ELEMENTIS
SPECIALTIES

Research and Development Report

Hair Conditioning and Strengthening via Penetration of FANCORSIL® LIM

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STUDY NO. 1 "CUTICULAR REPAIR AND HEAT-ACTIVATED PENETRATION INTO THE FIBER"

Objective:

It has been determined from previous studies that FANCORSIL® LIM products (Dimethiconol Meadowfoamate and PEG-8 Dimethicone Meadowfoamate) are effective hair conditioning agents. The purpose of these studies is to determine if the application of heat accelerates and/or enhances the degree and extent of conditioning provided by these ingredients.

Protocols:

Hair samples:

European blonde hair deliberately damaged by processing with permanent wave agents and permanent hair color.

Test materials:

FANCORSIL® LIM-2 (Dimethiconol Meadowfoamate) and a water control, both used at 1% in an emulsified leave-in conditioner. Test swatches were completely immersed in the leave-in conditioner for 5 minutes and subsequently air dried at room temperature or rapidly dried with the aid of a commercial blow drier.

Measurements:

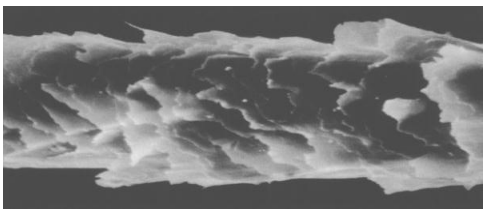
Scanning Electron Microscopy: Hair samples were mounted onto aluminum SEM holders using double-stick tape and colloidal graphite paint. The hair samples were then coated with a thin (about 20 nanometers) conductive film of gold-palladium in a vacuum evaporator. The samples were then examined and photographed using a Philips Model 500 scanning electron microscope.

Elemental Microanalysis: Elemental composition was studied on thin sections using a Philips Model 711F EDAX microanalyzer (Energy Dispersive Analysis of X-Rays). The atom silicon (atomic number 14) is present in FANCORSIL® LIM-2 and, since there is no native silicone present in hair, it can be used as a marker for cuticle substantivity and penetration. The silicone atom, when bombarded with electrons, generates x-rays with a 1740 EV energy peak which shows up slightly to the left of the pronounced 2310 EV sulfur peak present in the hair sulfhydryl groups. Therefore, any detection of Si is clearly indicative of LIM and the location can be determined from the EDAX scan.

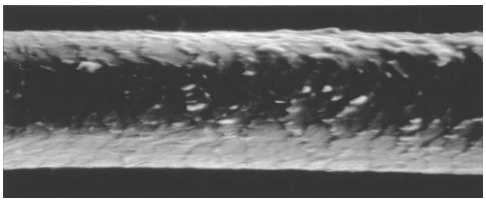
Results:

SEM results are shown in the following figures:

Control
Cuticle before treatment with
FANCORSIL® LIM-2:

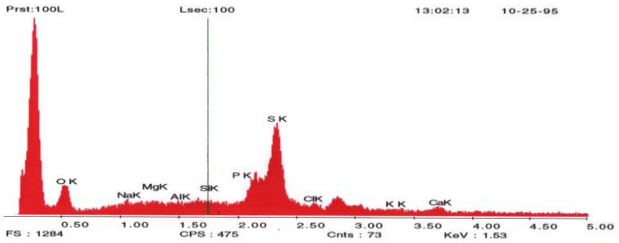


Test fiber
(after treated with FANCORSIL® LIM-2):

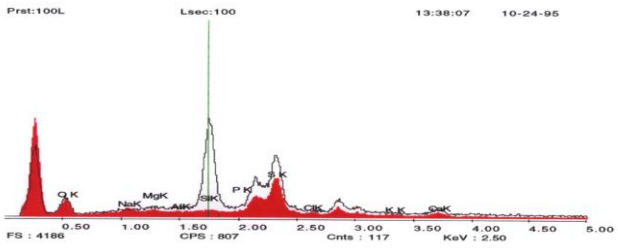


EDAX (X-Ray microanalysis for the presence of silicone to mark FANCORSIL® LIM-2)

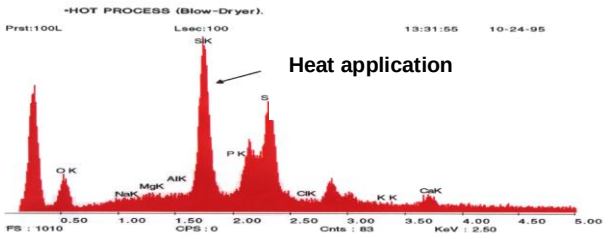
Control EDAX scan (no treatment)



Cuticle surface scan
(FANCORSIL® LIM-2 treatment)
Note: scan superimposed over control



Endocuticle/cortex scan
(FANCORSIL® LIM-2 treatment
using heat from a conventional blow-drier)



Discussion:

The effects of FANCORSIL® LIM-2 on cuticular repair confirm earlier studies wherein FANCORSIL® LIM-1 was used at a 5% level in a simple water rinse. In the present case, FANCORSIL® LIM-2, at a level of 1% in a leave-in conditioner, also clearly demonstrates the ability to facilitate the natural realignment of the cuticular cellular plates.

EDAX measurements confirmed the presence of silicone on the cuticular surface demonstrating the substantive nature of the conditioning agent. After drying with the aid of a conventional blow-drier, a significant silicone peak was observed in the endocutlicle/cortex region of the fiber indicating effective penetration of FANCORSIL® LIM-2.

STUDY NO. 2 “REPAIR OF THE HAIR SHAFT”

Polarized light microscopy to determine degree of fiber orientation and repair

Objective:

Considering the lipophilic and hydrophilic nature of the chemical entities that comprise the FANCORSIL® LIM molecules, one would expect to achieve a certain degree of molecular spatial orientation. In addition, it is likely that orientation of the FANCORSIL® LIM molecule will influence the alignment of asymmetric molecules in the immediate environment into which FANCORSIL® LIM has penetrated. The present study is designed to determine if the penetration of LIM into the hair fiber results in a reorientation of the fibrillar structure within the hair shaft.

Materials:

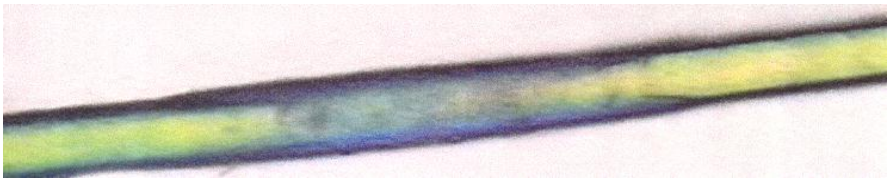
Single damaged hair fibers were mounted in an immersion microscopic slide. An Olympus polarized light microscope equipped with a full wave filter and photomicrograph equipment was used for time-lapse recording of changes in birefringence in the hair fiber.
Test solutions: FANCORSIL® LIM-1 at 1% in water and, as a control, water alone introduced onto the microscopic slide and allowed to enter the viewing area during photographic recording. Additionally, FANCORSIL® LIM-2 at a level of 1% in an emulsified leave-in conditioner was introduced directly to the hair fiber while the fiber was being viewed and photographed through polarized light microscopic optics.

Results:

The resulting video clearly demonstrates repair of the damaged fiber as observed by cuticular realignment as well as a return of the overall fiber shape and size to “normal” dimensions:

Damaged hair fiber as seen in polarized light microscopy:

Same damaged hair fiber, treated with FANCORSIL® LIM, as seen in polarized light microscopy:



Discussion:

The still photos above were obtained from the video. Treatment with 1% FANCORSIL® LIM-1 in water or 1% FANCORSIL® LIM-2 in a leave-in conditioner resulted in the damaged hair fiber undergoing a clearly visible degree of repair as evidenced by the reorientation of structure and return to its normal dimensions (“revolumized”). It appears that during damage, the internal fibrillar structure of the hair shaft is disrupted giving rise to a condensed anisotropic section that is likely prone to be easily broken. Upon treatment with FANCORSIL® LIM, the fiber assumes a more normal isotropic architecture, which is oriented, and revolumized.

STUDY NO. 3 “STRENGTHENING OF THE HAIR SHAFT”

Objective:

In the first two studies it was determined that FANCORSIL® LIM can facilitate cuticular realignment, penetrate into the hair fiber and encourage repair and revoluminzation. In addition, it was determined that heat significantly accelerates the degree of penetration into the hair fiber. The present study was designed to determine if there is a consequent strengthening of the hair shaft resulting from the FANCORSIL® LIM-induced repair as observed in polarized light.

Protocol:

Unprocessed hair:

Unprocessed Caucasian hair swatches of equal weight were submerged in test/control solutions at 37° C for 10 minutes and then air-dried at room temperature. The “test” sample consisted of water with 2% FANCORSIL® LIM-1, while the controls were 2% PEG-8 Dimethicone (same material as that used to make FANCORSIL® LIM-1) as well as water.

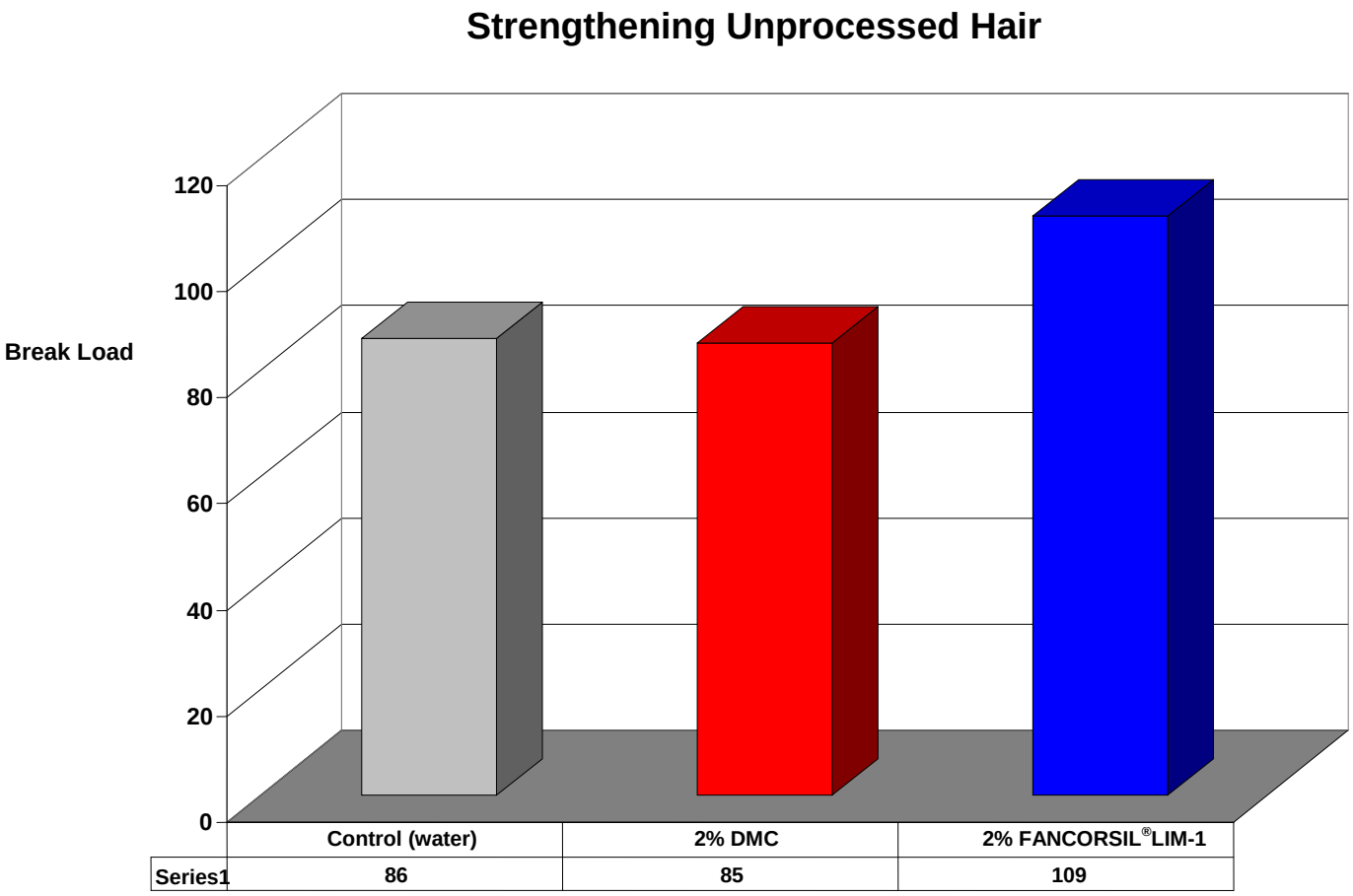
Individual fibers were randomly chosen from each swatch and tested for strength (break load) using an MTT Dia-Stron tensile tester and statistically analyzed for significance.

Processed hair:

In subsequent experiments the ability of FANCORSIL® LIM-3 to repair/strengthen hair was evaluated at 1% - 2% during the dying process with permanent hair color and FANCORSIL® LIM-3, at 1% or less, was evaluated for its ability to protect/strengthen hair during relaxation with sodium hydroxide. In both of these latter cases, measurements of tensile strength were made using the Dia-Stron apparatus.

Results:

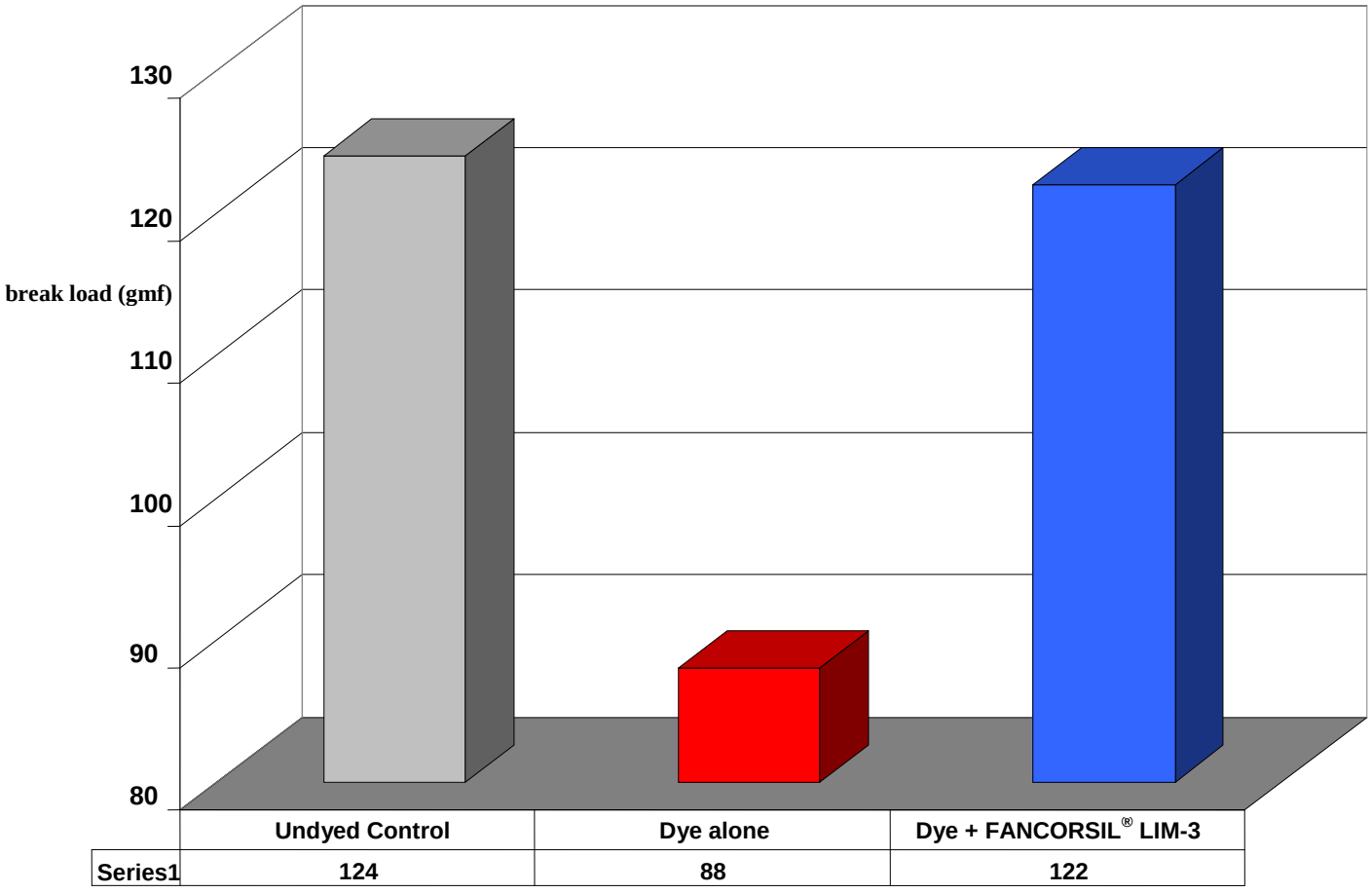
The strength of unprocessed (“virgin” or “normal”) hair was increased by 27% after treatment with FANCORSIL® LIM-1 (2% in water) whereas treatment with PEG-8 Dimethicone (DMC = Dimethicone Copolyol) had no effect, negative or positive, upon hair strength.



p (control Vs. LIM-1) = 0.004

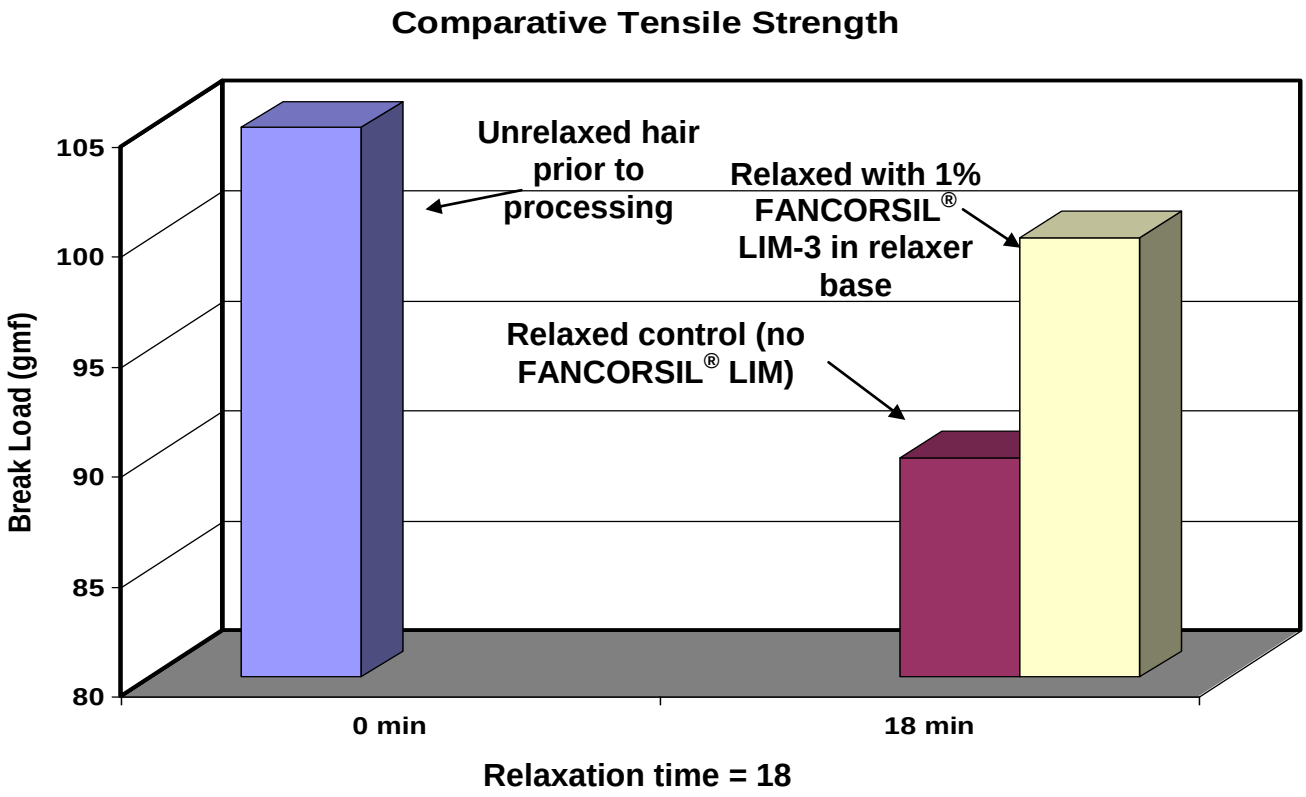
The use of FANCORSIL® LIM-3 with permanent hair color significantly increased tensile strength as can be seen from the following results:

Effect of 2% FANCORSIL® LIM-3 with Permanent Hair Color



p (dye alone Vs dye + FANCORSIL® LIM-3) < 0.0001

African American hair subjected to sodium hydroxide relaxer was also strengthened by the addition of FANCORSIL® LIM-3 to the relaxer formulation prior to application:



p (control relaxer Vs FANCOR® UNI-EMBASE relaxer) = 0.021

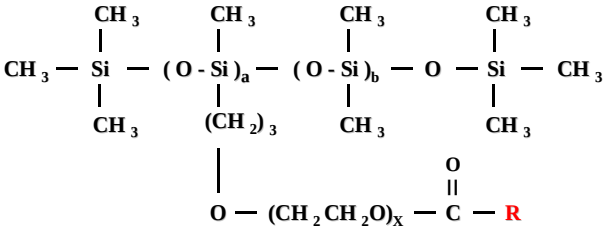
Discussion:

FANCORSIL® LIM-1, FANCORSIL® LIM-2 and FANCORSIL® LIM-3 all had the ability to strengthen hair when used in different situations. This phenomenon was observed with normal unprocessed hair, hair being dyed with permanent hair color and hair in the process of being straightened with a sodium hydroxide relaxer. Given the results of previous studies demonstrating cuticle repair, penetration into the cortex and restructuring of the fiber, the results on strengthening were hypothetically anticipated. The results of the present study confirm the hypothesis.

It is worth considering the mechanism by which FANCORSIL® LIM brings about repair and strengthening of the hair fiber. FANCORSIL® LIM-1 and FANCORSIL® LIM-3 are ethoxylated Dimethicone Copolyol esters of Meadowfoam fatty acids while FANCORSIL® LIM-2, the oil soluble form of this family of siliconized Meadowfoam esters, carries two fatty acids and is non-ethoxylated. The molecules have the following structures:

FANCORSIL® LIM-1 and FANCORSIL® LIM-3

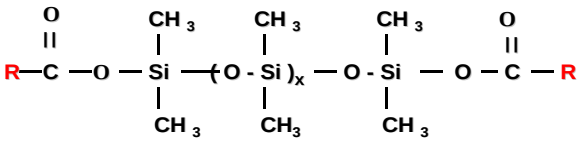
PEG-8 Dimethicone meadowfoamate



R= Meadowfoam C_{20} and C_{22} Fatty Acids

FANCORSIL® LIM-2

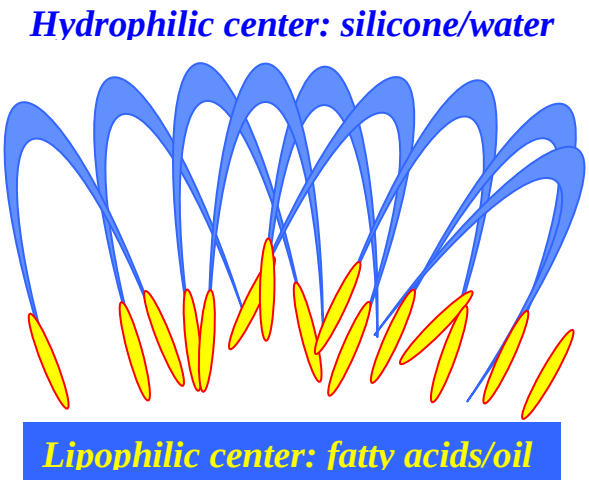
Dimethiconol meadowfoamate



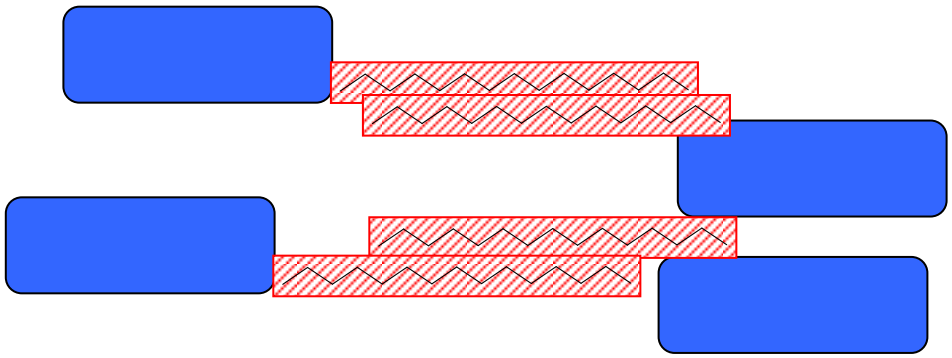
R= Meadowfoam C_{20} and C_{22} Fatty Acids

In both cases, the silicone-meadowfoam fatty acid esters have lipophilic centers as well as hydrophilic areas. FANCORSIL® LIM-2 has two fatty acids that are on the extreme ends of the molecule and therefore the lipophilic centers are polarized. The central silicone moiety has the ability to bond water through hydrogen bonding to the silicone-oxygen positions. In the case of FANCORSIL® LIM-1 and FANCORSIL® LIM-3 there is a single lipophilic focus and an even greater hydrophilic area by virtue of the addition of the ethoxylate. Biological systems such as skin and hair contain both water and oil constituents (e.g. membrane systems) and molecules with combined lipophilic and hydrophilic centers, such as the FANCORSIL® LIM's, will tend to become oriented in these environments. This orientation serves to promote penetration (increased permeability) into tissue and subsequently facilitates orientation of adjacent molecular structures such as microfibers in hair.

One can visualize the orientation of FANCORSIL® LIM's as follows: FANCORSIL®LIM-2 with a fatty acid at each end of the central Dimethicone structure:

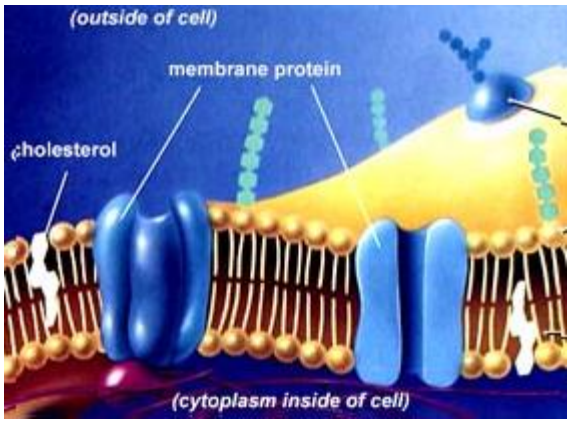


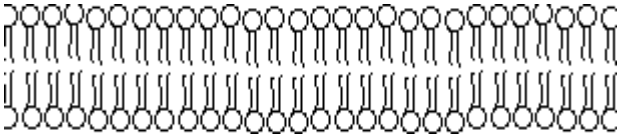
FANCORSIL® LIM-1 and FANCORSIL® LIM-3 with a single fatty acid esterified to one end of the Dimethicone Copolyol central structure may be visualized as follows:



In both cases the molecules orient such that the lipophilic and hydrophilic portions commingle within their own environment since that represents the lowest energy level or minimum entropy for the system.

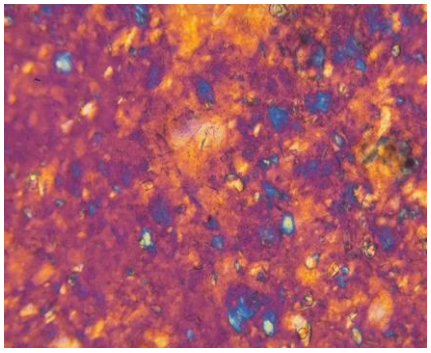
Note the similarity between the bipolar nature of the FANCORSIL® LIM molecules and a bilipid cellular membrane structure:



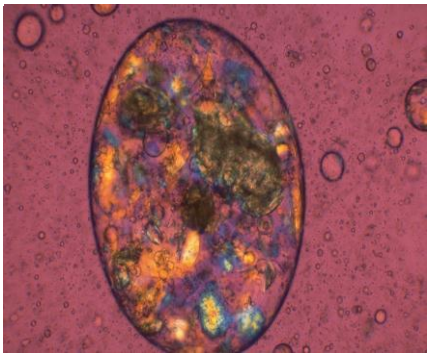


In order to validate this premise, FANCORSIL® LIM-2 was suspended in an oil/water media and allowed to equilibrate. The resulting system was photographed using polarized light microscopic optics.

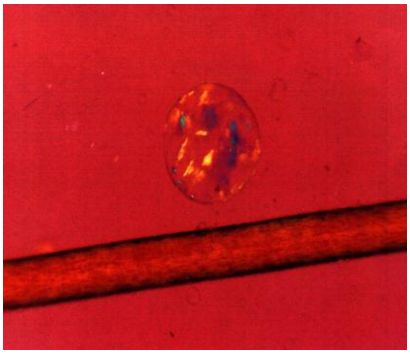
FANCORSIL® LIM-2 as seen through polarized light microscopy



FANCORSIL® LIM-2 allowed to equilibrate in an oil/water environment



The equilibrated macroglobule in the presence of a hair shaft



Orientation of the FANCORSIL® LIM molecule generates a macroglobule with a self-enclosed membranous structure created by molecular orientation. The globule in the presence of the hair shaft was photographed to give the viewer an idea of relative size. Subsequent experiments demonstrated that heat from a commercial hair dryer was sufficient to break the macroglobules and allow the conditioner to come in contact and then penetrate into the hair shaft.

Heat from a blow dryer

The polar orientation of FANCORSIL® LIM molecules generates a self-contained macroglobule of the conditioner which ruptures upon heating with a blow dryer. Subsequently, the conditioning agent penetrates into the hair shaft and appears to “revolumize” the fiber.

In summary:

These research studies document the following observations and conclusions:

1. FANCORSIL® LIMs penetrate into the endocuticle and cortex of the hair fiber;

2. Heat significantly enhances the degree of penetration and subsequent conditioning benefits;

3. LIMs facilitate realignment of the cuticular surface of the hair shaft;

4. Owing to their unique molecular configuration, FANCORSIL® LIMs tend to form oriented macro-structures and thereby encourage the reorientation of natural hair components giving rise to morphological repair;

5. Repair of the hair shaft results in a significantly stronger fiber.