SCHOTT

Vitryxx® – a skin-friendly alkalizing agent

For permanent hair dyeing products

Introduction to Vitryxx® bioactive glass powder

Vitryxx® is made entirely of elements that also naturally occur in the human body, such as silicon, calcium, sodium and phosphorus. The elements used in Vitryxx® are closely integrated into its material structure and work synergistically to create an inert bioactive glass with unique properties. The material has an amorphous structure and is sold as a fine white powder with hydrophilic properties.

Benefits of Vitryxx® for cosmetic applications:

- Fine powdery consistency for a pleasantly soft feeling on the skin
- Odorless and tasteless
- Withstands light and temperature extremes thanks to its inorganic composition
- Requires no solvent or preservation
- Contains no nanoscale raw materials
- Free of micro-plastics
- Can be used in natural cosmetics
- Vegan, free of animal ingredients
- Free of mineral and silicone oils
- No use of palm oil

Purity:

When making bioactive glass, strict production procedures minimize the presence of inorganic impurities. The melting process occurs at over 1,200 °C to eliminate any organic impurities left in the material.

Chemical composition:

Vitryxx® is composed of four inorganic oxides:

Name	[wt-%]
SiO_2	45 ± 5
CaO	24.5 ± 3
Na_2O	24.5 ± 3
P_2O_5	6 ± 2

Grain sizes:

SM4.0 specified by d_{50}: (4.0 ± 1.0) µm d_{95}: ≤ 20 µm. Customized grain sizes are also available on request.

Key efficacies of bioactive glass powder:

Anti-odor properties
Independent external institutes have proven the anti-odor properties of bioactive glass powder

Mineral-enriching effects
In contact with water, bioactive glass powder releases calcium and silica, which can build a mineral layer on keratin surfaces

Preservative-boosting properties
In aqueous suspensions, bioactive glass powder shows a high efficacy against bacteria

Excellent biocompatibility
Bioactive glass powder is composed of the inorganic oxides SiO_2, CaO, Na_2O, P_2O_5 and exhibits proven skin compatibility

Anti-inflammatory effects
In tests, cosmeceutical products including bioactive glass powder, demonstrated an ability to reduce the redness of skin

Alkalizing agent
Bioactive glass powder offers a skin friendly and well controllable local alkaline ambient without any annoying smell

Disclaimer: Efficacy varies depending on formulation of end product. Properties and characteristics refer to the bioactive glass powder only. Tests by renowned institutes available upon request.

Vitryxx® bioactive glass powder as a replacement for amine-containing alkalizing agents

The hair dyeing process

The hair dyeing market continues to grow at a lively pace. Whether trying out a new color or covering up gray hairs, many people turn to permanent hair color to feel beautiful.

But how does the hair coloration process work? To color hair permanently often requires an oxidative process involving several steps that take place in a formulation. First, an alkalizing agent such as ammonia or 2-ethanolamine is used to increase the pH and cause the hair cuticle to swell. This allows dye particles – often derived from easily oxidizable precursor molecules such as aromatic amino compounds (e.g., p-phenylenediamine and p-aminophenol) to penetrate the hair. With the help of an aqueous hydrogen peroxide solution, the desired dye is formed through oxidation of the assembled precursor molecules. This produces complex, larger dye molecules.

Because of its insolubility, size-related diffusion capabilities, and chemical bonds, the dye connects with the hair's keratin. The resulting color cannot be washed out and is permanent.

These oxidation dyes are now, in their finest form, present in the hair. When the dyes interact with the lightened natural pigment in the hair, a new color is produced.

Common alkalizing agents vs. Vitryxx®

Typically, ammonia water (NH_4OH) or 2-ethanolamine are used as the alkalizing agent, which increases the pH and, thus, causes the hair cuticle to swell, which is necessary for the coloring process.

However, there are significant disadvantages when using these chemicals. In addition to the unpleasant pungent odor of ammonia, the skin irritation caused by amines is problematic. Therefore, the development of alternative methods is of great interest.

Vitryxx® bioactive glass powder can overcome these disadvantages because it is odorless, as verified by external institutes. Its skin friendliness has also been proven, so there is almost no risk of irritation from this alkalizing agent. Thus, Vitryxx® is a valid alternative to currently available alkalizing agents.

Colorimetric study

In collaboration with SKH GmbH, an institute associated with the University of Regensburg, permanent hair coloring experiments were carried out on blond human hair samples using the formulation in Table 1. An aqueous hydrogen peroxide solution (3 %) was used as the terminal oxidant in the developing solution.

Hair coloring product components

Table 1: Composition of exemplary hair dye formulations; numbers are in grams.

	Reference	Vitryxx® [1 wt-%]	Vitryxx® [5 wt-%]
Water-phase			
Water	14.70	14.70	14.70
Xanthan gum	0.07	0.07	0.07
Propylene glycol	0.60	0.60	0.60
Sodium sulfite	0.09	0.09	0.09
Ascorbic acid	0.02	0.02	0.02
Sodium laurethyl sulfate	0.11	0.11	0.11
Dyes			
2,5-diaminotoluene sulfate	0.20	0.20	0.20
Resorcinol	0.15	0.15	0.15
p-aminophenol	0.05	0.05	0.05
4-amino-2-hydroxytoluene	0.04	0.04	0.04
m-aminophenol	0.03	0.03	0.03
Fatty phase			
Cetylstearyl alcohol	1.20	1.20	1.20
2-Octyldodecan-1-ol	0.80	0.80	0.80
Stearic acid	0.32	0.32	0.32
Palmite acid	0.32	0.32	0.32
Alkalization agents			
2-Ethanolamine	0.90	–	–
Ammonium hydroxide	0.40	–	–
Vitryxx® MD01 SM 4.0 (INCI: Calcium Sodium Phosphosilicate)		1.3 g H_2O + 0.2 g Vitryxx®	1.3 g H_2O + 1.0 g Vitryxx®

Hair color preparation

1. Melt the fatty phase at 70 °C
2. Homogenize the thickener and water at 70 °C
3. Add and dissolve the water-soluble components and the dyes
4. Add the bases
5. Add the fatty phase to the water phase
6. Homogenize while cooling (up to 50 °C)
7. Add a fragrance
8. Cool to room temperature

Evaluation of hair color measurements

The formulations shown in table 1 were applied to human blond hair. Hair color and developing solution were used in a 1:1 weight-ratio with an exposure time of 30 minutes. The hair was then washed using tap water, dried with a hair dryer, and analyzed by colorimetry. To investigate how long the hair coloration lasted, the hair strands were washed five times using a commercially available shampoo and the color intensity measured again.

According to the CIELAB color space, the ΔE value is calculated using the formula $\Delta E=\sqrt{(a^2+b^2+L^2)}$ (figure 1). It is assumed that L is most important while a and b are almost constant. Consequently, a lower ΔE value corresponds to a more intense coloration. In addition, the pH-value of the formulation was determined to access skin-friendliness.

The performance of Vitryxx® powder was compared to the benchmark system of ammonia and 2 ethanolamine. Therefore, different amounts (1 wt-% and 5 wt-%) of Vitryxx® powder were used and compared to a reference formulation and a formulation without any alkalizing agent (figure 2).

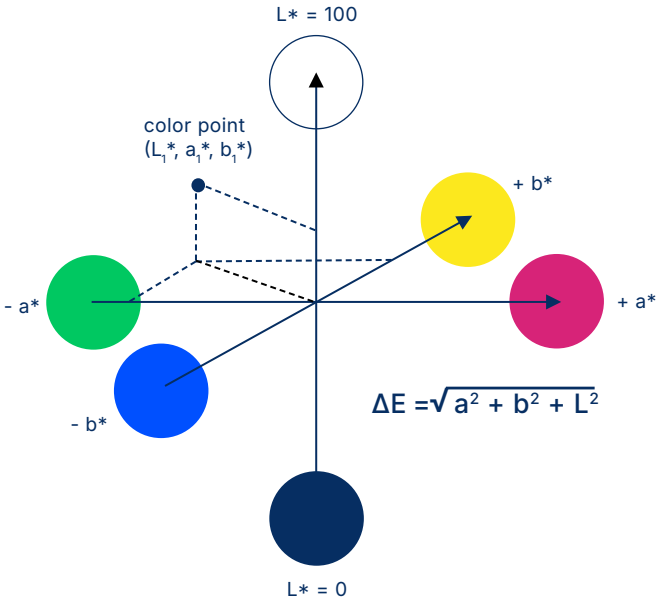

Figure 1:
The CIELAB color space and the formula to determine ΔE.

Hair dyeing experiments

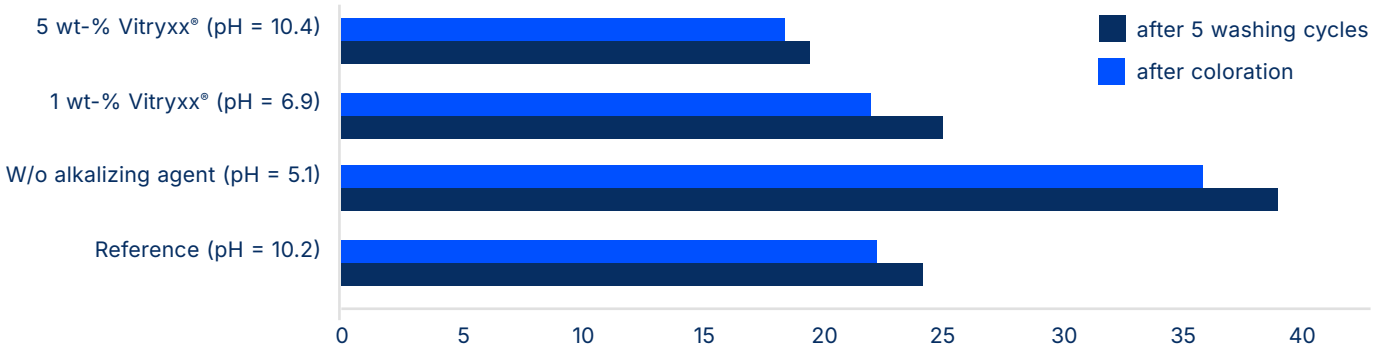

Figure 2: Results of colorimetric measurement; a lower ΔE means a better staining result.

The reference sample with a pH-value of 10.2 showed a color intensity of ΔE = 22.5 after dyeing and ΔE = 24.3 after five washing cycles. The formulation without an alkalizing agent showed worse results with a ΔE of 35.9 and 39.0, respectively. The sample was slightly acid (pH 5.1). At a similar basic pH of 10.4, the hair coloration experiment using 5 wt-% Vitryxx® led to lower ΔE values of 18.4 and 19.6, which indicate better performance compared to the benchmark system. Interestingly, when using only 1 wt-% Vitryxx® powder, a neutral pH of 6.9 was observed with ΔE values of 22.2 and 25.1, which are still attractive.

Figure 3: Hair strands from the test series, before coloration (left) and after coloration and five cycles of washing (right)

Figure 4: Hair strands from the test series

In conclusion, Vitryxx® glass powder offers a better-performing replacement for commonly used alkalizing agents such as ammonia and 2-ethanolamine (figures 3,4). It also provides good results at a neutral pH-value, which can significantly reduce the risk of skin irritation. Its use in bleaching hair is limited as Vitryxx® glass powder is not able to decompose melanin itself. Thus, a two-step coloration including bleaching and coloration is necessary.

High biocompatibility and skin-friendliness

Relevant standard irritation tests demonstrate the high biocompatibility and skin- friendliness of Vitryxx®. Even though the tests were conducted with extremely high concentrations of Vitryxx®, no irritation was reported, even at high pH-values.

Table 2: Standard irritation tests conducted with Vitryxx®

Test name	Institute	Date	Test product/vehicle	Positive control	Official result	N
Patch test (4 weeks)	Dermatest	Sep. 2000	Vitryxx® MD01 SM 4.0 (30 wt-%) in 70 % glycerine	–	No irritation	20
Human patch test (3 days)	Dermatest	Jun. 2000	Vitryxx® MD01 SM 4.0 (30 wt-%) in 70 % glycerine	–	No irritation	30
Human patch test (3 days)	Fresenius	Feb. 2001	Vitryxx® MD01 SM 4.0 (30 wt-%) in 70 % glycerol	1 % SDS	Classified as harmless	50
Human patch test (3 days)	Dermatest	Feb. 2001	Vitryxx® MD01 SM 4.0 (30 wt-%) in 70 % O/W emulsion (acc. DAC)	–	No irritation	30
Human patch test (3 days)	Dermatest	Feb. 2001	Vitryxx® MD01 SM 4.0 (30 wt-%) in 70 % O/W emulsion (acc. DAC)	–	No irritation	30
HET-CAM test	L + S AG	Nov. 2001	5 % Vitryxx® MD01 SM 4.0 in water	Texapon ASV 5 %	Lowest irritation class	6
HET-CAM test	L + S AG	Nov. 2001	Vitryxx® MD01 SM 4.0 in DAC Basic formulation	Texapon ASV 5 %	Lowest irritation class	6

N = Number of tests DAC = German Drug Codex HET-CAM = Hen's Egg Test Chorio-Allantoic-Membrane

Conclusion and evaluation of hair color measurements

The tests carried out by SKH GmbH (University of Regensburg) delivered the following results:

- Vitryxx® was successfully used as alkalizing agent in hair dye formulations.
- The odor and skin irritation that occur with ammonia and 2-ethanolamine concerning odor and skin irritation were avoided.
- A formulation using 5 wt-% Vitryxx® showed remarkable results in the permanent dyeing of blond hair in comparison to a standard formulation with ammonia and 2-ethanolamine.
- In addition, using a lower concentration of 1 wt-% Vitryxx® was even more skin- friendly with a pH-value in the neutral range and showed good hair coloration performance, comparable to the standard formulation.

In conclusion, this study shows the benefits that Vitryxx® can offer as an alternative alkalizing agent.

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