Abstracts:
Oral presentations and posters

Hair and Energy: Measuring Hair Cell Respiratory Effects *In Vitro*

By: James V. Gruber
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Like any other aspect of human cutaneous biology, the hair is living and growing. However, the growing aspects of the hair shaft are not in areas that are seen visually by others, but rather are buried inside the follicular envelope where the hair bulb and stem cells reside. However, like all cells within the skin, the hair requires oxygen to thrive and grow and the bulk of the oxygen delivered to critical hair cells such as dermal papillae cells comes from the circulatory system and microcapillaries surrounding these important cells. The oxygen delivered to the dermal papillae cells is consumed and utilized within the mitochondria of the cells and the resultant impact is hair growth, strength and vitality. Using techniques developed within our laboratories, Arch has been able to measure cellular respiration on a number of important skin cell lines including fibroblasts, keratinocytes, adipocytes and nerve cells. Recently, we began exploring whether or not some of our well-established cellular energizers could, perhaps, influence dermal papillae cell respiration. This talk will focus on our efforts in this area to develop an *in vitro* model for examining respiration on dermal papillae cells and the implications of these effects on hair health.

Tribology of Hair

By: Maxime Fougere
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Full of studies on hair deal with the improvement of cosmetic products, but there is a lack of works talking about the impact of straighteners on hair. Hair straitening that consists in playing a lock between two heating plates for which the temperature can attempt more than 200°C, gets better steepness, brightness and softness of hair. Thus, it seems to be interesting to study the performance of these shaping apparatus of hair on a tribological point of view which means considering the friction coefficient, the topography and the hardness of the surface in contact and the speed of contact. A tribometer has been designed for this specific application. The apparatus records the normal force applied by the plate on the tress and the tangential force induced during the friction. The plate can heat from 130°C to 200°C and the speed of the tress displacement is controlled. After the treatment, the brightness and the smoothness are evaluated either by interferometric imaging for micro scale evaluation (hair) or brightness meter and image analysis for macro scale evaluation (hair tress). This study shows good correlation between the increase of performance (smoothness and brightness) and the increase of the friction coefficient. It reveals a relation between the friction coefficient and the different topographic scales and confirms influence of the hardness.

Aspects of Time/Humidity Equivalence for the Cohesive Bending Set of Hair Fibres and Their Consequences for the Stability of a Non-Permanent Hair Style

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For human hair and in the daily consumer practice, viscoelastic bending deformation and recovery under conditions of varying temperatures and humidities play an important role for the formation and stability of a non-permanent hair style. Against this background, we report here on the time-dependent bending recovery of human hair fibres for a range of relative humidities, giving specific consideration to the effects of physical ageing.

Human hair as an α-keratinous material exhibits a highly complex morphological structure on the micro- as well as on the nano-scale. For the context of mechanical investigations, however, the structures can generally be simplified in a good, first approximation through a two-phase, filament/matrix model. The filaments are identified as the α-helical, para-crystalline fraction of the intermediate filaments (IF, diameter approx. 10nm), which are embedded in axial orientation into a matrix phase, comprised mainly of amorphous, IF-associated proteins (IFAP). While the matrix swells in water and exhibits strongly humidity-dependent, viscoelastic properties, including the glass transition, the elastic filaments are largely unaffected by humidity.

The experiments were performed within the constraints of the high natural variability of the bending stiffness of hair, which was to be determined for long experimental times and for a variety of humidity conditions. For this the ring test procedure was applied, which yields the recovery of single hairs from cohesive bending set, described by:

$$R(t,t_A)=\frac{B_\infty}{B_\infty+\Delta B\,\psi(t,t_A)} \quad with \quad \psi(t)=\exp\left(-t/\tau\right)^m$$

$R(t)$ is the time-dependent recovery, B_∞ the elastic component of bending rigidity provided by the filaments, and ΔB the limiting elastic rigidity of the matrix. Ψ is the Kohlrausch-Williams-Watts (KWW) relaxation function, t_A the ageing time, τ the mean relaxation time, and m the exponential factor.

For selected conditions (65%rh, 20°C) it was established that, bending relaxation of hair follows the principles of physical ageing outlined by Struik with an ageing rate of $\mu=1$. Conducting the experiments under non-ageing conditions for relative humidities between 15% and 80% gave a constant exponent of m=0.282 (±0.02) for the relaxation function, which agrees well with the "universal" value of m≈0.3 given by Struik.

With a constant value of m, the changes of ΔB as well as of the mean relaxation time τ with humidity were determined, giving further insight into the plasticizing action of water in the matrix of α-keratins. On this basis and including the concept of effective time, a time/humidity superposition principle is established, in analogy to thermo-rheologically complex materials. This allows the prediction of the viscoelastic performance of human hair for any humidity within the ageing range and for long-term conditions of practical relevance.

Against this background, first, the essential role of physical ageing for the practical efficacy of non-permanent hair styling is elucidated. Second, the effects of hair damage, namely in the intermediate filaments, for the formation and stability of water waves are evaluated.

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Detangling and Friction Simulation of Hair Tresses

By: Peter Spicka* and Anirudh Mukhopadhyay
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Computational simulation tools have been used in cosmetic industries especially on the process side to speed up design and scale up of various processes such as extrusion, blow molding, mixing, filling and packaging. Such tools are also being employed to analyze performance of cosmetics products. In the previous Applied Hair Science Conferences, we had been demonstrating the usefulness of simulation technologies in Hair Care industry. Fluid Dynamic analysis of shampoo and conditioners in bulk assembly of hairs, dynamic flocking of hairs with streams of liquid around them were studied and the simulation framework was described. Examples focused on grease removal from the hair and scalp as a result of surfactant presence in shampoos or migration of charged conditioner particles towards freshly washed hair surface. Besides the visualization and analysis of fluid flow, CAE tools can provide an invaluable insight into mechanical and structural responses of hair. One example is mechanical hair combing that frequently results in hair breakage and hair tear off, especially when excessive forces are applied and hair. This year we present results from stress and deformation modeling of hair during combing operation. We demonstrate the ability to analyze the comb-hair contacts and friction as a transient process. We will also demonstrate the differences in dry, wet and treated hair performances. Various typical and extreme conditions will be evaluated and an analysis framework will be established to perform virtual experiments on different hair characteristics in combination with combing parameters. Additionally, connectivity will be established on the hair pre-processing steps with shampoos and conditioners.

Recovery of Covalently Linked Fatty Acid Monolayer on the Hair Surface Using Biomimetic Lipid

By: Ei Suk Kim*, Seong Kil Son, In-Ho Lee and Sangjin Kang
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18-methyleicosanoic acid (18-MEA) is an unusual anteiso fatty acid covalently linked to the outmost surface of hair cuticle. A layer of 18-MEA located in the upper ¥â-layer of the CMC that is responsible for the low surface energy and low friction resistance of the hair's outer surface. This high mobility of 18-MEA molecule facilitates spreading of extraneous lipid due to decreasing interfacial shear strength. In this study, we introduced N-hydroxyl succinimidyl ester functional group to the one end of 18-MEA for regenerating hair surface with covalently bound 18-MEA layer. The re-hydrophobicization of hair surface has been investigated by contact angle measurement. The inner moisture content of hair by different humidity (40, 55, 70%RH) was observed by electric moisture analyzer. It was thought that the hair surface treated with functionalized 18-MEA had been smooth and uniform because of the crack between cuticle filled up with covalently bound 18-MEA monomolecular layer like cuticle glue. This glue effect was also confirmed with line profile of AFM images. Therefore, the moisture and structural component of inner hair was not easily flown out and the optimum moisture content could be kept constantly though humidity in outside air was changed. As a result of lateral force microscopy (LFM) by using atomic force microscope (AFM), the friction force of hair surface treated with functionalized 18-MEA was decreased. It also showed the same friction value even after 15 times shampooing process. Through lipid extraction analysis on hair, non-functionalized lipid covered with hair surface was removed completely even by 5 times shampooing, however, a great deal of functionalized 18-MEA covalently bound with hair keratin was remained by 15 times shampooing treatment. In conclusion, the treatment of hair surface with functionalized 18-MEA could make covalently bound 18-MEA monomolecular layer originally, the hair surface regenerated to the natural state.

18-MEA is not the Only Factor Contributing to the Hydrophobic Nature of Hair Surface

By: Shinichi Tokunaga*, Noriyuki Tanji, Shigeto Inoue and Hiroto Tanamachi
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The relationship between the amount of 18-MEA (18-methyleicosanoic acid) on the outermost surface of hair and the surface properties is presented. It is well known that 18-MEA is bound to the cuticle surface and makes the surface hydrophobic. We found, however, that there are some fibers where the surface shows hydrophobicity even in the absence of 18-MEA. A decrease in 18-MEA led to a decrease in the advancing contact angle. There were two stages in this decrease: firstly process when the amount of 18-MEA decreased to 0, the advancing contact angle decreased gradually from 120° to around 90°. Thus a strong correlation between the advancing contact angle and the amount of 18-MEA was observed. In the second process, after the amount of 18-MEA reached 0, the advancing contact angle decreased drastically from around 90° to below 70°. In the first stage, it is thought that there are some factors, not related to 18-MEA, that makes the surface hydrophobic. Such other factors that provide hydrophobicity to the surface will be discussed.

Overview of New Methodologies for the Evaluation of Hair and Hair Care Products

By: Janusz Jachowicz
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Analysis of the cosmetic scientific literature, patents and trade publications suggests a considerable progress in the instrumental techniques employed for research, product development, and claim substantiation. In general, the methodology is becoming more quantitative and capable of simulating real usage conditions of final products. It is also becoming more sensitive to detecting small differences in the effects of various treatments. In the area of hair research significant progress has occurred in

- Microscopy (AFM, SEM, Raman, Confocal)
- Spectroscopy (Integrating Sphere Spectrophotometry, Fluorescence, Chemiluminescence, NIR, Raman)
- Image Analysis (Luster, 3-D Imaging (hair body), Shape and Orientation Measurements)
- Surface Analysis (Wettability, Electrokinetics)
- Rheology (Mechanical and Thermal Analysis)

The paper will concentrate on reviewing techniques most frequently used in product development practice such as the methods employed for quantification of hair damage and repair, improvement in hair appearance, characterization of rheological properties of hair-care products, and delineation of interactions between hair and raw materials.

Realistic Measurement of Hair 'Body' by Image Analysis

By: Th. Gassenmeier, D. Fischer, M. Pricop, R. Bayersdoerfer*, B. Mueller and C. Popescu
Henkel KGaA, Hamburg, Germany

Current methods for evaluating the hair characteristics 'body' and 'volume' include biophysical approaches such as the ring method (with several variants), the cylinder method and image analysis. The efficacy of cosmetic formulations on hair body and volume is also evaluated in test salons and consumer tests. The available biophysical methods are objective but far removed from real life conditions while subjective assessments do not provide reliable quantitative data. Against this background, we have developed a method for evaluating the body of hair tresses that is close to the real life situation. It is based on pseudo-3D volume measurements performed using image analysis. Key elements for achieving results that are close to real life include hair tresses that simulate hairy scalp skin with respect to hair density and geometry, as well as realistic product application, drying angles and combing procedures. Styling products are designed to provide all day hold, durability and high style retention irrespective of environmental conditions. Using the new method we investigated the influence of the application procedure, drying angle, combing stroke, product concentration and variations in the environmental conditions. Other parameters generally regarded as having an effect on hair body include fiber-fiber interactions as well as fiber diameter and tensile strength. Consequently we also investigated how these properties vary following different hair treatments and related the observed changes to the results from our proposed method. The new method proved to be reliable in quantifying both hair body and volume and it can therefore indicate to the hair stylist the conditions
necessary to achieve optimal effects.

Advances in Hair Protection Using Film Forming Technology

By: Melissa Vitale
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With many consumers using styling products, heating implements, and hair color, the demand for products that protect the hair is growing more than ever before. Hair protection can be segmented out further into two categories: Hair Color Protection and Thermal Protection. Consumers who color their hair want to protect the color from fading, while consumers who use hair dryers, curling irons, or flat irons want to protect their hair from becoming dry, brittle, and damaged. National Starch Personal Care has several film forming technologies that are available to deliver such hair protection benefits.

The poster's overall theme will cover hair protection, highlighting CELQUAT® LS-50 polymer (INCI Name: Polyquaternium-4/Hydroxypropyl Starch Copolymer) and DynamX® polymer (INCI Name: Polyurethane-14 (and) AMP-Acrylates Copolymer). More specifically we will be highlighting the use of CELQUAT® LS-50 polymer for hair color protection, demonstrated by photos and data collected from an in-house color panel. In addition, we will also be highlighting the use of DynamX® polymer for thermal protection when delivered from an aerosol hairspray system. Thermal protection data was collected by measuring contact angle of the hair and Scanning Electron Microscopy.

Polyquaternium-87– A New Highly Conditioning Polymer for Excellent Combability, Volume Control, and Soft and Natural Hair Feel

By: Joel Basilan* and Claudia Wood
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Commercially available shampoos, rinse-off conditioners or hair treatments contain cationic surfactants or cationic polymers, fatty alcohols, waxes and / or (silicone) oils for conditioning. Often the most effective conditioning system in rinse-off shampoo application includes the combination of SiO oil and a cationic polymer. This combination is most useful because of the polymers ability to deposit the SiO oil on the hair shaft yielding to an improvement in wet combability. Unfortunately, such combination is highly patented thereby minimizing formulator's ability to achieve excellent wet combing reduction. The new conditioning polymer Polyquaternium-87 provides extremely high wet combing force reduction and could offer comparative benefits state of the art technologies could give in a rinse off application. The cationic components form polymer surfactant complexes with the anionic surfactants in shampoo formulations, which deposit during a rinse-off application to hair surface and deliver their conditioning effects. Furthermore, Polyquaternium-87 leaves the hair soft and natural feel with improved shine and manageability.

Discover Benefits of the Polyurethane Dispersion Technology in Hair Care

By: Janusz Jachowicz and Yuliya Berezkin*
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A new class of hair fixative polymers based on waterborne segmented polyurethanes (PU) was developed. These zero-VOC, aqueous PU were prepared with a controlled balance of hydrophobicity and hydrophilicity, and tailored mechanical properties. The key characteristics of PU composition perfectly correlated with the holding power (high humidity curl retention), flexibility, water resistance and feel, which are important properties of hair fixatives.

Mechanical properties of the polymers were tested by analyzing elasticity and flexibility of polymer treated hair utilizing a texture analyzer. The derived data allowed to classify the polymers into categories referred to as brittle, quite flexible and non-plastic, flexible and plastic, and very flexible. Optical properties of polymers on hair were investigated by performing the analysis of light distribution and luster by using Image Analysis.

Various forms of hair styling products, including hair sprays, gels and mousses, were formulated and tested on hair. Initial studies with these formulations demonstrated outstanding high humidity curl retention, ease of washability and strong holding power combined with natural feel and lustrous healthy look of treated hair. These polymers also enhanced conditioning and protective qualities of the hair styling product. Overall, novel BMS PUDs can serve as multifunctional film-formers and hair styling ingredients suitable for aqueous hair sprays, low and zero VOC products.

Full Decomposition of Light Scattered by Hair Tresses Based on Simultaneous Analysis of Polarization and Color Information

By: N. Lefaudeux*, N. Lechocinski, P. Clemenceau, and S. Breugnot
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Human hair visual appearance is dictated by its specific way of scattering incoming light. It is commonly accepted that light incident on a human hair fiber will be scattered in three components which are: the light scattered inside the hair fiber, the light reflected by the front surface and the light reflected by the back surface. As scattering changes the polarization of light, it has already been demonstrated that the internal scattering can be efficiently separated from the front and back reflected parts using polarization analysis. However, knowing that only the back reflection carries the information of pigmentation of the hair fiber, we prove that it is also possible to distinguish front and back reflections by using a specific color analysis. Here, we propose to present a new method combining polarization and color analysis to separate and measure independently the three components. Using an imaging system providing color polarization images of hair tresses, data was acquired and results obtained show the validity of the decomposition and allows better understanding of the effect of hair treatments. The new method is based on a physical decomposition and does not use mathematical fits to find each angular distribution.

Damage to Human Hair Cuticle Cells by Extreme Grooming Stresses

By: Shaun Barker
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During hair grooming there are various conditions for the onset of extreme stresses. In this paper three types of these stresses will be discussed. The first one occurs when static fly away induces electric discharges on the hair surface. The second one takes place when water stream currents and gaseous bubbles, typical of a rinsing process, impinge on the hair surface producing wear by abrasion or cavitation. Finally, the third one occurs when the hair is subjected to temperatures typical of curling irons. The occurrences of these three events were found to result in highly localized disruptive processes that damage the cuticle sheath. The results show that the disruptive processes can take the form of localized bulges, blisters, craters, and cement breakage at the cuticle cell subsurface. For instance, the action of extreme temperatures characteristic of "fly away" discharges on the cuticle cell surfaces was found to produce bulges that ruptured the cuticle sheath. In many cases the bulges were accompanied by projections of cuticular material towards the hair surface. The action of water stream currents was found, on the other hand, to result in localized breakage of the cuticular cement and also ablation. High temperatures typical of curling irons were seen to result in surface cracks, bulging, and cuticle lifting.

Hair Protection Using Silicone-Based Solutions

By: Bethany K. Johnson
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Silicones are recognized for their benefits in a variety of hair care products, where they give a soft and smooth feel, aid detangling and combing, add shine, enhance straightening, provide curl definition, add body, and act as anti-frizz agents. Initially used for conditioning, silicones also act as protective agents against heat damage and discoloration after color treatments, and also enhance hair strength. Demand for protective products is rising: of 1,155 hair care products recorded in 2007 and early 2008, 31% claimed strengthening, 20% color protection, and 13% heat protection.

A variety of silicones were evaluated for protection from color loss, heat aggression and mechanical stress. Color protection was established using colorimetry evaluations with a spectrophotometer to record the influence of washes and UV exposure on color depth, anti-yellowing and loss of redness. Heat protection was determined using thermogravimetric analysis to evaluate moisture loss during heat treatments, and differential scanning calorimetry was used to assess heat absorption. Hair strengthening was measured using a single-fiber tensile test method. Sensory evaluations supported validation of the conditioning claims.

While considering global market needs based on hair types and conditions, ethnic preferences and evolving fashion trends, the silicones evaluated offer a range of innovative technology and formulation concepts. They allow formulators to develop highly differentiated products that protect hair and help create and maintain its healthy appearance.

Repair & Protection of Hair via a Natural Ingredient with Proven Efficacy

By: Brian Yang* and Murat Quadir
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Recently research work from our laboratories has identified a natural amino acid derivative, Creatine (trade name: TEGO® Cosmo C 100), as a new active ingredient for incorporation into hair care products. Test results in our laboratories have shown that Creatine is able to substantially strengthen the mechanical properties of damaged hair, thus repair the damage effectively. In addition to repairing existing damage, TEGO® Cosmo C 100 further acts to protect the hair from further damage. The efficacy of TEGO® Cosmo C 100 in this application equals, or in many instances exceeds, the benefits achieved with the commonly used protein hydrolysates. The effects are especially evident on hair that has been chemically damaged such as bleaching, and can be readily assessed via tensile strength properties or wet combing forces.

The presence of both positive and negative charge in the same molecule enables Creatine to serve as a linker between the alkaline amino acid side chains of hair protein (Arginine, Lysine) and the anionic amino acid side chains of hair protein (Cysteine, Cysteic acid, Glutamic acid). It is hypothesized that the amphoteric natural of Creatine contributes to its repair and protection properties via enhanced electrostatic interactions between hair proteins.

Effects of Polymers and Protein Hydrolyzates on the Surface Properties of Hair

By: Robert Bianchini and Susan Daly*
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Natural polymers, including proteins and their hydrolyzates, are widely used in hair and skin care formulations [1,2]. Most commonly used are materials obtained from hydrolyzates derived from animal and vegetable sources such as keratin, collagen, elastin, silk, soy, corn, wheat, etc. The deposition of proteins on hair and their ability to modify the physical properties of fibers is related to their chemical composition, molecular weight as well as the type and degree of chemical modification. Quantitative analysis of sorption was performed previously by Karjala [3,4] for virgin and chemically modified hair. Stern [5] studied protein hydrolyzates of various molecular weights, and others have investigated collagen and collagen derivatives [6-10]. A Substantial amount of work has also been carried out in the area of chemical modification of proteins including esterification, quaternization, silylation, and formation of complexes with cationic surfactants. These have been employed to provide increased interaction of proteins to hair and improved cosmetic properties. The present work concentrates on the analysis of polymer-hair and protein-hair interactions by using various surface analysis techniques such as streaming potential. By using electrokinetic measurements one can follow polymer or protein adsorption/desorption from hair and quantify the deposition in terms of changes in the zeta potential values before and after treatment. The results of electrokinetic analysis are complemented by physical measurements which can detect variations in hydrophilicity/hydrophobicity of various hair types as a result of protein adsorption. The paper will discuss the methods to follow changes in the surface properties of hair as a result of treatments involving commercially available proteins, polymers, and surfactants.

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Characterization of Persistent Hydrophobic Surface Generated by 18-MEA Combined with Cationic Surfactants

By: Shigeto Inoue
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18-Methyleicosanoc acid (18-MEA) is an unusual branched-chain fatty acid that is covalently bonded to the outermost cuticle surface of human hair and provides both a soft, smooth feeling and hydrophobicity. 18-MEA is easily damaged by chemical treatment, such as hair coloring and permanent waving, however, and reduction of 18-MEA through damage affects hydrophobicity and the natural feeling of hair. Therefore, damage to 18-MEA is thought to be a serious problem. There are many different types of chemicals used for improving the damaged surface of hair, such as cationic surfactant, polymers and silicones. The improving effects of such compounds for damaged hair do not last all day long, however, and the sensory feeling is different from natural hair. It was found that treatment of damaged hair with 18-MEA, combined with a specific cationic surfactant (stearoxypropyldimethylamine, SPDA), forms a persistent hydrophobic layer on the hair surface, and this property is maintained even after washing with shampoo. In this study, characterization of adsorbed layers of 18-MEA/SPDA on mica, as models for conditioner treated hair, was performed using Atomic Force Microscopy (AFM) and Angle-Resolved X-ray Photoelectron Spectroscopy (ARXPS). AFM results revealed that 18-MEA/SPDA conditioner formulation was homogeneously adsorbed on a mica surface and possessed a high wear resistance. From ARXPS results, both 18-MEA and SPDA were adsorbed on the mica surface via carboxyl and amido groups, with orientation of the hydrophobic part to the air interface. It is concluded that sustainable hydrophobicity and the soft, smooth feeling of hair can be achieved by forming a durable hydrophobic layer of 18-MEA/SPDA on the hair surface.

Rapid Screening Protocol of Sunlight Exposure to Damaged Hair

By: Eric Abrutyn
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Consumers are unsatisfied with the loss of color shortly after they have colored their hair. They are looking for a more consistent hair color over a 4-8 week period. One of the potential causes of artificial color loss is exposure to sunlight due to the deleterious effect on hair and chemical degradation of the artificial coloring. Also, sunlight (mostly VIS, UVa and UVb exposure) has been identified as a cause for degradation of the cuticle and cortex that allows for more rapid leaching of artificial and natural color. Can one really slow or control the aging process so the cuticle and cortex are more intact and the color has a better chance to of being maintained longer? The work reported here will deal with typical consumer exposure to sunlight on bleached and artificially colored hair. There are a large number of UV absorbers available to the formulating chemist. Which one to chose and how do you screen their potential to prevent damage and color loss? This paper will focus on the use of a rapid screening protocol and to show that color loss and hair damage can be minimized better with a broad spectrum sunscreen.

A Tentative Mechanism of Oxidative Dyeing for Keratin Fibers: Pert 4

By: Joko Kyohei
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A number of papers have been published on the oxidation coupling reactions of active intermediate of a dye precursor with an electron rich dye coupler. At the present stage, however, little information is available about the oxidative reaction mechanism to colored oxidation products and the dye distribution inside the keratin fibers. On the results of dyeing under the presence of both reducing agent and chelate agent, we found that the coupling reaction developing oxidation dyes occurred on the outer surface of cuticle cell phase, and that not only the CMC regions play an important role as accumulation regions of the finished dye, but also the components of CMC contribute directly to the oxidation coupling reactions. Furthermore, we suggested form the other results that the metal ions and disulphide bond presented primarily within the intercellular materials play an important role in developing the colored oxidation dye. Then, on the basis of the general scheme of the oxidation dye process, we proposed a tentative mechanistic scheme of oxidative dyeing to account for the oxidation dying phenomenon of keratin fibers. The scheme is made up of four step- reactions. However, in the fourth step, it is still uncertain whether the colorless leucoindo-dye is oxidized to its corresponding indo-dye at the surface or in the inside of keratin fiber. So, the aim of this study is to clarify the penetration mechanism in the fourth step.

Surface Properties of the Dried Coacervate Film and Dry Feel of the Shampoo Composed of Cationic Polymer and Anionic/Amphoteric Surfactant

By: Seong-Kil Son
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Conventional shampoo contains anionic/amphoteric surfactant for cleansing and foaming, and cationic polymer for the hair conditioning, stabilizing, increasing viscosity, foam stabilizing and deposition of other conditioning materials. Anionic/amphoteric surfactant and cationic polymer coexisted by mixed micelle or structured micelle in shampoo. But, in specific composition, these make polymer-surfactant complex coacervate that separates as distinct phase during rinsing step of shampoo process. This phase separation (or coacervation) is a well-known phenomenon as the Lochhead Effect. The complex coacervate can improve wet hair condition by reducing combing force and providing soft/smooth feel and it also improve dry hair condition by forming thin film with insoluble active ingredients on hair surface. But, physical properties of dried coacervate film are not clearly defined so far. We studied correlation between hydrophilic and hygroscopic properties of dried coacervate film and dry feel of shampoo composed of cationic polymer and anionic/amphoteric surfactant. Simple composition was made from various cationic polymer grades in standard surfactant system. The simple composition was diluted 7%(w/w) or 20%(w/w) with distilled water. We consider 7~20%(w/w) dilution which is approximately the same as concentration of shampoo during massage on hair fiber. Formed coacervate are collected by centrifuge (3,000rpm, 30min). Coacervate are coated on the glass plate and dried in the dry oven (for 1hr, 50) for the purpose of forming thin film. Physical properties of dried coacervate film are evaluated by measuring contact angle and moisture loss ratio. Simple compositions are tested the sensory dry feel for hair tress. Finally, we examine the correlation between physical properties of dried coacervate film and dry feel of the simple composition composed of cationic polymer and anionic/amphoteric surfactant.

Improvement of the Surface Hair with Application of the Nanoemulsion Products

By: Leandra Santos; Karla Macian; Ana Luísa Silva;
Adriana Fregonesi*; Clarissa Romeu;
Cassiano Escudeiro and Jean Luc Gesztesi
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Daily care like the process of washing with shampoos, it leads to damage on hair. This process can generate into the hair fibers detaching the cuticles, until the ends split. In recent years, the new technologies have been developed to enhance the esthetic appearance of hair. Body, smooth, gloss may be considered as candidates for conditioning. The nanoemulsion technology is one this innovation. Conditioning hair with this technology is claimed to improve the surface characteristics of individual fibers. The aim of this study was to analyze the effects of application of non–ionic nanoemulsion (conceded Patent) on hair comparing to market product. Nanoemulsion products were applied on damage bleached hair in this study and there was an alteration in fiber hair.
Studies with scanning electron microscopy have suggested the formation of film on surface hair. In addition, it was possible to quantify the reduction of the damage on cuticle hair. Penetrates migrated into cuticle and fragmentation and lifting were inhibited. Hair treated with nanoemulsion products showed a statistic difference ($P<0.001$) in comparison to control. The subjective tests also showed improvement in the smooth of hair.

Use of Microwave Resonance to Determine the Moisture Content of Hair Switches

By: Sam W. Stofel and Michael G. Davis*
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Measurements of the moisture content of hair have historically relied on traditional analytical methods. While these methods are sensitive and considered the "gold standard", they are typically time-consuming, low-throughput, and expensive to perform. To address this, we have deployed the use of microwave resonance to measure the moisture content of hair switches. The MoistureWave™ instrument by Tews Elektronik takes advantage of the dipole moment in water by utilizing low power, high frequency microwaves to measure the moisture content of a sample. We have validated the use of this device for use on hair switches; to date we have been able to show that the measurements are instantaneous, nondestructive and density independent. In addition, we have shown that the moisture content of a hair switch can be measured statically or as a function of time to allow for kinetic analysis. The instrument is readily calibrated using standard analytical techniques and appears capable of detecting the hysteresis reported for hair using other techniques. The deployment of this moisture measurement technique has provided us the opportunity to study the moisture properties of hair using a larger sample size, accurately and quickly.

Stylist's Hair Perception Meets Objective Hair Measurement

By: Annette Schwan-Jonczyk* and Beatriz Blum
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A couple of hair fibre properties like hair geometry, diameter, ellipticity, cross sectional shape, medullation, natural colour, gray hair status or hair surface topography from individual's hair were measured objectively and related to bulk hair properties. Hairdressers rated subjectively the hair thickness, volume/body, colour, shine, texture and handle on the head of hair of those individuals with untreated, natural hair. The correlation of the objective and subjective assessments revealed which single hair properties contribute most to the perception of a good/bad hair quality and overall appearance. The reasons for and consequences of a misleading diagnosis by stylists on clients hair is discussed.

Analysis of Glass Transition and Enthalpy Relaxation of Human Hair, and Application to New Perming System

By: Tomoko Miyake
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Glass transition and enthalpy relaxation behavior of human hair and their dependent on water content and aging time were investigated by means of differential scanning calorimetry (DSC). The obtained values of heat capacity change (ΔCp) and of execs enthalpy (ΔH) determined by DSC were used for analyzing the glass transition and the enthalpy relaxation process, respectively. In the relationship between the value of ΔCp and ΔH and the water content of hair samples aged for 4 days at various relative humidity, the value of ΔCp and ΔH increased to a maximum around 10%-15% water content, and then decreased. when the water content was over 15%.However, in the case of the long storage under the conditions of the constant temperature and humidity, the different relationship was found from that mentioned above. This indicates that ΔCp and ΔH at glass transition of hair depend on both the water content and the aging time. So, for the hair samples aged under three storage conditions with the different humidity, the values of ΔCp and ΔH for all aged samples was found to change periodically during isothermal aging, and their changes tended to be opposite phase, indicating that the increase of polymer chain mobility increased the extent of the enthalpy relaxation but decreased the extent of heat capacity change. These results suggest that the polymer chain network of glassy state repeated periodically a stable ⇔ unstable structural transformation through plasticization by water, and that the mobility of the macromolecular chain occurred mainly in a lower cross-linked and higher hydrophilic region of the amorphous components, such as endocuticle, cell membrane complex, intermacrofibril material and nuclear remnants, in hair fiber. By applying these results, we have developed a new perming system.

Raman Spectroscopy of Hair: A Study of Excitation Laser Wavelength for the Collection of Spectra

By: F.I. Bell, C. Taylor, and P. Carpenter*
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Many of the sensorial indicators of damaged hair, namely tactile and visual attribute indicators, are related to the surface morphology and the mechanical properties of single fibres, and reliable quantification of fibre characteristics at all length scales is critical. In particular, characterisation of the fibres at the micron and sub-micron scale will improve our understanding of the chemical and physical changes that have taken place in damaged hair by comparing to virgin hair and will assist, for example by correlating local mechanical properties with chemical composition, in the design and development of prevention/repair strategies. A multiple wavelength study to determine the optimal experimental laser for the collection of Raman spectra of hair fibres has found that the 780nm excitation is the most appropriate wavelength out of the set of visible to near IR (NIR) wavelengths explored. It has been observed that as more powerful, lower wavelength lasers as used to obtain Raman Spectra, although data collection times can be reduced, the energy of the lasers are such that both photochemical and thermal degradation of the samples occurs.

Dynamic Wetting of Fibers

By: David Seveno
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Understanding the way a liquid spreads around a fiber is a crucial requirement when dealing with the characterization of its surface. Friction at the contact line or dissipation due to viscosity are the key parameters which control the dynamics of wetting. It depends both on the chemical and physical properties of the materials. Therefore, wetting experiments and molecular dynamics simulations in the spontaneous and forced wetting cases have been performed to establish a relation between these properties (mainly the liquid-air surface tension, liquid viscosity and fiber radius) and the relevant friction parameter. The spontaneous spreading studies have first shown that two major channels of energy dissipation successively predominate during the rise phenomenon around the fiber. Energy dissipated by the system is consumed either according to the hydrodynamic approach or the molecular-kinetic theory. Then, the forced wetting studies clearly establish a link between the static and dynamic wetting properties of the materials. A relation between the observable parameter, the stationary contact angle and the friction at the triple line is for the first time derived. Therefore, it becomes possible to predict the dynamic behavior of a liquid only knowing its static contact angle around the fiber.

Novel Approach for In Situ Diffusion Study in Human Hair using FTIR Imaging

By: C. Taylor*, P. Carpenter, K. L. Andrew Chan,
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A new approach to study the diffusion of chemical components in the form of a solute into human hair has been demonstrated.

Keywords: Biological tissue; Skin; Diffuse; Penetration; Spectroscopic; FPA

Using Scanning Electron Microscopy to Study the Structure and Health of Hair

By: Trefor Evans
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An old saying declares that a picture is worth a thousand words. Consequently, scanning electron micrographs are often the most dramatic illustration of hair's complex structure - and the different ways by which it degrades. Our poster shows images of the internal features of hair that are exposed and visible through the examination of fractured fibers. We also show different forms of surface damage to the cuticle structure which have been induced by a variety of external stimuli - e.g. heat damage, chemical damage, mechanical damage, etc.

Product and Humidity Effects on the Shear Modulus of Hair

By: Don Harper* and Peter Kaplan
TRI/Princeton, New Jersey, US

Previous research on the torsional properties of hair fibers has shown the strong dependence on humidity. Further, bleach damage is more apparent at lower or at higher humidity levels than the commonly used 65% RH. Data collected at a variety of controlled humidity levels are presented. Studies include measurements demonstrating softening effects of a conditioner and drying effects of a hygroscopic treatment and of a polymer containing hair gel.

This work is made possible by a torsion pendulum developed for these measurements. This automated instrument incorporates a laser scanning micrometer to measure cross sectional data and fiber length before each torsional measurement and the entire instrument is housed inside a humidity controlled chamber. Cross sectional data can be collected at numerous locations on the fiber and repeated time-based measurements can be run automatically.

Poisson's Ratio of Hair Fibers and its Dependence on Damage Level

By: Mythili Nori* and Peter Kaplan
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The measurement of singe-fiber tensile mechanical properties as a method for assessing hair damage is well entrenched. The very special nature of the hair fiber – its heterogeneity and the sensitivity of measured values to ambient humidity – can make the detailed interpretation of results complicated and occasionally controversial. In particular, the connection of the cuticle to the matrix and the relative contributions of cortical proteins to dry mechanical properties could withstand further study. Hence there is need for developing further methods so as to help reveal the relations between the architecture, the chemistry and the mechanical properties of hair fibers.

In this context, a detailed investigation of Poisson's ratio for hair fibers merits some consideration. It is recalled that this ratio is defined as the ratio between transverse and longitudinal strains when a cylindrical fiber is elongated. Since hair is elliptical in cross-section, the Poisson ratio is actually a tensor, taking on complexity since the transverse strain could *in principle* be referenced with respect to either of the axes (major or minor). In this investigation we explore the Poisson ratio, with respect to both these axes for both virgin and damaged hair. We have found that the Poisson ratio relaxes steadily following extension. We present the initial and final ratio at various levels of strain. The implications of these behaviors for our understanding of fiber mechanics will also be presented.

Quantification of Hair Shine by Polarized Imaging

By: Kimun Park* and Peter Kaplan
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The SAMBA HVASS offers the possibility of using polarized imaging to quantify hair shine. Early results have shown excellent performance in measuring categorical shine differences. Measuring difference in product effects, however, is complicated by the availability of multiple potential shine metrics combined with the difficult nature of the problem. We have made an initial progress at TRI/Princeton in developing appropriate methods of using the system to quantify the degree of improvement in shine and appearance of the hair.

Spectroscopic and Thermomechanical Investigation of Product Treated Hair Fibers

By: Ram K. Ramaprasad*, Binhua Yang and Yash K. Kamath
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The nature of the interaction between a hair fiber surface and any of the main actives commonly used in hair care formulations is an important technical insight that benefits better and, more importantly for the future, greener products. Such interactions are both physical and chemical. Further, depending on the chemical nature and the molecular size, the location of these actives could be on the surface or in the interior of the hair fiber.

The object of this investigation was to explore the use of physical methods to understand the nature of this fiber/active interaction, and in favorable cases, obtain information as to specific sites on the fiber surface that the actives seek, driven by their molecular size and chemical nature.

Fourier Transform Infrared spectroscopic investigation of hair fiber surface was carried out in the ATR mode, where the hair had been treated with either a polyquat-10 or a monoquat, such as cetyl trimethylammonium bromide (CTAB). It is known, for example, that such polyquats reside on the surface and in the top cuticular domain. The monoquats are known to penetrate the hair fibers. It was observed that the polyquat-10 shifts the amide peaks, whereas the monoquat affects the absorption of the finger print cysteic acid bands. Hypothesis regarding possible chemicals links of these actives to specific functionalities in the surface regions (a few cuticular layers) of the fiber are proposed.

Thermomechanical studies were also carried out on bleached hair treated with the same kind of actives – surface adsorptive and fiber penetrating. The results from temperature dependent stress relaxation rates give two types of Arrhenius plots. The polyquat-10, located on the fiber surface only, has little effect on the Arrhenius plot. Those actives that are known to penetrate the fiber (monoquats and panthenol) give an *anti-Arrhenius plot*, that is, a curve with positive slope. An explanation is given in terms of rigidification of the fiber by the penetrated molecule whose effect is facilitated by their greater mobility and better linking by enhanced temperature. Additional support for this hypothesis is given by a similar positive slope for bleached fibers that had been subjected to prolonged contact with water. The leaching out of ions and the improved intra-fiber crosslinking (via salt linkages) leading to a more rigid fiber is known now from other work and could again be the reason for the observed positive slope of the Arrhenius plot.

Higher-throughput Study of Cu^{+2} Uptake by Damaged Human Hair

By: Kongsheng Yang* and Peter D. Kaplan
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Copper ions (Cu^{+2}) binding to human hair is a well-known indicator of chemical damage (Bernard L. Kabacoff *et al.*, US Patent 4,665,741; Annette Schwan-Jonczyk *et al.*, US Patent 6,730,493 B1) because the ions can coordinate with ligands such as anions and other nucleophiles in hair. The build-up of copper ions results in increasing green hue in hair. We have used copper ion solutions as a probe to investigate mechanically, chemically and photochemically damaged hair by absorption spectroscopy, reflection spectroscopy, color change, and mechanical property measurements. We will present the mechanical parameters of damaged hair and relate them to copper ion uptake and kinetics. Copper ion diffusion kinetics have also been studied by using new higher-throughput methods.