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Evaluation of the Viability of Turpentine Oil at High Density Printing on Cotton Fabric

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ABSTRACT: Printing is a popular method for all fabrics and garments. It is referred to as localized dyeing, in which dyes or pigments are applied using different techniques that can provide a particular color effect on the fabric surface according to the design. High-density printing is one of the most essential fabric and garment printing processes which results in a raised or textured surface on the fabric. In this study, we examined the performance of turpentine oil instead of silicon oil in high-density rubber printing on cotton cloth. Based on colorfastness to washing, colorfastness to rubbing, colorfastness to perspiration, colorfastness to saliva, and colorfastness to light, the performance of the printed fabric was assessed. We also evaluated the expense of the printing chemicals and the smell of the printed fabric. Turpentine oil saves around 10% on chemical costs, brings satisfactory results, and smells like kerosene. By curing the printed cloth or exposing it to sunlight for 4-5 days, this odor can be eliminated.

KEYWORDS: Cotton Fabric, High-Density Printing, Silicone Oil, Turpentine Oil, Color Fastness.

1 INTRODUCTION

Cotton is the most important natural and cellulosic fiber used in the production of clothing, home furnishings, and industrial applications [1]. Cotton fibers are most popular in the textile industry because they combine durability, attractive qualities, and comfort – their strength, softness, absorbency, and coloration ability [2]. Cotton fiber has a fibrillar structure which consists of a primary wall, a secondary wall, and a lumen [3]. Cotton fiber contains hundreds to thousands of connected D-glucose units held together by hydroxyl groups. The fiber's ability to absorb water and swell is owing to the cellulose macromolecule's numerous polar OH groups. Cotton fabrics can be printed with natural dyes, synthetic dyes, and pigments.

Textile printing is the practice of applying color to fibers in distinct patterns or designs with sharp outlines [4]. It is a coloring technique in which colors are applied to specific areas of fabric rather than the entire fabric. The resulting multi-colored patterns are beautiful and artistic, adding to the value of the dyed fabrics [5]. There are different techniques available for textile printing. High-density printing is one of the most important printing methods for fabrics and garments. It is a printing technique that creates extremely detailed and fine prints with extreme precision. It creates a special effect that rises from the garment and has a rough, rubbery feel with sharp edges. It is one of the most amazing approaches in the apparel design scene today. When printed using this approach, the ink lifts off the fabric, creating a three-dimensional effect not possible with standard procedures. It is done with more strokes to make the printed area thicker during printing. High-density printing can be done in two ways: rubber-based high-density printing and plastisol-based high-density printing. Silicone oil is used in rubber-based high-density printing. It creates a slippery effect on the printed portion of the fabric or garments.

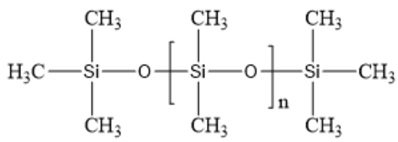

Fig. 1. Chemical Structure of Silicone Oil [6]

In this research work, we replaced silicone oil with turpentine oil. Turpentine oil is a liquid derived from living trees, primarily pines. Terpenes such as monoterpenes, alpha-pinene, beta-pinene, and trace amounts of careen, camphene, dipentene, and terpinolene make up its composition. Turpentine oil is a highly flammable and volatile solvent with various industrial applications including paint brush cleaning, paint thinner, and floor and furniture waxes and polishes [7].

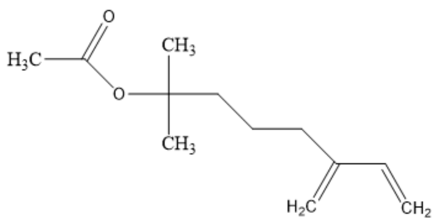

Fig. 2. Chemical Structure of Turpentine Oil

Turpentine oil has few applications in textile dyeing, printing, and finishing industry. Ghada A. Elsayed et al. investigated the eco-friendly printing of jute fabrics using natural dyes. In this work, he showed that pigment colors are printed on jute fabrics using kerosene or mineral turpentine oil (MTO) --based emulsion thickeners [8]. Turpentine oil has numerous applications outside of the textile industry. A.K. Jeevanantham et al. investigated the influence of a cetane improver using turpentine oil on the parameters of a CI engine [9]. Rakesh A. Afre et al. investigated carbon nanotubes using spray pyrolysis of turpentine oil at various temperatures [10]. B. Prem Anand et al. studied the performance and exhaust emissions of direct injection diesel engines fuelled by turpentine oil [11]. Youchang Liu et al. investigated the effect of turpentine oil on the generation of C-reactive protein (CRP) in rainbow trout [12]. Naseem Ahmad Charoo et al. investigated the effect of tulsi (Ocimum sanctum) and turpentine oil on the bioavailability of transdermally applied flurbiprofen [13]. Nanik Wijayati et al. investigated the composition and antibacterial efficacy of a hand sanitizer gel containing pinene extracted from turpentine oil [14]. Meanwhile, there has been no research regarding the use of turpentine oil in high-density textile printing. Thus, in this work, we investigated the efficacy of turpentine oil on high-density textile printing. The printed fabric's odor and chemical costs were also compared to existing high-density printing processes.

2 MATERIALS & METHODS

2.1 MATERIALS

In this study, 100% cotton fabric (knitted single jersey) was used. Impress-Newtex Composite Textiles Ltd provided the fabric, which had previously been desized, scoured, and bleached. The fabric's areal density was 150 g/m2. Masco Knit Composite Ltd provided rubber-based high-density printing paste (Silkflex High-Density Rubber White WHD-302 and Silkflex High-Density Rubber Clear CHD-301), a fixing agent (Silkflex Eco Oxal Fixer SU 400 E), and basic pigment colors (Koritex Red PGR3). Silicone oil and turpentine oil were purchased from the local market.

2.2 PRINTING PROCEDURE

At first, we gathered desized, scoured, and bleached fabric. The screen was then prepared according to the design. The printing table was then prepped for smooth printing. The print paste was then prepared by mixing a rubber-based high-density print paste, a fixing agent, silicone oil or turpentine oil, and basic colors. The design was then printed (stock-4, impression-3) on the fabric. The printed fabric was then dried for 2 minutes at 120 °C. Finally, we cured the printed fabric at 160 °C for 5 minutes. The printing recipe is represented in Table 1.

Table 1. Printing Recipe

Chemicals	With Silicone Oil	With Turpentine Oil
Silkflex High-Density Rubber White WHD 302	30%	30%
Silkflex High-Density Rubber Clear CHD-301	60%	60%
Silkflex Eco Oxal Fixer SU 400 E	2%	2%
Silicone Oil	5%	-
Turpentine Oil	-	5%
Koritex Red PGR3	3%	3%
Total	100%	100%

2.3 Test Methods

Colorfastness to washing, rubbing (dry and wet), sweat (acidic and alkaline), saliva, and light were tested using the ISO 105 C06 (C2S): 2010, ISO 105 X12: 2016, ISO 105 E04: 2013, GB/T 18886: 2019, and ISO 105 B02: 2014 methods, respectively. The printed fabric's smell and the printing chemical costs were also compared.

3 Results And Discussions

3.1 Colorfastness To Washing

The color of a textile material refers to the dye that is used to impart a certain color or any pigment that is used to print on the fabric. These dyes or pigments tend to fade over time and also because of repeated washing. So, it is important to test the fastness of any dyed or printed textile to assess the quality of the dye or pigment being used. The resistance of a material to change in any of its color characteristics, when subjected to washing is called color fastness to washing. In this investigation, Colorfastness to washing was evaluated by ISO 105 C06 (C2S): 2010 which is shown in Fig 3. From this figure, it is observed that turpentine oil provides good results (grade 4 in the case of cotton) when compared to silicone oil (grade 4.5 in the case of cotton) in terms of color change and stains on multi-fiber fabrics. This occurs due to the use of turpentine oil in the print paste, which maintains its proper viscosity.

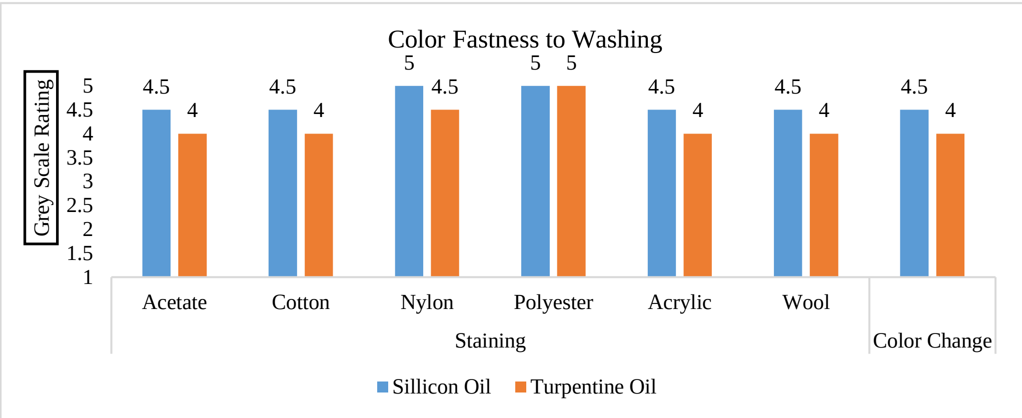

Fig. 3. Colorfastness to washing

3.2 Colorfastness To Rubbing

Crocking fastness is the migration of color from the dyed surface to another surface by intense contact, for example by rubbing. Crocking is the transfer of the colorants from the surface of the colored fabric or yarn to adjacent areas of the same fabric or the other fabric principally by rubbing. Under controlled conditions, the colored specimen is rubbed with the white test cloth. Color transfer to the white cloth is evaluated by comparison with the standard grayscale. In this research, colorfastness to rubbing was assessed using ISO 105 X12: 2016.

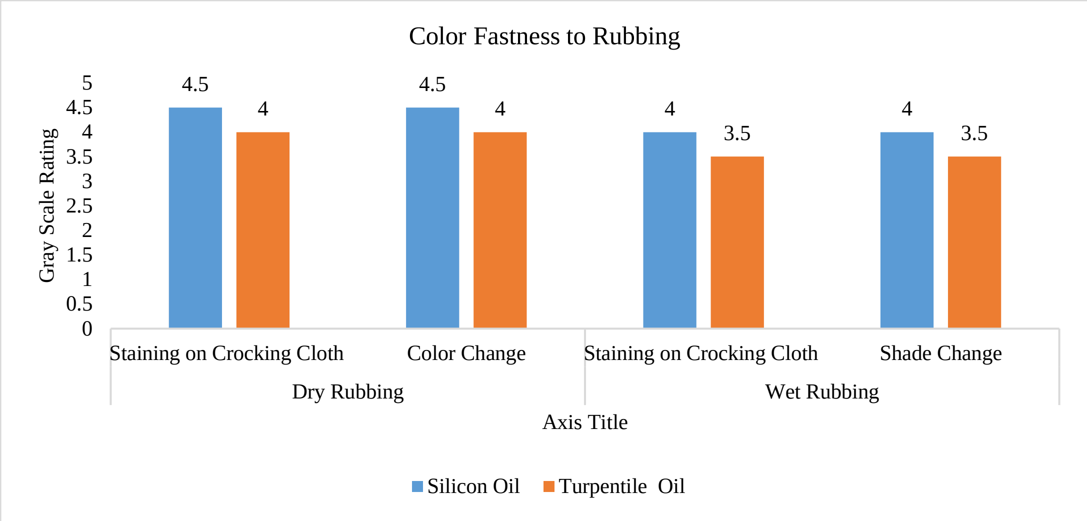

Fig. 4. Colorfastness to rubbing

In Fig 4, the colorfastness of the rubbing test result is analyzed and we see that turpentine oil provides good results (grade 4 for dry rubbing) when compared to silicone oil (grade 4.5 for dry rubbing) and provides satisfactory results (grade 3.5 for wet rubbing) when compared to silicone oil (grade 4 for wet rubbing). This is due to the resistance ability of turpentine oil against frictional exerted in the rubbing fastness tester. Color change grading for both dry and wet rubbing is also satisfactory for the rubbing of printed fabric.

3.3 Colorfastness To Perspiration

Perspiration from the human body is a complex chemical containing large quantities of salts. Depending on the human metabolism, it can be either acidic or alkaline. The tests for color fastness to perspiration are based on the solution prepared by simulating the acid and alkaline perspiration. The color fastness to perspiration refers to the ability not to fade and not to stain when the dyed fabric is perspired, and it is one of the main color fastness testing items of textiles. In this study, colorfastness to perspiration was assessed using ISO 105 E04: 2013 is represented in Fig 5. In this investigation, we discovered that turpentine oil provides good results for acidic sweat and the same results for alkaline perspiration when compared to silicone oil in terms stains on multi-fiber fabrics. This may occur due to the more resistance ability of turpentine oil against acidic sweet than alkaline sweet. Color change grading for both acidic and alkaline sweet are also satisfied for perspiration of printed fabric.

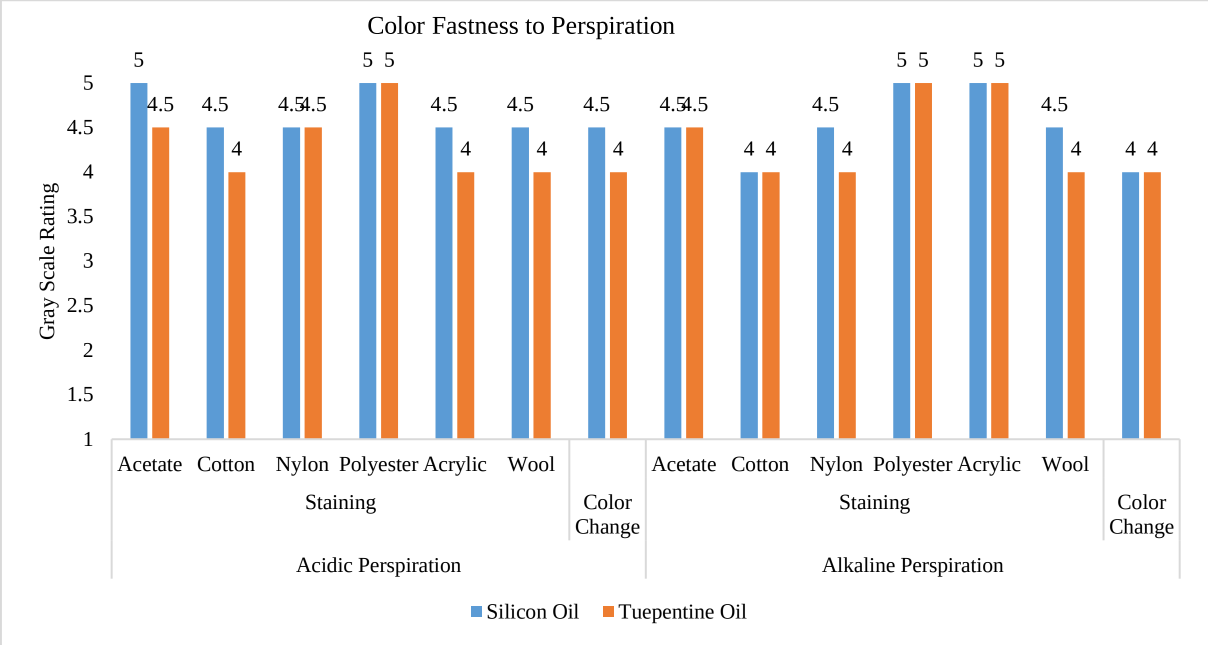

Fig. 5. Colorfastness to perspiration

3.4 Colorfastness To Saliva

Colorfastness to saliva is a measure of how well a dyed or printed textile material can resist fading or bleeding when exposed to saliva. Saliva is a fluid secreted by the salivary glands in the mouth and contains enzymes, electrolytes, and other substances. Colorfastness to saliva is an important factor when selecting clothing or other clothing materials for infants and young children, who may frequently lick or put items in their mouths. In this study, colorfastness to saliva was assessed by GB/T 18886: 2019.

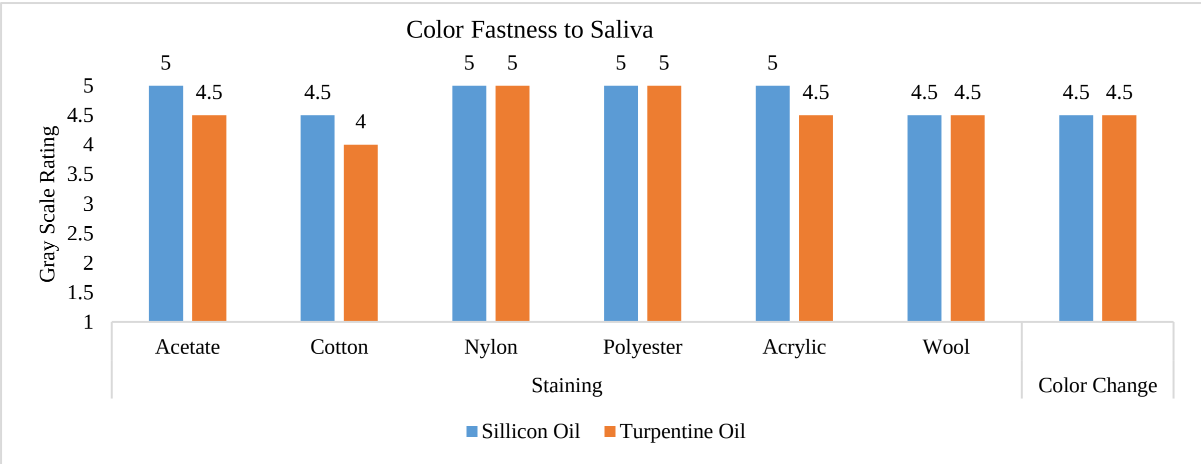

Fig. 6. Colorfastness to saliva

In Fig 6, colorfastness to saliva test result was analyzed. From this figure, we see that turpentine oil provides good results (grade 4 for cotton) when compared to silicone oil (grade 4.5 for cotton). Color changing grade for both turpentine oil and silicone oil are similar.

3.5 Colorfastness To Light

The light fastness test is conducted by exposing a textile specimen together with a set of blue wool references to artificial light under specified conditions and then comparing the two for color change to assess the color fastness. Textiles are often exposed to light when in use and light can damage dyes and thus cause discoloration, darkening, etc. In this study, Colorfastness to light was assessed using ISO 105 B02: 2014 is shown in Fig 7.

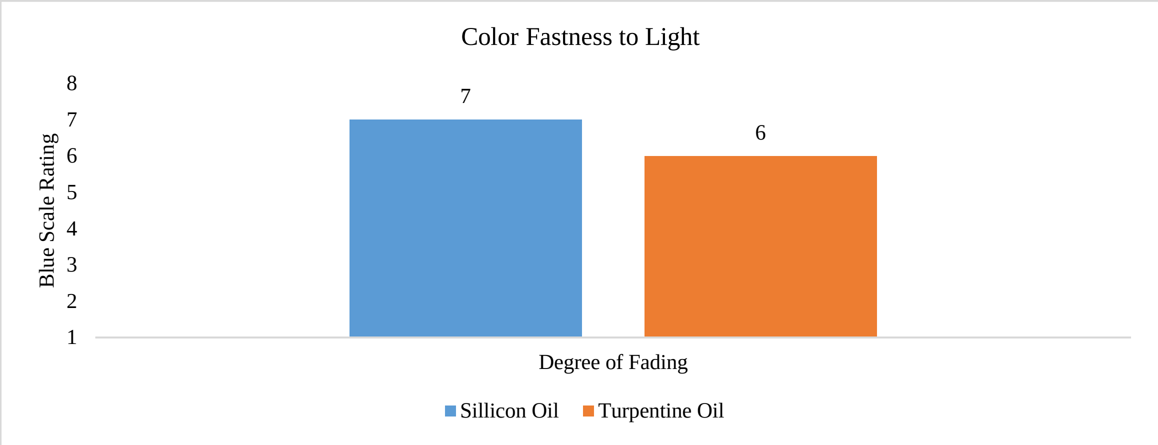

Fig. 7. Colorfastness to light

From this table, we observe that turpentine oil has a color fading grade of 6, which is acceptable when compared to silicone oil, which has a color fading grade of 7. This may occur due to the decomposition properties of turpentine oil when exposure to sunlight.

3.6 Smell Check

The meaning of smell is to perceive the odor or scent of through stimuli affecting the olfactory nerves. In this study, the smell of the printed fabric was tested by human nose. A kerosene-like smell is produced by fabric printed with turpentine oil.

Table 2. Smell check results

Parameter	Smell
Silicone Oil	No smell
Turpentine Oil	Kerosene-like

From table 2, it clearly seen that turpentine oil gives kerosene like smell. This smell may irritate some human being when wearing turpentine oil printed fabric. But, this smell can be easily removed by curing the fabric several times or exposing it to sunlight for 4-5 days.

3.7 Chemical Cost Comparison

Cost typically can be defined as the economic value placed upon the resources consumed to make a product. Costing is the process of estimating and then determining the total cost of producing a garment, including the cost of materials, labor and transportation as well as the general expenses of the operating the business. Silicone oil, which is an expensive substance, is commonly used in high-density printing. The cos comparison is represented in Table 3. From this data, we see the price of one kg of turpentine oil and silicone oil. We observed that turpentine oil is less expensive than silicon oil and saves around 10% on chemical costs which reduced the production cost and increased profit margin.

Table 3. Chemical cost comparison

Parameter	Price (TK/KG)
Silicone Oil	2000-2200 TK
Turpentine Oil	180-220 TK

4 CONCLUSION

A cost-effective alternative method of high-density printing on cotton cloth utilizing turpentine oil instead of silicone oil was developed in this research. Silicone oil has numerous applications in the textile industry but it is an expensive chemical. On the other hand, turpentine oil is less expensive in comparison to silicone oil. In our research, we discovered that turpentine oil produces comparable effects to silicone oil while having a 10% cheaper chemical cost. This reduced cost increased the profit margin of the industry while maintaining the required product quality. One restriction of our research is that turpentine oil has a kerosene-like odor. This odor may irritate some human beings while wearing the garments. But this odor can be erased by curing the printed cloth numerous times. It can also be removed by exposing the printed fabric to sunlight for 4-5 days. Further research may reveal any other odor elimination methods.

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