



## Mini Review

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## Darkening Agent for Polyester Fabric

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Received Date: October 24, 2019

Published Date: October 29, 2019

## Abstract

Energy saving, emission reduction and cost decrease are always necessary in dyeing industry, and darkening agent can suit this trend. In this paper, a brief review is also presented about darkening agents for dyed polyester fabric, then the darkening agent emulsified with cationic organic fluorosilicone resin is introduced. The interaction model of the darkening agent and the fiber was analyzed, and the ammonia value of the deepening resin has a great influence on the softness and the finishing durability for polyester fabric.

**Keywords:** Darkening agent; Resin; Finishing; Polyester fabric; Interaction model

## Introduction

Without increasing the amount of dye, the fabric can be dyed deeply, which can result in saving dye, decreasing cost, and reducing the amount of the colored effluent in dyeing. Many researchers have done much research in this field and had many achievements [1,2]. The method of fabric deepening can be mainly summarized into three types, the first one is physical or chemical treatment of the fiber to roughen the surface of the textile, reducing the surface reflection of light, which the absorption of the dye can be increased and the apparent depth of the dyed fabric can be improved [3]. The second method is to improve the dyeing fixation rate of the fabric, including graft modification, fiber surface modification, dyeing auxiliary and suitable dyeing process, etc. [4-7] The third approach is to use a finishing with darkening agent, reducing the refractive index of the surface of the dyed fabric, thereby obtaining a dark color effect [8]. Among them, the dyed fabric is treated using a finishing with darkening agent with a low refractive index, and the film on the surface of the fiber is formed to reduce the amount of reflected light so as to achieve a visual shade darkening effect, which is a conventional method used in the dyeing and finishing process of textiles [9].

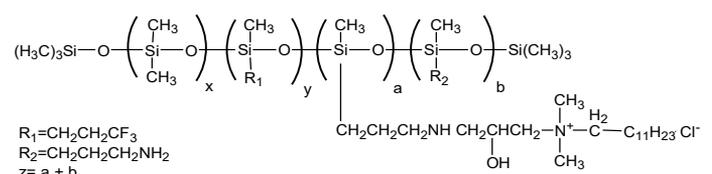
## Darkening Agent

To obtain a darkening agent with excellent shade darkening effect, a lot of research and exploration have been conducted, and many types of darkening agents have been developed [10-

13]. For low reflectivity, darkening agents based on organosilicon resin are the most conventional one, while the others based on organic fluorine resin have the lower refractive index, but they are expensive and strong hydrophobicity of the finished fabrics [14,15]. The darkening agents based on polyacrylic resin or modified polyacrylic resin have good shade darkening effect, but the finished fabrics are hard, which cannot meet practical wearing needs [16]. Although the darkening agents based on organosilicon are the most commonly used, which can improve the hand feeling of the fabric [17], but their shade darkening effect still needs to be further improved to lower their refractive index. In addition, darkening agents often have many problems in practical use, such as "floating oil" phenomenon.

## Cationic Organic Fluorosilicone Resin

The darkening agent emulsified with cationic organic fluorosilicone resin has excellent overall performance, whose molecular structure is illustrated as [18].



It is a typical darkening agent for polyester fabric. Compared with other darkening agent in the market, it has many

outstanding and substantial features as follows. Firstly, the raw materials used are easy to obtain and it is easy to prepare. Organic fluorosilicone was synthesized directly by bis-amino-type silane coupling agent with octamethylcyclotetrasiloxane and trifluoropropylmethylcyclotrisiloxane with a traditional bulk polymerization reaction, instead of using the linear octamethylcyclotetrasiloxane and the linear trifluoropropylmethylcyclotrisiloxane [19,20]. Secondly, the resin containing quaternary ammonium salt can be easily emulsified with water after the emulsifier is added [21], the obtained emulsion has smaller particle size and better stability and does not occur "floating oil" phenomenon. The resin in the emulsion can be easily combined with the fiber surface due to charge attraction [22]. Thirdly, the darkening agent with the resin can be used alone or in combination, the darkening effect is obvious, and the feeling and style of the textile after finishing are not only unchanged, but also improved a little, especially for polyester fabrics [23-25].

### Interaction Model of Darkening Agent and Polyester Fiber

When the fabric is treated with the finishing agent emulsified with amino silicone, the resin is uniformly distributed to form a monomolecular layer-aligned film on the surface of the fiber [26], the silicon methyl group extends toward the outside, and the silicon-oxygen dipole bond and the polar amino group are directed to the inside of fiber interface [27,28]. The ammonia value of the finishing agent has a great influence on the morphological structure of siloxane chain during film formation [29]. The siloxane chain between two amino hydrocarbon groups forms a free ring shape, which is easy to move and bend, the result is that the friction coefficient between the fibers can be effectively reduced, and the fabric after finishing has soft and smooth feeling [30-32]. However, polyester fiber with dense structure, smooth surface, fewer surface polar groups and strong hydrophobicity is completely different from cotton fiber [33]. Polyester fiber has less polar groups on the surface, the ammonia value of finishing agent has less significant effect than cotton fiber, but still has some influence, the finishing agent with lower ammonia value was used to achieve a good finishing effect. The film formation mechanism of the resin on the surface of polyester fiber is similar to that of cotton fiber [34]. The amino silicone has weaker interaction with polyester fiber [35]. The partial polar side chains of the resin are randomly distributed in the upper layer of polysiloxane, and the adjacent quaternary ammonium salt groups electrostatically repel each other. The polysiloxane segment has a helical structure, so the ammonia value of the resin affects the conformation of the polysiloxane chain on the surface of the fiber [36,37]. Compared with conventional amino silicone, the organosilicon with quaternary ammonium salt groups has stronger interaction with negatively-charged polyester fiber on the surface, which can improve the adhesion and reduce the yellowing [38,39]. Suitable length of polysiloxane chains is important to facilitate the formation of uniform film of the resin on the surface of the polyester fiber, and can bend, rotate and slide freely, imparting the softness performance of the fabric [40]. If the

ammonia value is too high, the length of the polysiloxane segment is too short, and the main chain cannot move freely, which does not give the fabric a soft feeling. On the contrary, If the ammonia value is too low, the length of the polysiloxane segment is too long to form a non-uniform film of the resin on the surface of the polyester fiber, which also reduces the softness.

### Conclusion

A brief review is presented about darkening agents for dyed polyester fabric. The darkening agent emulsified with cationic organic fluorosilicone resin has excellent overall performance, especially used for polyester fabric. After analyzing the interaction model of the darkening agent and the fiber, it was drawn that the ammonia value of the deepening resin has a great influence on the softness and the finishing durability for polyester fabric.

### Acknowledgement

This work was supported by the Major Program of National Science and Technology of China (135 Program, No. 2017YFB0309700).

### Conflict of Interest

No conflict of interest.

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