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INGREDIENT TECHNOLOGY

FOR SIGNIFICANTLY IMPROVED HAIR COLOURS

In this article, we will explore the fastest growing area of consumption for hair care products in Asia – Hair Colourants. We will analyze current trends in the marketplace. In addition, we will examine the various types of colouring systems, including, their positive and negative attributes. Finally, we will present several new ingredients which will alleviate many of the negative attributes to some of the systems, and enhance the end consumer products through proper protection of the hair shaft – both cuticle and cortex regions. *In vivo* and *in vitro* data will accompany this presentation.

Trends

The growth of the Asian marketplace for consumption of hair colourants is spectacular. It is estimated that over 60% of all women in Japan and Korea colour their hair. In the other nations of Asia, one only has to visit and observe that the use of hair colours is rapidly expanding.

The trend in colours is varied – from enhancement of normal black, to highlights, to red, and now – blonde.

Needless to say, the attraction to use hair colourants is primarily in the younger female segment of the population. *However*, as we have seen in America, and Europe, and are now witnessing in Japan, it is logical to expect that the use of hair colourants throughout Asia will expand to both older generations of women, followed by aging men. It is all part of looking different, appealing to alternate cultures and life styles, and, finally, another step in the unending quest for "youth" (sometimes referred to as "anti-aging").

Therefore, those companies currently marketing hair care products, or those who want to enter the hair care products' market, it is incumbent upon you to consider a hair colourant line of products for the professional (salon) marketplace, in-home use marketplace, or both.

Factors to consider

Launching a hair colourant line is not easy. It requires much research – both product development and marketing.

In developing a product, we must first understand the chemistry of hair colours and the mechanisms by which they act and re-act.

Figure 1 depicts in schematic form, the structure of a hair fibre. There are two areas of primary interest – the cuticle, or outer region; and the cortex, or inner region. This structure is the typical composition for all hair types – Asian, Caucasian, Hispanic and African.

Although the structure is the same, the colours, in their naturally occurring state, are different.

The naturally occurring colours are the result of a mixture of two types of melanin occurring in the cortex region of the hair.

The black pigment is called "Eumelanin; and the Red/Yellow pigment is called "Pheomelanin."

Eumelanin is a black to dark brown insoluble material with chemical structure as depicted in Figure 2. It is predominant in human black hair. The structure of Pheomelanin is also shown, which is a reddish-brown alkali soluble material, predominant in red hair. Thus, the four primary natural hair colours are composed of melanin as follows:

- Black – Eumelanin – densely "packed"
- Brown – a mixture of Eumelanin and Pheomelanin
- Blonde – very small amount of mixed melanin
- Red – Pheomelanin – loosely "packed"

It is not intended to get into a discussion concerning the factors which have, or may have, determined noticeable differences in natural hair colour based upon ancestral, geographic and hereditary influences. This type of discussion would prove time consuming and somewhat irrelevant to the practical considerations needed to develop technologically advanced hair colourant systems.

The word "systems" is used on purpose, since hair colourants are truly systems – both in their chemical structure and in their application.

In the consumer marketplace, hair colourant systems are classified as follows:

- Temporary
- Semi-permanent
- Demi-permanent
- Permanent

All of these systems are manufactured by mixtures of various chemical intermediates. The end results are both predictable and reproducible. These results are perceptible to even the most inexperienced user. And thus, products must be specifically designed for an intended result if they are to be successful in the marketplace.

Temporary – These are dyes that "coat" the cuticle surface of the hair shaft. They are

Figure 1: *The structure of a hair fibre.*

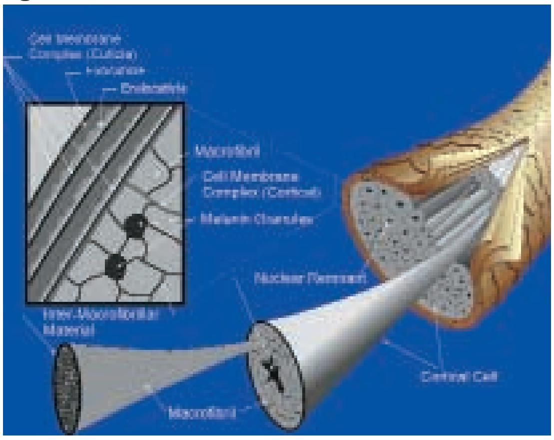


Figure 2: *Chemical structures*

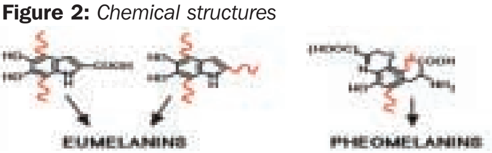


Figure. 3

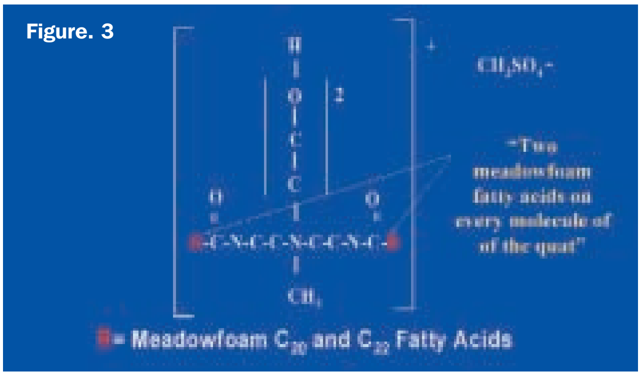


Figure. 4

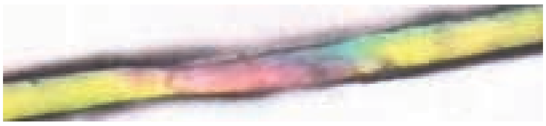
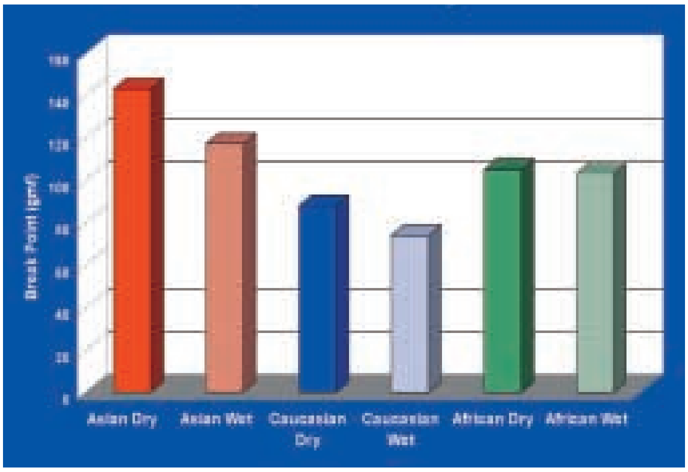
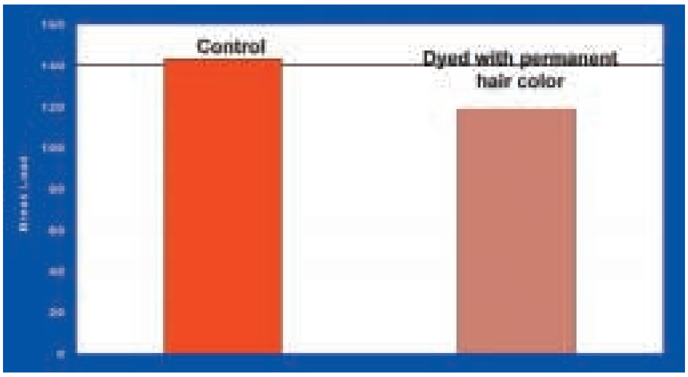


Figure 5: *The severe effect of bleaching on the internal structure (Cortex) of the hair*



Graph 1: *Asia hair study – comparative hair strength*



Graph 2: *The effect of permanent hair colour on the strength of asian hair*

usually water soluble acid dyes, of higher molecular weight. Thus, they do not penetrate the hair surface structure (cuticle). Since they are non-oxidative, they will not "lighten" hair from its natural colour and they tend to rinse out after one or two applications of shampoo.

Semi-Permanent – These dyes are typically based upon anthraquinone or azobenzene chemistry. They are also non-oxidative and tend to penetrate slightly through the cuticle owing to their smaller molecular size. While they do not "lighten" hair, they last longer than *Temporary* dyes – six to ten applications of shampoo.

Demi-Permanent – These dyes are classified as "oxidative" and are usually based upon phenyl type chemistry. They are activated by low levels of peroxide, and, as such, can bleach or "lighten" hair. They are developed to serve as a "less damaging" form of permanent hair colour and use about 3% peroxide (as opposed to the 6% used in permanent systems). This avoids the use of ammonia by using an organic base such as an alkanolamine

In general, demi-permanent hair colour systems provide reasonably good coverage of gray hair without the associated damage associated with higher levels of oxidation. In addition, the colour tends to last through twenty to twenty-four washings.

Permanent – These dyes are oxidative – utilizing both peroxide and an alkali – such as ammonia. As the word indicates, they are permanent in effect and do not wash out. Rather, they "grow" out. They can bleach ("lighten") to pre-determined shades, and provide effective "grey" coverage. Owing to their inherent damaging effect to the hair, they should not be used with other hair reactive systems such as "perms" or "relaxers" (straighteners).

In this article we will now concentrate on the complexities and problems associated with the development and marketing of *Semi-Permanet, Demi-Permanent*, and *Permanent* hair colourants.

Thus far, we have presented the *similarities in structure* of the four major hair types – Asian, Caucasian, Hispanic, and African.

While they are *similar* in chemical structure, they are *different* in physical structure, Caucasian hair is circular in its cross section, while African hair is flat.

Asian hair tends to be wider in diameter than Caucasian hair. In addition, Asian hair tends to be coarse, very straight, with a thick cuticle

Further, Asian hair has a smaller number of follicular units than Caucasian (2 versus 3 to 4) and has a lower density on the scalp (170 hairs per cm^2 versus 210 hairs per cm^2). Also, Asian hair emerges with a more perpendicular angle to the scalp, and grows very rapidly to great lengths. Of most importance, Asian hair tends to be "stronger" than Caucasian or African hair and studies conducted in this regard using a Dia-Stron tensile tester have found this to be true.

The results are shown in Graph 1. It can be seen that the break point in "gmf" is significantly higher for Asian hair, both when dry and wet, as compared to Caucasian and African. On a dry basis, Asian hair is near double the force when compared to Caucasian (140 vs. 80 respectively). These factors should be taken into consideration when formulating and developing a hair colour product for Asia.

Specifics to improve hair colourant systems

Semi-Permanent dye systems are smaller molecule systems that do not use an oxidizing agent. They are usually formulated into a viscous liquid that will remain on the hair for 30-40 minutes. Some are basic (cationic) and/or alkaline to achieve longer lasting results.

Extensive research has been conducted on the use of a lipid quarternary and its effects on *Semi-Permanent* hair dyes. This quaternary is trademarked *Meadowquat HG*. It is a amidoethylmonium methosulfate quat with the INCI name PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate (Fig. 3), with two lipid groups attached in the molecule. The lipid is composed of the fatty acids derived from Meadowfoam Seed Oil. As mentioned before, some of the commercial hair dye colours are systems which are basic (i.e. cationic). The theory is that these colours will be more substantive. In using these colours a problem emerges in that should we desire to incorporate a "conditioning" quaternary into a hair colour formula, the "conditioning" quaternary will compete for the negatively charges sites on the hair surface, and thus effect the substantivity of the colour.

This is not a problem when PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate is incorporated as the "conditioning" agent. To substantiate this, we took hair swatches and dyed them with a well respected consumer hair colour product. We then incorporated both Stearylkonium Chloride and PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate at levels of 5% respectively. The results are shown in Figure 4. As can be seen, the colour of the swatch with 5% PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate is close to the control; whereas, the swatch with Stearylkonium Chloride shows significantly reduced colour uptake.

Further studies have shown that this new material tends to give a "brighter" or more dense look to the colour on the hair and an improved conditioning effect, which has a much softer silky feel.

Demi-Permanent and *Permanent* – we will now consider *Permanent* systems, since the same results would apply to *Demi-Permanent* systems.

What is the process for an oxidative dye system?. The process consists of using dye intermediates with alkali to penetrate into the hair fibre. The addition of an oxidizing agent, such as hydrogen peroxide, causes the intermediates to form colour polymers and to bleach ("lighten") the hair.

The positive effect is COLOUR. The negative effects are possible erroneous colour (or shade) and DAMAGE (usually severe) to the hair fibre – both external and internal.

Frequently, when we say "healthy" hair we only refer to the condition of the cuticle. Damage to a "healthy" cuticle can be the result of oxidative treatment.

But of greater importance is damage to the cortex. By using the technique of Polarized Light Microscopy, we observed both the damage and the "repair" of the cortex. (Fig. 5). The photograph taken using time lapse photography shows the severe effect of bleaching on the internal structure (Cortex). This damage is typical, regardless of the origin of the hair.

It has been shown that Asian hair is stronger than Caucasian or African. This makes little difference when processing the hair, since the strength of Asian hair is severely damaged by the oxidative process, as can be seen by the results (Graph 2). The break load of the Asian hair was reduced from 140g to 117g as a result of the dyeing process indicating less strength and therefore severe damage. The question in formulating is: how to allow the efficiency of the oxidation process to take place without severe destruction of the hair fibre.

We researched the use of a series of products known as *Fancorsil Lim* in oxidative hair dye formulas in order to try and address this question.

Graph 3: *Dyed control severely impacted by oxidation*

Figure 6

The LIM series have the official INCI designation of PEG-8 Dimethicone Meadowfoamate. The fatty acids of Meadowfoam Seed Oil were taken and complexed to a silicone backbone. Their effectiveness in strengthening hair is remarkable.

In one series of tests we used *Fancorsil Lim-3* [INCI: PEG-8 Dimethicone Meadowfoamate] according to the following protocol.

Test materials to be evaluated were added to the hair swatches at the same time as 20 volume developer, mixed well with commercial permanent hair colour and applied to the hair. All swatches were rinsed well with tepid tap water and air dried. Samples for tensile strength measurements were taken from undyed control swatches, dyed controls that received no additional conditioners and test samples that were treated with 2% of the test material.

The MTT system measures the forces applied to samples during uni-axial extension. Single hair fibres were extended at a rate of 10mm/min until each fibre broke. The data is plotted as load (force) against % extension.

2% PEG-8 Dimethicone Meadowfoamate was added to the hair colour at the same time as the peroxide developer. The effect was measured using a Dia-Stron. As a control both undyed hair and dyed hair with no additives was used and this was assessed against the hair dyed with colour that also contained 2% of the Dimethicone Meadowfoamate.

The results showed that the dyed control was severely impacted by oxidation (Graph 3). The addition of LIM-3, restored its strength to that of the original control.

The fibre strength in extension was significantly improved by the addition of PEG-8 Dimethicone Meadowfoamate.

PEG-8 Dimethicone Meadowfoamate was also used in a tensile strength study on Asian hair with a *Semi-Permanent* hair dye. The results of incorporating this material at 2% are significant.

From this and many previous studies documenting the penetration of *Fancorsil Lim* products into the hair shaft, we conclude that the addition of these materials in an oxidative hair dye system significantly restores the strength of the fibre which has been severely damaged as a result of the oxidative process.

Another study involved the use of *Meadowquat HG* [INCI: PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate] in *Permanent* hair colour systems. In this study we evaluated the effect of PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate to improve resistance to "wash out" and light induced fading when added to these systems (Fig. 6).

Sample preparation and protocol:

virgin blonde hair tresses were dyed using commercial permanent hair colour and 20 volume hydrogen peroxide developer. PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate was added at a level of 2% during the mixing of the developer and colour. The corresponding control was 2% water. Following 25 min. processing time, the swatches were rinsed well with tepid tap water and air dried.

Durability studies

***(a)** Resistance to "washout": dyed and control hair swatches were washed with anionic shampoo once per day and dried. Samples were retained for evaluation after 1, 10 and 20 washings.*

***(b)** Resistance to light-induced fading: dyed and control hair swatches were exposed to direct sunlight on a Chicago day/night cycle. Samples were retained for evaluation at 10, 20 and 30 days exposure.*

PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate was used at a level of 2% and added to the colour as it was mixed with the developer. (Other studies have shown this material to be stable in the developer).

Resistance to wash-out was done on swatches which were washed with anionic shampoo each day and evaluated after one, ten, and twenty, washings. Resistance to fading was done on swatches which were exposed to direct sunlight and evaluated at ten, twenty, and thirty day intervals.

After ten washings, resistance to "wash out" is evident – the swatch treated with PEG-2 Dimeadowfoam Amidoethylmonium Methosulfate has a significant retention of colour. Also, resistance to light induced fading, measured at 30 days, shows a more intense colour as compared to the control. PC