Review on Benzophenone and its derivatives used as UV absorbers in textile

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Abstract
Since benzophenone and its derivatives containing dyes are a significant class of organic molecules with applications in a variety of textiles, such as cotton, nylon, polyester, silk, and wool fibers.This review article focuses on discussing various benzophenone and their derivatives containing dyes with UV absorbers. The dyes with UV absorber derivatives like "4-hydroxy benzophenone," "2-hydroxy-4-methoxy benzophenone," and "4-dihydroxy benzophenone" exhibit good UV protection and excellent fastness properties on textiles.

Key words:
benzophenones, lightfastness, UV absorber, UV protection

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1.0 Introduction:

Sunlight, which exposes the skin to UV radiation all the time, can lead to skin damage like sunburn and cancer. Given that Indonesia is a tropical country with year-round sunshine, it's critical to know the dangers of extended sun exposure. Still, a lot of individuals don't seem to care about the dangers of prolonged sun exposure. UV protection in fabrics has received a lot of attention recently. Although not all clothing is UVR-protective, it is commonly acknowledged as an essential source of sun protection[1]. To avoid UVR exposure, it is necessary to make UV-protective goods with a UPF more excellent than 40.By using these UV-protective fabrics, you can prevent yourself from skin infections including allergic conditions and offensive smells while wearing them. In high-altitude settings, textiles frequently serve as both active agents in the spread of microorganisms and media for microbial development[2,3].

Two primary categories of UV protection finishes are organic and inorganic compounds, which can be distinguished by their chemical composition. The primary function of UV protection is to capture damaging UV rays and transform their electron excitation energy into nontoxic thermal energy. Organic substances, which can promptly absorb UV radiation and convert it into kinetic and thermal energy without photodegradation, are covered by this UV protection mechanism [4].

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The UV Protection Factor (UPF) value on fabric represented the level of UV protection. UV absorbers are another way to improve UV fabric protection. A colorless organic substance with a substantial absorption at the UV wavelength range of 280–400 nm is known as a UV absorber. There are two different kinds of UV absorbers: inorganic UV absorbers like TiO2 and ZnO, and organic UV absorbers like benzophenone and benzotriozole[5–7].

Moderate sun exposure has beneficial health effects but serious harmful health effects since both UVA (320–400 nm) and UVB (280–320 nm) rays induce different cellular responses that manifest as pigmentation, sunburn, skin aging, skin cancer, and DNA damage[8–10].Figure 1 shows several UV absorbers used in the textile industry [11–22].Hindered amine, phenyl esters, and cinnamic acids are examples of UV absorbers. UV absorbers with absorption characteristics can protect colors on fabrics, but only four other classes have attained economic significance. "2-hydroxybenzophenone, phenyl ester, cinnamic acids, and 2-(2H-benzotriazole-2-yl)phenols" are examples[23].

1.2 List of UV absorbers with structure

UV absorbers serve as the conventional term for these substances. These chemicals are sometimes called photostablilizing additives because they are commonly employed to stop photo-oxidation and the photo-aging process in textile fibers [6].

UV absorbers exhibit distinctive intramolecular hydrogen bonding, such as 2,2,6,6-tetramethylpiperidin-4-one,

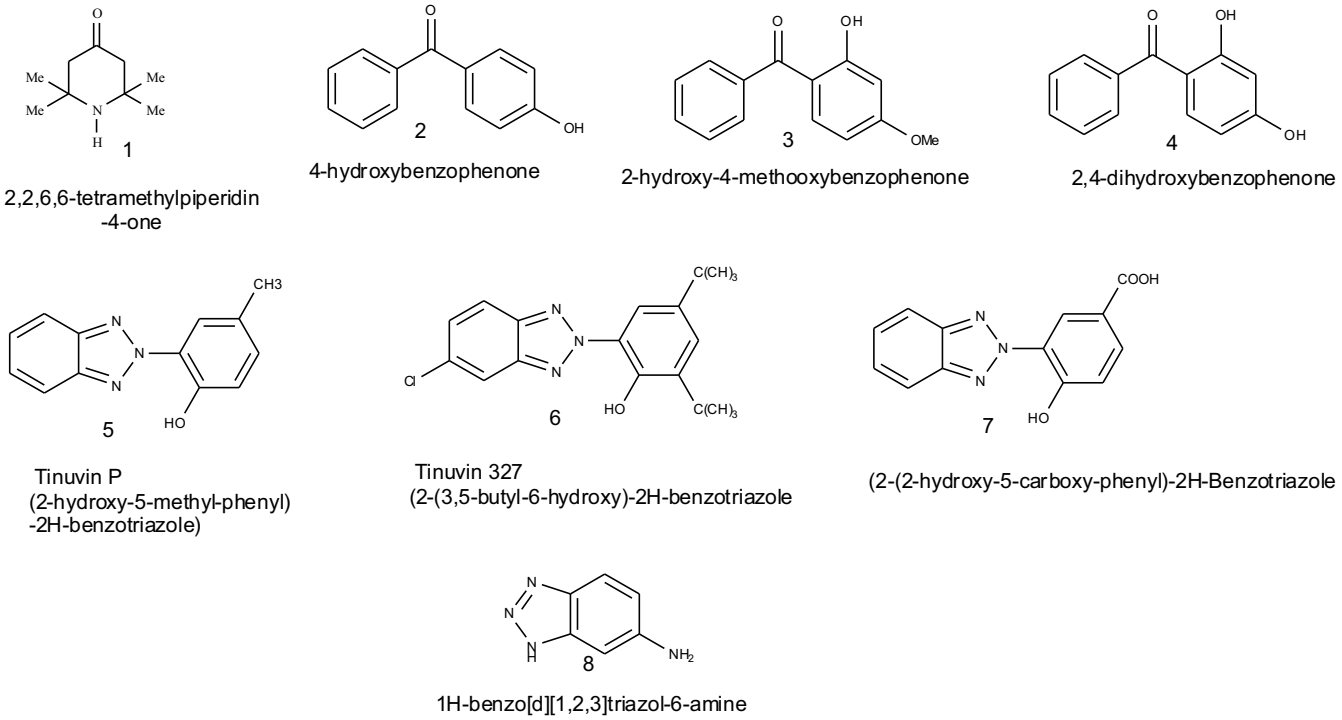


Figure 1. List of various UV absorbers

hydroxybenzophenone, and benzotriazole. UV absorbers of this type are utilized in azo dyes to retain intramolecular H-bonding (dipole-dipole interaction) between the carbonyl and hydroxyl groups positioned ortho to the azo linkage, resulting in increased lightfastness[24–26]. The presence of functional groups at ortho locations, such as "hydroxyl, sulphonic, acetamido, and amine," increases the lightfastness of azo dyes [27,28] as they attribute hydrogen bonding between the hydroxyl and the azo group [28–38].

1.3 Effects of benzophenone-based UV absorber on textiles

Benzotriazole-based UV absorbers were formed to increase the anionic dyes' photostability. A similar absorber was designed to improve the photostability of the anionic dyes applied while dyeing the wool. The sulphonic group in its molecule gives solubility in water and allows fixation of the absorber onto the fibre[17,39].

1.4 What is UV absorber

UV absorbers can be used in dyeing of fibers like cotton, polyester, nylon, and silk with different kinds of dyes to improve the light fastness properties of fabric.

An organic substance that is colorless and exhibits a substantial absorption in the UV spectrum between 280 and 400 nm is called a UV absorber. UV absorbers included into the fibers serve as singlet oxygen quenchers, radical scavengers, and transformers of electronic excitation energy into thermal energy. The UV absorber is excited to a higher energy state by the short-wavelength, high-energy UVR; After that, the absorbed energy might release longer-wave radiation [40].

1.5 UV blocking mechanism

Photochemistry is the mechanism via which the UV absorber protects the material. Generally speaking, a UV absorber works by blocking UV light before it reaches a dye pigment, where it is then transformed into vibrational energy within the UV absorber molecule. Thus, the fabric is protected from ultraviolet radiation by the conversion of this vibrational energy into heat energy surrounding it without causing the dye to deteriorate [41–43].

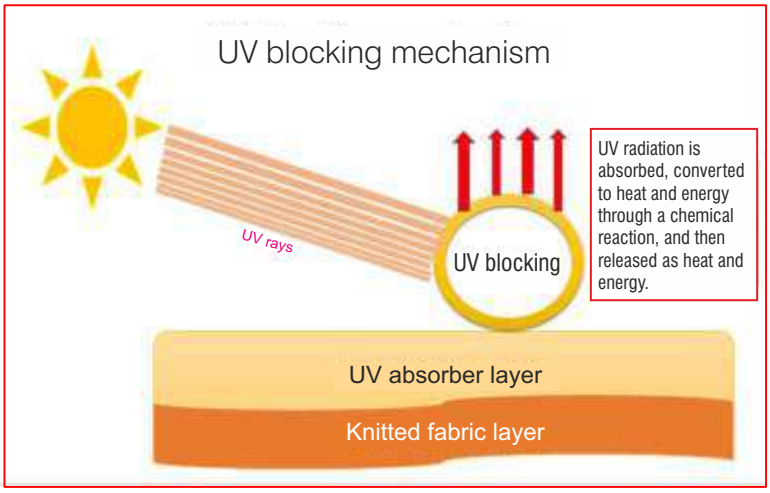


Figure 2. UV blocking mechanism

1.6 Lightfast dyes with UV absorber

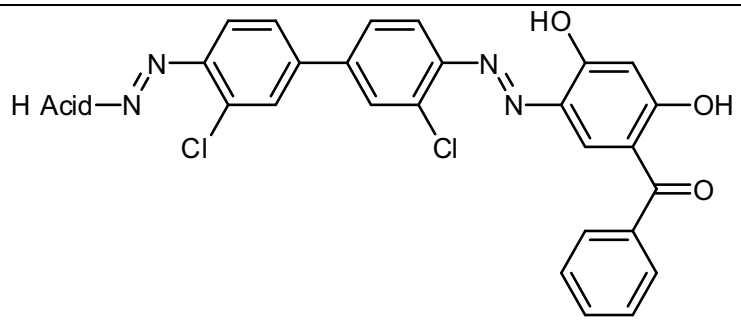
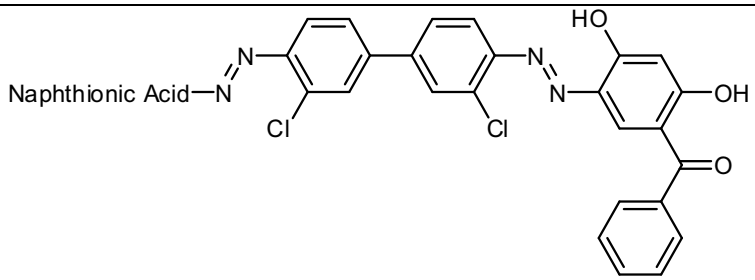
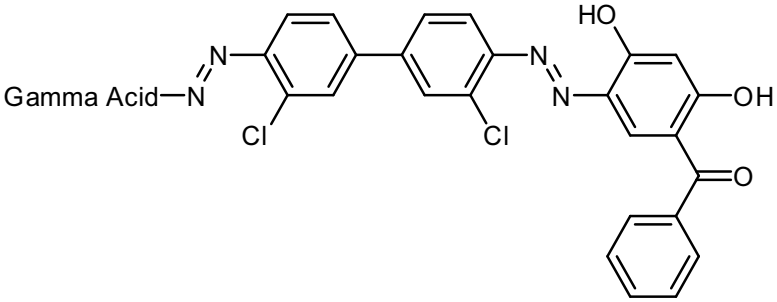
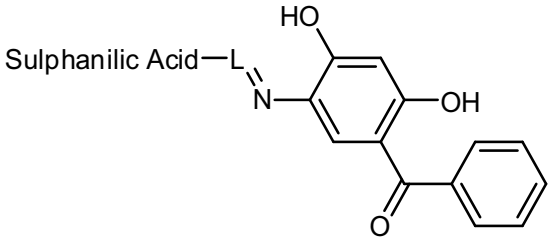
Since the longevity of both color and substrate, photodegradation of textile colorants and substrates has gained importance. The colorant may occasionally absorb

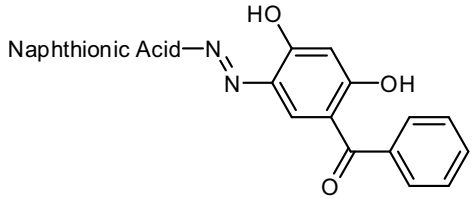
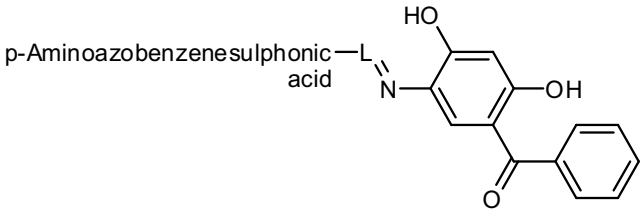
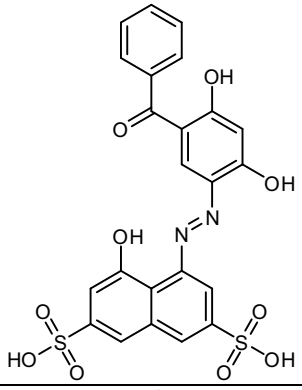
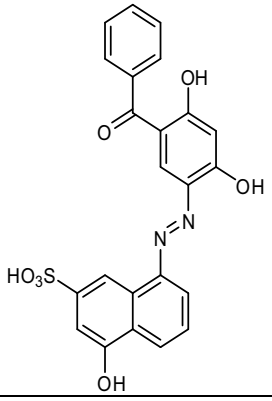
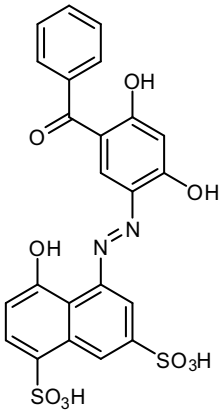
the energy from the high-energy radiation and transmit it to the textile substrate, weakening the polymeric substrate. UV absorbers are applied as additives during the fiber manufacturing or textile finishing process to get around these issues. Most of them are derivatives of benzotriazoles, hindered amines, or benzophenones[44–46].

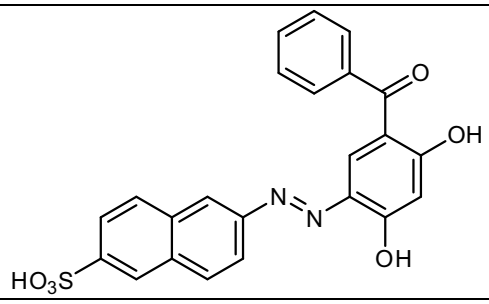
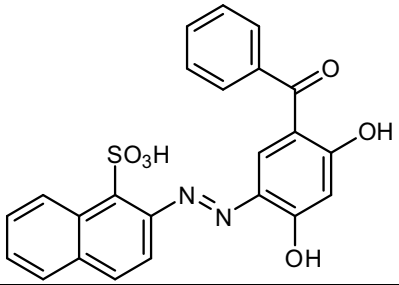
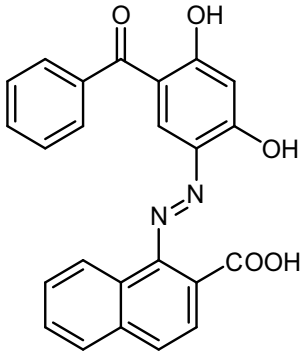
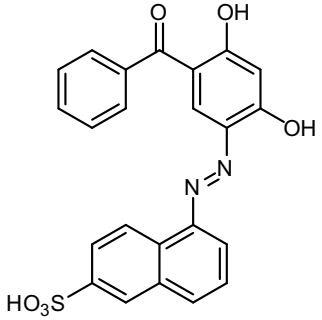
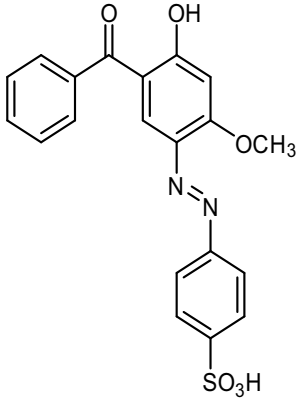
2. Applications of benzophenone-based dyes with UV absorber

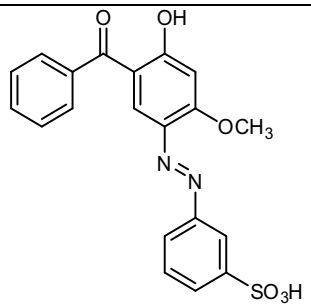
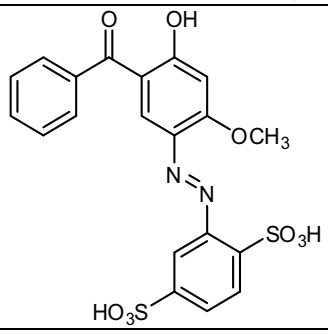
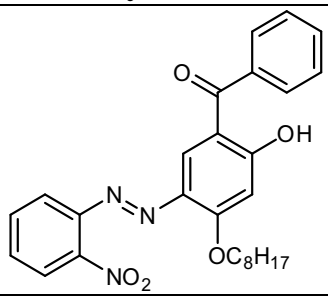
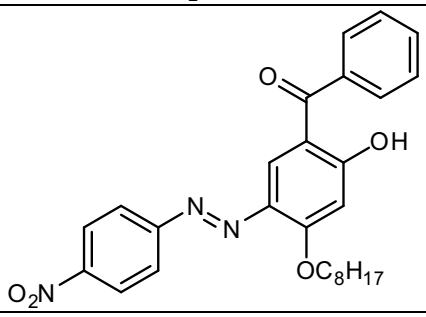
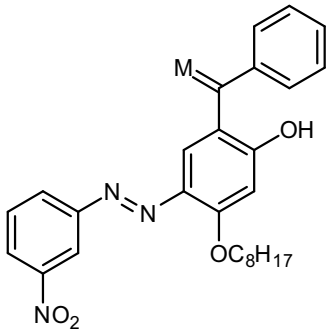
Azo dyes containing phenols as an intermediate are a class of commercial dyes along with sodium salts of a sulfonic acid group referred to as acid azo dye[47]. These dyes contain phenolic and sulfonic acid moieties which represent an auxochromic group, and are widely used as polymer additives [48]. The acid azo dyes have excellent UV absorbing properties which helps to avert the photodegradation of most vinyl polymers [49].

Table 1.Dyes with UV absorber

Dyes no.	UV absorber with dye	UPF	Light fastness	References
9			3-4 On cotton	[50]
10			4 On cotton	[50]
11			3-4 On cotton	[50]
12			5 On cotton	[50]

Dyes no.	UV absorber with dye	UPF	Light fastness	References
13			5 On cotton	[50]
14			5 On cotton	[50]
15			5 on wool 5 on silk	[51]
16			5 on wool 5 on silk	[51]
17			5 on wool 5 on silk	[51]

Dyes no.	UV absorber with dye	UPF	Light fastness	References
18			4 on wool 4 on silk	[51]
19			4 on wool 4 on silk	[51]
20			5 on wool 5 on silk	[51]
21			5 on wool 5 on silk	[51]
22		39.7		[52]

Dyes no.	UV absorber with dye	UPF	Light fastness	References
23		43.7		[52]
24		27.8		[52]
25				[53]
26				[53]
27				[53]

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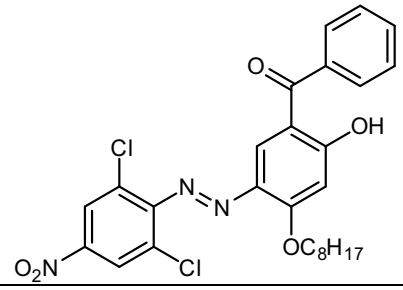
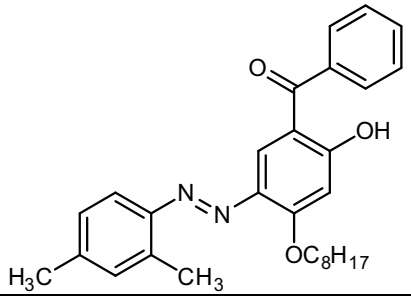
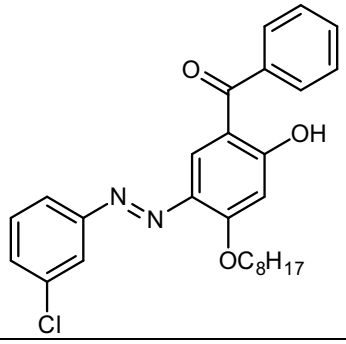
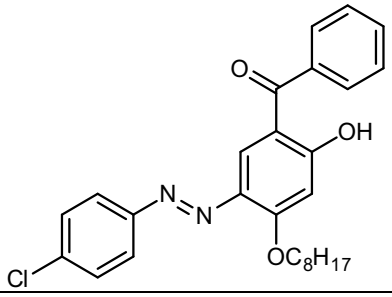
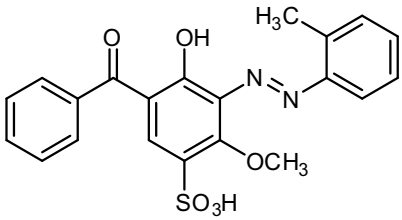
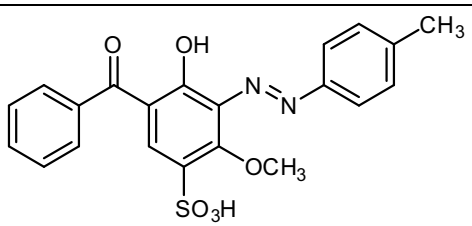
28				[53]
29				[53]
30				[53]
31				[53]
32			4	[54]
33			5	[54]

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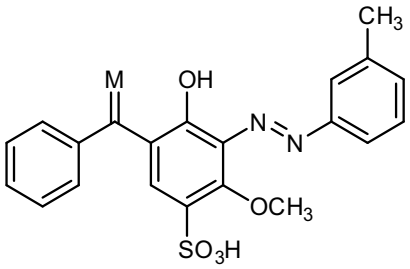
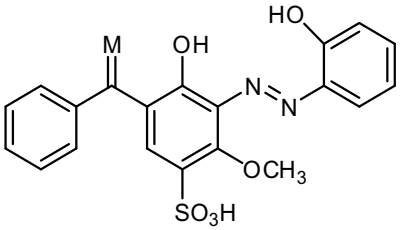
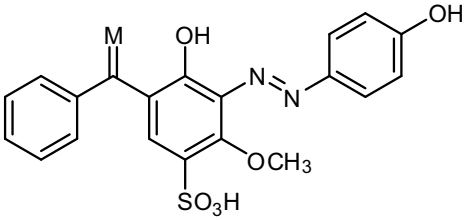
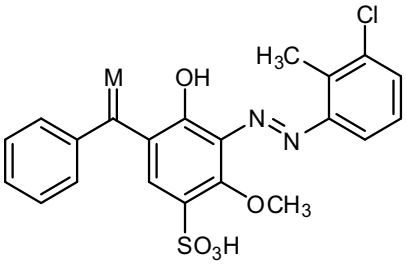
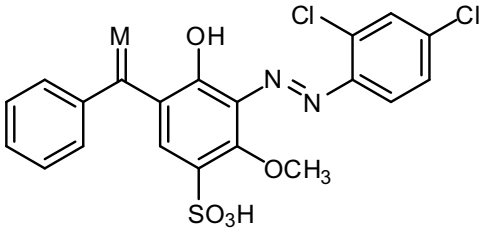
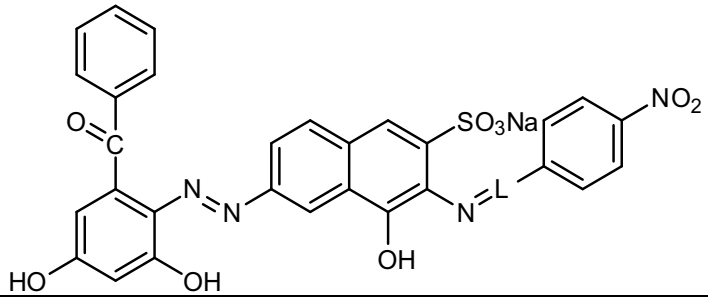
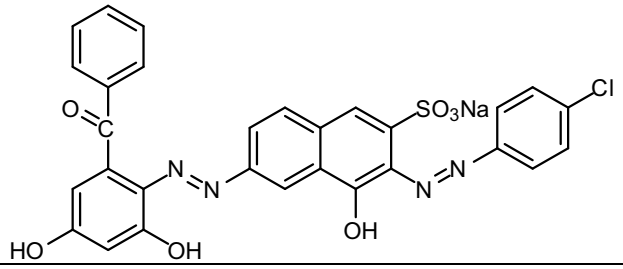
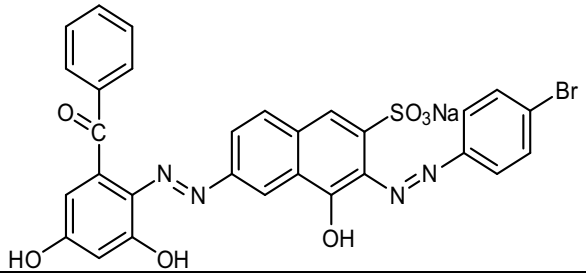
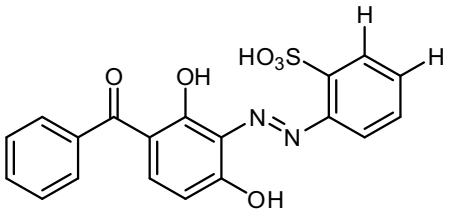
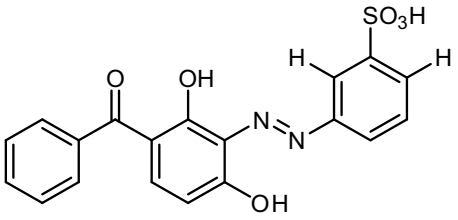
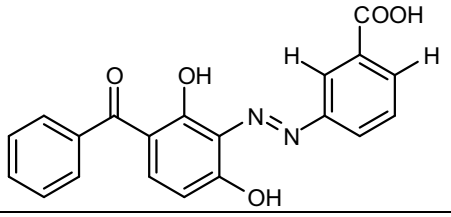
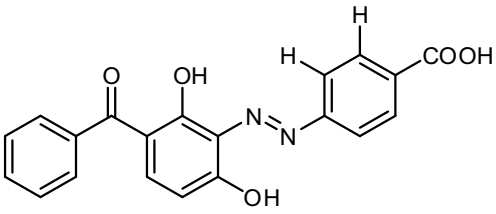
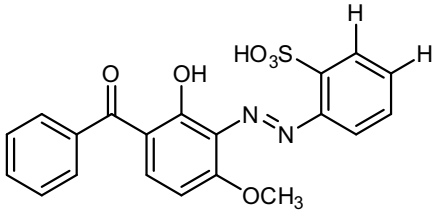
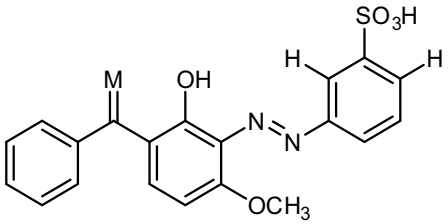
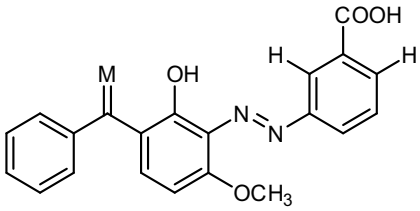
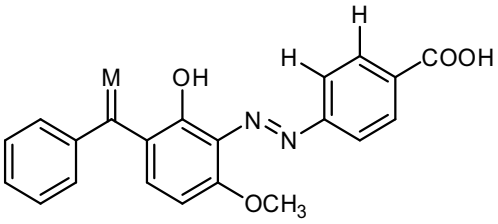
12			2	Y32[
13			3	Y32[
14			5	Y32[
15			3	Y32[
16			2	Y32[
17			4-7	Y[

Dyes no.	UV absorber with dye	UPF	Light fastness	References
40			6-7	[3]
41			6-7	[3]
42		18-22	6	[55]
43		18-22	6	[55]
44		18-22	6	[55]
45		18-22	6	[55]
46		18-22	6	[55]

Bwcq no.	S T _` qnp` cp u gf bwc	S ND	J gf r fastness	P eferences
25		/ 6-2	3-6	Y33[
26		18-22	6	Y33[
27		/ 6-22	5	Y33[

2.1 2,4- dihydroxybenzophenone based dyes

Rajgopal and Seshadri have reported that 2,4-dihydroxybenzophenone-based acid dyes 9-14 (shown in table 1.) shows deeper shades on wool with higher lightfastness because these dyes containing benzoyl group than the dyes derived from resorcinol [50].

Youssef et al have reported that dye 39-41(given in table1.) containing 2,4-dihydroxybenzophenone group, it shows excellent light fastness properties on wool fabric as compared to dyes containing intermediate dyes due to presence of carbonyl group in 2,4-dihydroxy benzophenone shows greater reactivity [3].

Dixit and Patel have reported that dyes16 to 21 (given in table -1) containing 2,4- dihydroxybenzophenone group with acid dyes show good fastness properties on wool and silk fabric. Dye 16 to 21 containing 2,4-dihydroxybenzophenone group with chrome on cotton mordantdyes shows excellent fastness properties on wool and silk fabric as compare to acid dyes because the formation of chrome complex on fibre matrix. The most prominent feature of these dyes is that, the dye patterns treated with Cr (III) salt solution afford excellent shining shade of dyes[51].

Bait et al reported the UPF of dyes 42-45 with 1% shade shows UPF between 42-75, indicating excellent UV rays protection on wool fabric, and on silk fabric UPF is in the range between 18-28, indicating very good ultraviolet protection. Silk fabric shows good UV-protective properties whereas wool shows excellent UV-protective properties. Synthesized dyes applied on wool and silk substrate shows excellent lightfastness properties as shown in table 1[55].

Bait et. al, reported that dyes 46-49 mentioned in table 2 applied on wool and silk fibre with 1% shade and 2% shade. Dyes synthesised with 1% shade shows UPF is 42-75, which indicates excellent UV rays protection. Silk fabric dyed with 1% shade shows UPF in the range of 18-28, indicating very good ultraviolet protection. Evidently, silk fabric shows good UV-protective properties whereas wool shows excellent UV-protective and lightfastness properties[55].

2.2 2-Hydroxy-4 methoxy benzophenone

Wang et al have reported that dye 22-24 (given in table 1.) containing 2-hydroxy-4-methoxy benzophenone group, it shows darker shades on silk. In the structures of the dyes, 2-hydroxy-4-methoxybenzophenone was used as coupling component, which directly formed conjugate system with diazo component. [56].The ultraviolet transmittance of the silk fabrics dyed with the dyes 1-3 appeared to be lower than 3.4% (including the UV-B band and UV-A band). Therefore, the dyes exhibited good dyeing performance for silk fabric, and the dyed silk showed good anti-UV radiation capability[56].

Bait et al reported the UPF of dyes 46-49 with 1% shade shows UPF between 42 to 75, it specifies UV rays protection on wool fabric, and on silk fabric UPF is in range between 18-

28, indicating very good ultraviolet protection. Evidently, silk fabric shows good UV-protective properties whereas wool shows excellent UV-protective properties. Synthesized dyes applied on wool and silk substrates show excellent lightfastness properties as shown in table 1[55].

2.3 2-hydroxy-4-n-octyloxybenzophenone

Dixit and Patel (2011) have reported that dye 25-31 (given in table 1.) containing 2-hydroxy-4-n-octyloxybenzophenone group, it shows good lightfastness properties due to the variation in the shades of the dye fabric results from both the nature and position of the substituent like -Cl and -NO2 present on the diazotized compound[57], which increases the polarizability.

2.4 2-hydroxy-4 methoxy benzophenone-5-sulphonic acid

Dixit and Patel (2014) have reported that dye 32-38 (given in table 1.) containing 2-hydroxy-4-methoxy benzophenone, it shows good to excellent lightfastness properties [54]. The most prominent feature of these dyes is that the dye treated with Cr(III) salt solution afforded an excellent shining shade of the dyes. This might be due to chrome complex formation on the fabric matrix [54].

3.0 Future scope

The dyed materials demonstrate the dyes' photostability on polyester and nylon. When creating new integrated UV absorber dyes, UV protection characteristics should be taken into account to improve the fastness properties. Nevertheless, adding UV-absorbing residues to dyes with a structure would require further work. In the future, UV absorber dyes with built-in UV absorbers might be used to dye textile items in bright colors.

4.0 Conclusion

This review article summarizes various benzophenone and their derivatives containing dyes with UV absorbers. The dyes with UV absorber derivatives like "4-hydroxy benzophenone," "2-hydroxy-4-methoxy benzophenone," and "4-dihydroxy benzophenone" are presented and discussed with application on textiles.

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