Review Article

Blue Light Protective Cosmetics: Demand of the Digital Era

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ABSTRACT

Blue lights are practically a high energy visible light (HEV) emitted from screens of digital devices and having the wavelength about 390 to 500 nm. These lights have higher penetration potential in to the skin layers as compare to ultraviolet lights and causes damage to the topical surfaces inducing oxidative stress via reactive oxygen species (ROS) and reactive nitrogen species (RNS) which are responsible to protein and lipid damage. The exposure and harmful effect of blue lights can be avoided or reduced by using various cosmetics and ingredients like antioxidants, blue light absorbers which assist in combating the free radical production in skin. Some of the cosmetic products like skin creams, gels, mists, sprays, lotions, and ointments can be found efficient in preventing or reducing the production of free reactive oxygen species in skin. Inorganic materials like titanium dioxide, zinc, cerium oxide are used but due to their certain drawbacks associated with refractive index, photolytic activity the need for newer type of excipient is generated. Cerium oxide, organic absorbent acts as shield against blue radiations, when dispersed in water it becomes transparent to skin as an aqueous material. Zinc Oxide (ZnO) and Titanium Dioxide (TiO2) which are approved to be used by US FDA. Chemically they are metal oxide particles which have proven efficiency in absorbing, reflecting and refracting UV as

well as blue light.With the introduction of an anti-blue light mist by Garancia in 2016, the production of this new wave of cosmetic products was initiated. UV Transparent Broad-Spectrum SPF 46 by EltaMD, Super serum tint SPF 40 was developed by ILIA, Murad PomphenolSunguard Dietary Supplement, Blue light protection hyaluronic serum was developed by Olivia are some of the marketed products to protect the blue light and its harmful effect.There is still ample opportunity in the field of blue light protection approaches in cosmetic filed with novel approaches.

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INTRODUCTION:

Today everyone is most familiar with the word "Digital Aging", which denotes premature ageing of skin upon exposure to harmful, blue rays emitted from either sun or most prominently from our digital gadgets like cell phones, laptop screens, and desktops. These devices are swiftly labelled as slow agers for new "techies" who spends hours facing towards screens [1]. When surveyed it was found that tons of people spend on an average of four to five hours on their smart phones for various reasons. So, practically we are exposing to these blue light more from devices than from sun itself [1,2]. This is referred the reversible damage of skin caused by a deep penetrating visible lights i.e. blue light coming straight from device screens, making skin age faster.

Blue lights are practically a high energy visible light (HEV) emitted from screens of digital devices and having the wavelength about 390 to 500 nm **(See Fig. 1.)**. These lights/ rays have demonstrated the ability to penetrate deeper into the skin layers when compared to UV-A and UV-B rays emitted from sunlight [3]. These Blue lights have observed for energy level more than infra-red lights. So, eventually these can damage the skin and can't be even noticed (slow agers).

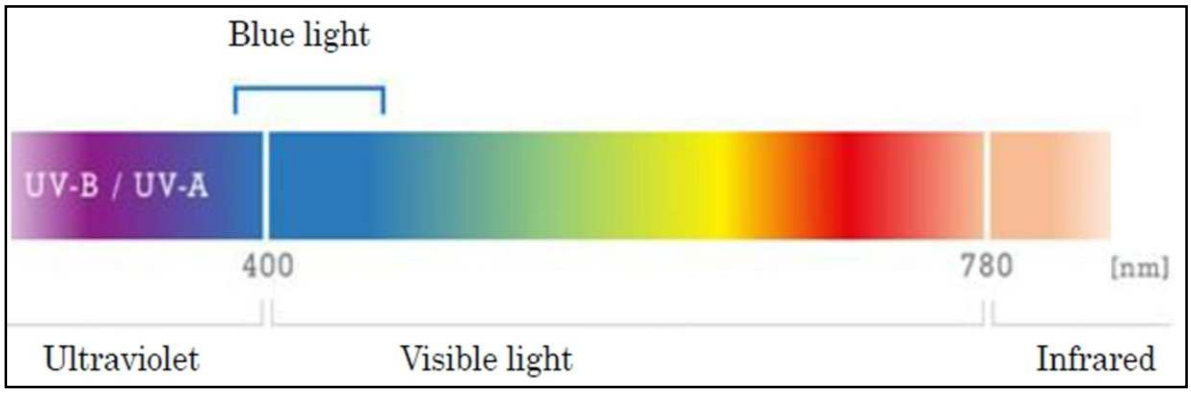

Figure 1: Blue light band with wavelength of 390 to 500 nm[3]

There are several ways by which blue light contribute to skin ageing. This light is found to induce oxidative stress via reactive oxygen species (ROS) and reactive nitrogen species (RNS) which are responsible to protein and lipid damage. These ROS (Fig: 3) are responsible for change in cellular structure such as DNA, proteins, lipids which directly results into skin damage which is quite difficult to manage by skins own defence or anti oxidant system [4]. The photo aging and skin glycation was observed due to weaken epidermal barrier with considerably

delayed recovery. Pigmentation is also considered as a major problem associated with Blue light due to disruption of melanocyte activity which caused uneven pigmentation of skin. The research has been going on effect of blue light on sleep cycle [5]. When tested at different wavelengths the blue light has been found to induce oxidative stress which fastens the ageing process of skin while on other hand the antiproliferative property of blue light has been utilized in treating and preventing of fibrotic skin disease [6]. The effects exerted by blue light on humans are paramount to those shown by UV-A radiations due to close resemblance of blue light and UV-A spectrum.

Advantages of blue Light:

Although it has shown most of the skin damaging effects still some of the properties of blue light can be considered as beneficial for treatment purposes. The devices emitting blue light can be commonly observed in medical outlets, dermatological centres to treat certain conditions like Jaundice in by eradication the organism responsible for it. The blue light has also proved its usefulness in some of the dental and tooth gum related diseases. It has also shown nullifying effect in bacterial responsible for gastritis. The effect of blue light on circadian rhythm has been under investigation but still it is believed to use in some sleep disorder. It is also found to be used in certain disease conditions like fatigue, drowsiness, dementia, depression. Apart from medical use the blue light was famously used in some of the beauty devices used to fight skin imperfections due to acne [7,8]. The blue light has also been seen to help memory, boost alertness.

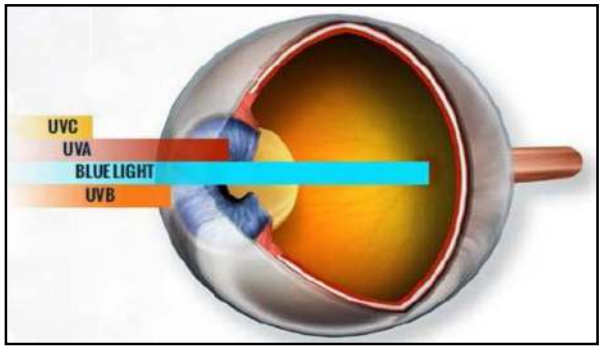

Figure 2: Penetration potential of blue light [9,11]

Disadvantages of Blue Light:

The blue light waves emitted from digital devices are proven to cause retinal photo toxicity. Some research studies carried out by Gattesfosse and Cytoo [9] have successfully proved the direct effect of blue light on mitochondrial network of cutaneous fibroblast. Both the fragmentation and mitochondrial production of ATP (powerhouse for conduction of activities) are hampered due to excessive exposure of blue light. It have also been proved that blue light are responsible for generating oxidative stress and therefore generating pigment spots and accelerate the ageing process as a result of

molecular level damage [10]. When it comes to the clinical and histological effects of blue light on human skin it is well established that the biological effects produce by blue lights are equal to that of UV-A radiation [11]. In one study conducted to assess the effect of blue radiation on healthy skin to assess melanogenesis, skin ageing, and photo damage few findings have been confirmed. Previously it was clear that oxidative DNA damage is result of higher penetration of UV-A radiations through skin layers [11,12] but now this is also confirmed that hyper-pigmentation of the skin exposed to blue light along with increase in level of Melan-A. These values were found to decrease when the exposure is stopped. Apart from these, the blue light is expected to produce transient melanogenesis and vacuolization but not apoptosis [13]. How blue light and skin interact is quite a complicated phenomenon. Although it has been used in treating some of disease condition especially dermatological, the long-term exposure is hazardous and all this damage is associated with generation of free oxidative reactive species. The effect of blue light is also prominent in case of sleep cycle. The regulation of circadian rhythm and sleeping behaviour is closely associated with retinol hypothalamic tract. Blue light leads to activation of these ganglionic cells. But when these blue rays are hindered due to aging process, the impairment in sleep cycle has been observed [14,15]. While on other hand few have commented that this blocking of blue light by intra ocular lenses exhibit no significant impact on sleep cycle [16]. When the effect of blue light artificially emitted from diode is evaluated on B 16 melanoma (timorous tissue) it has found that the cell growth was inhibited in time dependent manner of exposure plus it has shown no remarkable effect on dead cells. So it has been postulated that blue light emitted from any source (natural / artificial) is not contributing towards development of cancer but in fact it is inhibiting the growth of cancerous cells [17]. When the effect of blue light on cornea is observed it has been found that corneal epithelial cells on exposure showed marked reduction in survival rate due to increase production of ROS. The oxidative damage caused by this ROS and apoptosis has shown xerophthalmia formation along with visible ocular inflammation. This ROS induced oxidative stress can be on the top list for pathogenesis of age induced Cataract. [18,19]. The irradiation with blue light is indirectly responsible for inflammatory as well as photoreceptor cell damage when blood retinal barrier is absent or disrupt [20]. The trials conducted on animals have proved the inhibition of

growth of eye axis have been inhibited by short wave blue light. It is also observed that reversion of myopia to hyperopia is possible after exposure to blue light. The phenomenon is thought be well sufficient to explain refractive development and reverse [21].

After observing all above effects of blue light, researchers, cosmetologist and even cosmetic industries have felt the need for stronger protection against blue light and also easy and suitable testing methods to conduct assessment of so. Therefore, the cosmetic industries are tremendously launching skin care range to prevent loss. Few companies are being the pioneers in launching specifically "anti-blue light" cosmetics. The anti blue light mist was launched company Garancia and it all it was only called as a boom. Then Uriage launched "Age Protect" followed by Patyka and Anne Marie Borlinds facial oil.

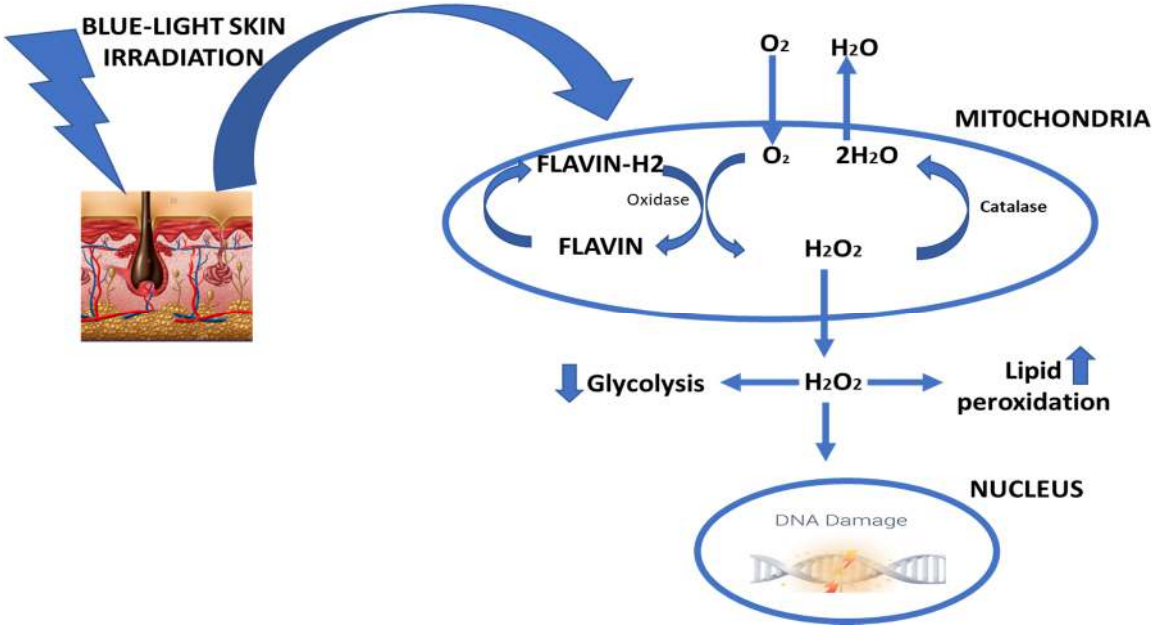

Figure 3: Oxidative damage potential of blue light [26]

Different approaches to protect against Blue Light:

There can be two ways by which protection from blue light can be obtained. The one is to reduce or minimise the free radical by either absorbing, scattering or reflecting and is known as establishing first line of defence. On other hand ingredients which assist in combating the free radical production in skin (e.g. Antioxidant) are acting as second line of defence [21,22]. When we have to put forth different approaches to protect against blue light they can be broadly classified as cosmetic and non-cosmetic approach for protection from blue light. The Non-cosmetic approach for protection against blue light includes mainly

preventive measures like to prevent or at least decrease the direct exposure of blue light. One of the good ways to do this is reduce screen time that is amount of time spent in front of screens. Take frequent breaks while working online. A good quality screen filters are available for smart phones, tablets and computer screens to decrease the amount of blue light emission. A yellow tinted computer glasses are easily available in market which help relieving strain on eye [23,24]. The glare and contrast can be reduced by using anti reflective lenses which are efficient in blocking this blue light also.

Role of cosmetics and their active ingredients in protection of blue light:

Some of the cosmetic products like skin creams, gels, mists, sprays, lotions, and ointments can be found efficient in preventing or reducing the production of free reactive oxygen species in skin. The effect exerted by this cosmetic is attributed use of some therapeutic active ingredients which are either synthesized or extracted naturally [25]. Skin being one of the most exposed surfaces to blue light undergoes excessive stress produced by reactive oxygen species (ROS), which affects at cellular level like DNA, protein. This damage of the skin caused by ROS can be prevented by stimulating skins defence mechanism. There are some active ingredients which are proven for their activity to reduce ROS induced stress level [26]. Some organic filters (e.g. avobenzone, octinoxate, benzophenone) which have been part of composition sunscreen formulation for long time have been stopped in use due to their huge impact environment. After being photodegrade these filters tend to produce chlorinated phenols in when dissolved in water. [27]. Since ages the inorganic materials like titanium dioxide, zinc, cerium oxide are used but due to their certain drawbacks associated with refractive index, photolytic activity the need for newer type of excipient is generated [28]. Cerium oxide, organic absorbent acts as shield against blue radiations, when dispersed in water it becomes transparent to skin as an aqueous material. A being transparent to the skin is primary and foremost requirement so as to absorb maximum wavelength coming from light. It also beneficially aesthetically. The primary mechanism involved in the action is said to be absorption of UV as well as blue light incident from atmosphere [29]. The action of Cerium oxide is proven a exhibiting more than shielding effect at light range of 460 nm. The activity of the Cerium Oxide is not limited by only shielding effect but is also effective as fully preventive agent to blue light [29,30]. Another inorganic filter are Zinc Oxide

(ZnO) and Titanium Dioxide (TiO2) which are approved to be used by US FDA. Chemically they are metal oxide particles which have proven efficiency in absorbing, reflecting and refracting UV as well as blue light. Although the multiple mechanism has been predicted against blue light, the primary action of absorption remains the most efficient [31]. Apart from this synthetic protectant, few naturally occurring extracts and /or combination of them is tested for their effect on skin. Vitachelox, is a combination of three natural extract having good proportion of phenols is when tested for its protective action against blue light in human keratinocytes it is found to acts as a natural protectant active ingredient for human skin by reducing protein oxidation induced by blue light irradiation. The action of extract was found to be against blue light ranging from 72% to 82 % in 24 and 6 hours respectively. The protectiveantioxidant effect of together with the anti-inflammatory and anti-microbial propertiesmake this natural active ingredient a valuable tool in the maintenance ofhealthy skin [32,33]. Carotenoids that shield blue light and guard against plant oxidative stress caused by blue-light. The active ingredient in Lipoid KosmetikCarotolino is meant to provide the skin with carotenoids where they can naturally serve as a protective barrier against blue light and minimise oxidative stress. In addition to its photoprotective function, carotenoids added topically enhance skin tone. Indeed, our *in vivo* research reveals that Carotolino produces a subtle optimization of colour, changing bland skin tones to a more vivid and healthier look. The strongest carrots, including stabilised carotenoids, are incorporated into Carotolino. This makes our botanical activity a trendy ingredient that synergistically decreases skin damage caused by blue light while adding a vibrant look at the same time [34]. **Table 1** describes the various natural and synthetic blue light protectants.

Table 1: Natural and synthetic blue light protectants.

Sr. No	Natural	Synthetic
1	Carotenoids	Titanium dioxide
2	Carotolino	Zinc oxide
3	Carnosolic acid	Cerium oxide
4	Ethyl ferulate	chitosan oligosaccharides
5	O-galloylquinic acids	
6	Oleuropein	
7	Niacinamide	
8	Ferulic acid	
9	Vitamin C	
10	Pomegranate extract	

Work done so far in blue light protective cosmetics:

Stefan *Hettwer et.al*; studied blue light protecting potential of cosmetics including CELLIGENT (carnosolic acid from rosemary and ethyl ferulate as ROS scavenging molecules), MYRAMAZE (O-galloylquinic acids as antioxidant) and PROTEOLEA (oleuropein as antioxidant). The cosmetic ingredients selected in their studies showed reduction in additional ROS load when exposed to HaCaT cell lines at nearly concentration of 0.01% to 0.05 %. All these three cosmetics products contain antioxidant ingredients and helped to reduce the concentration of ROS generated by blue lights. The active ingredients in these formulations were used at the concentration of 0.5% to 4%w/w which was sufficient to reduce the eminent ROS load to the baseline within period of 2 hours of blue light exposure to the cells.Application of one topical active ingredient to the skin of the face showed a statistically significant reduction in the number of red spots and a significant 44.3 percent reduction in the number of rosacea teleangiectoides in one research subject [35].***Stefano Togni et. al*;** investigated protective effect of Vitachelox which is the mixture of three polyphenols rich standardized natural extract, against protein carbonylation caused by irradiation of blue light in human keratinocytes. This protective effect was due to the antioxidant compounds present in the formulation which neutralized ROS and thereby reduced protein oxidative modifications.Along with the anti-inflammatory and anti-microbial properties previously mentioned, Vitachelox's defensive antioxidant effect allows this natural active ingredient a useful tool for preserving healthy skin [36]. ***Marina Lefort et. al*;** presented newfindings demonstrating that combinations of suitable TiO2 UV filters with a selected range of functional mica-based fillers due to a special inorganic oxide coating will provide considerable first-level protection against harmful high energy visible light (HEVL) and thus represent a revolutionary idea for modern and safe skin care. In addition, we suggest a new in vitro approach for determining the effectiveness of cosmetic formulations in the safety of blue light, based on transmission measurements on Poly (methyl methacrylate) PMMA plates [37]. ***Bernd Walzel et.al*;** studied carrot extract as excellentnatural ingredient for blue light protection and vivid skin. According to their research, carotolino can act as source of carotenoids to the skin and naturally shield the blue light and reduce oxidative stress. Apart from its protective action, carotenoid when applied topically helped in improvement of skin color furthermore

their*in vivo* studies created subtle color optimization and turned pale, dull skin appearance to healthy and more lively tone [33].Carotolino may serve as a unique active ingredient for skin care uses, suitable for anti-aging, face and body care, as well as after-sun, lip balm or hair care, due to the combination of blue-light protection and skin color effects.***Jee-Bum Lee et. al***; studied the protective effects of six

ethanolic extracts of medicinal plants (Schizonepeta tenuifolia var. japonica Kitagawa, Angelica dahurica Bentham ET hooker, RehmanniaglutinosaLiboschitz var. purpurea Makino, and Cassia toraL) on blue light induced oxidative stress in human corneal epithelial cells. Their results demonstrated that blue light can cause oxidative injuries to the corneal epithelium and those selected medicinal plants were found effective in reducing ROS by production of antioxidant enzymes in epithelial cell lines [38].***Man-Ru Wu et. al*;** investigated protective effect of Cistanchetubulosa extract (CTE) which is traditional Chinese medicinal plant against low luminance blue light induced degenerative retinopathy alongwith its mechanism in vitro and *in vivo*. In their experiments sodium azide, hydrogen peroxide, t-butyl hydrogen peroxide and blue light emitting diode light (BLL) induced human retinal pigment epithelial (RPE) cells damage was substantially inhibited by CTE. In addition, through inactivating apoptotic pathways, CTE decreased the expression of apoptotic markers such as cleaved caspase-3 and terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) staining following BLL exposure, as seen by immunofluorescent staining. Furthermore, BLL-induced phosphorylation of c-Jun N-terminal kinase, extra signal-related kinase 1/2, and p38 in RPE cells was inhibited by CTE. *In vivo*, 60-day intermittent BLL exposure-induced reductions in retinal thickness were saved by oral administration of CTE and decreased the number of TUNEL-positive cells in the brown Norwegian rat model. Finally, they concluded that CTE as a possible prophylactic agent against the photo toxicity caused by BLL [39].***P.M.Farr et. al*;** developed microtine titanium dioxide-based sunscreen products and found substantially higher protection of blue light, UVA and UVB in comparison to marketed formulation. The formulated products Sun K4S lotion, SPF15 and Sun E4S cream SPF 20 showed protection in patients sensitive to blue light [40].***Sparrow JR et. al***; compared the blue light absorbing potential and ability to protect retinal pigment epithelial cells (RPE) of AcrySof natural (SN60AT), AcrySof (SA60AT), Sensar (AR40e),

ClariFlex, CeeOn Edge 911A intraocular lenses (IOLs). In their study it was finally concluded that AcrySof natural IOL protected the RPE cells by absorbing the blue light [41].***Zou XL et. al*;** studied the protective effects of lipoic acid-niacin dimmers (N2L) against blue light induced oxidative damage to retinal pigment epithelial cells. N2L had shown advanced antioxidant and neuroprotective activities and enhanced bioavailability in few studies. Due to such beneficial properties high-dose treatment with N2L (> 100 mol / L) minimised oxidative damage with an effectiveness comparable to ALA in degenerating hRPE cells exposed to blue light [42].***Lin CW et. al*;** studied theprotective effect of chitosan oligosaccharides (COSs) on blue light light-emitting diode induced retinal pigment epithelial cell damage. They found that with longer light exposure, RPE cell apoptosis rose dramatically. In a dose-dependent way, therapy with COSs greatly decreased apoptosis. The development of reactive oxygen species and the expression of inflammation and apoptosis-related proteins had also been suppressed by these molecules. In addition, COSs preserved the cells' mitochondrial membrane potential and down-regulated the pathway of NF-egB [43].

Overview of marketed formulation used to protect from blue light:

Consider wide need of protection from blue light, cosmetic industry has developed number of formulations to avoid the damages caused due to the blue light.Cosmetic manufacturers are gradually selling skin cosmetics for preventative uses, mindful of the challenges associated with blue light.With the introduction of an anti-blue light mist by Garancia in 2016, the production of this new wave of cosmetic products was initiated; it then encountered a real boom following the introduction of a full dedicated product line, "Age Protect" by Uriage. Around the same time, other products, such as Patyka products and Anne Marie Börlind 's facial oil, have emerged on the market.Cosmetic brands such as Murad and Dr.Sebagh, which also concentrate on anti-blue light goods, were developed by physicians. Finally, major groups like Lancôme and its UV Specialist XL Shield CC Cover beauty shield are beginning to join the market, ever so timidly [44]. UV Transparent Broad-Spectrum SPF 46 by EltaMD protects the skin from toxic UVA and UVB rays by shielding the complexion. Fragrance-free, the soft formula of this face sunscreen contains sodium hyaluronate to moisturise while lactic acid refines the skin to clear pores and reduces shine. This facial sun screen contains niacinamide and zinc oxide as major ingredients which are responsible for the

protection of blue light due to antioxidant and blue light absorbing property respectively [45]. A synergistic antioxidant blend of ferulic acid and pure vitamins C and E is developed by SkinCeuticals' C E Ferulic to boost the defence of skin against environmental harm caused by free radicals including blue light. This formula reduces symptoms of ageing and photodamage, in addition to antioxidant preventive benefits, to reduce the appearance of lines and wrinkles while firming and brightening the skin. This strong solution helps to neutralise UVA / UVB, infrared radiation (IRA) and ozone emissions (O3)-induced free radicals [46]. Super serum tint SPF 40 was developed by ILIA which contains nano zinc oxide and combination of hyaluronic acids, natural origin squalane and niacinamide. This perfect blend of ingredients helps to provide the natural shield for the skin from blue lights and other radiations [47].Murad PomphenolSunguard Dietary Supplement improves the complexion from the inside, along with UV and UVB rays that account for 80 percent of premature ageing, to protect against free radicals. 100 percent pure, antioxidant-rich pomegranate extract appears in this dietary supplement that neutralises environmental aggressors [48]. Blue light protection hyaluronic serum was developed by Olivia. An anti-aging, deeply moisturising pre-serum fuelled by a pioneering combination of botanicals that improve the skin's own production of hyaluronic acid. This silky gel also protects the skin from blue light emission due to prolonged technological exposure, offering rapid, long-lasting hydration and plumping strength. This serum contains a potent mix of botanicals that encourage elasticity and youthful volume while combating the symptoms of ageing: dehydration, dullness, lack of firmness and age spots. It is an intelligent formula that meets a wide range of skincare needs [49].

Conclusion:

Blue lights have demonstrated the ability to penetrate deeper into the skin layers when compared to UV-A and UV-B rays emitted from sunlight and protection of such lights is quite compulsory considering the harmful nature of these lights. Various cosmetics products, ingredients have been developed by pharmaceutical and cosmetic industry to fulfil the need of the problems associated with blue light exposure. Still there is wide scope in the research of novel technologies to protect the blue lights using cosmetic products.

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