The Application of Natural Dye on Tinted Vehicle Films – A Review

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Abstract. The study present the utilization of natural dye from onion skin on tinted film. Tinted film for the car and helmet visor is produced from Polyethylene Terephthalate (PET) as the main material. However, tinted films that do not meet the Visible Light Transmission (VLT) values authorized for automobiles are being used by some people. Tinted films are also often manufactured using synthetic dyes, which have negative environmental impacts. Thus, the objective of this study was to prepare the tinted film for car and helmet visors that can comply with safety standards (MS1). Tinted film produced must comply with the percentage of VLT allowed which is 30%, 50% and 70%. Synthetic dyes, which are frequently used in the plastic manufacturing sector, will be substituted with natural colours in this study. PET is excellent for manufacturing plastic films because it has a number of benefits, including the ability to act as an amorphous and semi-crystalline material. Natural dye extracted from onion skin is a good dye because there are Auxochrome groups. By choosing natural dyes over other options, we are helping to protect the environment and reducing human reliance on toxic chemicals.

1 Introduction

With the emergence of new technology and increasing customer demands as well as sustainability rules, the car industry is witnessing major developments. At the same time, the new era of industrialized production (4.0) is also internationally transforming the automobile business. Today, the industries are advancing rapidly towards emissions-free transportation through the electrification transition, whereas COVID-19 is dictating future changes and confounding previous forecasts [1].

There is trend that shows the estimation of worldwide automobile production from year 2000 to 2020 in million vehicles [2][5]. As noted earlier, there has been a decline in the last two years. In 2020, almost 78 million motor vehicles were produced worldwide. This figure translates into a decline of around 15 percent, compared with the previous year. China, Japan, and Germany were the largest producers of cars and commercial vehicles in 2020 [3].

The decline in total vehicle sales due to the Covid-19 crisis, shows that many passenger vehicles have become the preferred vehicle in Malaysia compared to commercial vehicles. Furthermore, the enforcement of tinted glass infractions occurred from time to time, whether on domestic or imported automobiles. For vehicle owners who have cars that do not meet tinted glass criteria and have committed violations under the Rules of Motor Vehicles (Prohibition of Certain Types of Glass) 1991. The number of tinted glass violations identified by the Road Transport Department (JPJ) in 2011 was 15,336. Meanwhile, there were 51,431

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instances in 2012 and 22,663 cases as of June 2013. This demonstrates a rise in the use of tinted glass in Malaysia [4]. Various circumstances contribute to the utilization of tinted film on windshields and helmet visors. Variables include weather factors, safety considerations, health factors, reduced vehicle interior temperature, vehicle privacy and the styling of the car.

2 Polyethylene Terephthalate (PET) as tinted film

Amongst of the thermoplastic polyester family, Polyethylene Terephthalate (PET) is often utilized in a broad variety of applications such as textile fibers, films, bottles and other molded items. Most PET products worldwide are made for synthetic fibers over 60 % with the manufacturing of bottles representing around 30 % of global demand. The vast usage of PET is mainly because a variety of degree levels are produced in one single multi-product polymerization facility, covering a wide range of molecular weights. The chemical structure of PET consists of chain that have repeating unit [6].

It may be present as amorphous (transparent) and semi-crystalline (opaque and white) material, depending on PET production and thermal history. The esterification reaction between terephthalic acid and ethylene glycol, which produces water as a byproduct, or the transesterification process between ethylene glycol and dimethyl terephthalate, which creates methanol as a byproduct, can be used to make its monomer [7]. Polymerization occurs via a polycondensation process of the monomers (which occurs immediately following esterification/transesterification), with ethylene glycol as a byproduct (the ethylene glycol is recycled in production) [6].

The plastics industry is divided into two categories which are thermoplastics and thermosets [8]. The bulk of the plastic industry is made up of thermoplastics. Each sector is further subdivided into highly specialized sectors that produce all of the plastic items people encounter daily.

3 Colorants for the plastic industry

Color and appearance in the polymer sector are dependent on numerous elements and a range of aspects are also determined based on material type and grade. There has been some material transparency studies and it is well known that if the polymer itself is transparent, the refractive index of ingredients is close to that of the polymer material and the components’ dispersion domain size is below a quarter of the visible light-wave length, it is possible to create a transparent polymeric object [9]. Although the color improves the part's usefulness, it also has the potential to damage some material attributes such as impact strength if not applied appropriately.

Plastics coloring is not just utilized for ornamental objectives, but for identification, safety, branding of products, segmentation and environment objectives. Organic and inorganic pigments, solvent, dispersed dyes and other polymer dyes can be used to generate coloration. To improve plastics’ optical qualities, effect pigments like aluminium, bronze, pearlescent and phosphorescent polylys can also be applied. In certain circumstances, pearlescent pigments may be utilized to convey laser markings [10].

According to [8] colorants can be dyes or pigments. Pigments are classified as organic or inorganic. Dyes are extremely strong, have excellent thermal stability, and are transparent. Typically, these colorants are applied to tint or darken a resin. The solvency of dyes only permits its usage in specified resins. Because of its opacification, broad color intensity, and good heat stability for various resins, the pigment is increasingly widely utilized. In a resin
matrix, pigments are dispersed and the dyes solubilizes in the resin. The selection of colorants will rely on the kind of resin, the circumstances of production and end-use requirements.

The choice of colorant is dictated by the base polymer. Pigments are commonly employed in polyolefins since most colors migrate in these materials. Because of their color strength and transparency, dyes are frequently employed with polycarbonate, polystyrene, acrylic, and other types of polymers. Last but not least, whichever colorant is chosen, it must be compatible with the base resin. This is to keep a color change from happening over time [11]. The qualities of a handful of the colorants that make up both dyes and pigments are listed below.

4 Overview of Tinted Films Types

In general, a polyester base layer, such as polyethylene terephthalate (PET) is used to create tinted films with a thickness between 1 to 4 mils. While shatter-resistant tinted security films can be as thick as 14 mils [12]. A pressure or water sensitive adhesive is placed to one side of the film to enable the tint to attach to the glass surface, and a scratch proof coating is put to the opposite side to extend the film's lifetime. On the market, there are three primary types of window tint: dyed, metallized, and hybrid [13].

a) Dyed tinted film: The first sort of tint to be offered was dyed window tint. Dyed window tint is made out of a transparent polyethylene terephthalate (PET) film that has been dyed for a certain amount of time to obtain the desired colour darkness. Some infrared and visible light will be absorbed by it. Dyed films are the simplest to produce and the cost effective of the film kinds.

b) Metallised tinted film: Metallised tints, as contrast to dyed tints, function by reflecting light instead of absorbing it. It is made up of one or more metal layers separated by translucent dielectric layers that do not contain any dye. This type of film is prone to interfering with wireless communications and has a high reflectivity, which might result in an unfavourable mirrored effect.

c) Hybrid tinted film: Through a combined function of dyed and metallised films, hybrid films combine the benefits of both while eliminating the downsides. As a result, it allows for heat absorption as well as heat reflection. Using a sputtering or vapour deposition procedure, one or more metal layers are deposited to the dyed polyester.

5 Natural dyes before synthetic dyes

Natural dyes derived from plants, animals (less frequently), and minerals have long been used for dyeing textiles, leather, bodies, and hair, as well as for cosmetic and craft applications and food coloring. The progress of science is unstoppable and the golden period of natural dyes ends in the second part of the 19th century, when the chemical industry began producing its synthetic alternatives [14]. The fundamental distinctions between natural and synthetic dyes are in terms of stability and cost, with synthetic dyes being more stable and less expensive than natural dyes [15].

Natural dyes can be categorized in a variety of ways. The first categorization was based on alphabetical order. Later, it was moved to a chemical structure-based approach, with color-based grouping inside each group structure class. Later, they were categorized in a variety of additional categories, such as color, chemical composition, use, and provenance [6]. The various methods for extracting colored ingredients are as follows: aqueous extraction, alkali
or acid extraction, microwave and ultrasonic-assisted extraction, fermentation, enzymatic extraction, solvent extraction and also supercritical fluid extraction. As natural coloring substances contain a small percentage of coloring material, as well as various other plants and animal constituents including water-insoluble fibers, carbohydrates, protein, chlorophyll and tannins, extraction is a necessary aspect not only in the preparation of purified natural dyes but is also required to be carried out by users of crude dye-bearing materials [17].

6 Onion Peel Natural Dye - Pelargonidin

Extraction of natural dyes from byproducts such as food, wood and agricultural waste at lower costs is one of the measures to reduce the use of chemicals. The use of onion skin as a natural dye is also not something new nowadays because there are several studies related to its use such as dye fabrics with antimicrobial and anti-UV properties as well as dyes for leather [18].

Onions are farmed on 6.30 million hectares of land worldwide, producing 122.21 million tonnes of onion each year. In 2017, a total of 144 nations were involved in onion production, according to the United Nations Food and Agriculture Organization. However, over 65% of the world's onion production is produced in the eight leading onion nations. India is the world's second-largest onion producer, producing 22.43 million tonnes per year on average while China is the largest [19]. This data shows that onions are one of the most often utilized veggies and are in great demand all around the world.

Onion peels are essentially removed before use, and the percent yield of useable peeled onions ranges from 73.5 to 81.6 percent depending on onion size (2.5 inches to 4.5 inches) [20]. Extrapolating the figures, India produces between 2.3 and 4.5 million tonnes of onion peels every year. Onion skin dyes, also known as pelargonidin (3,5,7,4-tetrahydroxyanthocyanidin) is a good dye for natural fibers due to the presence of four hydroxy groups (Auxochrome groups) pelargonidin. Flavonoid, Tannin, Cardiac glycoside, Anthraquinone and many more are found in the onion's outer peel [21]. The chemical structure of Pelargonidin. consist of (3, 5, 7, 4 tetrahydroxyl anthocyanidol [22].

7 Natural Dyes Advantages and Significance

The colors used in textiles can provide details about a country’s economic, social, and cultural history. Natural dyes have the benefit of requiring renewable resources, resulting in less environmental damage, and having a low-risk factor in terms of human health. The use of natural resources in a sustainable and diversified manner is critical in the future development of environmentally friendly processes and products. The use of renewable natural resources is important [23].

There is experimental evidence that some synthetic dyes cause allergic and toxic reactions. Natural dyes are generally non-toxic and non-allergic. Some natural colors have added value because of their medicinal effects on the skin and are more than skin-friendly. By using a mix and match system, natural dye stuff can produce a wide range of colors. Natural dyes have the potential to earn carbon credits by minimizing the use of synthetic colors made from fossil fuels (petroleum). Natural dyes generate colors that are often smooth, glossy, and pleasant to the eye. Natural dyes are appropriate for maintaining and maintaining historical and traditional dyeing techniques, as well as for researching historic dyeing processes, colored museum textiles, and other textiles retrieved by archaeology for the conservation and restoration of historical textile heritage [24].
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