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White Paper

**Isopentyldiol in hair care:
Color Care, Strength
and Anti-frizz**



Summary

The raw material Isopentyldiol was tested in hair care applications in order to investigate its influence in hair dyeing, strengthening and the anti-frizzy effect.

After the use of a hair dye preparation containing 5% IPD and repeated wash and rinse cycles with a shampoo containing 2.5% IPD, the expression of hair color and its brightness increased, evidencing that IPD improves the dye retention, protecting the hair from color fading.

The treatment of blond depigmented hair with a solution containing 5% IPD enhances its strength, improving the resistance to breakage by 45% in comparison to untreated hair. With dyed-treated hair too, which are generally more stressed and brittle, the same treatment increases hair strength, dramatically improving the resistance to breakage of 78.6%.

Wavy hair strands treated with a shampoo and a conditioner containing IPD (2.5% and 5% respectively) and then straightened are less frizzy compared to untreated hair. The difference keeps significant until approximately 3 hours.

Content

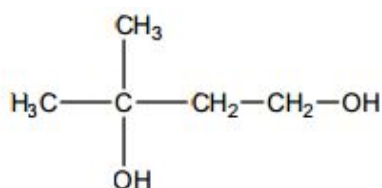
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Introduction

Isopentyldiol (IPD), a branched chain bi-alcohol with 5 carbon atoms (structurally 3-methyl-1,3-butanediol, Fig.1) a moiety of low molecular weight, shows a special molecular structure. Indeed, the space configuration of its atoms allows a very versatile amphiphilic behaviour, capable of interactions with both hydrophilic and lipophilic substances. Thanks to its solvent, coupling and humectant properties and its positive influence on sensory performances, IPD is already widely used in very many different types of cosmetic recipes. Its low molecular weight, diffusion properties and special solvent power suggested its possible use in hair care products, where diffusion into the keratin structures could provide advantages related to the technology and process of hair dyeing. Indeed, the findings of this study proved this hypothesis, with many other interesting benefits.

The hair care planet moves fast in the cosmetic galaxy, always demanding new ideas to follow the continuous changing trends. Deriving from the skin care world, a recent trend is the use of multi-functional ingredients that perform different actions in a finished product. On the other hand, cosmetic formulators need constantly new tools to satisfy the countless marketing demands and create successful formulations. The key for success is the research of innovative products with fascinating aesthetics, seductive sensory properties and proved functionality. All this possibly achieved by the use of interesting multi-tasking and adaptable ingredients.

Figure 1: Chemical formula of Isopentyldiol



In a previous study, the reparative effects of IPD on damaged hair were investigated. After treatment with a 5% IPD aqueous solution with 5% sorbitol, the smoothness of damaged hair increased if compared to IPD used alone or to hydrolyzed proteins or other polyols instead of sorbitol. Indeed, the appearance of damaged hair fibers by microscopic analysis improves thanks to the synergistic effect of IPD with sorbitol.

Tested in combination with sodium laureth sulfate (SLES), IPD provided an increase of foam height and stability, proportionally to its concentration. In mild surfactant systems, best results took place at 2% IPD content. Moreover, the after feel of cleansing formulations containing IPD was less dry and more emollient than reference products without it. In cleansing formulations containing an oil phase, IPD was able to improve the hair shining effect and provided ease of combing and soft feel on hair.

In the present study, the cosmetic applications of IPD in hair products were deeply investigated, in particular the influence in hair dyeing in terms of color retention, the ability to improve the resistance of hair to breakage and the anti-frizzy effect.

HAIR DYE RETENTION AFTER REPEATED WASHING CYCLES

In the world of hair dyeing, one issue of great concern for consumers is the fading of the hair color after repeated washing cycles, which especially visible with red shades. The aim of this test was the evaluation of the effect of IPD on color retention after 15 washing cycles, by the comparison of standard hair strands and IPD treated strands.

Materials and methods

The strands of hair used for the test were composed of Italian straight, bleached blond hair. The braids were divided into 4 test strands, weighing around 4.5g each.

Hair equalization

All the 4 strands were first conditioned by cleansing with a shampoo (WAS≈15), then rinsed with tap water, with the purpose of equalizing the surface of the hair. After that, the strands were blow-dried.

Hair dyeing

The strands were treated with a red dyeing preparation activated by an oxidizing cream (20 vol.) in the ratio 1:1,5 and kept in place for 30 minutes.

Two strands were treated with the dyeing preparation added with IPD 5%. The other 2 strands (STD) were treated with just the same dyeing formula plus 5% of demineralized water. After the dyeing procedure, all the strands were rinsed with tap water, then blow-dried.

Washing cycles

Successively the strands were repeatedly washed and dried for 15 times: 2 strands (STD) were cleansed with the shampoo shown in formula 1; the other 2 strands were cleansed with the same shampoo added with 2,5% IPD (replacing the same amount of water).

The following parameters were evaluated for the assessment of the color retention performances after repeated washing cycles:

- L^* = related to the covering effectiveness of the dye;
- C = saturation, calculated as $[(a)^2 + (b)^2]^{1/2}$, describes the intensity of color/brightness.
- L^* variation after 15 washes in comparison to T_0 (ΔL): L^* increase corresponds to a reduction of the covering effect of the color;
- C variation after 15 washes in comparison to T_0 (ΔC): a significant increase of C parameter is related to a more intense color, while its reduction corresponds to a more opaque color;
- ΔE , total color variation, calculated as $[(\Delta L)^2+(\Delta a)^2+(\Delta b)^2]^{1/2}$: the higher the variation in absolute value, the higher the difference between initial and final color of the strands. [6]

Results

Five measurements were performed for each strand in 5 different positions for a total of 10 values for STD hair and 10 for IPD treated hair.

ΔE value

	STD hair	IPD treated hair
ΔE	9.82	6.52

Conclusion : The absolute color variation (ΔE) is significantly lower for the hair cleansed with shampoo containing IPD. This means that the expression of color and the brightness after repeated wash and rinse cycles have improved by the treatment containing IPD, evidencing that it increases the dye retention and protects the hair from color fading.

HAIR STRENGTHENING

The technical meaning of hair strength is the measure of hair resistance to a force. It can be measured in different ways; in this test it was done by checking the hair resistance to breakage when challenged by applying a progressively increased weight. The load required to break a single hair fibre under the action of a constant traction effort was measured in grams.

Materials and methods

The test equipment is made of a metallic stand with a cast iron bar. Pliers with a clamp are positioned on the head of the bar. The hair is fixed on one side to the pliers and is hung to the other side with a Hoffmann clamp. An increasing amount of standard weights (1 and 5g of E2 certified class) is hung to the Hoffmann clamp. (Figure 1).

The first test (A) was carried out on Italian straight, depigmented blond hair, 16cm long, divided into 2 test strands, weighing around 4.5g each. They were cleansed with the standard shampoo (same as previous test) in order to equalize the hair and successively blow-dried. The following solution was sprayed homogeneously onto one of them:

Water	75%
Alcohol denat.	20%
Isopentyldiol	5%

After drying, 20 single hairs were randomly taken from the strand for the evaluation of the breaking load. 20 hairs were randomly taken from the STD strand too. The second test (B) was carried out in a similar way on the same hair coloured with a red dye preparation, activated by an oxidizing cream (20 vol.) in the ratio 1:1,5 and kept in place for 30 minutes.

Results

A) Straight blond hair

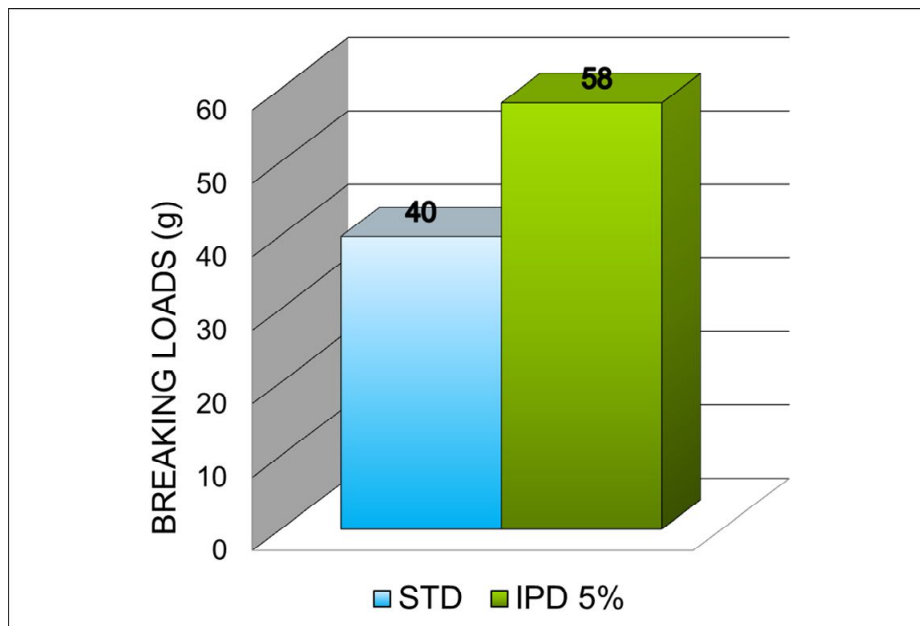
In table 8, the breaking load values of the STD hair are compared to the ones related to 5% IPD treated hair.

Breaking loads STD vs 5% IPD on blond hair

HAIR	STD	5% IPD LOTION
AVERAGE	40	58
ST. DEV.	17.97	13.30
% Variation	+45%	

Conclusion : The treatment of hair with a solution containing 5% IPD increases their strength, by improving the resistance to breakage by 45% in comparison to the standard hair.

Breaking loads STD vs 5% IPD on blond hair



B) Red coloured hair

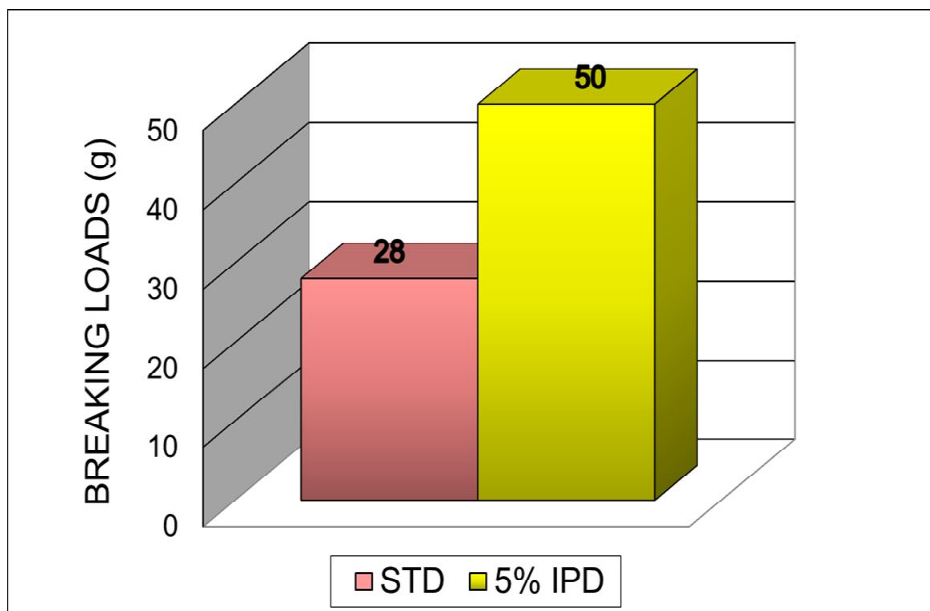
In table 9, the breaking load values of the STD red hair are compared to those of 5% IPD treated red hair.

Breaking loads STD vs 5% IPD on red hair

HAIR	STD	5% IPD LOTION
AVERAGE	28	50
ST. DEV.	9.72	14.46
% Variation	78.6%	

Conclusion : for coloured red hair as well, the treatment with a solution containing 5% IPD increases its strength, by improving the resistance to breakage of 78.6%.

Breaking loads STD vs 5% IPD on red coloured hair



ANTI-FRIZZY EFFECT

A high degree of fiber alignment makes the hair smooth, shiny, practically free of frizzles. High-humidity conditions can quickly destroy temporary fiber alignment, attained through heat styling, resulting in a frizzy appearance. The rate and extent of style loss will be proportionate to the climatic conditions. Hot, humid days lead to especially rapid style deterioration. In order to quantitatively evaluate the anti-frizzy effect of IPD, a test was carried out by comparing wavy hair strands cleansed with a shampoo and a conditioner containing IPD versus standard hair strands (cleansed with shampoo and conditioner without IPD), kept in hot and high humidity conditions for some hours.

Materials and methods

Hair strands

European wavy dark brown hair, 16-18cm long, were divided into 6 strands of around 2.5g each. Three strands (STD) were cleansed with basic shampoo (same as previous test) and conditioner. The other 3 strands were treated with shampoo and conditioner containing IPD (Shampoo at 2.5% and conditioner at 5%).

Procedure

The hair strands were washed with shampoo for one minute, then treated with the conditioner for another minute. Then, they were blow-dried and straightened with a hair straightener. They were kept in a stove Binder series BD-115, at 35°C and 75% RH, hung up on a grill, at the back of which a sheet of graph paper was arranged vertically (parallel to the strands). Strand lengths and widths were measured using the millimeter paper sheet after increasing time intervals (1, 2, 3 and 24 hours) of stove storage.

Results and conclusion of this test

In order to quantify the anti-frizzy effect of IPD, measurements of shortening and widening of the tresses were considered. The shortening of hair strands dimensions is similar and the differences are not significant. On the contrary, the widths of STD strands are higher than the ones of IPD strands and the difference keep significant until 3 hours after the treatment. After 24 hours, all the strands are similarly frizzy and the

difference is not significant any more. As no styling fixatives were used on hair strands, the effect achieved with this simple test can be considered good.

In table 10, the **width** (cm) of the strands at the different check times are reported.

Widening values of hair strands

STD hair					
	T0	1 h	2 h	3 h	24 h
1	2.03	2.30	2.45	2.74	2.74
2	2.59	2.79	2.82	3.06	3.27
3	2.89	3.26	3.34	3.34	3.34
IPD hair					
	T0	1 h	2 h	3 h	24 h
1	1.34	1.44	1.73	1.73	2.41
2	1.16	2.04	2.17	2.25	2.25
3	1.57	2.25	2.58	2.94	3.20

This study has been conducted by Luigi Rigano, Ph.D. and Deola Miriam, Rigano Laboratories, Srl, Milan.

*This study has been published in **Cosmetics & Toiletries**:*

<https://www.cosmeticsandtoiletries.com/formulating/category/haircare/Hair-Trio-Triumph-Isopentyldiol-for-Color-Care-Strength-and-Anti-frizz-483741071.html>

More details about the study are available upon request.

Please contact us: <https://www.kuraray.eu/contact>

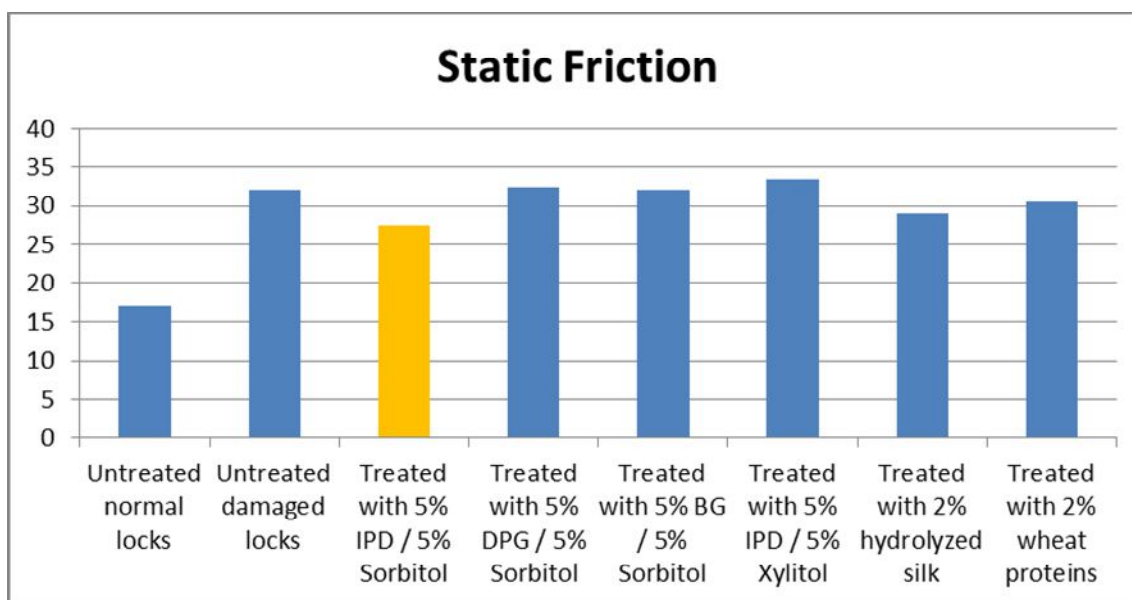
APPENDIX

Hereunder an extract of previous results also on Hair Care with IPD. More details are available upon request.

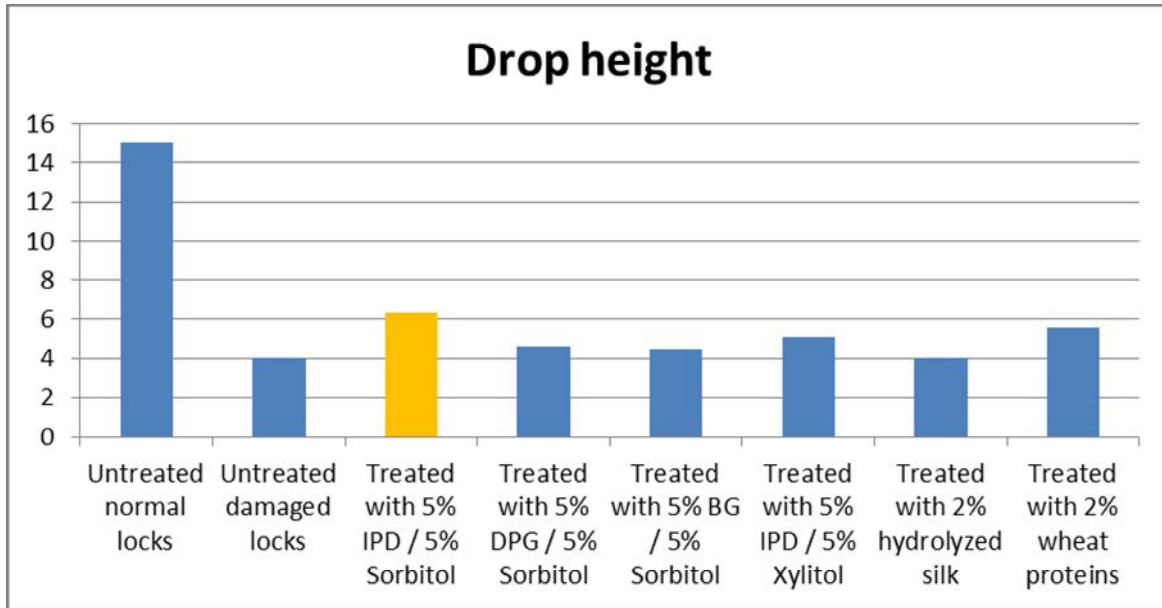
ISOPENTYLDIOL IN HAIR CARE

The repairing effects of IPD on damaged hair and the sensorial properties in oil-based hair cleansers were considered.

1. Effect on damaged hair: after treatment with IPD and sorbitol (5% + 5%), the smoothness of damaged hair increases if compared to IPD used alone, or to hydrolyzed proteins or to the addition of other glycols to sorbitol. The smoothness effect is evaluated as hair sliding by drop height (ring test) and coefficient of static friction (sliding angle test). Results are showed in Graph 2 and 3. The repairing effect obtained is also clear by microscopic analysis (Fig. 3). In other words, IPD shows a synergistic effect with sorbitol (ratio 1:1) in the treatment of damaged hair. When combined the two polyols improve the aspect of damaged hair fibers.
2. Oil shampoos: IPD has a good influence on the foam of cleansing systems and is able to improve the hair shining effect of cleansing formulae containing an oil phase. Oil shampoos containing IPD provide ease of combing and soft feel on hair.



Graph 2: Static friction results. IPD and sorbitol protect hair shafts if compared with dipropylene glycol (DPG), butylene glycol (BG), propylene glycol (PG) and hydrolyzed proteins - study performed on Caucasian hair locks



Graph 3: Drop height results. IPD and sorbitol together confirm their protection power of hair if compared with dipropylene glycol (DPG), butylene glycol (BG), propylene glycol (PG) and hydrolyzed proteins - study performed on Caucasian hair locks

Figure 3: Repairing effect of Isopentylidol + sorbitol, clearly visible by SEM

