GLUTA APTERA DYEING ON SURFACE TREATED KNIT COTTON STRUCTURE

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ABSTRACT

Demand for natural sources in textile processing has increased due to environmental concerns among consumers and manufacturers. In this study, the effectiveness of chitosan and sodium nitrite treatment on knitted cotton fabric dyed with Gluta Aptera were investigated. The fabrics were brought to a series of wet treatments before dyed, and the colour fastness to light, colour fastness to washing, colour fastness to perspiration and their stiffness were then tested. The results were analysed to determine the most effective treatment could be applied in improving the fastness properties of the fabric. Overall results shown that chitosan-sodium nitrite treated fabric has better performance than the fabric treated with chitosan alone. It was also shown that the colour fastness of the fabric has been improved without affecting the appearance (stiffness) of the structure.

Keywords: chitosan, gluta aptera, natural dye, surface treatment.

INTRODUCTION

Recently, the environmental concerns have increased the demands for natural sources which are more eco-friendly. It includes their usage in textile application especially in finishing process which including dyeing, mordanting and any other finishing treatments. Natural dyes can be anything that comes from natural sources such as flowers, leaves, roots, insects, shells and mineral substances [1]. Examples of natural dyes made from plants are onion skin, pink guava fruit, mango leaves, turmeric and *rengas*.

Rengas (Figure-1), also known as Gluta Aptera is one type of the timber tree from the *Anacardiaceae* family. It is one type of timber with good strength properties which usually used in the furniture industry. Thus, the fully utilization of *rengas* waste from furniture industry is a good attempt since this type of tree is highly in cost. As cited in Business in Batam [2], the *rengas* may yield different type of colour using different type of mordant from orange to black.

Figure-1. Rengas [3]

However, the natural dyes are less permanent and wash out easily. Thus, it requires mordant to act as fixing agent. As stated by Daykin [4], the mordant joins with the fibre and the dye to set the colour permanently. Some of the natural substances that may be used as a mordant are slaked lime, lime juice and tamarind. The mordant may be applied by using three methods which are pre-mordanting, meta-mordanting and post-mordanting.

Generally, the vegetable fibres, for example cotton, flax and linen are less suitable to be dyed with natural dyes than protein fibre. Thus, they need to be modified with cationic agents such as, chitosan in order to get higher colour intensity [1]. Chitosan is derived from the deacytelation of chitin which is derived from the exoskeleton of crustaceans. Commercial chitosan is derived from the shell of shrimps and other sea crustaceans [5]. Chitosan can be used as dye-fixing agents, for shade and neps coverage, improve fastness of dyed fabric, as a binder of pigment printing, and as a thickener in printing [6].

Chitosan favours active sites in acidic solution. As in textile application, the higher the active site that chitosan favour, the higher the dye absorption as well as film formation on the fibre surface [7]. However, some problems arise from the film formation of chitosan on the fabric surfaces which cause the increase of fabric stiffness [8]. Sutcharit *et al*. [7] reported that the stiffness problem of the chitosan treated fabric could be adjusted by the usage of chitosan proper molecular weight. These could be done by depolymerisation of the chitosan using sodium nitrite under mild conditions. However, care must be taken during handling the chitosan liquid due to susceptibility to further degradation [8].

Hence, the objective of this research was to investigate the effectiveness of chitosan and sodium nitrite on the colour absorption of *rengas* on knitted cotton fabric. The effect of sodium nitrite on the stiffness was also examined.

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MATERIALS AND METHODS

Materials

In this research, nine samples of knitted cotton fabrics were used. The fabrics used were finished, with size of each sample was 45 x 25 cm^2 and the weight was 196 g/m2.

Rengas wood (Figure-2) was obtained from Forest Research and Institute of Malaysia (FRIM), Kepong, Kuala Lumpur. The chitosan flake, methanol, acetic acid and sodium nitrite were of laboratory grade while vinegar, soda bicarbonate and lime juice were chosen for the mordants.

Figure-2. *Rengas* Wood.

Table-1. Shows the summary of the fabric samples used in this research project.

Sample	Chitosan	$NaNO_2$	Lime juice	Soda bicarbonate	Vinegar
CFL			√		
CCL	√		√		
CNL	√	√	√		
CFS				√	
CCS	√			√	
CNS	√	√		√	
CFV					√
CCV	√				√
CNV	√	√			√

Where;

CFL = Control fabric/lime juice)
CCL = Fabric treated with chitosan/lime juice
CNL = Fabric treated with chitosan and sodium nitrite/lime juice
CFS = Control fabric/soda bicarbonate
CCS = Fabric treated with chitosan/soda bicarbonate
CNS = Fabric treated with chitosan and sodium nitrite/soda bicarbonate
CFV = Control fabric/vinegar
CCV = Fabric treated with chitosan/vinegar
CNV = Fabric treated with chitosan and sodium nitrite/vinegar

a) Extraction of *Rengas* Dye

Rengas wood was chopped into small pieces and taken into a beaker. Then, methanol was added into the flask with a liquor ratio of 1:20. In order to get 1: 20 liquor ratio, 50g of rengas wood was poured into the beaker containing 1000ml of methanol. The flask was left at room temperature for one week.

After one week, the mixture was extracted by using Rotavapor (Figure-3) under 45ºC in order to get the crude of extraction. As the result of extraction, 4.5g of *rengas* crude was formed. The crude was then dissolved in water in order to prepare 1% of stock solution.

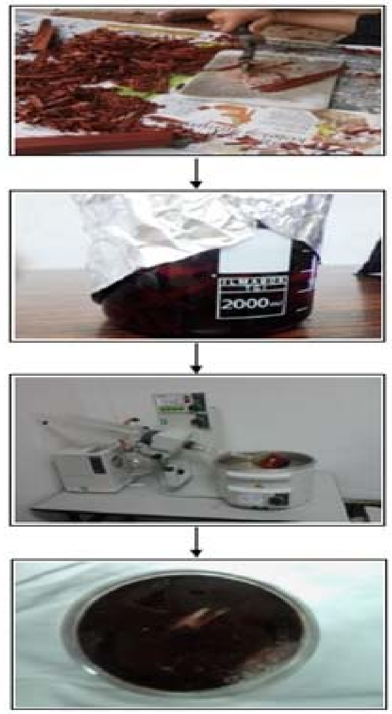

Figure-3. *Rengas* Extraction

Fabric Treatment

The chitosan flake was mixed in acetic acid and was left overnight at room temperature before filtered to remove any insoluble material. Then, the fabrics were treated with the chitosan solution by using laboratory padding mangle with wet pick-up of 80-85%, 3 psi of padding pressure and speed of 2 m/minute. The fabrics were dried at 100ºC for 10 minutes by using hot air oven.
For fabric sample CNL, CNS and CNV, they were brought to further treatment with 10g/L of sodium nitrite solution. The process was conducted in Labtec dyeing machine at room temperature with a liquor ratio of 1:25 for 30 minutes. Finally, the treated fabrics were rinsed with water and subsequently air dried.

Dyeing and Mordanting

Rengas dye was obtained by dissolving the crude in water by preparing 1% of stock solution. The meta-mordanting method was used, where the fabrics and mordants were mixed at one time. The dyeing was conducted at 60ºC for three hours by using Labtec laboratory dyeing machine. The amount of *rengas* dye is

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based on 4% o.w.f (weight of fabric) while each studied mordant is based on 10% o.w.f. [1, 9].

Fabric Tests

The fabric samples were evaluated on their colour fastness to light, washing and perspiration. The standards referred were according to MS ISO 105-B02-2001, MS ISO 105-C01-1996, MS ISO 105-A05-2003 and MS ISO 105E04-1996 [10, 11, 12, 13]. The importance of the tests was to observe how well the dyestuff is able to stay in the fibre after exposing them to stated factors.

The fabrics were also tested for their stiffness (ASTM D 1388-96/2002) [14], as this was to see whether the chitosan treatment has impaired the appearance of the fabric.

RESULTS AND DISCUSSIONS

Colour Shades

In general, the colour shades produced on the fabric samples were from light beige to dark brown (Figure-4). The rich colour were of those mordanted with lime and vinegar, with the darkest treated with both chitosan and sodium nitrite. The ability of the acid-based mordants to secure colour in the fibre was better than basic mordant.

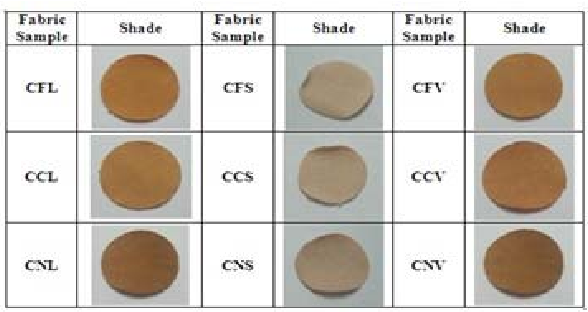

Figure-4. Colour Shades of Fabric Samples.

Colour Fastness

When a comparison is made between the treatment methods, chitosan-sodium nitrite treated fabric (CN) performed better in terms of colour fastness to light (Figure-5), colour fastness to washing (Figure-6), and colour fastness to perspiration (Figure-7). This was shown with the higher rating of the blue wool and colour change. Blue wool rating is a scale developed in order to measure the degree of colour permanence under long exposure to light (rating 1 – 8, poor - excellent), while colour change rating is used specifically to evaluate the colour durability due to washing and perspiration (rating 1 – 5, poor - excellent).

Chitosan-sodium nitrite treated fabric has good light fastness properties except for fabric mordanted with sodium bicarbonate which has average fastness to light. The rating was followed by chitosan treated fabric with an average rating and lastly untreated fabric shows a poor light fastness. The treatment has contributed to the strong bonding between the fibre and the dyes, which it took longer time to fade.

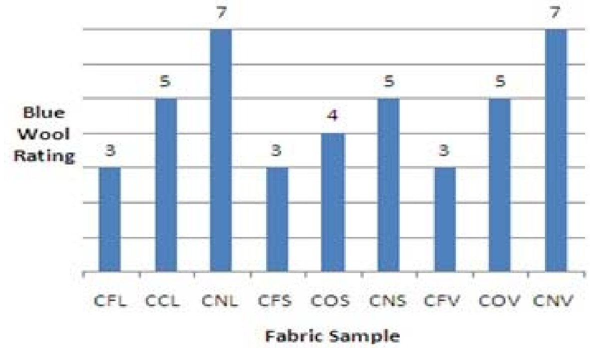

Figure-5. Colour Fastness to Light of Fabric Samples.

The colour change rating shows the degree of colour change. From Figure-6, the colour change rating shows that fabric mordanted with lime juice and treated with chitosan-sodium nitrite has the best wash fastness properties for all types of fabric. This indicates that the bonding between dyes and CN fabric was strong compared to CC and CF fabric. This is because, the sodium nitrite helps in restraining the negative charge of fabric surface. As for the fabric mordanted with soda bicarbonate and vinegar, they show a low to medium wash fastness rating. This indicates that the dyed fabric tend to change its colour after several washings.

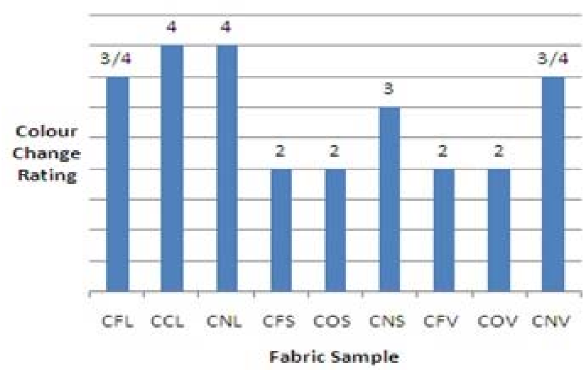

Figure-6. Colour Fastness to Washing of Fabric Samples.

Figure-7. Colour Fastness to Perspiration of Fabric Samples.

The same results are shown for the colour change due to perspiration where the chitosan-sodium nitrite fabric has better colour fastness. This indicates that the treatment of sodium nitrite on the chitosan treated fabric gave better adhesion between the dyes and the fabric compared to fabric treated with chitosan alone.

In comparison with lime and vinegar, soda bicarbonate has better performance in giving good colour fastness to perspiration. The soda bicarbonate gave better help for the *rengas* dye to impart its colour and formed stronger bonding within the cotton fibre.

Fabric Stiffness

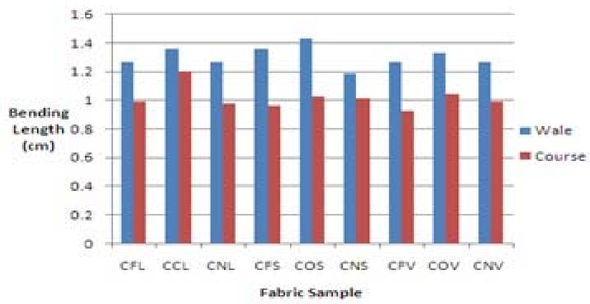

Figure-8. Bending Length of Fabric Samples.

The stiffness of the fabrics was examined in order to check how the treatments have influenced the fabric appearance by examining the bending length and flexural rigidity. Bending length indicates the length of the fabric tend to bend under its own weight to a certain angle while flexural rigidity is the resistance of a fabric to bend by external forces. Fabric that has high bending length and high flexural rigidity tends to fall stiffly and tends to feel stiff respectively.

From Figure-7 and Figure-8, it was found that the value of bending length and flexural rigidity increased after the fabric was treated with chitosan solution. However, the fabric became softer after sodium nitrite application. This was shown with the decrease in the bending length and flexural rigidity for all tested samples. In comparison with course direction, wale direction of fabric has higher value due to larger number of loops in a wale as compared to course which made the fabric fell stiffly.

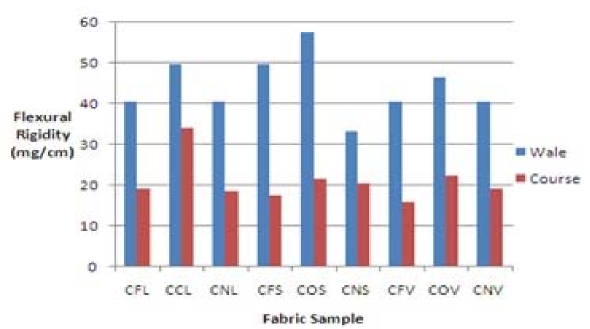

Figure-9. Flexural Rigidity of Fabric Samples.

It was proven that the stiffness problem on chitosan-treated fabric could be overcome with the help of sodium nitrite [7]. Sodium nitrite which is the depolymerising agent helps to break the chitosan molecules without disturbing its properties. In this study, the stiffness of the fabric has been reduced while the chitosan role in helping to increase the dyeing performance properties of *rengas* dye was maintained.

CONCLUSIONS

The results from this study showed that the dyeing of knit cotton fabric with *rengas* dye was successful with the presence of chitosan and sodium nitrite. The colour fastness to light, washing and perspiration did improve with the treatments and acidic mordants. In contrast, the basic mordanted fabric just gave moderate fastness properties. Using sodium nitrite as finishing agent also has enhanced the fabric hand where the fabric became more flexible without hard surface which was due to chitosan treatment.

In a conclusion, the chitosan-sodium nitrite treatment did affect the fabric colour fastness without increasing the fabric stiffness. Thus, the chitosan-sodium nitrite treated fabric would be able to withstand the light, washing and perspiration effect better than the untreated and chitosan treated fabric.

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