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Agents Used in UV Protective Finish on Textile

PINKI SINGH[1], PRIYANKA KESARWANI*[2] AND SHREYA MISHRA[3]
[1&3]Research Scholar and [2]Assistance Professor
Department of Family and Community Sciences, Faculty of Science,
University of Allahabad, Prayagraj (U.P.) India

ABSTRACT

A human skin is the largest organ comprises 16% of body mass. It is a boundary between internal organ and environment. UV rays penetrate deeply into the skin and results in harmful health effects like pigmentation, sun-burn, skin ageing, skin cancer and DNA damage. The long-term UV exposure of textile directly associates with chemical changes of fabric. These changes are photochemical degradation of textiles fibres, color fading, increased crystallinity and other physical as well as chemical changes. UV protective finishes represents one of the most important group of chemical finishing agents which protects the textiles from harmful effect of UV radiation. UV protective finish can be done with the help of organic UV absorber, bioactive substances, natural dyes and inorganic UV absorber. These finishes are widely used in production of functional textiles like high-altitude clothing, sportswear and now-a-days it is becoming the need of the people working in outdoor in hot climate.

Keywords : UVR, UV protective finish, UV absorber, UV shielding agents

INTRODUCTION

In the ancient era animal skin and vegetation were used to protect the humans from cold, heat and rain. The skin is largest human organ, which comprises of 16% of body mass. It serves as a boundary between an internal organ and the environment. When the sun light falls on the skin the basic phenomenon take place either transmission or diffusion or reflection. The life-saving function of ozone, water vapour, CO_2 in the stratosphere is to absorb the majority of high-energy UV-C and approximately 90% of UV-B radiation. Therefore, 94% of radiation reaching the earth is UV-A, which penetrates deeply into the skin and about 1 to 10% of UV-B, reaches to the earth (Tran *et al.,* 2008**)**. The energy of UV radiation which is significantly higher than visible light has the potential to initiate different chemical reaction. Although moderate sun exposure has beneficial health effects but overexposure to UV radiation results in serious harmful health effects. Since UV rays induce different cellular responses that manifest as pigmentation, sunburn, skin ageing, skin cancer and DNA damage. The long-term exposure of textiles to UV weathering are associated with the cleavage of different chemical bonds by the UV radiation, which leads to photochemical degradation of textile fibres, color fading, increased crystallinity and other chemical and physical changes. Ultraviolet protection finishes, which are sometimes referred to as UV shielding agents, represent one of the most important group of chemical finishing agents applied to textile material that protects from the harmful effects of UV radiation. Therefore, UV protective finishes are widely used in production of functional textile for sportswear, high-altitude clothing, covering materials, wearable sensors and other technical textiles with high added value.

UV protective finishes can be done with the help of organic UV absorber, bioactive substances, natural dyes and inorganic UV absorbers (Fig. 1).

Organic UV absorber:

Organic UV absorber are uncoloured organic aromatic molecules with conjugated double bond that

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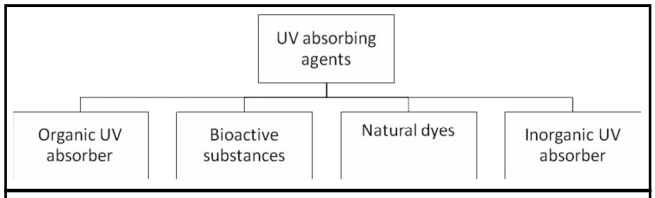

Fig. 1 : types of anti UV agents

absorb UV energy with wavelengths of 290–360 nm, which causes the molecules to reach an excited state; UV energy is then transformed to vibration energy in the UV absorber molecule and heat energy is released to the surrounding environment when the molecules return to the ground state (Das, 2010, Schindler and Hauser, 2004, Alebeid *et al.,* 2017).

UV absorber protects the textile fibres from chain fission and cross-linking reaction caused by the photo oxidation of polymers. It helps in reducing the damage caused to the textile fibres. A UV absorber should be stable enough on exposure to UV radiation and they should return to their original state after the reaction (Bodur *et al.,* 2017). If UV absorber's molecules get permanently transformed into their non-absorbing isomers then their UV absorbing properties will be destroyed.

Organic UV absorber includes derivatives of hydroxyphenylbenzotriazoles, hydroxyphenyl-benzophesssnones and hydroxyphenyltriazines (Fig. 2) (Das, 2010, Schindler and Hauser, 2004, Bodur *et al.,* 2017, Akrman and Prikryl, 2008, Chakraborty *et al.,* 2014, Staffa *et al.,* 2017). They can be use on natural as well as synthetic fibres. These UV absorbers can be applied alone or with combination of compatible active antioxidants (Bodur *et al.,* 2017). Organic UV absorber can also be incorporate as fillers in spinning process. One of the

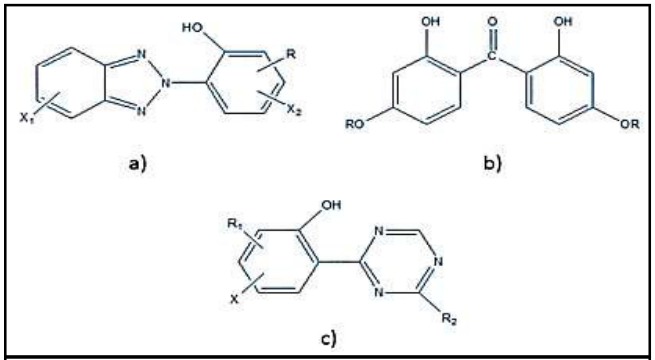

Fig. 2 : Chemical structures of derivatives of hydroxyphenylbenzotriazoles (a), hydroxyphenylbenzophenones (b), and hydroxyphenyltriazines (c)

disadvantages of this absorber is poor washing durability.

To provide high fixation efficiency reactive group such as chlorotriazine, vinyl sulfone and N-dihydroxy ethylene have been introduced to UV absorber molecule (Akrman and Prikryl, 2008, Czajkowski *et al.,* 2010, Feng *et al.,* 2017, Shen *et al.,* 2014). Among reactive UV absorber, condensation products of on benzotriazole derivative, symmetrical triazine derivative, benzophenone derivative and N-dihydroxy ethylene cyanoguanidine (Fig. 3) were incorporated. These compounds were able to covalently bond to hydroxyl group of cellulose fibres, which helps in increasing their durability. This kind of modified UV absorber may also call as synthetic UV absorbers.

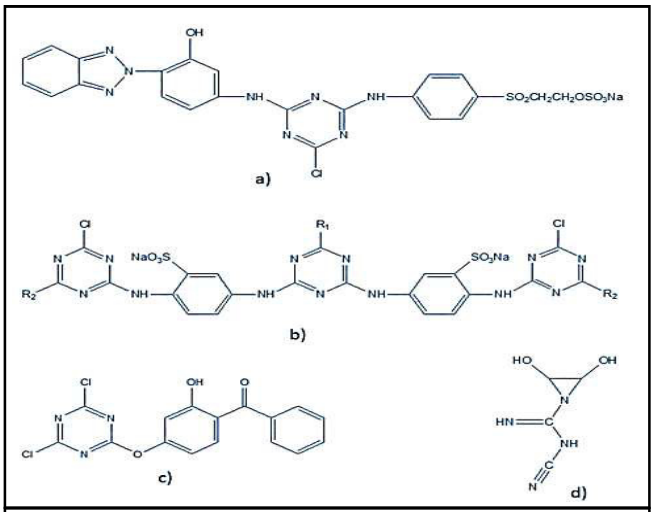

Fig. 3 : Chemical structures of fibre-reactive UV absorbers based on benzotriazole derivative (a), symmetricaltriazine derivative (b), benzophenone derivative (c) and N-dihydroxy ethylene cyanoguanidine (d)

UV absorbing bioactive substances:

Bioactive substances represent biodegradable and never-ending resources of natural finishes. Extracts of various plants are usedas an UV-absorbing bioactive substance. These include flavonoids, such as flavone, flavonol, luteolin and baicalin, mycrosphorine-like amino acids, tannin, lutein and aloin (Fig. 4) (Janarthan *et al.,* 2018, Shabbiret *et al.,* 2018, Subramani *et al.,* 2017, Zhou *et al.,* 2016, Koh *et al.,* 2017, Saewan *et al.,* 2013, Adeel *et al.*, 2017, Ghayenpour *et al.,* 2016).

Aloa-vera has several positive characteristics, such as non-cytotoxicity, antimicrobial, UV absorbing, wound healing and other therapeutic properties. *Aloe-vera*

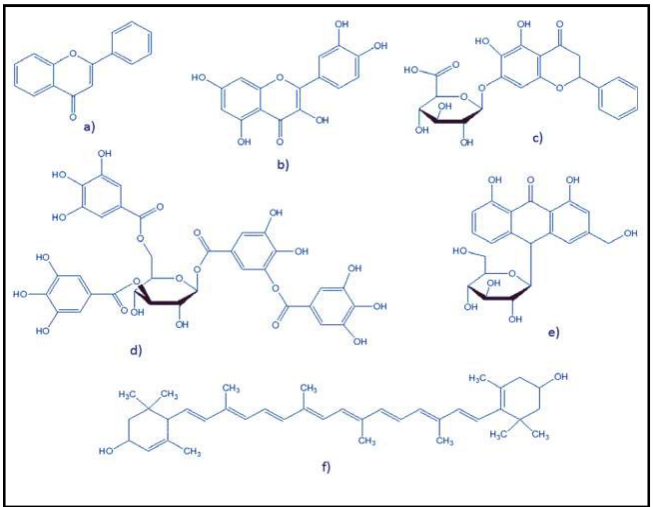

Fig. 4 : Chemical structures of natural organic UV absorbers: flavone (a), luteolin (b) baicalin (c), tannin (d), aloin (e) and lutein (f)

bioactive substances include flavonoids, aloins, tannins, terpenoids, saponins, anthraquinone derivatives, aloe-emodin-9-anthrone and anthrone-C-glycosidesin. (Janarthanan and Senthil Kumar, 2018).

Carotenoid compounds lutein and lutein esters which represent the main chemical components of marigold (*Tageteserecta*) flowers extract have been established in textile dyeing and UV protective finishing (Zhou *et al.,* 2016, Koh *et al.*, 2017) .

Baicalin which is a plant extract from *Scutellaria baicalensis* and belongs to the family of flavonoids was applied to silk fabric by exhaustion procedure (Saewan *et al.,* 2017). It was found that the presence of baicalin provided very good UV protection ability for silk fabric.

As a source of natural UV protection finishes with the antioxidant property, flavonoids, tannins and mycrosphorine-like amino acids are found in seaweed. Marine macro-algae (seaweeds) have various functionalities, such as antioxidant, antimicrobial, UV protective, anti-inflammatory, anticoagulant, anti-tumour and biodegradable properties. These are highly promising plant-like organisms of brown, red and green colours, already have a widespread use in the production of medical, healthcare, hygiene and anti UV textiles (Ghayempour *et al.,* 2016).

Natural dyes:

Government has made strict policies on the quality control of textile wet processing industries. Many age-old chemicals are banded for their harmful effects on environment (Ammayappan *et al.,* 2016). Researchers have now been shifted towards greener and sustainable technologies for dyeing and finishing. The phytochemical constituents of the plants, which safeguard them from ill effects of the environment, are now being utilized by human beings to impart the functional properties of the fabrics. In this way, apart from the aesthetic natural color, the functionalities such as deodorant, cool finishes, anti-bacterial and anti-UV properties are highlighted as the value addition. There are many studies on the beneficial use of natural dyes for treating fabrics with UV protection.

Sarkar reported in their study that cotton fabric which has been dyed with vegetable and animal dyes from madder, indigo and cochineal had improved UV protectiveness (Sarkar, 2004). Dark shades and high concentration of the dye enhanced the UPF which point out that the direct dependence of UV absorption on the dye concentration. The same further evidenced from a report by (Feng *et al.,* 2016) stated that 80% of UVR is being absorbed by cotton and silk fabric dyed with *Rheum* and *Lithospermum erythrorhizon*.

Mongkholrattanasit *et al.* (2014) extracted dye in their study from *Lacciferlacca Kerr* to dye silk fabric by post mordanting process. The light pink color extract of *L. lacca* gave different shades with different metallic mordants. It has been observed that very good to excellent UV protection is offered by metal mordant with *lac* powder but without mordant good UV protect property was observed.

Pargai *et al.* (2016) stated that, *Acacia catechu* and *Rubiacordifolia* also hold UV protective property by applying them on nettle fabric. Phytochemical constituents such as tannins content in *A. catechu* and anthraquinon in *R. cordifolia* are responsible for high UPF (Samant *et al.,* 2020). Some attempts have made to study the dyeing ability and UPF of natural dyes extracted from agro residues (Jose *et al.,* 2020). This dye was extracted from peanut skin and chickpea husk which was found to have high UPF (Pandey *et al.,* 2018, Jose *et al.,* 2019, Pandit *et al.,* 2020). It is also found that addition of 5-20% lemongrass oil resulted in substantial enhancement of UPF of wool fabric (Gogoi *et al.,* 2020).

Inorganic UV absorber:

TiO_2 (Titanium dioxide) and ZnO (Zinc oxide) are most widely used as inorganic UV absorber. They are used separately or in the combination with each other

(Hossain *et al.,* 2015, Reinosa *et al.,* 2017).

Various semiconducting materials exhibit UV blocking properties, including Titanium dioxide (TiO_2), Zinc oxide (ZnO), cerium dioxide (CeO_2), zirconium dioxide (ZrO_2), magnesium oxide (MgO), aluminium trioxide (Al_2O_3), silicon dioxide (SiO_2), copper and copper sulphide (CuS), silver (Ag) as well as graphene based materials (Yang *et al.,* 2004, Moafi *et al.,* 2010, Dadvar *et al.,* 2011, Lu *et al.,* 2014, Ibrahim *et al.,*2017, Ke *et al.,* 2017, Tian *et al.,* 2016, XU *et al.,* 2018, Hasani *et al.,* 2017, Ouadil *et al.,* 2017, Jiang *et al.,* 2017, Wiener *et al.,* 2017).

Inorganic UV absorbers are more biocompatible and much cheaper. They possess high thermal and chemical stability. Inorganic UV absorbers have high durability and excellent UV blocking properties over a broad range of ultraviolet wavelength.

Conclusion:

People nowadays getting aware about harmful effect of UV exposure therefore UV protective finishes are widely used in functional textiles production. A group of certain chemical agents possess the anti-UV properties which protects textile from degradation. There are basically four types of UV absorber *viz.,* organic UV absorber, bioactive components, natural dyes and inorganic UV absorber. One of disadvantage of organic UV absorber is that it have a poor washing durability. UV absorbing bioactive substances is biodegradable and never ending resource. Extract of aloe-vera, marigold, scutellariabaicalensis and sea weed possess highly promising anti UV property with them. Some of dyes obtained from the natural resources also have UV absorbing property. Inorganic UV absorbers are semiconducting material which exhibit UV blocking property.

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