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# Recent studies for printing cotton/polyester blended fabrics with different techniques

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**Abstract**

APPLICATION of the paste containing the dyes to the required areas on the fabrics is designated as direct printing, consequently dyeing and steaming followed by washing to remove any residues. In pigment printing, the pigments and cured binder adhere to the fabric surface with the cured binder film. No further treatment is required. Direct printing is considered the most important printing. Fibers have been defined by the textile institute as units of matter which are characterized by fineness flexibility and a high ratio of length to thickness. Fibers are the basic unit from which all textile materials are made. Textile goods are manufactured from fibrous material which may be either of natural or man-made origin.

Keywords: Textile printing, cotton/polyester fabric, printing techniques.

## 1. Introduction

Textile printing is the practice of applying color to fibers in distinct patterns or designs with sharp outlines. In appropriately printed fibers, the color is tied to the fiber, so as to defend against washing and crocking. The selection of dyestuffs used depends on several factors including fiber chemical structure, in order to achieve fibers with acceptable colorfastness properties. Textile printing is the creation of color model or drawing on textile fabrics. [1-15]

Textile fibers with more than one type of fibers, synthetic or natural, are known as blend fibers. Blend fibers present the most important economic choice on raw material cost particularly if one of its components is relatively costly, or in order to build up a novel material with enhanced or particular properties, which cannot be afforded with fibers made from single fibers kind. Because of fibers different properties, there are limitless probabilities for the formation of countless blends of different properties such as polyester/wool and polyester/cotton. Fiber blends merge the advantage characteristics of two or more fibers into one fabric. They are accessible as blends of natural origin, synthetic origin, or natural fibers blended with synthetic ones. [16, 17]

The approval of polyester/cotton blended fabrics is increasing day by day because of their ease of use. Polyester has performance qualities, like wicking and quick-dry properties, so may be added to make the cotton absorb sweat better. On the flip side, polyester is not breathable and cotton is, so by blending the two materials, you can get a fabric that is both breathable and sweat-resistant. Thus, the selections of such fibers offer sufficient comfort level and better resistance due to the different properties of materials. [18]

Polyester and cotton blends, for instance, have become very important and wide spreading; the blend merges the softness and moisture absorption of cotton fibers with the dimensional stability, hard-clothing and anticrease performance of polyester fibers especially polyester/cotton mixtures in the ratios 50:50 and 67:33. The popularity of these blends comes out from the desirable balance of both physical and comfort properties for clothes, such as shirts,

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blouses and other outer clothing. Several techniques, dyes and dye combinations can be used for the printing of polyester/ cotton blends fabrics. Many variations and combinations have been applied and good results were obtained, but always there were some difficulties or undesirable complication. [19, 20]

**Printing Styles**

There are three basic styles to printing a colour on fabric namely: direct, discharge, and resist

**Direct Printing**

The most common style for applying a colour pattern is direct printing. It may be done on white fabric or over a previously dyed fabric, in which case it is called over printing. The dyes are usually dissolved in a limited amount of water to which a thickening agent has been added to give the necessary viscosity to the print paste. All pastes or printing materials contact the fabric surface with no subsequent processing alterations. [21]

**Discharge Printing**

The discharge style depends on dyeing the fabric first and then printed with a chemicals that will destroy the colour in designed areas. Sometimes the base colour is removed and another colour printed in its place but usually a white area is desirable to brighten the over all design. Thus in discharge style of printing, a readily reducible dye, say, azo dye, is dyed on a cloth and a reducing agent, is printed and the fabric steamed, when the dye at the printed portion is destroyed by the reducing agents. The final washing removes the dye decomposition products there by producing a white printed effect on a coloured ground. This is known as the white discharge style of printing. By incorporating a dye, which is not dischargeable by reducing agent, in the discharge printing paste and printing of the dyed cloth followed by steaming, a coloured printed effect on a differently coloured ground can be produced (coloured discharge style). [22-24]

**Resist Printing**

The resist printing style, as its name implies, comes from printing the material with a substance which will resist dyeing later. The dye will affect only the parts that are not covered by resist paste and hence produce a pattern on a coloured ground. Resist style are divided into chemical (those that employ agents such as glyoxal-bisulfite adducts or stannous chloride) and physical (those that use wax to block the fibre from being dyed). [8, 25]

Each of these printing styles used one or more methods of application described below:

**Printing Methods**

• **Traditional**
  - Block printing (wooden blocks with printing paste imprints fabric) .
  - Roller printing (fabric passes over engraved copper rollers, each containing a different colour).

• **Screen printing**
  - Hand, semi-automated and fully automatic screen printing; (silk fabric in a wooden frame serves as stencil through which the colourant is selectively transformed to a fabric in contact with the screen)
  - Rotary screen printing (continuous movement of the fabric has been achieved by moving the screen along with the fabric while printing.

• **Transfer printing:**
  - Colour is transferred from the surface of paper to surface of fabric.

• **Foam printing:**
  - Low wet pick-up method in which the dye is part of foam and applied to fabrics.

• **Digital "ink jet" printing:**
  - New printing method that is being evaluated for its commercial potential. [21, 26]

**Advanced researches in printing textile**

Tarek Abou Elmaaty et al. demonstrated one step thermochromic pigment printing and antibacterial functionality of cotton (100%) and cotton/polyester blend (50/50%) by including Ag-NPs (30 g/kg) into pigment printing paste followed by printing and microwave curing at 700 W for 5 min. Modes of interactions were proposed and surface modification was confirmed by SEM and EDX analysis. The results demonstrated that incorporation of the nominated Ag-NPs into thermochromic pigment printing paste is accompanied by an enhancement in colour strength, fastness properties values, along with a noticeable improvement in antibacterial functionalities. This simple and easy scaled up single step process can be applied to achieve functionalized textile products with outstanding performance and protection properties. [27]

Shekh Md. Mamun Kabir et al studied Jackfruit latex gum as a new binder in combination with synthetic binder for pigment printing on cotton and PET/cotton fabrics. The binder combination containing Jackfruit latex gum achieved a reasonable level of color strength, drape, softness, and fastness properties. The optimum pigment printing paste recipe and printing conditions were suggested from a series of experimental results. Considering both the overall pigment printing performance and environmental eco-friendliness effect, it seems feasible to use Jackfruit latex gum as a binder combination in the pigment printing process. Further studies are necessary before any definite conclusion can be drawn. [28]

NA Ibrahim et al. conducted a pretreatment of polyester-containing fabrics with chitosan, polyethylene glycol, N-methylol crosslinking agent (Arkofix NDW, DMDHEU) in the presence of MgCl2. 6H2O/citric acid as a mixed catalyst to enhance their printability with disperse dyes and upgrade their ultraviolet-protecting properties. The results showed that the changes in the depth of the obtained prints were governed by the type of substrate, chitosan concentration and steaming conditions. The suggested pretreatment resulted in a significant modification of the treated substrates via introducing of chitosan primary amino groups as well as PEG moieties onto and/or into the fabric structure, improving the extent of disperse printing as well as upgrading washing, rubbing and perspiration fastness properties of the obtained prints. SEM photographs revealed the deposition of chitosan on the treated fabrics. The type of substrate, PEG and disperse dye affect the depth of the obtained prints. Pretreatment has a significant influence on both the depth and UV-protection capacities. The highest UPF values appear with pretreated and disperse printed PET and PET/W fabrics, regardless of the used disperse dye. Chitosan and other additives can be used to improve printing properties and antibacterial functions of polyester-containing fabrics. [29]

Madiha Elkashouti et al improved fabrics printability using metal oxides nanoparticles. Polyester, PET, Cotton, Polyamide, and viscose were treated with different nanoparticle metal oxides (MgO, ZnO, and TiO2) with many ratios. The fabric samples were soaked for 10 min, then padded to wet pick-up 80%, dried at 60°C for 10 min, and then cured at 160°C for 5 min. The treated fabrics were printed by disperse dye red 60. The result showed that the color strength of treated fabrics significantly improved in comparison with untreated fabrics. Additionally, the mechanical performances of treated fabrics were also investigated.[30]

Ibrahim DF pre-treated Cotton/polyester blended fabrics were printed with kayacelon reactive/disperse dyes in one step process using slightly acidic medium (pH 6). Comparative study between enzymatic and alkaline treatments showed an improvement in color strength for printed areas. However, the environmental impact for both treatments differs in the way to green technology. The printing paste used with nearly neutral medium for fixing both dyes on the blended fabrics ensures the research aim. [31]

J.I.Abd-El Thalouth isolated Printing pastes containing eco-friendly galactomannan gum and safety natural dye simultaneously in one step process from tara plant seeds using sodium hydroxide solution. Technological evaluation of the obtained pastes was achieved via measuring the % loss in weight, K/S of the coloured area and tensile strength for the printed area. The results showed that all the isolated pastes are characterized by non-Newtonian pseudoplastic behaviour, and its apparent viscosity depends on the concentration of sodium hydroxide and also on the time of storing. The prepared pastes can be used as a screen printing and burn-out paste simultaneously. The % loss in weight increases by increasing sodium hydroxide concentration and/or the portion of wool in the blend. The K/S of the printed area depends on the nature of the component of the blend and is higher on protenic fabrics than that of cellulosic. Unique colour and attractive texture can be achieved using the current technique. Tensile strength decreases is not high and satisfactory for industrial application.[32]

S A Bahmani et al showed that pigment printing from a system containing only pigment, chitosan and acetic acid can be carried out to give prints of satisfactory colour fastness to rubbing, washing and light. The rheological behaviour of the chitosan paste was slightly different from the Alcoprint paste, but no difficulties or drawbacks were observed. The major problems with the chitosan system were the poor colour value and stiffness of the printed fabrics. Future work should confirm that higher colour values are possible and examine in detail the use of appropriate auxiliaries in chitosan pigment printing systems to reduce the fabric stiffness. [33]

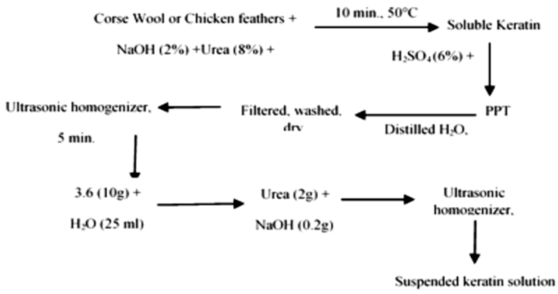
Lin Lu et al successfully prepared fluorosilicone modified polyacrylate/pigment hybrid latexes via one-step in situ emulsion polymerization. The effects of the weight ratio of D3F and D4 on the morphology and size of the miniemulsion, characterization of the hybrid films, and applications of textile pigment were investigated. The obtained FSi-PAcr/PB hybrid latex particles had a monodisperse micro-nano particle size in the range of 178.7 to 207.9 nm, and the hybrid latex film exhibited better hydrophobicity and easier migratory. WCAs on the printed PET fabric with the hybrid latex of FSi-PAcr/PB-0/1 attained 103.7 .The FSi-PAcr/PB hybrid latex printed fabric has improved dry and wet fastness, hand feeling, and air permeability compared to PAcr/PB printed fabric. The hybrid latex film can flow smoothly and cover the fabric surface discontinuously due to its lower surface energy and good flexibility. This one-step in situ strategy could be used to synthesize binder-free pigment colorant.[34]

N.S. Elshemy et al have successfully used modified alkyd resins from sunflower oil as binders in pigment printing pastes. They were characterized by non-Newtonian pseudo plastic behavior, weight loss, and water absorption. Microwave irradiation reduced reaction time to 45-60 min, while conventional heating caused separation of oil at 8-10 hr. Color strength and overall fastness properties of the prints were comparable or better than commercial binder.[35]

Shah et al., Also invented a type of binder, a polymer of dicarboxylic acid, a functional monomer, such as alkyl hydroxyl alkyl, a neuromonomer or monomer, and an emulsifier of phosphate esters, producing a printing media that improves performance and excellent redispersibility. The binder-printing tool is useful in producing pigment prints with good wet and dry amount, soft hand, and good stability for washing. The link of this invention does not require the presence of formaldehyde interlocking agents containing or generating such as N-methylol acrylamide. [36]

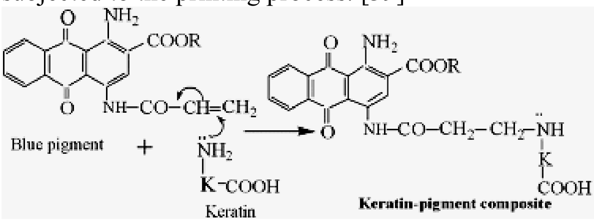
Hamilton and Chiweshe prepared a binder for textile pigment printing using modified gluten with methyl acrylate group. They used polyester/cotton (50:50)(35:65) fabrics, the 1st set (control sample) was printed with four printing pastes, the 2nd set was printed with a printing baste containing a combination from a prepared modified binder with the commercial one by using two different dyes. The results showed that the addition of gluten prepared modified binder had good water, solvent, perspiration, and lightweight resistance, poor to rubbing fastness, increased stiffness, increased viscosity, and had good pigment print paste binders for textiles. Rheological properties, Tg, FTR, fixation factors, and color strength (K/S) of every printed area were also tested.[37]

Keratin was used to prepare an ecofriendly binder used in pigment printing of textile fabrics. a flow chart for preparation of keratin-based binder from raw material . The prepared keratin-based binder is eco-friendly and cost effective. It was successfully utilized in pigment of polyester, polyacrylonitrile, viscose as well as polyester/viscose, and polyester/acrylic blends. This binder is a benign alternative to the commercial synthetic binders which are conventionally used in pigment printing of textiles. The chemical, physical, and thermal characteristics of the synthesized binder were evaluated and compared with the commercial one. The effect of the used binder on the color strength (K/S), and the bending stiffness of the printed area of each fabric, and their fastness properties were evaluated. [38]




Schematic diagram for preparation of keratin-based binder

The highest K/S values and fastness properties of the pigment-printed samples using keratin-based binder were obtained upon using crosslinker such as glutardialdhyde. For the same printing operation, the K/S values of the printed fabrics using keratin-based binder are similar to those obtained upon using commercial binder. All printed fabrics exhibit good fastness properties to light, wash and perspiration. The rheological measurements of the printing pastes containing keratin-based binder revealed that this type of printing paste pastes are a non-Newtonian pseudoplastic. The water absorption of the keratin based binder film is higher than that of the commercial binder. Keratin macromolecule can bind with M. D. Blue pigment via Michael addition reaction between the electron donor amino group of keratin and the electron acceptor olefinic double bond in the said pigment. The carboxylic and amino groups along the keratin macromolecules are the reactive sites which can bond with the textile substrate subjected to the printing process. [39]




N.A. Ibrahim et al carried out Pretreatment of wool/polyester blend fabric with monochlorotriazinyl b-CD for modifying the wool component to be able to form ‘‘host–guest” inclusion complexes with disperse dyes during the subsequent disperse printing step thereby leading to union disperse printing. The optimum sequence/conditions of treatment based on the data obtained were: padding of the blend fabric with an aqueous formulation composed of monochlorotriazinyl b-CD (60 g/L), Fixapret_ ECO (20 g/L), citric acid (5 g/L), PEG-600 (10 g/L), wet-pickup (70%), thermofixing at 120 _C/5 min, thoroughly washing, drying, followed by postprinting with disperse dyes and finally steaming at 140 _C for 30 min. Our experimental results reveal that fixing of the used monochlorotriazinyl b-CD onto and/or within the wool component has modified its structure thereby increasing its ability to pick-up, adsorb aswell as to retain the guest disperse dye vapors into its grafted hydrophobic cavities, which in turn resulted in attaining union-disperse printing with deeper shades and remarkable fastness properties. As a result of inclusions, the obtained prints exhibit excellent UV-protecting functions. The surface morphology has been studied using SEM micrographs. [40]

Ali A. Zolriasatein treated cotton/polyester blend fabrics with ultraviolet light (UVB) at an air pressure of 1 atm to improve printability. Experiments were carried out at different exposure times. Untreated and UV treated fabrics were analysed by Fourier-transform infrared spectroscopy to investigate changes in the chemical composition of fabrics. It was observed that carbonyl groups were formed on the surface of UV pretreated cotton fibers. Scanning Electron Microscopy (SEM) was used to investigate the roughness and cracks on the treated fiber surface. Then, all UV treated and untreated fabrics were screen printed with different kinds of pigments. The color strength of the printed fabrics and fastness properties to washing and dry/wet rubbing were evaluated. Experimental data showed that atmospheric UV pretreatment led to an increase in pigment uptake. Moreover, UV pretreated fabrics had better dry and wet rubbing fastness compared with untreated fabrics. The washing fastness of UV pretreated fabric showed no significant change and was comparable with that of untreated fabric. The loss in tensile strength of UV pretreated fabrics was greater than untreated samples. [41]

S. H. Nassar carried out pretreatment of polyester, polyester/ cotton blends 50/50, and 65/35 using seven different organic solvents and subsequently printed with disperse or disperse/reactive dyes. The same organic solvents are also incorporated in printing the same substrates to compare their effect in pretreatment and printing on the K/S values of the prints. Optimum results are obtained on using glycerol, dimethyl sulfoxide, and dimethyl formamide in pretreatment of polyester, polyester/cotton 65/35, and polyester/cotton 50/50, respectively, as increases of the K/S values of the prints are obtained by 35.40, 27.71, and 33.07% compared with the untreated fabrics printed under the same conditions. Incorporation of the same solvents in the printing paste enhanced the K/S of the prints with lower degree, because it increased the K/S by 30.93, 20.72, and 25.72% on printing polyester, polyester/cotton 50/50 and 65/35, respectively. These results are due to the dissolution of dye molecules and swelling effect of the plasticizers/ organic solvents, also decreasing the Tg of the fabric. The use of organic solvents increased water absorption of the pretreated unprinted fabrics by 20, 40, and 50% for polyester, polyester/cotton 50/50, and 65/35, respectively, while it has a reverse but limited effect on the tensile strength of the same fabrics. It could be concluded that incorporation of glycerol, dimethyl sulfoxide, dimethyl formamide in the printing pastes of polyester, polyester/cotton 50/50, and polyester/cotton 65/35 gives the best results in K/S and minimizes many problems of common occurrence in printing. [42]

Four different blended fabrics which comprised polyester/viscose (50/50), wool/cotton (50/50), wool/cotton (30/70) and cotton/linen (50/50) were subject to burn-out printing style using different agents. The latter comprised different concentrations of aluminum sulphate, sodium mono hydrogen phosphate, aluminum potassium sulphate, sodium hydroxide, tartaric acid, oxalic acid and citric acid. The burn-out printed blends were subject to dyeing using an eco-friendly natural dye, namely madder. The results obtained were evaluated via measuring the percentage (%) loss in weight, the K/S of the colored samples as well as the overall color fastness properties. The results revealed that the loss in weight was dependent on (a) the nature of the blend components, (b) the nature of the burn-out reagent, and (c) the concentration of the used reagent. The dyed burn-out areas were found to have a higher or lesser K/S than that of the ground shade. Hence, different color tones could be obtained which reflect attractive and beauty features. The overall color fastness properties for the blended fabrics printed before and after the burn-out treatment were nearly identical. Salts of inorganic acids (i.e. aluminium sulphate, sodium monohydrogen phosphate and aluminium potassium sulphate) cause a percentage loss in weight which follows the order of polyester / viscose > cotton / linen > wool / cotton (30-70) > wool / cotton (50-50), irrespective of the concentration of the burn-out material. Sodium hydroxide is a strong alkali and can burn out the protenic fabric.

The blended fabrics were subject to printing using colorless burn-out printing paste prepared according to the following recipe:

| | |
|---|---|
| Burn-out agent | x g |
| Glycerol | 80 g |
| Meypro Gum (8%) | 500 g |
| Water | y g |
| Total | 1000 g |

Therefore, the most affected blend was the one which had a high percentage of protein i.e. wool/cotton (50-50) followed by wool/cotton (30/70), polyester/viscose (50-50) and ended by the cellulosic blend (i.e. cotton/linen (50/50)). Irrespective of the nature of the burn-out material used, increasing the concentration of the chemical used was accompanied by an increase in the percentage loss in weight. Higher or lesser K/S values than those of the ground shade, while the overall colour fastness properties were nearly the same.[43]

Samiha M Abo El-Ola et al finished and transfer printed of polyester blended fabrics against bacteria and UV radiation. A mixture of DMDHEU and Sanitized® T99-19 is optimized as functional finishing for different types of fabrics using a simultaneous pad–dry–curing/transfer printing. It was concluded that the maximum antibacterial activity was obtained at 25g/L DMDHEU, and further increases in its concentration decreased the activity of finished fabrics against bacteria as well as the color strength of the printed area. On the other side, the crease recovery angle improved with increasing DMDHEU concentration. Increasing temperature up to 180○C improved both the antibacterial activity as well as the color strength of the printed fabrics. Crease recovery angle of finished wool/polyester fabric was not affected by increasing DMDHEU concentration in the finishing mixture. It was found that after 20 washing cycles, about 40% of the antibacterial efficiency was retained against gram-negative bacteria of finished cotton/polyester 50/50. For cotton/polyester 33/67 fabric, the antibacterial activity against gram-negative and gram-positive bacteria was retained at 38.7% and 33.3%, respectively. For wool/polyester 40/60, the percentage of antibacterial efficiency was retained at 37.5% and 25% for gram-negative and gram-positive bacteria, respectively. UPF values of finished (cotton/polyester 50/50 and wool/polyester 40/60 blended fabrics) were increased and showing enhancement in UV protection rating achieving excellent protection category compared with the absence of UV absorber. [44]

E. S. Abdou et al used Chitosan, a naturally available biopolymer which is now increasingly used as a functional finish on textile substrates to impart antimicrobial characteristics and increase dye uptake of fabrics, was blended with different ratios of gelatinized starch. the chitosan was extracted and characterized by IR, 1H-NMR, and X-ray powder diffraction. These blends were tested as thickeners in textile screen printing using *Curcuma tinctoria* as natural dye. The rheological properties and the viscosity of the printing paste were measured. The effect of chitosan on the printing properties of different fabrics (natural, blends, and synthetic fabrics) was studied by measuring the color strength value (K/S) and related color parameters of the printed fabrics. The antimicrobial properties of printed fabrics were assessed. The results proved that the printed fabrics using these new thickeners showed increase in the color strength value (K/S) giving darker color which means that chitosan increased the dye uptake on fabrics. Fastness properties of the printed fabrics to washing, rubbing, perspiration, and light have also been improved. The treated fabrics were found to be antimicrobial. [45]

S.A Bahmani et al has examined The use of chitosan as a combined thickener and binder in pigment printing in comparison with a commercial printing system (Alcoprint). Printing pastes made up from mixtures of chitosan, pigment and acetic acid at the appropriate viscosity gave satisfactory prints on polyester and 67:33 polyester/cotton woven fabrics. Rheological data showed the chitosan pigment paste had a much lower yield point than commercial printing paste though no difficulties were found in its use. Curing of the chitosan print at 150 °C for 6 min gave samples of comparable colour fastness to the commercial printed samples when subjected to the rubbing and washing tests. The only drawbacks noted in using chitosan in this way were a reduced colour yield and much higher fabric stiffness. The major problems with the chitosan system were the poor colour value and the stiffness of the printed fabrics. It is believed that the former occurred because of reduced stability of the pigment dispersion at pH 4. Future work should confirm that higher colour values are possible and examine in detail the use of appropriate auxiliaries in chitosan pigment printing systems to reduce the fabric stiffness. [45]

**Conflicts of interest**

There are no conflicts to declare

**Funding sources**

There is no fund to declare

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# دراسات حديثة لطباعة الاقمشة المخلوطة قطن/بوليستر بتقنيات مختلفة

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**الملخص**

يتم تعيين تطبيق العجينة التي تحتوي على الأصباغ على المناطق المطلوبة على الأقمشة على أنها طباعة مباشرة ، وبالتالي الصباغة والبخار متبوعة بالغسيل لإزالة أي بقايا. في طباعة الصباغ ، تلتصق الأصباغ والموثق المعالج بسطح القماش باستخدام فيلم الموثق المعالج. لا حاجة لمزيد من العلاج. تعتبر الطباعة المباشرة أهم طباعة. تم تعريف الألياف من قبل معهد النسيج على أنها وحدات من المادة تتميز بمرونة النعومة ونسبة عالية من الطول إلى السماكة. الألياف هي الوحدة الأساسية التي تصنع منها جميع المواد النسيجية. يتم تصنيع السلع النسيجية من مواد ليفية قد تكون إما من أصل طبيعي أو من صنع الإنسان.

***الكلمات الدالة:*** المنسوجات الذكية ، تقنية النانو ، الملابس الرياضية ، المنسوجات التقنية ، الأقمشة الواقية