration of bleaching and dyeing on hair.

Results

Part I



Part IIA **Effect of Time on Hair Bleaching**



Part IIA

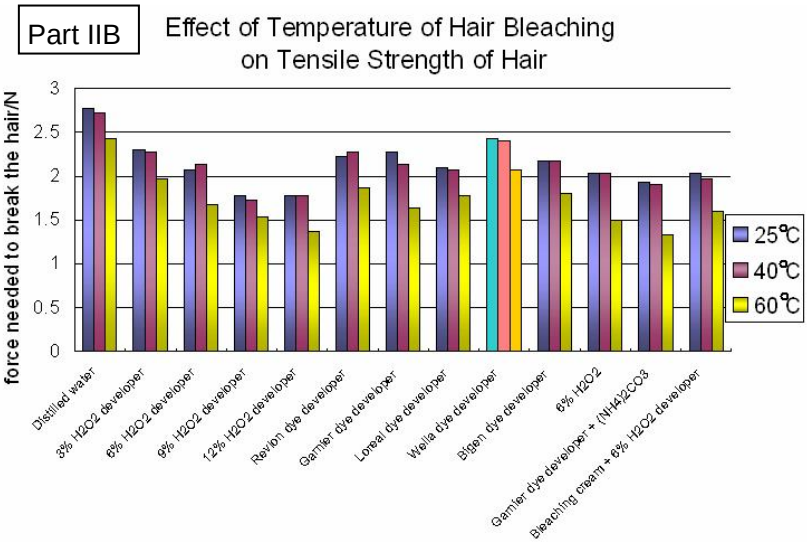
		25°C	40°C	60°C
Without Base	Distilled water	☺	☺	☺
	6% H_2O_2	☺☺	☺☺	☺☺☺
	6% H_2O_2 developer	☺☺	☺☺	☺☺☺☺
	Loreal dye developer	☺	☺☺☺	☺☺☺☺☺
	Garnier dye developer	☺☺	☺☺☺	☺☺☺☺☺
	$K_2S_2O_8$ + 6% H_2O_2	☺☺	☺☺	☺☺☺☺☺
With Base	Garnier dye developer + $(NH_4)_2CO_3$	☺☺☺☺	☺☺☺☺☺☺	☺☺☺☺☺☺☺
	Bleaching cream + 6% H_2O_2 developer	☺☺☺☺	☺☺☺☺☺☺☺	☺☺☺☺☺☺☺☺
	$(NH_4)_2CO_3$ + 6% H_2O_2	☺☺☺	☺☺☺☺	☺☺☺☺☺

Key:

☺☺☺☺☺☺☺☺☺: greatest bleaching power

☺: lowest bleaching power

Part IIB



Part III

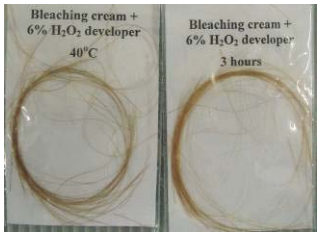
Part IV

Discussion

In Part I, Garnier – Nutrisse had the highest H_2O_2 content, followed by Wella and Garnier. The variation of H_2O_2 content against temperature increase was found to be insignificant.

Garnier-Nutrisse

In Part IIA, bleaching effect was significantly increased with the addition of a bleaching base and the presence of a booster could further enhance the bleaching effect. Without a base, only limited bleaching effect can be observed even at 60°C. The concluded best bleaching condition was using bleaching cream and 6% H_2O_2 developer for either 1 hour at 40°C or 3 hours at 25°C. In Part IIB, hair bleached by Wella had the highest tensile strength. Tensile strengths for hair bleached at 25°C and 40 °C were similar but that for 60°C declined greatly.



Wella *Garnier-Nutrisse* *cherry*

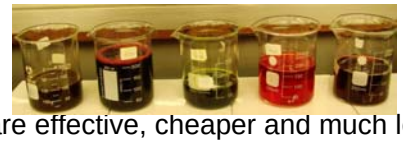
In Part IIIA, lemon juice together with green tea produced a better bleaching effect while white and black tea almost had no bleaching effect. In Part IIIB, binding agents was found to improve the dyeing effect and tensile strength of naturally dyed hair samples. Cherry dyed hair produced a similar reddish brown colour as Wella and Garnier - Nutrisse, which were the most effective dyeing brands. Colour of naturally dyed hair remained even after 5 times of washing. Thus, first bleaching black hair with bleaching cream and 6% H_2O_2 developer at 40 °C for 1 hour, then dyeing with egg white and cherry extract for 3 hours was recommended for natural dyeing of reddish brown hair.

Number of washings	0	1	2	3	4	5
Colour						

In Part IV, white hair bleached for 1 hour and dyed for 3 hours produced the best black dyeing effect. It was recommended bleach their white hair by following the previous procedure, then dyeing with egg white and blueberry or black bean extract for 3 hours.

egg white *blueberry extract*

Conclusion



Natural dyes are effective, cheaper and much less damaging in hair dyeing than commercial dyes. Further research could definitely make natural dyeing methods more convenient and feasible.