

Blue Dyed Polypropylene Material and Its Influence to Prolong Life

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Abstract: In this paper, it analyzes the causes that polypropylene/PP woven basketwork damage in the outdoor. It plays a significant role against ultraviolet degradation in short wavelength that blue dyed material PP Flat Yarn, according to experimental data. Weather resistance of polypropylene is relative to the dye color. Blue dye may be reflective of short wavelength the blue and blue-violet light, and part of the absorption of ultraviolet light. The short wavelength penetration into the polypropylene body's energy is reduction. In addition, it is not enough to interrupt PP molecular chains by the long-wavelength energy. In contrast, red dyes, which reflect long-wavelength red light, while it penetrates into the colored plastic body by the short wavelength blue light, blue-violet and UV light. High-energy light is easily broken molecular chain. It is bringing in photodegradation, and its direct results are the poor outdoor durability of PP woven basketwork. The dyed spectrum is supported it. The conclusion is polypropylene material properties determine its poor outdoor weatherability. The PP Flat Yarn is minimal impact on the outdoor durability that woven packing cloth or bag colored red dye. Colored blue is outdoor durability far better than non-color PP material. It must pay attention to the weatherability problems on the woven bags for flood disaster, to prevent dyke break flood caused by prolonged outdoor exposure. Maybe, blue color dye has anti UV agent function.

Keywords: photo oxidation; light degradation; Polypropylene/PP ribbon-like filament; colored woven; weatherability; outdoor life; anti UV

1. Introduction

Polyethylene (PE) and polypropylene (PP) is the largest output, the most widely used plastic class, more than 38% of the world's plastic production. Polyethylene gradually becomes brittle, less mechanical strength and electrical performance in the atmosphere, the sun, under the action of oxygen. In the molding temperature, it leads to decreased melt viscosity, discoloration and streaks for oxidation. PP is prone to aging under light, heat, and oxygen conditions in the forming and in the use. It becomes aging and crisping after 12 days in the atmosphere. In addition, it will turn bad for 4 months indoor exposure. Usually it improves the weather resistance to add UV absorbers, antioxidants, carbon black, zinc oxide and other products. It widely used in the manufacture of plastic products and synthetic spinning, because PP is higher than the melting point of PE, lower density, and better mechanical strength^[1]. Plastic woven adopts flat yarn to woven, widely used for bags especially for flood disaster, and temporary retaining material. A variety of tarpaulin is widely used as covering materials in the transport and storage with plastic, instead of easy-mildew-and-rot worn-out heavy cotton tarpaulins. Construction of fence, netting, etc is also widely used in plastic knit. There are in common: logistics and its packaging, freight logistics bag, bag, and

other freight transportation^[2], as shown in Figure. 1.



Figure 1. Common PP polywoven bag , lackluster surface

Since 1966, it developed polywoven bag with ribbon-like filament in our country. It has been rapid development of the product and has formed a variety of sizes and specifications of products. It has reached the standard of overseas similar varieties of products and quality, and has a certain competition in the international market. Over the past 30 years, domestic to adopt alternative linen woven PP, resulting in the largest Zhejiang Gunny Manufacturer in the Asia has not exist.

2. Photodegradation Case Of Colored PP And Its Woven

2.1. Photodegradation Case in Woven Applications

Three-color woven fabric is the most commonly used braided packing materials. The course of construc-

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tion in the city, often serves as surface coverings, decorative items, as a temporary appearance.

Case 1: It saw as a retaining wall, north side along the road with the tri-color woven decorative fabric in the beginning of August. It has been great dilapidated when the end of August in 1999, for only 1 month outdoor. There is a large number of missing PP woven flat yarn in the white part; difficult to see the red part of the original color, and there are many defects in that parts, but still maintained a blue color and the colored entire fabric. The conditions is which just south of the envelope woven blocked by the wall on the north side of a road, there is direct sunlight only in the morning and before evening, scattered light from the summer sky in the other time. The weather of July and August in Hangzhou, solar radiation intensity is long duration. The city's monthly average global solar radiation in most conditions is 12.5 to 14.5 kcal/cm², sunshine hours of 230 ~ 260 hours and sunshine percentage of 55 ~ 60%^[3].

Case 2: It experienced natural aging from the end of September 1996 to next January, only remaining the parts of the blue and little red flat wire braided ones looked like white that PP woven material as the retaining in the field. In Hangzhou, the monthly average total radiation is less than 6 kcal/cm², sunshine less than 150 hours, sunshine percentage less than 50% in December to next February^[3].



Figure 2. Breakage holes on the aging tri-colored woven for enclosure

Notice: Woven stripe colors see the left block which R-red, W-white, B-blue

Case 3: Building side just put on old woven. There are some broken holes on the woven, their region on the white or red stripes, shown as the Figure 2. We mark W, R and B to describe white, red and blue stripes in the picture, for the same brightness between red and blue in grey mode.

2.2. Other PP Products' Fading and Aging Conditions with Different Colors

We can find other PP products fading and aging rate with different colors also. Figure 3 shows red PP components in city public bikes. They fade greatly from fresh red to nearly non-colored after using 3 months, seen the color of bicycle baskets and rim guards in the Figure 3. Thus, fading plastic accumulates catabolite under ultraviolet radiation due to its pellucidity changing. It brings about replacing the worn plastic parts frequency, compared of a bike basket and guards with different colors shown in the picture.



Figure 3. Faded bicycle PP baskets and rim guards with red color

Notice: In the grey printing, red color displaying dark and fading doing bright

Another thing is red, green or blue PP thin film string. Sometimes, red thin PP string becomes powdery after several months in the air, but blue one is still keeping the shape and the color.

2.3. Another Plastic Kind Fading and Aging Cases

Polyethylene (PE) blowmoulding housing of thermos bottle, colors red, blue or green etc. We find the red is easy to fade and become powder. For example a red housing becomes fading enough to nearly no color, further more, it falls to pieces when grasping it after storing several years indoor. Blue colored housing keeps its color for a long time; of course, it prolongs its working time. It shows 3 same thermos bottles which keeping and using at same place indoor everyday. The diffused light in the day and diffused lighting at evening induced red one becoming fading visibly, but light acidblue especially blue one changes little. In the printing grey mode, fading red region is whiter than light acidblue, shown in Figure 4(a). New red plastic is flesh in color,

but in the grey mode, it is much darker than green even blue, shown as (b), a matched group.



(a) Fading plastic thermos housings

Left-red, middle-light acidblue and right-blue color ones



(b) New thermos as matched group:

Left-red and right-green one

Figure 4. Different colored PE thermos housing and their fading conditions

By the way, the upper part shown in Figure 5 is deep green network; further more, it is less breakage holes on that and is currently used in the field nowadays. We also can see it in most building sides for its long using times. It kept nearly 2 years observed in reference [4] picture.



Figure 5. Dark green netting in construction building site

We can also see black netting material for covering and shadow on some gardening plant or in the field, which works hard under sunshine for a long period so that the plastic needs very good weather resistance. It shows the real material in Figure 6, the black part at least double net pieces. It fills a large carbon black as its packing in plastic and other stabilizers. Dark black is good UV absorbing.



Figure 6. Dark network for sunshade and its structure

3. Light and Heating Degradation About High Polymer Material

3.1. Woven Outdoor Weatherability

According to No.6 Inspection Rules in National Standard of The Plastic Woven Bag GB/T8946-1998, it is only one term for heat detection; there is no testing project about outdoor weathering resistance or tolerance to optical performance [5]. Therefore, we should design and do weatherability tests ourselves.

In fact, most surface of woven or polywoven bag is lackluster, like Figure 1 shown. Little polywoven bag, e.g. rice bag surface is gloss and semitransparent. It has 20% talcum powder as filling to make ribbonfil^[1]. Strap is even filling up to 100%. According to its lackluster material in the visual, the woven must fill a large number of packing. The sunlight enters into woven body, and it scatters. Thus, the light changes its directions, and reflects and strengthens the damage.

3.2. Light Degradation Mechanism

Photodegradation is the photoinitiated molecular bonds weaken after photodegradable plastic absorbing ultraviolet radiation in the sunlight, so that long chain split into fragments of a low-molecular-weight polymer of destruction of the physical integrity of performance degradation. Low molecular weight of debris in the air oxidizes further, resulting in broken chain reaction with free radicals, degradation becomes biodegradable being and low molecular weight compounds, and it finally been completely oxidized to CO₂ and H₂O. The degradation

process is combination of chain broken degradation and free radical oxidation reaction with Norrish action.

UV light energy range at 290nm ~ 400nm, is higher than break energy required in the plastic polymer chain induced by different chemical bonds. However, a variety of High Polymer Material structure has different sensitivity on the wavelength. It would be very little degradation if the wavelength were not the light sensitive one [6].

3.3. Natural Cellulose Degradation Mechanism

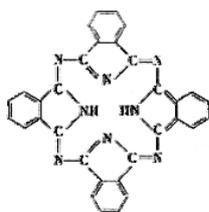
Cellulose is a polysaccharide, the macromolecules are connected by a number of glucose residue group formed, molecular formula (C₆H₁₀O₅)_n, a complex mixture of homologues, n for the degree of polymerization, polymerization degree of cotton for the 2500 to 10000, gunny degree of polymerization 10000 ~ 15000, viscose fiber polymerization degree of 250 ~ 500. They are larger than plastic PE or PP, etc. Cellulose exists but most manmade plastic does not in nature. PE exists only for several minutes if no antioxidant and plasticizer.

J. Ladewijks introduction, the ε value in breaking cellulose is 58.6×10³ calories/mol (C-C bond breaking energy) and 80×10³ calories/mol (the fracture energy between the linear saturated bonds). From the formula, light wavelength 486nm can be broken in the C-C bond, shorter than UV 385 nm can be broken in the linear saturated bonds [7]. Thermal degradation of cellulose is about 120 °C instability, 300 °C or more dramatic degradation, heating at 100 °C for a long time will also cause decreased degree of polymerization [8]. High Polymer Material bonds are similar to cellulose, but the molecular weight is less than cellulose, so its photodegradation is stronger than the last one.

4. Dye, Light Absorbing And Spectrum

4.1. Dye and Its Absorbing Ability

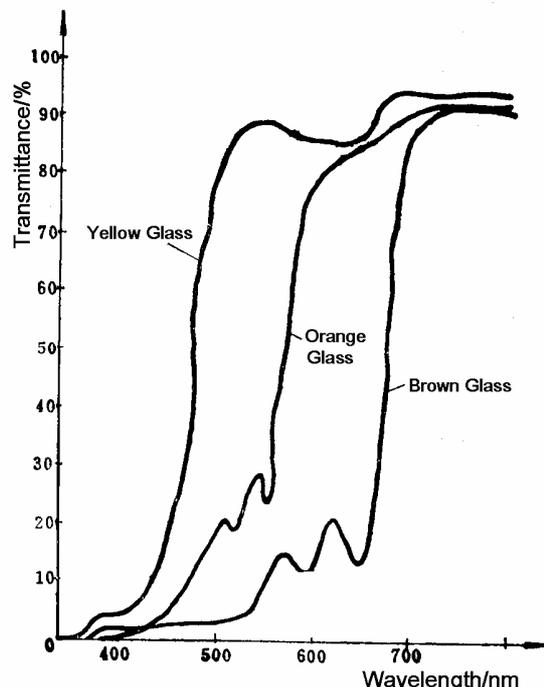
Phthalo cyanine, abbreviation PC, the molecular structure is:



Brightly-colored dye phthalo cyanine has sun-resistant, weather resistant, washable, and rubbing fastness are very good, now it is the most prominent use of dye species, the drawback is Chromatographic incomplete, only dark colors blue, green.

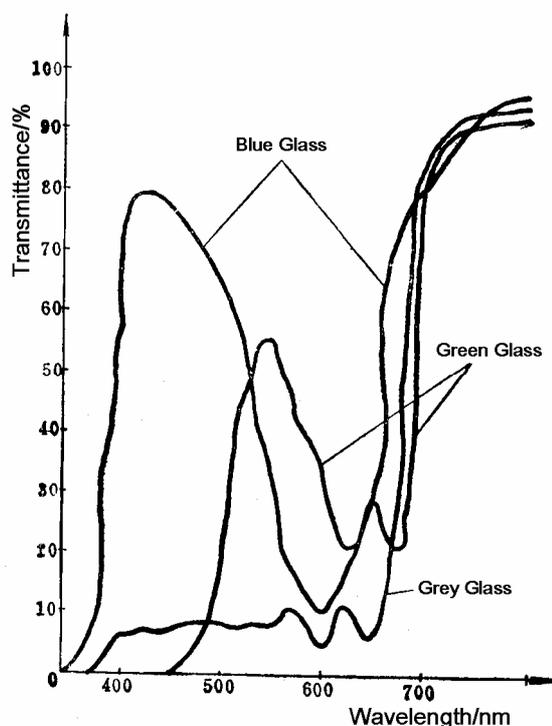
4.2. Color Dyeing Glass Transmittance with Wavelength

Let us research the spectrum of different colors



(a) The spectrum curves of the warm tone glasses

(b)



(b) The spectrum curves of the cool tone glasses

Figure 7. The spectrum curves of different colored CR-39 glass

affection. Figure 7 is dyeing glass transmittance curves with CR-39. They all have low transmittance in near UV region (wavelength 350-400nm), and in the middle UV (200-350nm)^[9]. That means, dye has absorbing ability in short wavelength.

4.2. Red Color Fading and Damage Mechanism

Anti-UV dye has conjugated structure containing the internal hydrogen bond formation and molecular structure of sequestration. Found direct red 28, direct green 26, Direct Black 38 dyes such as some very prominent UV absorption properties (Note: direct red 28, Direct Black 38 inclusive of benzidine structure, the list of banned dyes). The structure of Phthalocyanine dye (Direct Blue 86, Reactive Blue 7) has better UV protection performance.

Red colored plastic is bad in UV protection, we know. It fades fast and exposes the body in the sunshine deeply. So it needs anti UV agent in the plastic. The Direct Red 28 is outstanding in the reduction of UV transmission of fabric, the dye depth even 0.5% only, but it increases UPF values from Background 4 to dyed 40^[10]. Therefore, selecting good anti UV dye is an most important thing to plastic processing industry.

5. Comments

PP color is great influence to its fading and prolong. PP woven material has much packing, e.g. talcum powder, it becomes weakness of the structure and anti light functions. Bad red dye is easy fading, it must add anti-UV agent. Some dye has anti UV function, it keeps dye's color and protects the body avoiding UV damage. According to Figure 7, blue color filter glass is not good

enough to absorbing UV, so anti UV functional radical were include in the dye. Color selection in PP, PE or other kinds of plastic can avoid products damage early. Polywoven bag's material must color blue, even a speck of it, for prolonging products. Rescue and relief polywoven bag in flood disaster needs available strength in a long period. For example, in 1998, Yangzi River flood disaster used bags on the banks occurred bag degradation, faced to Broken Dam danger. Add little dye Direct Blue could change polywoven bag prolonging, like the middle thermos with a light color in Figure 4(a).

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