

# DIHYDROXYACETONE

*A safer alternative to sunbathing*

## INTRODUCTION

Where tanned skin is considered to be attractive, people are becoming increasingly aware of the harmful effects of sunlight as well as the risk of skin cancer. The desire to acquire a natural looking tan without sunbathing is growing. Dihydroxyacetone, or DHA, has been used successfully as a self-tanning agent for more than half a century. It is the main active ingredient in all sunless tanning skincare preparations, and is considered the most effective sun-free tanning additive.

### Natural Source

DHA is a 3-carbon sugar involved in carbohydrate metabolism in higher plants and animals through process such as glycolysis and photosynthesis. It is a physiologic product of the body and is presumed to be nontoxic.

### Molecular Structure

DHA occurs as a mixture of a monomer and 4 dimers. The monomer is formed by heating or melting dimeric DHA or by dissolving it in water. The monomeric crystals revert to dimeric forms within about 30 days of storage at room temperature. Therefore, solid DHA mainly presents in the dimeric form.

### The Browning Mechanism

Dihydroxyacetone tans the skin by binding to amines, peptides and free amino acids of the outer layers of the stratum corneum to generate a Maillard reaction. A brown "tan" forms within two or three hours after skin contacts DHA, and continues to darken for approximately six hours. The result is a substantive tan and diminishes only as the dead cells of the horny layer flake off.

The tan's intensity depends on the type and thickness of the horny layer. Where the stratum corneum is very thick (at the elbows, for example), the tan is intense. Where the horny layer is thin (such as on the face) the tan is less intense.

## STABILITY

### Temperature

Elevated temperatures induce degradation, especially at higher concentrations of DHA. The loss of DHA (in powder form) is negligible under storage at room temperature for one year. The same applies to DHA in aqueous solution. A 10% DHA solution stored at 40°C for 6 months showed a loss of approx. 25% of the active ingredients.

Fig 1 shows that, in contrast to room temperature, elevated temperature (40°C) accelerates DHA degradation along with the drop of pH of the solution.

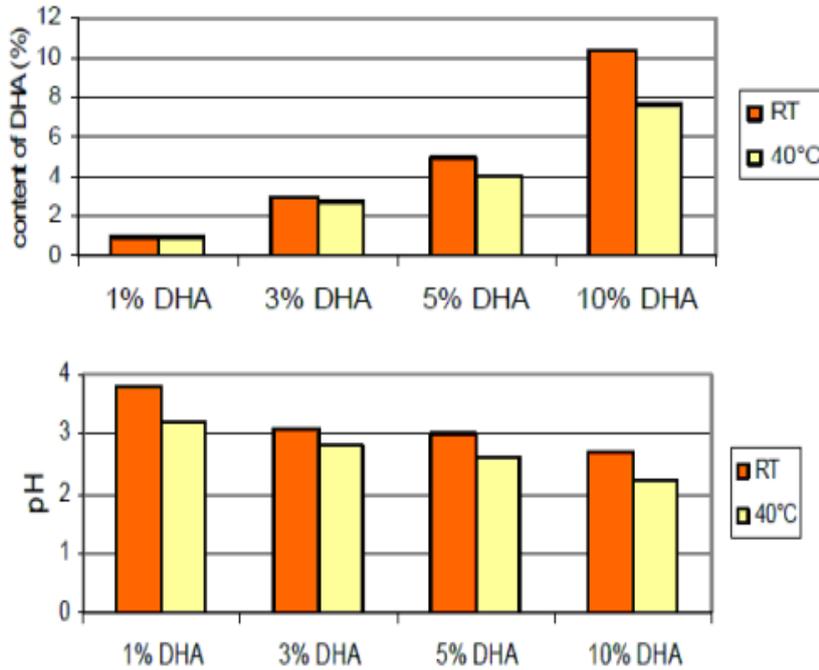


Fig 1 Stability of DHA solution after 6 months storage time (at RT and 40° C)

**pH**

Low pH improves the stability of solutions containing DHA. The optimum pH range is between 2 and 4. DHA should be used in un-buffered acidic systems. Going against the natural pH drop of self-tanning formulations containing DHA is contraindicated due to the loss of DHA stability. Fig 2 reveals that, the lower the pH, the higher the stability of DHA.

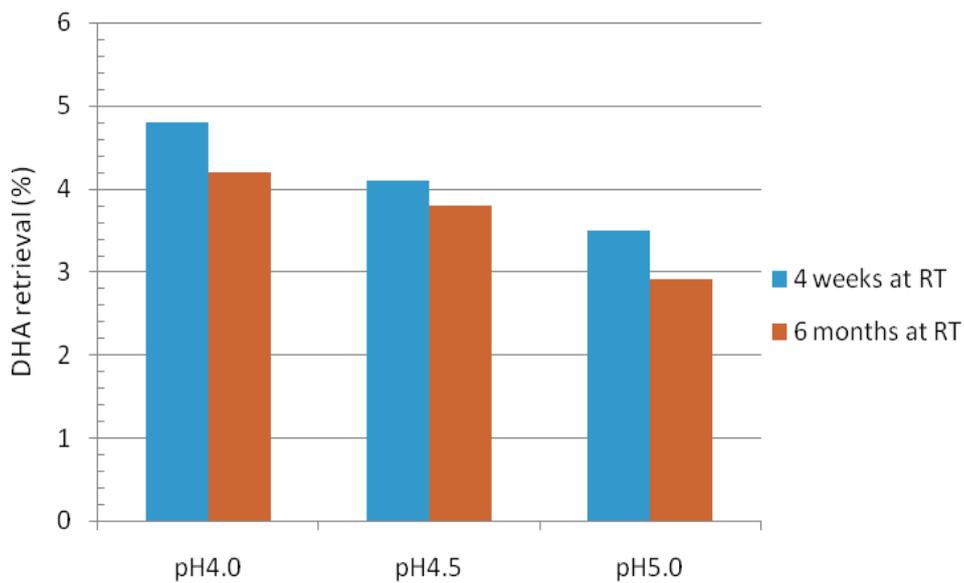


Fig 2 Influence of pH on DHA solutions (buffered with acetic acid/sodium acetate).

DHA is very sensitive to strongly acidic or strongly alkaline solutions. In a solution of pH 8 to 12, hydroxyacetone is produced and a small amount of methylglyoxal is formed. Methylglyoxal is also formed to some extent if the pH is between 4 and 9. DHA polymerizes in a strongly acidic solution.

## SOLUBILITY

<i>Solvent</i>	<i>Solubility in 100ml</i>
Water	< 70g
Glycerol	<75g
Propanediol-1,2	<55g
Ethanol (absolute)	<1.5g

## GHS SAFETY INFORMATION

<b>Disposal</b>	3 Relatively unreactive organic reagents should be collected in container A. If halogenated, they should be collected in container B. For solid residues use container C.
<b>Storage class</b>	10 - 13 Other liquids and solids
<b>WGK</b>	WGK 1 slightly water endangering
<b>RTECS</b>	UC1645000

## HAZARDS

### GHS pictograms



<b>GHS signal word</b>	WARNIG
<b>GHS hazard statements</b>	H319
<b>GHS precautionary statements</b>	P264, P280, P305+351+338, P337+313

## TECHNICAL DATA

<b>Description</b>	White to almost white, crystalline powder
<b>INCI</b>	dihydroxyacetone
<b>Chemical Name</b>	1,3-dihydroxy-2-propanone
<b>Product code</b>	C01002B
<b>CAS</b>	96-26-4 (monomer); 62147-49-3 (dimer)
<b>Hill Formula</b>	C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>
<b>Molar mass</b>	90.07 g/mol
<b>EINECS</b>	202-494-5
<b>Solubility</b>	Soluble in water, glycerol and propandiol-1,2
<b>Melting point</b>	83°C (monomer )
<b>Density</b>	1.52 g/cm <sup>3</sup> (20°C)
<b>pH</b>	3-5 (50g/l, H <sub>2</sub> O, 20°C)
<b>Boiling point</b>	188°C (decompose)
<b>Vapor pressure</b>	<-0.01 Pa (20°C)

<b>Handling</b>	DHA should be stored in a cool, dry place at 2-10°C. Allow to reach room temperature before opening the package.
<b>Shelf life</b>	24 months under specified conditions in unopened package

## FORMULATION GUIDELINES

DHA can be combined with most cosmetic ingredients in all types of formulations, providing some fundamental rules are adhered to.

Avoid formulating with amines, which react with DHA. Aromatic amines, including PVP and tertiary amines, such as EDTA, can react with DHA as well, even if relatively slow. Other sensitive raw materials include acrylates or methacrylates, fruit acids (  $\alpha$ -hydroxy acids), inorganic UV filters such as titanium dioxide and zinc oxide and phosphoric acid esters and their salts. All of these can induce different degree of degradation of DHA within short period of time.

Low pH improves the stability of solutions containing DHA. Besides, an alkaline pH turns the tan orange, whereas a slightly acidic pH reduces color problems. Store at room temperature (<30°C) for stable products.

Table 1. Some of examples of raw materials (not limited to) which are not compatible with DHA

<b>Product Name</b>	<b>INCI Name</b>	<b>Observations</b>
<b>Incompatible preservatives</b>		
<i>Eusyl K-702</i>	Phenoxyethanol, benzoic acid, dehydroacetic acid	Discoloration
<i>Potassium sorbate</i>	Potassium sorbate	Discoloration
<i>Suttocide A</i>	Sodium hydroxymethylglycinate	Discoloration
<i>Unicide U-13</i>	Imidazolidinyl Urea	Clouding
<b>Incompatible hydrocolloids</b>		
<i>Carbopol Ultrez 10</i>	Carbomer	Discoloration
<i>Pemulen TR-1</i>	Acrylates/C10-30 alkyl acrylate crosspolymer	Discoloration
<i>Sepigel 305</i>	Polyacrylamide, C13-14 isoparaffin, laureth-7	Discoloration
<b>Incompatible UV-filters</b>		
<i>Spectraveil TG</i>	Zinc oxide, Caprylic/Capric Triglyceride	Discoloration
<i>Tioveil AQ</i>	Water, Titanium dioxide	Discoloration
<b>Incompatible Miscellaneous substances</b>		
<i>AHAs</i>	-	Discoloration
<i>Amino acids</i>	-	Discoloration
<i>Chitosan</i>	Chitosan	Discoloration

## USES

### Cosmetic Use

DHA interacts with the Keratin in the Stratum Corneum forming a dark pigment similar to a suntan.

### Chemical/Pharmaceutical Use

DHA is used as a raw material in the synthesis of both chemicals and pharmaceuticals

**Nutraceuticals Use**

DHA is used in combination with Pyruvates as a dietary supplement in “Fat Burner” and other Health Food Supplements.