J. Text. Color. Polym. Sci., **Vol. 20,** No. 1, pp. 57-65 (2023)

Journal of Textiles, Coloration and Polymer Science

https://jtcps.journals.ekb.eg/

Potential Application of Natural Gums Suitable as Thickeners in Textile Printing

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Abstract

Of all the methods used to adorn textile materials today, printing is the most important. It is a well-known method applied in the textile business to improve the fabric's visual appeal and satisfy consumer preferences. Printing is primarily a sort of colouring in which a specific region rather than the entire fabric is coloured. During the printing process, thickeners are employed to limit the amount of colouring material on the pattern. The usage of artificial thickeners in the printing industry has a number of negative environmental implications. Therefore, in this study, we focused on using several environmentally friendly natural gums as thickeners to minimise the effects on the environment. Experimental results demonstrated that native and natural thickeners such as neem, almond, and arabic gums may be utilised successfully in fabric printing.
Keywords Thickener, Neem gum , Almond gum , Arabic gum

Introduction

In a society where tastes and fashions vary quickly between generations, printing is now the most notable procedure used to adorn textile materials. A piece of woven cloth may have a variety of patterns added to it utilising the skill of printing by employing magnificent, vivid colours. These printed pieces, which feature several recognisable current prints, were inspired by early global civilizations. [1]

The wet processing industry branch known as textile printing is gaining popularity as a technique for various types of fibres, textiles, and apparel. Fundamentally, printing is a form of colouring in which a specific portion of the cloth is painted with colour as opposed to the entire piece. The multicoloured patterns that emerge offer lovely and artistic qualities, raising the fabric's value over that of plain dyed. The colouring material is plastered with the aid of a thickening agent to keep it inside the design area. A successful print requires the right colour, a precise mark, levelness, a competent hand, and effective dye application. The kind of thickener being utilised affects each of these variables.

Thickeners are high molecular weight viscous chemicals that when mixed with water form a sticky paste and provide the printing paste its stickiness and flexibility. These thickeners make it easier to keep the design outlines intact and prevent them from spreading even under intense pressure. Thickeners are mostly used in the textile industry to retain or cling dye particles to the appropriate fabric locations until the dye transfers to the fabric surface and its fixation process is complete. A thickener will give the printing pastes the necessary viscosity, stop the chemicals from reacting too early, and assist the constituents of the printing paste adhere to the textiles. The thickener needs to be stable and agree with the utilised dyes and colouring aids.

A natural or artificial polymer may be used as the thickener. The usage of artificial thickeners in the printing industry has a number of negative environmental implications. However, this impact can be reduced by substituting environmentally beneficial natural thickeners for synthetic ones. [2]

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(Received 02/1/2023, accepted 21/1/2023)
DOI: 10.21608/JTCPS.2023.185110.1153

The sources of natural thickeners are widely dispersed across the plant world and are readily accessible to a significant degree.Natural thickening ingredients have no health risks to humans and are neither allergic nor poisonous to them. The most important need for thickeners in textile printing is that they either dissolve in water or absorb water to create a viscous solution.

As thickeners, we have employed in our work naturally occurring, widely accessible gums from plants cultivated around our institutes. Neem, almond, and Arabic gums are used as thickeners in textile printing. [3]

Natural gums

Neem gum

Azadirachta indica gum: Azadirachta indica, sometimes referred to as neem, is a modern-day wonder tree that is evergreen. Indians have utilised it for a variety of reasons from the beginning of time thanks to its wide qualities. It has cytotoxic, anti-inflammatory, antiviral, anticarcinogenic, and antibacterial effects. Nimbidin, Nimbin, Nimbolide, Azadirachtin, Gallic Acid, Epicatechin, Catechin, and Margolone are the phytochemical components found in Neem. A powerful antibacterial agent, azadirachtin is the main active component.

Neem gum typically exudes from Neem trees as a result of artificial or natural damage. Neem bark has antimicrobial and deodorising properties. The Neem bark emits a visible, strong, brown-colored gum material that dissolves in cold water and is produced by a variety of internal processes. The gum is a multipurpose product. The gum that Azadirachta indica tree stems exude is made up of a combination of proteins and polysugars. It is known that Azadirachta indica gum contains D-glucose, D-glucoronic acid, L-arabinose, L-fucose, mannose, xylose, rhamnose, D-glucosamine, aldobiuronic acid, serine, threonine, and aspartic acid. Furthermore, it includes organic fatty acids. [4, 5]

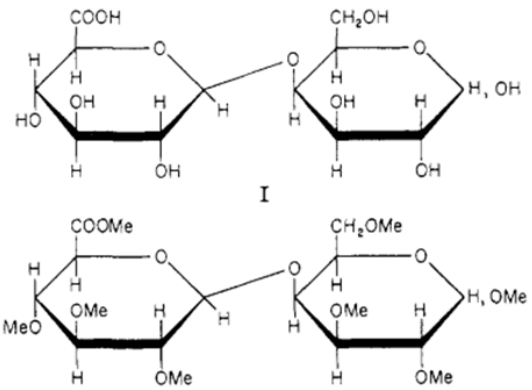

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Figure 1: Chemical Structure of Neem Gum

Collection and purification of neem gum

Neem gum (NG) was gathered in the Indian state of Maharashtra, in the town of Shirpur.

After being cleaned, dried, and ground into powder, the neem gum tears were sent through sieve #120. A mixture of 100 g of powdered undersized particles and 500 mL of distilled water was combined and let to settle for 24 hours. After boiling for an hour at 40 °C, the mixture was placed aside to cool for two hours.

After two hours, it was filtered, and the filtrate was then mixed with the same amount of ethanol and refrigerated for 24 hours at 8 to 10 °C. Further, dried and stored pure NG as precipitate for later use [3].

The neem plants in the area of Shirpur were used to harvest the neem gum's tears. By first dissolving in hot distilled water and then precipitating in alcohol, the powdered gum was cleaned. A 96% weight-to-weight yield of gum was discovered.[6]

Preparation of modified cross-linked neem gum

By distributing the pure NG (9 parts) in purified water, the colloidal solution of refined NG was created (10 parts). Purified water (40 parts) was used to dissolve the combination of urea (1 part) and calcium chloride (1 part), which was then heated to boiling. The prepared NG solution was added while boiling and stirred for 20 minutes to create NG cross-linking. The resulting crosslinked polymer was dried in a thin layer at 85 °C for 6 to 8 hours on a stainless steel plate. For further research, the dry polymer was ground into a powder and run through a mesh size of 120**.** [7]

The gums are polysaccharides made up of oxidised sugar and polymers of sugar that are joined together by glycosidic linkages. The gum's physicochemical characteristics can be changed by cross-linking it with urea. A hydrophilic, water-swellable polymer called gum—urea (carbamate) is created when the gum, or sugar, interacts with urea.

Modification of neem gum

Modified cross-linked neem gum was created using a chemical procedure including urea and calcium chloride. The creation of carbamates, a gum urea polymer, is the outcome of the reactions between polymerized sugars and urea. The resulting reactions are as follows:

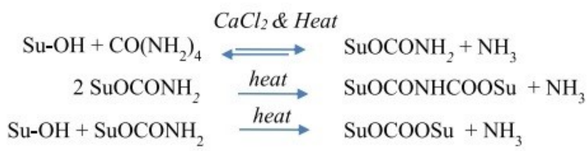

Figure 2: The creation of carbamates the gum sugars are represented by Su-OH.

Using calcium chloride as a treatment, gum urea was cross-linked. Calcium chloride is a typical method for creating cross-linked sugars, just like in polymer chemistry. Cross-linked polymers commonly expand and create gelatinous matrices, increasing the viscosity of the medium and making it appropriate for formulations like controlled release, emulsion, and suspension, just like in water and aqueous fluids.

Physicochemical study

Physical and chemical analysis of NG and MNG revealed that they were both brown in colour and had a mucilaginous taste and smell. It is discovered to be soluble in water while being insoluble in ethanol and chloroform. The additional metrics for the mucilage include the determination of total, acid-insoluble and water-soluble ash, moisture content, and swelling index (Table 1).

Table 1: Solubility behavior and physicochemical properties of NG and MNG.

Table 1 Solubility behaviour and physicochemical properties of NG and MNG

Parameters	NG	MNG
Solubility		
Water	Soluble	Soluble
Alcohol	Insoluble	Insoluble
pH 1.2 HCl buffer	Soluble	Colloidal
pH 7.4 phosphate buffer	Soluble	Insoluble
Physicochemical properties		
Moisture content	4.5% w/w	7.5% w/w
Ash value	3.2% w/w	6.8% w/w
Acid insoluble ash	0.1% w/w	0.5% w/w
Swelling factor	5	6
pH (0.1%)	Acidic	Alkaline

Determination of viscosity of suspension

The Brookfield synchroelectric viscometer was used to measure the effects of NG and MNG concentration on the viscosity of suspension at 25 °C and 100 rpm (spindle number 4). Within 24 hours after preparation, the viscosity of the suspensions was determined The outcomes are presented as the three decisions' mean.[8]

Determination of flow rate

The flow rates were calculated as the amount of time needed to convey a 10 mL suspension through a normal 10 mL pipette.[9]The average of three determinations is used to express the findings.

$$\text{Flow rate} = Vs/T$$

where T is the time (s) needed for the 10-mL suspension to elute out of the pipette, and Vs is the total volume of suspension in the pipette (mL).

Results: Neem gum collection and purification The neem plants in the area of Shirpur were used to harvest the neem gum's tears. By first dissolving in hot distilled water and then precipitating in alcohol, the powdered gum was cleaned. A 96% weight-to-weight yield of gum was discovered.

Almond gum

Over the past few decades, numerous plant gum exudates have been found. Gum arabic, gum ghatti, gum karaya, and tragacanth gum are common examples of this group. These organic gums, which are released by trees and bushes, solidify when they are exposed to air and sunlight, which causes them to become lumps, tears, and semisolid nodules. Exudation is not a phenomenon that occurs in typical trees. It is an absolute reaction, nevertheless, to the stimuli of an altering external environment.[10] Gummosis is the term for the exudation of gums in reaction to biotic and abiotic stresses such as infection, insect assault, mechanical injury, or chemical harm. Therefore, the defence mechanism to seal wounds, infection sites, or tree injuries results in the production of these exudates. Different regulating parameters, such as tapping intensity, rainfall, and temperature, have an impact on gum output. High temperatures lead to an increase in gum production. By slicing the bark or removing it off the tree or shrub, yields can be boosted. researchers discovered that the almond gum they isolated from P. amygdalus was a natural source of antioxidant and antibacterial properties.[11, 12]

The rosaceae family includes the almond (Prunus dulcis), which is a native of central Asia (Iran, India, and Pakistan). (11)It is mostly grown in India to produce nuts or as an orname. It is geographically spread across the states of Jammu & Kashmir and Himachal Pradesh and is known as Badam in the Indian subcontinent. Anti-inflammatory, antioxidant, and anti-cancerous effects are known to exist in natural polysaccharides.[13, 14]

As a result, food scientists are increasingly looking for novel sources of biopolymers that may be applied in the food sector.

Almond gum has been discovered as an unique gum in this regard; it is an exudate obtained from the trunk, branches, and fruits of the almond tree and has potential for extensive use in the food and related sectors. Gums and mucilages are employed in lithography, textiles (as a die thickening), and cosmetics.

Almond gum has gotten less attention in India, resulting in complete loss of this exudate. It is widely referred to as Badam in the Indian subcontinent and is geographically dispersed throughout the states of Jammu and Kashmir.

The state has the capacity to create sizable amounts of this gum, which might expand the range of applications for it in textile printing.

This organic polysachharide is almost colourless, odourless, and safe. On a dry weight basis, proteins (2.45%), lipids (0.85%), and carbohydrates (92.36%) make up the natural polymer known as almond gum. Arabinose (46.83%), galactose (35.49%), and uronic acid (5.77%) make up the majority of the carbohydrates, with traces of rhamnose, mannose, and glucose. Additionally, a variety of minerals, including as sodium, potassium, magnesium, calcium, and iron are abundant in the gum exudate. Gum Arabic cannot compare to it in terms of emulsifier power, and it is a known antioxidant and antibacterial.[15]

Although both almond and Arabic gums are classed as arabinogalactan polysaccharides, arabinose predominates in almond gum, whereas galactose predominates in arabic gum (galactose is 44% and arabinose is 27%). Almond gum is different from arabic gum in that it contains mannose, glucose, and xylose, while these sugars are absent from arabic gum. [16, 17]

In Budgam, Jammu and Kashmir, India, throughout the month of August 2015, fresh almond gum nodules were gathered by hand-picking from several almond trees (Prunus dulcis).

Extraction Procedure

Purchasing almonds (Prunus dulcis) at a local market in Greater Noida, India. The gum was meticulously cleaned, dried for 24 hours in the shade, and then dried again for another 30 to 40 hours to get a steady weight. Size was decreased using a grinder. gum powder was put into an airtight container after passing through filter number 22. Gum extraction required three processes: [18]

Step 1: Extraction of Gum

First, the gum was extracted by adding powdered fruit to a 1000 cc beaker containing 500 ml of distilled water, which was then heated and agitated constantly for around 4 hours at 60 °C. The concentrated solution was chilled at 4°C–6°C after being filtered through muslin fabric. [19, 20]

Step 2: Isolation of Gum

The gum precipitated after the extract was added to ethyl alcohol. This made it possible to filter water via muslin fabric. Precipitated gum has been filtered through muslin cloth after being washed with ethyl alcohol. Gum was further dried in a hot air oven at 35–45°C to a consistent weight. A sieve was used to ground and separate the hard gum cake.[21]

Step 3: Removal of Oil from Almond Gum

For 4-5 hours, extracted almond gum was maintained in petroleum ether. The petroleum ether solution mentioned above was filtered using muslin cloth or Whatman filter paper, and the filtered gum was dried in an oven at 45°C. Powdered dried polymer was kept in a dessicator for future research.[22]

Physicochemical Characterization of Almond Gum

Aqueous extract was combined with Molish's reagent and then sulfuric acid was added. At the intersection, a violet colour ring emerged, indicating the presence of carbs.[20, 23]

Determination the Purity of Almond Gum

Tests were done for alkaloids, proteins, gum, lipids, tannins, and amino acids to determine how pure the extracted gum was. [18, 20]

Organoleptic Evaluation of Isolated Gum

Organoleptic characteristics of the isolated gum were assessed, including colour, flavour, aroma, fracture, and texture. [20]

Ash Values

Equations 1, 2, and 3 were used to calculate ash values such as total ash, acid insoluble ash, and water-soluble ash, respectively.[23]

$$Total\ ash\ value = \frac{weight\ of\ ash}{weight\ of\ ploymer} \times 100$$

$$Acidin\ solubleash = \frac{weight\ of\ acidib\ solubleash}{weight\ of\ dried\ powder} \times 100$$

$$Water\ solubleash = \frac{weight\ of\ water\ solubleash}{weight\ of\ dried\ powder} \times 100$$

Solubility Behaviour

Other solvents were mixed with dry gum powder to assess its solubility. [23]

pH of Gum

To create a 1%w/v solution, the gum was individually weighed and dissolved in water. A digital pH metre was used to determine the solution's pH. [24]

Swelling Index

Following equation was used to determine the swelling index. [20]

$$Swelling\ index = \frac{final\ volume - initial\ volume}{final\ volume} \times 100$$

Surface Tension

Using a stalagmometer, the surface tension of the chosen gum was measured using the drop weight method. [20, 23] It has been suggested that the polymer's surface tension affects how well it binds. Equation 5 was used to compute surface tension.

$$\sigma_{solution} = \sigma_{water} = \frac{m(solution)}{m(water)}$$

where,

$\sigma_{solution}$	=	Surface tension of solution
σ_{water}	=	Surface tension of water
M (Solution)	=	Weight of solution
M (Water)	=	Weight of water

Viscosity

Viscosity of almond gum was determined by Oswald viscometer as per equation 6.

$$\eta_s = \eta_w \times \frac{t_s \rho_s}{t_w \rho_s}$$

where

η_s	=	Viscosity of solution
η_w	=	Viscosity of water
t_s and t_w	=	Time of solution and water
ρ_s and ρ_w	=	Density of solution and water

Gum Arabic

Gum Arabic (GA) is a dried, gummy exudate that is edible and high in non-viscous soluble fibre that comes from the stems and branches of Acacia senegal and Acacia seyal. In the middle Sudan, central Africa, and west Africa, these trees are widely distributed. Gum Arabic is frequently used as an emulsifier in the pharmaceutical and food industries.[25, 26]

GA's chemical makeup can change depending on its source, the age of the trees it was harvested from, the climate, and the soil environment. In the form of a calcium, magnesium, and potassium salt of a polysaccharidic acid (Arabic acid), gum Arabic is a branched-chain, complex polysaccharide that can be neutral or slightly acidic. [27]

While hydroxyproline, serine, and proline were the main amino acids in the proteins of an arabinogalactan (AG) and an arabinogalactan-protein complex (AGP), aspartic acid predominated in a glycoprotein (GP). [27]

Gum Arabic, which is made from dried exudates of A. Senegal [28], is high in dietary fibre and includes heterogeneous gum polysaccharides with a high molecular weight (lipoprotein). [29]

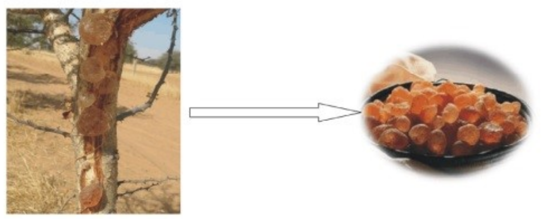

Figure 3: Collecting gum Arabic from low branches of acacia tree

Structure of Gum Arabic

One of the most widely used dietary hydrocolloids is gum arabic, a natural composite polymer produced from the exudates of A. senegal and A. seyal plants.

In culinary and cosmetic goods with oil-water interfaces, gum arabic works as a very effective emulsifier and a long-term stabiliser. Many scholars agree that gum arabic (GA) primarily consists of three parts.[30]

The majority of the compound is a highly branched polysaccharide with a galactose backbone and connected branches of arabinose and rhamnose that end in the naturally occurring salts of magnesium, potassium, and calcium known as glucuronic acid.

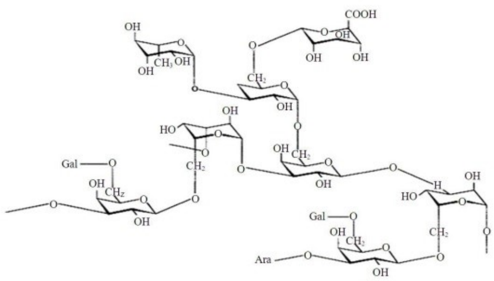

Fig. 2. Structure of Gum Arabic

Figure 4: shows the structure of gum Arabic:

Higher molecular weight arabinogalactan-protein complexes (GAGP-GA glycoproteins), in which arabinogalactan chains are covalently joined to a protein chain by serine and hydroxyproline groups, make up a lesser portion of the total. Glucoronic acid is present in the complex's connected arabinogalactan.

A glycoprotein, the smallest fraction with the greatest protein concentration, differs in the amino acid makeup.

Characteristics of Gum Arabic

Gum Arabic is a solid that is light to dark brown in colour and when broken releases a vitreous material. Gum Arabic of exceptional grade is spherical, tear-shaped, and orange-brown in colour. The fragments are lighter in colour and seem vitreous once it is broken or crushed. Unlike other vegetable gums, gum Arabic dissolves up to 50% better in water. A. Senegal has a poor viscosity (16ml/g on average). The resultant mixture has no flavour or colour and does not readily react with other chemical substances.

Gum Arabic is a complex chemical substance with a mildly acidic pH that is composed of the calcium, magnesium, and potassium salts of polysaccharides and glycoproteins. Arabic acid, a polysaccharide that connects a D-galactose with branches made of L-arabinose, L-rhamnose, and D-glucuronic acids, is the main polysaccharide.

The hydroxproline-rich proteins are essentially categorised as arabinogalactanes. Raw gum Arabic is seen in bits in Figure 5. The images are meant to show the appearance, feel, and transparency of gum Arabic.[27]

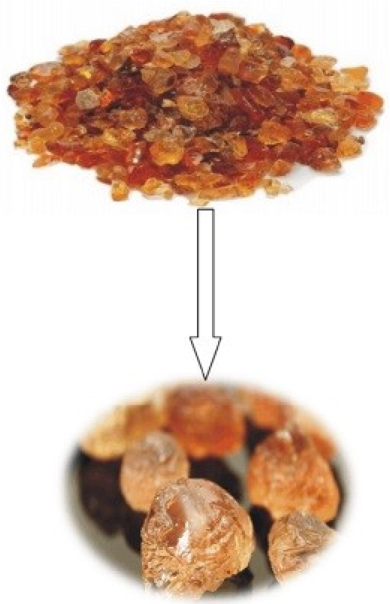

Figure 5: Pieces of raw Arabic gum

Applications of Gum Arabic

Exudate gums are utilised in an excessive amount of applications, mostly in the food industry. There are, however, a lot of non-food uses as well. Gum Arabic is used extensively in the food business for industrial reasons such stabilising, thickening, emulsifying, and encapsulating, and to a lesser extent in the textile, ceramic, lithography, cosmetic, and pharmaceutical industries. GA is largely utilised in confectionery, bakery, dairy, beverage, and as a microencapsulating agent in the food sector. [31]

In hot or cold water, gum arabic rapidly dissolves at concentrations of up to 50%. Gum Arabic solutions are characterised by a low viscosity due to the compact, branching structure and therefore limited hydrodynamic volume, which permits the use of high gum concentrations in a variety of applications. At concentrations up to 40%, solutions behave Newtonianly; at greater concentrations, they display pseudoplastic behaviour.[32]

Comparisons between Natural gums

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Table 2: Differences between Neem gum, Almond gum and Arabic gum

	Neem gum	Almond gum	Arabic gum
origin	Neem gum, a typical plant gum exudate from the tree (Meliaazadirachta, Meliaceae) is the salt of a complex polysaccharide acid.	The rosaceae family includes the almond (Prunus dulcis), which is a native of central Asia (Iran, India, and Pakistan). It is mostly grown in India to produce nuts or as an orname.	Gum Arabic (GA) is a dried, gummy exudate that is edible and high in non-viscous soluble fibre that comes from the stems and branches of Acacia senegal and Acacia seyal. In the middle Sudan, central Africa, and west Africa, these trees are widely distributed.
Chemical structure	The gum is a multipurpose product. The gum that Azadirachta indica tree stems exude is made up of a combination of proteins and polysugars. It is known that Azadirachta indica gum contains D-glucose, D-glucoronic acid, L-arabinose, L-fucose, mannose, xylose, rhamnose, D-glucosamine, aldobiuronic acid, serine, threonine, and aspartic acid. Furthermore, it includes organic fatty acids.	This organic polysachharide is almost colourless, odourless, and safe. On a dry weight basis, proteins (2.45%), lipids (0.85%), and carbohydrates (92.36%) make up the natural polymer known as almond gum. Arabinose (46.83%), galactose (35.49%), and uronic acid (5.77%) make up the majority of the carbohydrates, with traces of rhamnose, mannose, and glucose.	Gum Arabic has a branching molecular structure and contains additional sugars such arabinose, glucuronic acid, and rhamnose in addition to its primary chain of 1, 3-linked -D galactopyranosyl units.
color	The neem gum as obtained from the tree consisted of paleyellow to light-brown nodules (ash content, 5.4%)	Almond gum appears as tiny boulders across the tree's bark and is either white, pale yellow, or light brown in hue.	Gum Arabic is a solid that is light to dark brown in colour and when broken releases a vitreous material.
PH	pH spectrum (5.0–6.0)	pH spectrum (3.8-4.4)	pH spectrum(4.5-5.5)
solubility	In cold water, the gum disintegrated to produce light brown viscous solutions. By adding a solution of the gum	About 90% of the almond gum is made up of the water soluble component. In terms of almond gum, the insoluble	Arabic gum dissolves in water up to 50% and the resulting solution is colorless and tasteless and does

	acidified with diluted hydrochloric acid to 95% ethanol and stirring, the gum acid was precipitated.	fraction has a higher protein and fat content than the soluble fraction. the soluble fraction has the most sugar overall (93%).	not interact with other chemical compounds.

Summary

Gum arabic and neem gum were compared side by side with a view to use the unique properties of this new exudate to define its application as an additive and thickener. In this investigation, neem and almond gums outperformed gum arabic in terms of their physical characteristics. Almond gum's low compressibility indicates the fact that it flows more easily than gum arabic, which is a desirable quality in thickeners.

Conflict of Interest

There is no conflict of interest in the publication of this article.

Acknowledgment

The authors are gratefully thanks to National Research Centre, Giza, Egypt and Faculty of Applied Arts, Benha University

Funds

This research doesn't receive any fund

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الاستخدام الأمثل للصمغ الطبيعي المناسب كمتخنات في طباعة المنسوجات

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المستخلص: بجميع الأساليب المتبعة اليوم لتزيين الخامات النسيجية ، فإن الطباعة هي الأهم. إنها طريقة معروفة جيدًا يتم تطبيقها في مجال المنسوجات لتحسين المظهر المرئي للنسيج وإرضاء تفضيلات المستهلكين. الطباعة هي في الأساس نوع من التلوين يتم فيه تلوين منطقة معينة بدلاً من النسيج بأكمله. أثناء عملية الطباعة ، يتم استخدام المثخنات للحد من كمية مادة التلوين على النموذج. استخدام المكثفات الاصطناعية في صناعة الطباعة له عدد من الآثار البيئية السلبية. لذلك ، في هذه الدراسة ، ركزنا على استخدام العديد من اللثة الطبيعية الصديقة للبيئة كمكثفات لتقليل التأثيرات على البيئة. أظهرت النتائج التجريبية أنه يمكن استخدام مكثفات طبيعية وطبيعية مثل النيم واللوز والصمغ العربي بنجاح في طباعة النسيج.

الكلمات المفتاحية: مثخن ، صمغ النيم ، صمغ اللوز ، صمغ عربي.