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Utilization of Textile Discharge Printing Principle in Creation of Artistic Patterns

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Abstract

Textile discharge printing classified as one of textile colouring styles; direct, resist and discharge styles. This style depends on printing via paste containing colour removal on a previously dyed fabric via dischargeable dye, to obtain a white or lighter colour.

This research aims to benefit from white discharge principle to give an aesthetic look on the cellulosic fabrics dyed with dischargeable dye. Experimental part was achieved to get the satisfied recipe for discharge printing on cotton fabrics via Rongalite C as reducing agent (40-80 g/k). Measuring the degree of whiteness and lightness of printed samples were examined. Also Sodium hypochlorite, as an oxidizing agent were used to obtain artistic patterns, were applied in lab class by the students of sixth semester of Art Department in Education College - King Faisal University in Al-Ahsaa – KSA. Direct painting, Tie & dye and Stencil are artistic techniques will be used to achieve this goal.

Keywords: "cellulosic fabric", "discharge", "dischargeable dye". "azo dyes".

INTRODUCTION

Textile printing is one of the most artistic, decorative, and versatile method applied to introduce fine patterns on textile fabrics. (12) (14) Both science and art combine to give a great aesthetic look to the printed fabric. (5) Textile printing styles involve three methods; i.e. direct, resist and discharge printing. (2)

The discharge printing methods are applied with reducing or oxidizing agents on fabrics that previously dyed with dischargeable dye. Discharging refers to the standard way of making small white or lighter motifs on a mono dark background. (4)

Discharge printing comprised two discharge classes; white and colour. White discharge printing defines as a kind of printing where the discharge printing pastes mainly contain colour removing agent, to obtain white or lighter colour.(4)(15) Whereas, colour discharge printing has moreover un-dischargeable dye, that has stability against discharging agent to replace the dyed colour with printed one.

PART 1: Experimental part

1. Materials:

1.1. Pure cotton fabric mill desized, kier boiled and bleached supplied by Misr/Helwan Co. for Spinning and Weaving; Cairo, Egypt.

Fabric Specification:

- Weight of square meter = 165 g/m2.

- The number of yarn / cm = 40 and 36 for warp and weft respectively.

1.2. British gum was kindly supplied by - The Egyptian Co. for Starch and Glucose.

1.3. Rongalite C ($NaHSO_2.C_2HO.2H_2O$) (Sodium sulphoxylate formaldehyde), as a reducing agent.

1.4. Sodium hypochlorite ($NaClO$), as an oxidizing agent.

1.5. Sodium chloride ($NaCl$).

1.6. Titanium dioxide (TiO_2).

1.7. Sodium carbonate (Na_2CO_3).

1.8. Hostapal CV-ET (non-ionic wetting agent)

1.9. Dischargeable dye, namely Reactive dye, Remazol Brilliant Red GG, kindly supplied by DyStar, Germany; its reactive centre is vinyl sulphone.

2. Methods:

2.1. Preparation of pure thickener pastes:

British gum thickener pastes were prepared at conc. 40% by soaking the thickener overnight in distilled water.

2.2. Dyeing of cotton fabrics: (13)

Cotton fabrics were subjected to exhaust dyeing via padding in a bath containing the following recipe for 60 minutes at 65° C:

Remazol dye (Brilliant Red GG)	10 g/l
Sodium chloride	50 g/l
Sodium carbonate	15 g/l

2.3. Preparation of the printing pastes: (13)

White printing pastes were prepared according to the following recipe:

Rongalite C	X g
Titanium dioxide	100 g
British gum 40%	400 g
Water	*440 g*
Total	1000 g

Where (X) = 40, 50, 60, 70 or 80 g/kg.

2.4. Technique of Printing:

The fabrics is printed via a manual flat screen technique.

2.5. Fixation:

The printed goods fixed via steaming for 7 minutes at 105°C.

3. Procedures:

To achieve the goal, dischargeable reactive dye, namely Remazol Brilliant Red GG was chosen. Cotton fabrics were dyed via exhaustion in a bath containing the previously mentioned reactive dye. After that, different white discharge printing pastes thickened with the British gum were independently prepared with Rongalite C as a reducing agent conc. 40, 50, 60, 70 and 80 g/k respectively.

The previously dyed cotton fabrics were printed using these pastes via screen printing technique. After printing and drying, the samples were subjected to steaming, followed by washing as previously mentioned.

4. Analysis and Measurements:

4.1 Optimization of concentration of reducing agent (Rongalite C):

Different concentrations of Sodium sulphoxylate formaldehyde (Rongalite C) i.e. 40, 50, 60, 70 and 80 g/kg. were examined to determine the suitable degree of whiteness and lightness for printed fabric samples.

4.2 Whiteness and lightness measurements:

The evaluation of Whiteness and lightness of the printed samples was achieved via high reflectance technique. Reflectance measurements of the printed samples were performed on ICS-TEXICON computerised spectrophotometer, model M 520220. (5)

These measurements were done in the Textile Printing Department, Faculty of Applied Arts, Helwan University.

5. Results and Discussion of experimental part:

5.1. Rongalite C as a reducing agent action:

Sodium sulphoxylate formaldehyde ($NaHSO_2.CH_2O.2H_2O$) is not a powerful reducing agent at room temperature. This is available as hard lumps (stone) and has to be powdered and then dissolved in cold water. If it is boiled to effect dissolution quickly, the following reaction takes place, as shown in scheme (1).

Scheme (1): $NaHSO_2.CH_2O.2H_2O \xrightarrow{\Delta} NaHSO_2 + CH_2O + 2H_2O$.

The separation of formaldehyde leads to the formation of sodium sulphoxylate ($NaHSO_2$) which is a very powerful reducing agent. This can liberate four nascent hydrogen atoms as shown in scheme (2).

Scheme (2): $NaHSO_2 + 2H_2O \rightarrow NaHSO_4 + 4H$

The liberalized nascent hydrogen is the active reducing agent.

5.2. Optimized Rongalite C concentration according white discharge measurements results:

Table (1): *Effect of Rongalite C concentration on the degree of whiteness of cotton samples printed via white discharge.*

Rongalite C conc.	**40 g/k**	**50 g/k**	**60 g/k**	**70 g/k**	**80 g/k**
Degree of whiteness	12.92	13.78	16.43	17.08	17.81

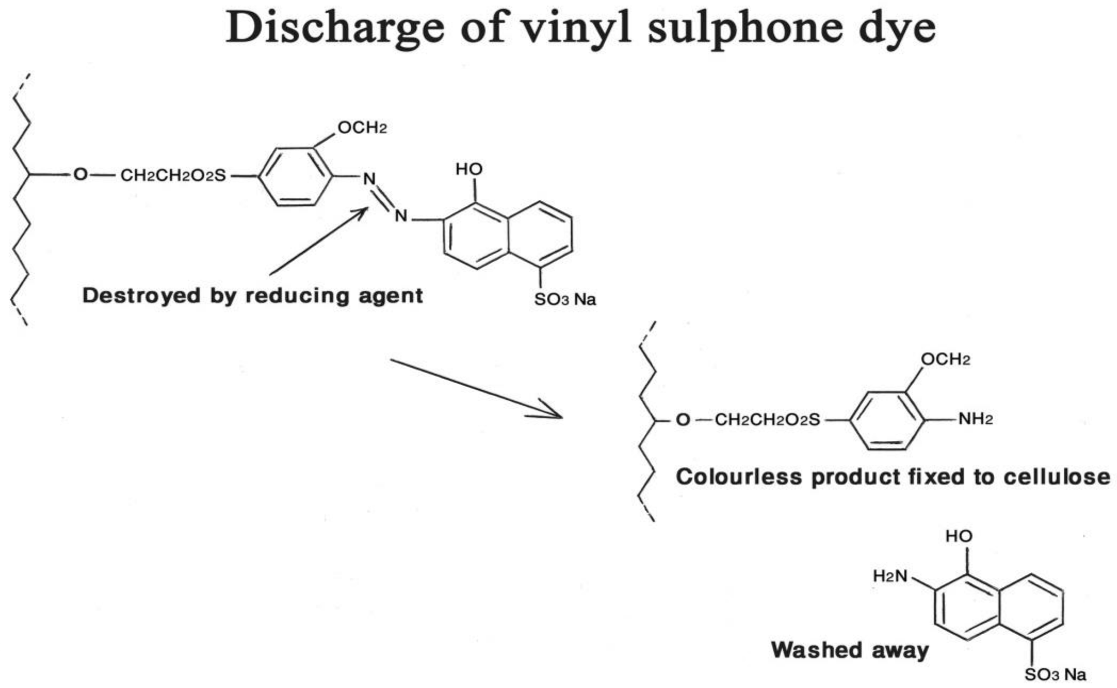
Table (2): *Effect of Rongalite C concentration on the degree of lightness of cotton samples printed via white discharge style.*

Rongalite C conc.	**40 g/k**	**50 g/k**	**60 g/k**	**70 g/k**	**80 g/k**
Degree of lightness	73.14	75.02	76.31	78.16	80.75

It is clear from the data of tables (1, 2) that, the degree of whiteness and lightness for the printed samples increases gradually by increasing the concentration of Rongalite C from 40 to 80 g/k. This may be due to the increasing of the free hydrogen atoms which reduce azo groups in Remazol dye. So, the highest whiteness and lightness of printed cotton fabrics was achieved using 80 g/kg of printing paste.

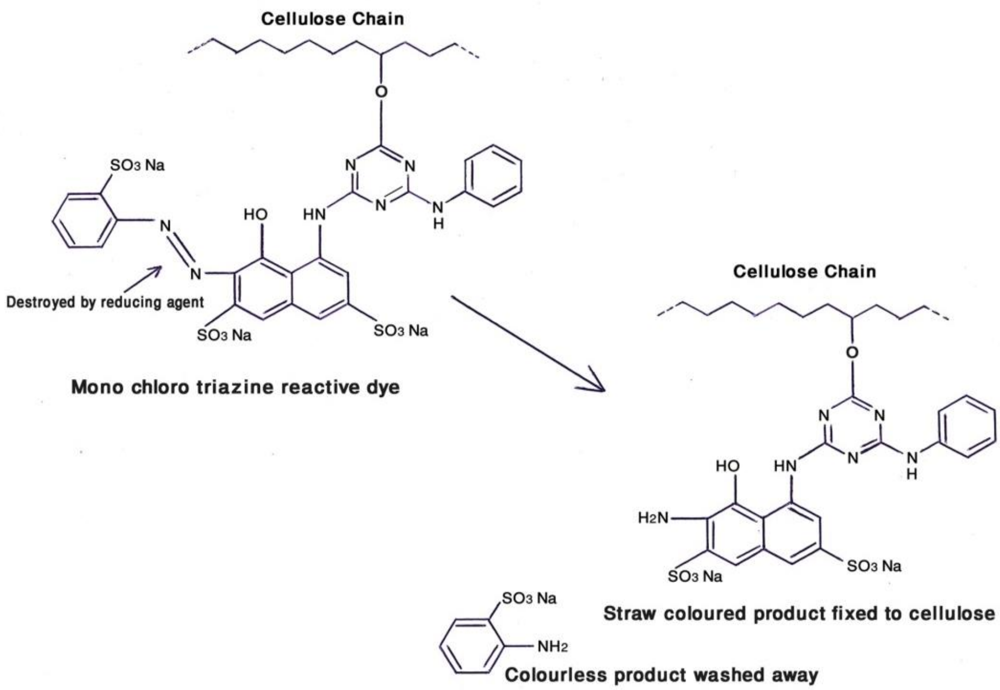
Also was known, according to the Remazol dye structure, it depends on azo groups (-N=N-) as chromophoric group, which is destroyed by reducing agent in essence the dye is cleaved into two parts. One part is removed by washing, but its reactive group still chemically bonds the other part to the cellulose.

So, with vinyl sulphone dyes, the reactive group is usually present in the diazonium half of the dye which is usually a small amine and therefore produces an uncolored residue chemically bonded to the cellulose as shown in Scheme(8). Vinyl sulphone dyes therefore give a full range of azo dyes that are dischargeable even in heavy shades. (1)



Scheme (3): *Discharge of Reactive Dyes (vinyl sulphone and mono chloro triazine).*

Whereas, with mono chlorotriazine and similar dyes, the reactive group is usually attached by a linking group to the large coupling component part of the dye structure. This means when the azo bond is broken, there is a colored –usually yellow or straw colored– decomposition product chemically bonded to the cellulose that cannot be removed.



Scheme (4): *Discharge of MCT (mono chlorotriazine) dye*

PART 2: Applied Part (Achieve Artistic Patterns)

According to the target of this paper to achieve artistic patterns, the principle of white discharge style was applied. Commercial Sodium hypochlorite as an oxidizing agent (more suitable in the class room application) was used instead of reducing agent which was utilized in the experimental part. This work was done as practical application of students at Art Education Department - College of Education - King Faisal University at the sixth level of the academic year 2020-2021, where they achieve them during study engraving and printing course.

1. Discussion of applied part:

1.1 White discharge via oxidizing agent:

The mechanism and success of white discharge in this case depends on the effect of discharging agents on chromophoric group of the dischargeable dye of the dyed fabrics.(4)(1) Simply, coloured compounds are components have unsaturated groups i.e. groups with multiple bonds. Oxidizing agents, discharge colours by removing hydrogen atoms containing in the dye colouring matter. Then discharge printed places could be converted into colourless compounds and the original colour could be restored.(8)

1.2 Action of oxidizing agent (Sodium Hypochlorite):

One of the most important oxidizing agent is sodium hypochlorite (NaClO). (15) (14) which is the active ingredient in liquid chlorine bleaches; the compound is usually made available as an aqueous solution. (4)(16) In solution form, sodium hypochlorite is quite stable and can be stored for long periods of time out of sunlight.

Commercially sodium hypochlorite (NaClO) is made by passing chlorine gas (Cl2) through a cold aqueous solution of sodium hydroxide (NaOH), as shown in scheme (5).

Scheme (5): Cl2 + 2NaOH → NaClO + NaCl + H2O (15)

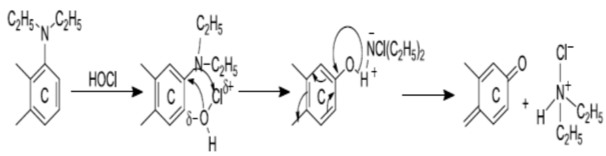
1.3 Mechanism of discharging of the dye compound with NaOCl:

The dye molecule consists of aromatic rings substituted with amino acid sulphonate groups. When sodium hypochlorite (NaOCl) is added to the aqueous dye solution, NaOCl dissociates and forms HOCl shown in scheme (6). (15) (16)

$$\boxed{NaClO + H2O \longrightarrow HOCl + NaOH}$$

Scheme (6): Behaviour of NaOCl in aqueous media (16)

According to a large difference in the electrochemical nature of oxygen and chlorine, the oxygen being more electronegative than chlorine, HOCl exists in ionic form as HO- Cl+ in water. (16) The Cl+ of HOCl reacts with dye molecule and this results in the cleavage of Car –N azo bond of the Car –N (CH2CH3)2 chromophore which facilitates -OH bonding at the electrophilic carbon atom of the Car –N (CH2CH3)2. As shown in scheme (7).

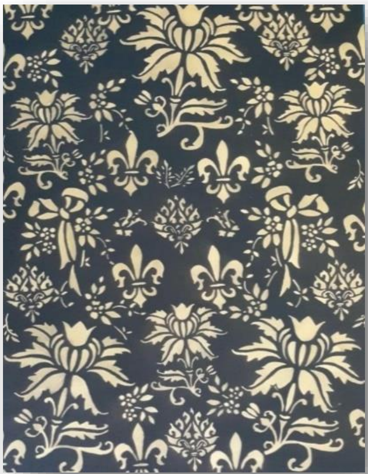
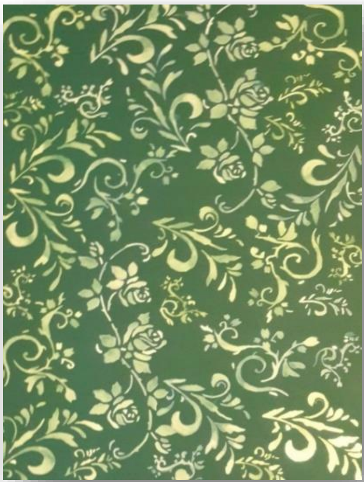


Scheme (7): Oxidative degradation of Car –N (CH2CH3)2 (16)

2. Artistic patterns techniques:

2.1 Stencil technique: regularly used to transform the printing paste on located stencilled design onto fabrics but in the application of this course, it was used to apply sodium hypochlorite through stencilled design onto dischargeable dyed T-Shirts and open width cotton fabrics.

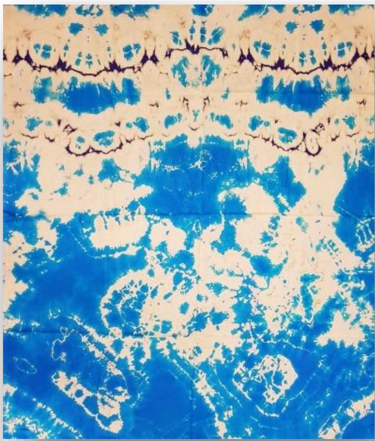





2.2. Tie & dye technique: known as artistic style of adding colour to the fabrics by fabric insulation during dyeing process via different ties. At this work, the dyed open width cotton fabrics and T-shirts were tied random then sprayed or immersed into locally oxidizing agent (sodium hypochlorite). Different discharging effects with different whiteness shades were achieved according to strength of tie and degree of insulation.









2.3. Direct painting technique: was used as another artistic way to apply sodium hypochlorite directly with brushes on determined places on dischargeable dyed fabrics and/or T-shirts for random blotches, drawings or sprayed dots. Some of pieces were applied with combined techniques direct painting and stencil printing in the same piece.

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