

ERYTHRULOSE

A safe way to acquire a superbly tanned skin

Erytan™

INTRODUCTION

A sun-tanned appearance is a symbol of a healthy, dynamic, and active life. Yet, the damaging effects of sunlight and other sources of ultraviolet radiation on the skin are well documented. These effects are cumulative and potentially serious, and include sunburn, skin cancer, and premature aging of the skin.

Dihydroxyacetone (DHA) has been used in cosmetic self tanning products for many years, but it does have many disadvantages which have been troubling the people. Therefore, there is an eager desire to find a more safe and effective self-tanning agent to supersede DHA.

Erythrulose has been developed to reduce or even eliminate the disadvantages of DHA, namely an irregular and streaky tan as well as an intense drying effect. It presents a new solution for the increasing demand of self-tanning. It is a natural keto-sugar occurring in Red Raspberries, and may be produced by fermentation of the bacterium *Gluconobacter* followed by multiple purification steps.

Erythrulose reacts with free primary or second amino groups of keratin in the upper layers of the epidermis. This conversion of reducing sugar with amino acids, peptides or proteins, similar to the “Maillard reaction”, also known as non-enzymatic browning, leads to the formation of brownish polymers, the so-called melanoids. The resulting brown polymers are bound to proteins of the stratum corneum mainly via lysine side-chains. The brown color is comparable to the appearance of natural sun tan. Tanning effect appears in 2-3 days, the maximal tanning intensity is reached with Erythrulose after 4 to 6 days. The tanned appearance typically lasts from 2 to 10 days depending on application type, and skin condition.

The coloring reaction of erythrulose with skin is slow and gentle, which makes it possible to produce a natural, long-lasting, even tan without stripes (DHA may create an orange tone & stripes). As an up-and-coming self-tanning agent, Erythrulose-only sunless tanning products have become increasingly popular.

TECHNICAL INFORMATION

SPECIFICATION

| | | |
|--------------|---|---------------------------------|
| Form | : | highly viscous liquid |
| Color | : | Yellow to orange-brown coloured |
| Odour | : | Characteristic |

| Controls | Unit | Low Limit | Upper Limit | Method |
|---------------------------|-------|--|-------------|-------------------------|
| Appearance | | Yellow to orange-brown coloured, highly viscous liquid | | visuell |
| Water content | % | | 24 | Karl Fischer, titration |
| pH (in 50 % water) | | 2.0 | 5.0 | Potentiometrical |
| Erythrulose content (m/m) | % | 75 | 84 | HPLC |
| Total nitrogen | % | | 0.5 | Kjeldahl |
| Sulfated ash | % | | 4.5 | Ph. Eur. 2.4.14 |
| Preservatives | | None | | |
| Total plate count | CFU/g | | 100 | Ph. Eur. 2.6.12 |
| Specified pathogens | | Negative | | Ph. Eur. 2.6.13 |

PRESERVATION AND MICROBIOLOGICAL PROPERTIES

Erythrulose does not contain any preservatives and is free of specified pathogens. It meets the CTFA microbiology guideline on the limit control of non-pathogenic microorganisms (less than 100CFU per g or ml).

SAFETY AND ECOLOGY

Erythrulose is found to be safe for cosmetic use and is not considered to pose a risk to the environment according to literatures reports.

STABILITY

Stability to temperature and pH

Low temperature and low pH is conducive to the stability of erythrulose. At pH greater than 5.5 Erythrulose in water becomes unstable, and may eventually hydrate to an aliphatic tetra alcohol. Erythrulose should be used in un-buffered acidic system. After a period of one year, the loss of erythrulose at pH 2.5 is negligible under storage at 25°C. For long-term storage, it is suggested to store erythrulose at a temperature of 4-8°C and a pH between 2.0 and 5.0, preferably between 2.0 and 3.5.

To guarantee a constant product quality, pure Erythrulose should never exceed a temperature of 40°C.

Stability with various cosmetic ingredients

The reactivity of erythrulose with amino groups is not restricted to the skin surface alone. All amines undergo the same Maillard reaction that takes place with the amines of the stratum corneum and should be avoided. In fact, the presence of nitrogen-containing molecules in a cosmetic formulation can trigger the reactivity of erythrulose. The aromatic amines, including PVP and tertiary amines such as EDTA may react with erythrulose, even if relatively slowly.

Other sensitive raw materials that can be combined with erythrulose, are gel formers and hydro-colloids

(polyacrylic acid and its derivatives), fruit acids (α -hydroxy acids), inorganic UV filters such as titanium dioxide and zinc oxide and phosphoric acids esters and their salts.

Ethanol

Ethanol shows no influence on the stability of erythrulose. However, we suggest to keep alcohol content to a concentration below ca. at 20-30%.

Cosmetic pigments and fillers

Ronastar® Silver and Ronastar® Copper from Merck, as well as Colorona® Bronze, are well designed to be compatible with erythrulose. Some other pigments and fillers are recommended to keep in low concentrations.

STORAGE AND SHELF LIFE

Erythrulose should be stored in the original sealed, light resistant containers in a clean place, at a temperature between 2 and 8°C. It is allowed to reach room temperature before opening drum. In order to avoid secondary microbial contamination, following opening, containers should be handled with special care. Erythrulose remains stable for at least 3 years under the recommended conditions.

GENERAL PRODUCTION INFORMATION

| | | |
|--------------------------|---|--|
| INCI Name (CTFA) | : | Erythrulose |
| Trade Name | : | Erytan |
| ELINCS No. | : | 443-800-9 |
| Molecular Formula | : | C ₄ H ₈ O ₄ |
| Molecular Weight | : | 120.10 |
| EU-Labeling Name | : | Not listed |
| JCID Approval No | : | Not approved |
| NICNAS | : | Not listed |

L-Erythrulose

| | | |
|--|---|--|
| CAS No. | : | 533-50-6 |
| Synonym | : | L-(+)-Erythrulose S-1,3,4-Trihydroxy-2-butanone (3S)-1,3,4-trihydroxybutan-2-one L-glycero-Tetrulose L-Glycero-2-tetrulose 2-Butanone, 1,3,4-Trihydroxy Tetrulose Glycerotetrulose Erithrulose |
| Syrup. $[\alpha]_D^{18}$ | : | +11.4° (c=2.4 in water) |

D-Erythrulose (Enantiomer)

| | | |
|----------------|---|----------|
| CAS No. | : | 496-55-9 |
|----------------|---|----------|

Synonym : (R)-1,3,4-Trihydroxybutan-2-one

DL-Erythrulose (Racemic Form)

CAS No. : 40031-31-0

Synonym : DL-Glycerotetrulose

¹ELINCS: European List of Notified Chemical Substances.

EINECS: European Inventory of Existing Chemical Substances.

FORMULATION GUIDELINES AND SUGGESTIONED APPLICATIONS

COMPATIBILITY

Although erythrulose is more stable and better compatible with cosmetic ingredients compared with DHA, it is still suggested that the incompatibility and precautions of DHA are taken into account in designing erythrulose-containing formulations, such as:

- Avoid amines and elevated temperatures
- Ensure pH range at 2.0-5.0
- Prevent from contact with α -Hydroxy acids, oxides like iron or zinc oxide or titanium dioxide
- Beware of high amounts of gel formers (e.g. Carbomers, Xanthan gum) or high amounts of ethanol
- Keep buffers at a minimum

Erythrulose can be formulated in combination with preservatives and all organic sunscreens that do not contain amino groups. Erythrulose is also compatible with encapsulated UV filters like Eusolex® UV-Pearls™. The combination of erythrulose with cosmetic pigments and fillers can only be recommended in low concentrations. Ronastar® silver, Ronastar® Copper, and Colorona® Bronze are specially designed to be used in combination with erythrulose in self-tanning formulations.

The addition of phospholipids with unsaturated side chain (phosphatidyl choline, lecithin, “empty” liposomes) may improve tanning results with regards to speed and intensity. These materials are regarded to improve the ability of cell membranes to transport erythrulose to the deeper layers of the stratum corneum.

Troloxerutin accelerates tanning effect, and supply anti-ageing and anti-inflammatory action. Besides, it can improve odour of self tanning products. It is also widely used as antioxidant and free-radical scavenger in cosmetic and dermatological compositions. Rutin or rutin sulfate shows similar action as troloxerutin. Other recommended antioxidants include sodium metabisulfite, Phyllanthus emblicaa fruit extract, ellagic acid, and Caffeic acid phenethyl ester (CAPE), etc..

Ecotin is a cell protection factor, protecting the skin against external aggressors by protecting Langerhans cells, protecting DNA and cells from UV-induced damage, significantly reducing formation of sunburn cells,

and retaining moisture in the skin.

Table 1 Some of ingredients often appear in self-tanning products containing erythrulose

| Function | Examples | Typical Trade Names | INCI Name |
|-------------------------------|--|--|---|
| Preservatives | Parabens, DMDH hydantoin, phenoxyethanol | Mikrokill Cos / Arch Personal Care Products | Phenoxyethanol, Caprylyl Glycol, Chlorphenesin |
| | | Euxyl PE9010 / Schulke & Mayr | Phenoxyethanol, Ethylhexylglycerin |
| | | Diocide / Centerchem | Caprylyl Glycol, Phenoxyethanol, Hexylene Glycol |
| | | Phenonip / Clariant | phenoxyethanol, methylparaben, ethylparaben, butylparaben, propylparaben, isobutylparaben |
| | | Paratexin DMD / Clariant | Aqua, DMDM Hydantoin |
| Organic sunscreens | Methylbenzylidene camphor, ethylhexyl methoxycinnamate, homosalate, butyl methoxydibenzoyl methane, benzophenones, octocrylene and ethylhexyl salicylate | Eusolex® UV-Pearls™ / Merck KGaA | Aqua (Water), Ethylhexyl Methoxycinnamate, Silica, PVP, Chlorphenesin, Disodium EDTA, BHT |
| | Jewelweed extract | NAB® Jewelweed extract | Water & Impatiens balsamina (Garden Balsam) leaf extract |
| Cosmetic pigments and fillers | Can only be recommended in low concentrations | Ronastar® silver / Merck KGaA | Calcium Aluminum Borosilicate, Silica, CI 77891 (Titanium Dioxide), Tin Oxide |
| | | Ronastar® Copper / Merck KGaA | |
| | | Colorona® Bronze / Merck KGaA | Mica and Iron oxides |
| Penetration enhancer | Phospholipids (e.g. Empty liposomes) | Probiol L 05018 / Kuhs GmbH & Co. KG | Aqua, alcohol denat., lecithin, glycerin, disodium phosphate |
| | Ethoxydiglycol | | |
| | Dimethyl isosorbide | Arlasolve DMI | |
| | alpha bisobola | | |
| Tanning accelerator | Troxeutin, Rutin, Rutin sulfate | | Troxeutin, Rutin |
| | Walnut extract | | Propylene glycol, walnut extract |
| | Lawsonia inermis | | Henna |
| | Eclipta alba Hassk extract (Mahakanni) | | Eclipta prostrata extract & water |
| | Acetyl tyrosine | | Tyrosine |

| | | | |
|-------------------------------|---------------------------------------|--|------------------------------------|
| Antioxidant | Sodium metabisulfite | | Sodium metabisulfite |
| | Phyllanthus emblicaa fruit extract | Rona Care Emblica / EMD chemicals Inc. | Phyllanthus emblicaa fruit extract |
| | Pomegranate extract | | Punica granatum extract |
| | Ellagic acid | | Ellagic acid |
| | Caffeic acid phenethyl ester (CAPE) | | |
| Cell protection factor | Ectoine | EMD Chemicals Inc. | Ecotin |
| Colorant | Caramel | | Caramel |

PROCESSING AND DOSAGE

Avoid prolonged contact with hot formulations, and never exceed a temperature of 40°C. Erythrulose is readily soluble in water. It can be incorporated into cold formulation, even into cold W/O emulsions. Erythrulose is stable at a pH range of 2.0-5.0, slightly acidic pH of ca.4 ensure stability of erythrulose and facilitate preservativation. In formulations, erythrulose is compatible at concentrations of up to 20%, generally around 1 to 5%.

COSMETIC APPLICATIONS

- Self tanning products
- sun care products
- body lotions
- skin care lines for healthy looking skin

ADVANTAGES of ERYTHRULOSE in comparison with DHA

DHA is too active in chemical property and is relatively sensitive to heat and light which bring about a series of problems for its use as self-tanning agent. Firstly, the shelf life of products containing DHA is very short, the only safe way is to prepare them only before use. Secondly, DHA reacts easily with many cosmetic ingredients, so ALMOST each component in the DHA-based self tanning products should be carefully identified for its compatibility with DHA, this greatly increase the difficulty and workload of cosmetic formulators. Thirdly, due to the quite active nature of DHA, in addition to its combination with free amino and imino group of amino acids, peptides and protein in the top-most layer of epidermis to form light brown polymers, it can also react with other substances in the skin to produce other colors of splashes.

The formed color shade may varies greatly hear and there, due to the too quick reaction of DHA with body skin, and the difference of skin in thickness everywhere, as well as the subtle non-uniformity on spreading DHA on to the skin. Of course, another reason to produce irregular and mottled tanning comes from the action of fission products of DHA.

Of all the troubles, the most serious problem is that, no matter how caution on processing and handling, or even under the action of body heat after applying on the skin, the great instability of DHA to heat will

inevitably produce split products, which include toxic formic acid, formaldehyde, and some unknown product. For example, during its storage, the pH value of DHA-based product may shift from between 5 and 6 down to around 3, which definitely demonstrate the formation of acid substances. A strong evidence that DHA may decompose with the action of body heat lies in the below fact: about 1 hour later after applying the DHA-contained product on to the skin, there will be an unpleasant smell on the body, which is quite different from the odor of DHA itself or of DHA-based product. This strange odor may come from formaldehyde, formic acid, or some unknown decomposed products. Many cosmetics manufacturers work very hard to try various essential oils to mask such objectionable odor, but can not fundamentally inhibit the development of the disagreeable off-odour, as well as a concomitant loss of product performance.

These cleavage products are harmful to skin, for example, formaldehyde and formic acid are strong strongly corrosive to skin. In addition to its possibly carcinogenic property, formaldehyde will also trigger allergic reactions, dermatitis, or eczema. Such side effects as skin allergy, itching and some other symptoms often occur in some people who use products containing DHA may attributed to the impact of its decomposition products. Since DHA itself, as an important intermediate in Glycolysis Metabolic Pathway in human body in the form of phosphate, is unlikely to cause allergic reactions and other side effects.

The strong corrosive of formic acid, formaldehyde and other harmful substances liberated by DHA will not only weaken the coloring effect of DHA on skin to the extent that only produce orange tone (rather than a dark brown skin), but also speed the uneven peeling. Besides, the intense skin drying effect caused by DHA will also accelerate the rapid fall off of cells in the outer layer of skin. These factors determine that the skin color due to DHA is uneven, temporary, and fade rapidly.

Some companies attempt to combine dihydroxyacetone with erythrulose together in their formulations just to take advantage of the characteristics of DHA's fast coloring skin. It is only to satisfy some people's needs of quick success in achieving tanned appearance. But it is not a fundamental solution to many problems both in the use of DHA and of injuries to skin due to cleaved products coming from DHA. The defects of DHA is masked on the surface by the advantages of erythrulose.

The flaws of DHA are not found when using erythrulose. erythrulose has a good skin permeability compared with DHA so that it's coloring effect can extend to lower layer of the epidermis. Besides, the coloring reaction of erythrulose with skin is slow and gentle. Thus, the tan by erythrulose is not only durable, but also uniform, and is comparable to the appearance of natural tanning.

Erythrulose is more stable than DHA, so under the same storage conditions, the shelf life of erythrulose-based product is markedly longer than that of product containing DHA. The former has much less probability than the latter to liberate harmful decomposed products. As a result, such troubles as skin irritation, pruritus, contact dermatitis, sordid odor, uneven peeling, very orange tone, which are often encountered on DHA, are less found when using erythrulose. And the intensive drying-out of skin due to DHA is also not exist in erythrulose.

To sum up, compared with DHA, the advantages of erythrulose can be enumerate as follows:

| | Erythrulose (Worry-free) | Dihydroxyacetone (Great Hassel) |
|--|--|---|
| Tanning results | | |
| <i>Nature</i> | Natural | Unnatural |
| <i>Uniformity</i> | Homogenous and soothing, stain-free | Irregular and mottled, undesired streaks |
| <i>Skin color</i> | Brown/bronze | Very orange |
| <i>Flaking</i> | Normal | Uneven peeling |
| <i>Sustainable time of tan</i> | Long-lasting | Temporary, the fading is more uneven and blotchy because of irregular peeling |
| Body odor after USE | No special odor | Nasty smell |
| Stability | Better than DHA | Very poor |
| Shelf life of formulated product | Longer than DHA-based product | Very short |
| Compatibility | Compatible with MOST cosmetic ingredients | Require special attention on selecting ingredients |
| Formaldehyde risk | No | Liberate fission products as well as formic acid, formaldehyde |
| Safety on skin | Safe | Irritation, contact dermatitis, skin itching, eczema, etc. |
| Skin drying | Rehydrate skin | Intense drying effect |
| Risk of Microbial Contamination in formulations | No special requirement | Require special attention on microbial attack |

In a word, the advantages of Erythrulose can only be fully realised when it is used solely and a product with the following advantages is desired:

- Seldom cleavage products and considerably less skin irritation as compared with DHA
- Gentle and homogeneous tanning, with similar tanning kinetics to natural sunlight
- Long lasting tan
- Less skin drying effect as compared with DHA