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Review Article

Chemical Composition of Sunscreen Chemicals

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Abstract

Initially, sunscreens were intended to protect users from the sun's rays when they went to the beach. Later, the same products were used in winter sports, because the sun's rays affect the skin more strongly when reflected by the surface of the snow. However, today, UV filters are found in cosmetic products used every day, such as day moisturizers, hair care products, aftershave products, lipstick or makeup products. Initially, UV filters were found in products intended for winter sports, such as lip balm, and later entered the composition of daily cosmetics. Moreover, along with consumer needs, new sunscreen products with different characteristics, intended for use on the beach, have appeared on the market.

Key words: sunscreen products; UV filters; photoaging; sun protection factor

1.Introduction

It is well known that the ozone layer absorbs approximately 44.3% of visible (VIS) radiation (400–760 nm), 49.5% of infrared (IR) radiation and only 6.2% of ultraviolet (UV) radiation. Within UV radiation, 98% is ultraviolet A (UVA) radiation (320–400 nm) and 2% is ultraviolet B (UVB) radiation (290–320 nm).

While ultraviolet C (UVC) radiation (100–290 nm), which has the highest energy potential and is therefore the most harmful, fortunately does not reach the Earth [1].

Exposure in small amounts to UV radiation has a therapeutic effect on various pathologies because it stimulates the endogenous synthesis of vitamin D by the human body.

This, in turn, increases calcium absorption and thus prevents osteoporosis and rickets, also has beneficial effects on arthritis, blood pressure regulation, diabetes and muscle endurance, and improves mood [2].

On the other hand, tanned skin has been associated with a standard of beauty by Caucasians. However, due to the degradation of the ozone layer, the intensity of UV solar radiation reaching the Earth has increased in recent years, which could explain the increased incidence of skin cancers.

In addition, it is scientifically proven that overexposure to sunlight can cause other harmful health effects, such as skin inflammation or sunburn, immunosuppression, hyperkeratosis or skin photoaging and photoallergic reactions [3] .

For this reason, the use of sunscreen products can prevent or minimize the adverse effects mentioned above. Sunscreen products contain different chemicals that have a high degree of UV absorption, called UV filters. These products are classified into different categories by different countries, which depend on the legislation in force in each country.

2. Types of sunscreen products

With consumer needs, new sunscreen products with different characteristics have appeared on the market, intended for use on the beach [4].

Abbreviation	Abbreviation INCI Name	EU	US	JP
3BC	3–Benzylidene camphor	2		
BCS	Benzylidene camphor sulfonic acid	6[a]		
BDM	Butyl methoxydibenzoylmethane	5	3	10
BZ1	Benzophenone–1			10

BZ2	Benzophenone–2			10
BZ3	Benzophenone–3	10	6	5
BZ4	Benzophenone–4b	5	10	10
BZ6	Benzophenone–6			10
BZ8	Benzophenone–8		3	
BZ9	Benzophenone–9			10
CBM	Camphor benzalkonium methosulfate	6		
CX	Cinoxate		3	5
DBT	Diethylhexyl butamido triazone	10		
DDP	1-(3,4–Dimethoxyphenyl)–4,4–dimethyl–1,3–pentanedione			7
DHH	Diethylamino hydroxybenzoyl hexyl benzoate	10		
DMC	Diisopropyl methyl cinnamate			10
DRT	Dromethizole trisiloxane	15		15
EDP	Ethylhexyl dimethyl PABA	8	8	10
EDDP	Ethylhexyl dimethoxybenzylidene dioxoimidazolidine propionate			3
EMC	Ethylhexyl methoxycinnamate	10	7.5	20
EMT	bis–Ethylhexyloxyphenol methoxyphenyl triazine	10		
ES	Ethylhexyl salicylate	5	5	10
ET	Ethylhexyl triazone	5		5
FA	Feluric acid			10
GED	Glyceryl ethylhexanoate dimethoxycinnamate			10
GPH	4-(2-beta-Glucopyranosyloxy) propoxy-2-hydroxybenzophenone			5
HS	Homosalate	10	15	10
IMC	Isoamyl p-methoxycinnamate	10		
IPM	Isopropyl methoxycinnamate			10
ITT	Isopentyl trimethoxycinnamate trisiloxane			7.5
MA	Menthyl anthranilate		5	
MBC	4-Methylbenzylidene camphor	4		
MBT	Methylene bis-benzotriazolyl tetramenthylbutylphenol	10		10
OCR	Octocrylene	10(ca acid)	10	10
P15	Polysilicone-15	10		
P25	PEG-25 PABA	10		
PAB	PABA	5	15	4[d]
PBC	Polyacrylamidomethyl benzylidene camphor	6		
PBS	Phenylbenzimidazole sulphonic acid	8	4	3
PDP	Pentyl dimethyl PABA (mixture of isomers)			10
PDT	Disodium phenyl dibenzimidazole tetrasulfonate	10(ca acid)		
TDS	Terephthalylidene dicamphor sulphonic acid	10[a]	10	
TiO2	Titanium dioxide	25	25	
TS	TEA-salicylate		12	
ZnO	Zinc oxide		25	

[a]Potassium, sodium and TEA (as acid) salts are also permitted.
[b]Benzophenone–5 (BZ5) is the sodium salt of the compound benzophenone–4 (BZ4).
[c]Contains 3–9% methyl diisopropyl cinnamate (MDC) and 15–21% ethyl diisopropyl cinnamate (EDC).
[d]Including all esters: ethyl PABA (EP), butyl PABA (BP) and glyceryl PABA (GP).
INCI, International Nomenclature for Cosmetics Ingredients.

Table 1: Presents organic UV filters that contain ionizable groups such as: sulfonic (SO2H) or carboxylic (COOH) groups, which give them solubility in water. In addition, UV filters can be classified into UVA filters and UVB filters depending on the type of radiation they absorb. Therefore, they can usually be added to all types of cosmetic products [5].

So, apart from traditional body creams and milks, which are water-in-oil (W/O) or oil-in-water (O/W) emulsions, with different degrees of viscosity, and oils, we can find a wide range of products, which include water-based products, hydroalcoholic lotions and microemulsions, which can be easily used as sunscreen products, since they can be sprayed [6].

In addition, UV filters can also be added to cosmetic products to protect them from sunlight.

All this has led to the design of a wide variety of UV filters, with different solubility properties, since products with different oil / water proportions are available on the market.

So, we can find fat-soluble and water-soluble UV filters.

Thus, lipsticks, oils, hydroalcoholic lotions and foundations (which have a high fat content) are usually formulated with fat-soluble UV filters [7].

Aqueous lotions and gels include water-soluble UV filters. Creams, cosmetic milks and microemulsions are formulated with both water-soluble and fat-soluble UV filters, where they remain in the aqueous or fatty phase of the emulsion [8].

3. Nature of UV filters

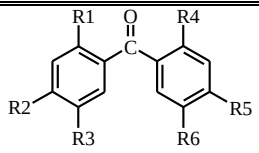
UV filters can be classified into two groups, depending on their nature. Inorganic UV filters, or so-called physical UV filters, which act mainly by reflecting and scattering UV radiation, while organic UV filters, called chemical UV filters, absorb light [9].

Physical UV filters are generally metal oxides, although silicates and talc have also been used. They offer greater protection than chemical ones and are not water-soluble. However, they are less commonly used by people because they generally form a screen on the skin, which is uncomfortable. Furthermore, cosmetic preparations based on physical UV filters are more difficult to formulate, as they can break the emulsion [10].

As can be seen in Table 1., currently, only titanium dioxide is approved as a physical UV filter by the European Union Cosmetics Directive, and zinc oxide is not considered to fall into this category.

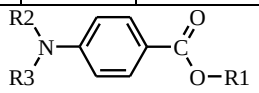
On the other hand, both titanium dioxide and zinc oxide are authorized by the FDA as UV filters. As for chemical UV filters, they are organic compounds that have a high molar absorption in the UV range [11].

Benzophenone derivatives



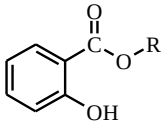
Code	R1	R2	R3	R4	R5	R6
BZ1	–OH	–OH	–H	–H	–H	–H
BZ2	–OH	–OH	–H	–OH	–OH	–H
BZ3	–OH	$–OCH_3$	–H	–H	–H	–H
BZ4	–OH	$–OCH_3$	$–SO_3H$	–H	–H	–H
BZ6	–OH	$–OCH_3$	–H	–OH	$–OCH_3$	–H
BZ8	–OH	$–OCH_3$	–H	–H	$–OCH_3$	–H
BZ9	–OH	$–OCH_3$	$–SO_3H$	–OH	$–OCH_3$	$–SO_3H$
GPH	–OH	$–O–(CH_2)_3OSi–$Glucoză	–H	–H	–H	–H

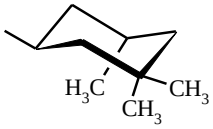
p-Aminobenzoic acid and derivatives



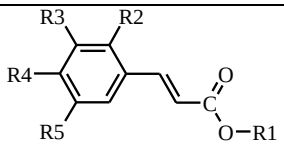
Code	R1	R2	R3
EDP	$–CH_2–CH(C_2H_5)–(CH_2)_3–CH_3$	$–CH_3$	$–CH_3$
EP	$–C_2H_5$	–H	–H
GP	$–CH_2–CH(OH)–CH_2OH$	–H	–H
PAB	–H	–H	–H
PDP	$–C_5H_{11}$	$–CH_3$	$–CH_3$
P25	$–(C_2H_4O)_x–C_2H_5$	$–(C_2H_4O)_i–C_2H_5$	$–(C_2H_4O)_z–C_2H_5$
	x + i + z = 25		

Salicylates

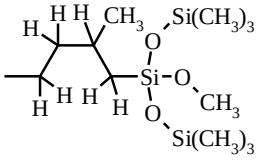
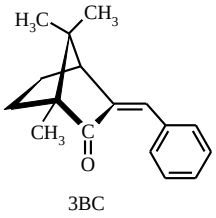
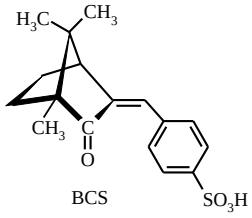
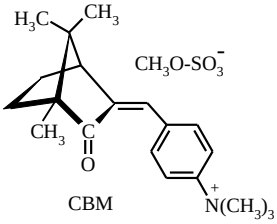
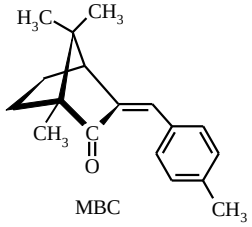
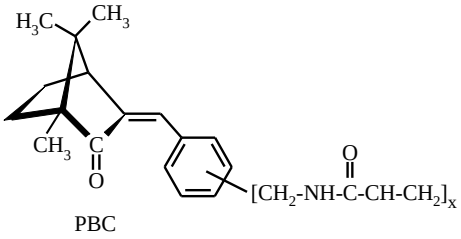
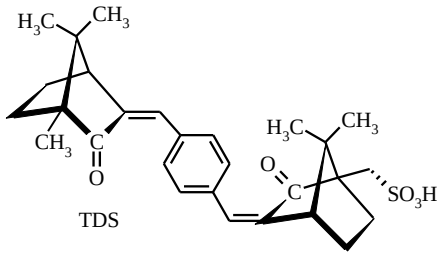
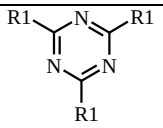
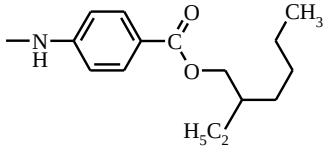
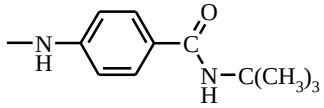
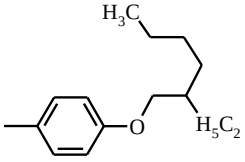
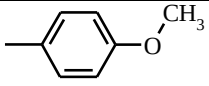
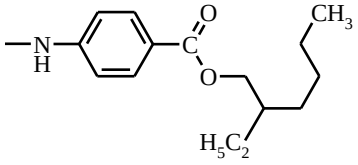


Code	R
ES	$–CH_2–CH(C_2H_5)–(CH_2)_3–CH_3$
HS	
TS	$[NH(CH_2–CH_2–OH)_3]^+$

Cinnamon sticks



Code	R1	R2	R3	R4	R5
CX	$–C_2H_4–OC_2H_4$	–H	–H	$–OCH_3$	–H
DMC	$–CH_3$	$–CH(CH_3)_2$	–H	$–CH(CH_3)_2$	–H
EDC	$–C_2H_5$	–H	$–CH(CH_3)_2$	–H	$–CH(CH_3)_2$
EMC	$–CH_2–CH(C_2H_5)–(CH_2)_3–CH_3$	–H	–H	$–OCH_3$	–H
FA	–H	–H	$–OCH_3$	–OH	–H
IMC	$–(CH_2)_2–CH(CH_3)_2$	–H	–H	$–OCH_3$	–H
IPM	$–CH(CH_3)_2$	–H	–H	$–OCH_3$	–H

ITT		–H	$–OCH_3$	$–OCH_3$	$–OCH_3$
MDC	$–CH_3$	–H	$–CH(CH_3)_2$	–H	$–CH(CH_3)_2$
Camphor derivatives					
 3BC				 BCS	
 CBM				 MBC	
 PBC				 TDS	
Triazine derivatives					
DBT	R1 = R2				
	R3				
EMT	R1 = R2				
	R3				
ET	R1 = R2 = R3				
Benzotriazoles					

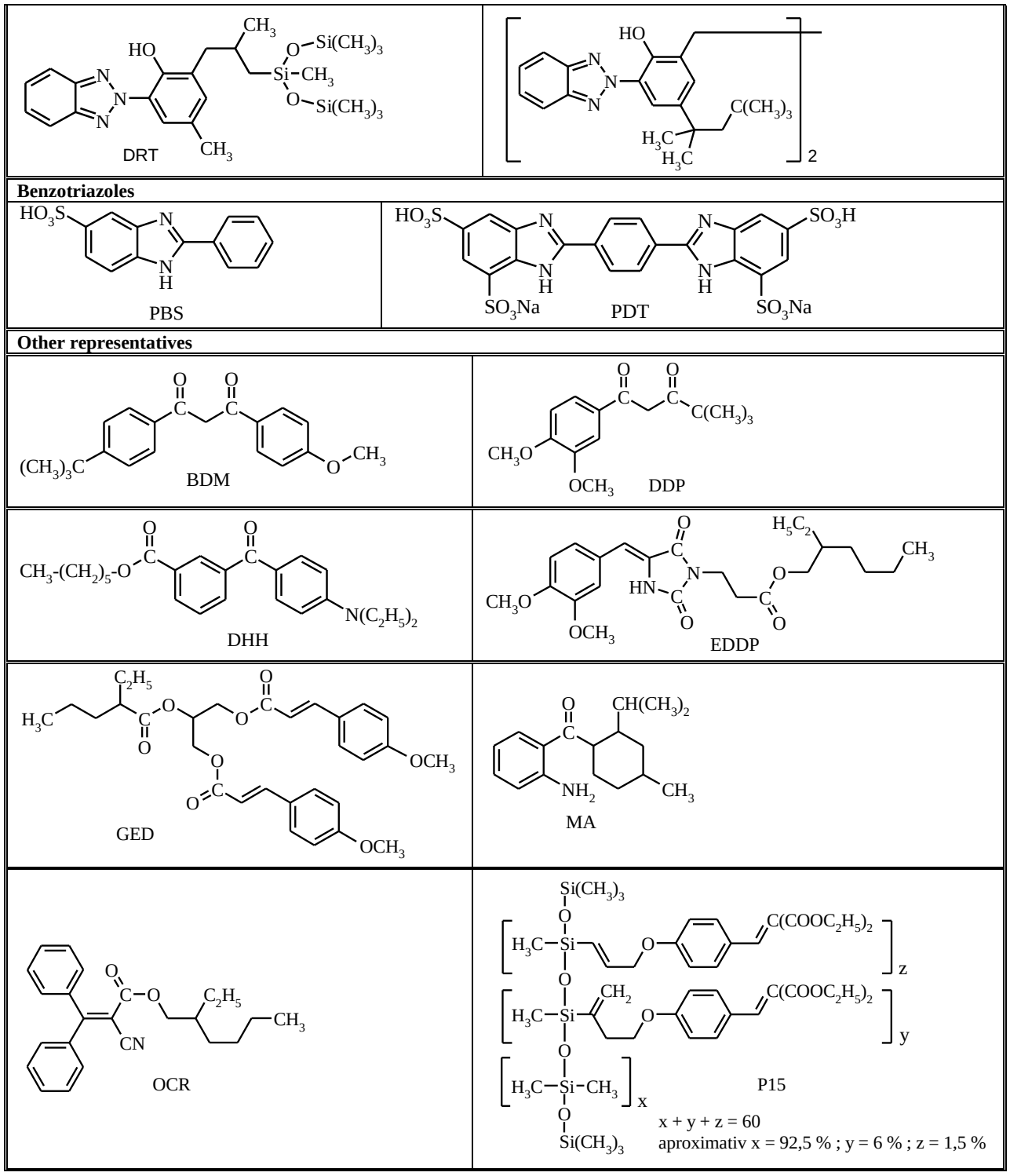


Figure 1: Classification of organic UV filters

These compounds usually contain single or multiple aromatic structures, sometimes conjugated with carbon-carbon double bonds and/or carbonyl groups [12].

Cosmetic products containing these compounds are, however, better accepted by people than physical filters, despite causing some dermatological side effects.

In addition, various toxicological studies performed on animals seem to indicate that some organic UV filters have significant estrogenic and antithyroid effects [13].

A study on hormonal changes performed on human volunteers after the application of sunscreen products indicated that these effects are not so great.

UV filters can be classified according to their chemical structure (Figure 1): benzophenone derivatives, p–aminobenzoic acid and its derivatives, salicylates, cinnamates, camphor derivatives, triazine derivatives, benzotriazole derivatives, benzimidazole derivatives and others [14].

Figure 2. illustrates the characteristic UVA, UVB and UVA+UVB spectra of BDM, EDP and BZ3.

5. Efficacy and safety of sunscreen products

The purpose of a sunscreen product is, of course, to protect the user from solar radiation. To achieve this purpose, users must be correctly informed about the protective capacity of the product used.

Various parameters have been used to evaluate the efficacy of sunscreen products and thus provide appropriate information through product labeling.

The most widely used parameter is the so–called sun protection factor (SPF) of a product, which corresponds to the increase in UV dose to which protected skin can be subjected without showing erythema, compared to unprotected skin. The Cosmetics Industry of Europe, Japan, the USA and South Africa, represented by their associations, the European Cosmetics, Cosmetics and Fragrance Association (COLIPA), the Japanese Cosmetics Industry Association (JCIA), the US Cosmetics, Cosmetics and Fragrance Association (CTFA) and the South African CTFA, signed the International SPF Test Method in June 2006.

This is an in vivo test based on the irradiation of UV rays on the skin of several volunteers, under specified conditions, and thus obtaining the time required for the formation of erythema.

The SPF value is presented by the values of this time obtained with and without the previous application of the sunscreen product to be analyzed. The method will initially be applied throughout the EU, Japan and South Africa.

In the United States, the FDA regulation provides for a slightly different method. The SPF of a product is related to the nature of the UV filters it contains and their concentration. Regarding safety, as previously mentioned, some secondary dermatological effects have been attributed to UV filters. The number, nature and maximum permitted concentrations are also restricted by various legislations.

Thus, it is clearly indicated that analytical control of UV filters is essential to ensure the efficacy and safety of sunscreen products.

On the other hand, UV filters, such as p-aminobenzoic acid (PABA) and its derivatives that potentiate the function of amines, could form nitrosamines, which are suspected of having carcinogenic properties. Therefore, a rigorous control of the finished product must be carried out. Some relevant aspects regarding the safety and efficacy of sunscreen products are dealt with in different articles.

Conflict of interest

The authors declare no conflicts of financial interest in any product or service mentioned in the manuscript, including grants, equipment, medications, employments, gifts, and honoraria. This article is a review and vegetal products have not been administered to men or animals.

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