Cationisation of Alginate Fiber to Improve the Dyeing Properties Using Natural Dyes from Rhubarb: A New Approach

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Abstract In this investigation dyeing of alginate fiber was carried out after cationic treatment of EPTAC (2, 3-Epoxypropyl Trimethyl Ammonium Chloride). Optimum dyeing process and parameter show good dyeing performance when alginate fiber dyed with rhubarb dye. In addition to cationic treatment is taken into account for alginate fiber to improve fastness, color strength, breaking strength. Later in dyeing for fixation ferrous sulfate, copper sulphate was considered as mordents. Moreover using pre-mordanting methods conveyed the dyeing of alginate fiber with the stave of metallic mordant and without metallic salt mordents. The evaluation of each color dyed material was done through following two terms for instance CIELAB (L*, a*, and b*) and K/S values. According to AATCC test methods color fastness to washing of the dyed fiber was determined whereas according to the ASTM D3822M standard the breaking strength of alginate fiber was estimated and tested. When dyeing was carried out on alginate fiber through considering optimum parameter like 80∘C for 90 min, M: L 1:40 and at pH 7 which showed optimum results. In addition to mostly very good wash fastness was obtained while there was no fading of the color, whereas the moderate level of color fastness to crocking was achieved. Later after dyeing the evaluations of SEM of the cationized alginate fiber and FTIR of powder from the rhubarb dye were observed. The results suggested that the surface of cationized alginate fiber was smoother than the raw alginate fiber.

Key words Alginate fiber; rhubarb natural dye; color strength &fastness; SEM; Eco-friendly

1. Introduction

With the consistent for new substances, always greater efficient, extra dependable and of more performance, one would not clearly don't forget seaweeds as an ability elegance (Wang et al., 2015). However, now not most effective do they play an essential function within the ecological machine (algae are the idea of all food chains inside the sea offering as much as half of the earth's oxygen), however a few have additionally been used for hundreds of years as food, as manure or as a supply of chemical compounds. Alginates, a form of brown seaweed, have been accrued in Scotland for the reason that 18th century for the treatment of blisters and lacerations. From the 1960's, seaweeds have been farmed and nowadays, alginates locate vast applications in both the fabric, food and the pharmaceutical industries (Badwan, Abumalooh, Sallam, Abukalaf, & Jawan, 1985; Burrows & Welch, 1983; Dey, Khan, & Chowdhury, 2011; King, 1983; Luo, Lode, & Gelinsky, 2013; Yimin, 2003; ZHAN, ZHU, ZHANG, & GUO, 2006; Zhu, Zhang, Sui, & Wang, 2009). The profit increased from the usage of these herbal polymers derives specially from their capacity to shape a hydrogel with

43   most divalent cations, inclusive of Ca2+ ions. Moreover, their excessive absorbency and inherent
44   haemo compatibility lead them to of precise attention within the making of wound dressings. Thirty
45   years in the past, it become found that wounds heal higher in a wet surroundings additionally, on
46   touch with blood, calcium alginate rapidly releases the calcium ions in trade for sodium ions,
47   stimulating each platelet activation and entire blood coagulation. Previous research task became
48   predominantly proposed to gain a larger perception into ion change ion binding within alginates
49   (Hong-bin, 2005). The second factors of hobby become a way to improve traits which includes
50   electricity and swelling of those biomaterials. This was accomplished following the course of
51   polymer blends which include alginate/pectin (a polysaccharide particularly ample in end result)
52   and alginate/carboxy methyl cellulose (essential constituent of the mobile wall of plant life). The
53   third factors of polysaccharide structures were considered in this painting: pure alginates,
54   alginate/pectin blends and alginate/carboxy methyl cellulose blends. The have a look at of every
55   system changed into completed following the identical pattern.

56   *1.1. Literature review*

57   1.1.1. Alginate fiber

58   Alginates are hydrophilic polysaccharides found in brown seaweed, comprising of as much as
59   forty wt. % of dry depend (the seaweed consists of other ionic polymers including fucoidan). They
60   occur within the intercellular matrix as a mixed sodium-magnesium-calcium-strontium gel, the
61   relative proportions of those ions being determined via an ion-change equilibrium response with sea
62   water (Morris, Rees, Thom, & Boyd, 1978).Their important feature is skeletal, giving both electricity
63   and flexibility to the algal tissue (Skjåk-Bræk, 1992). Those polymers have found tremendous
64   industrial use due to their capability to form a gel with divalent cations which includes Ca2+. A
65   method for the extraction of alginates becomes patented initially with the aid of Stanford in 1881. But
66   the first products from the Stanford method have been very crude (they contained high tiers of
67   nitrogen) (Siviello, 2016). Kelco business enterprise (San Diego) appeared to be the primary to
68   produce and to commercialize pure sodium alginates, within the 1920's. These days, about 15 000
69   tons dry weight of alginates are processed yearly from four hundred 000 tons of seaweed (Gacesa,
70   1988) maximum of the alginates are extracted from just three of the 265 reported species of the
71   marine brown algae. Macrocytic is the most commonplace one and is harvested off the west coast of
72   America. Further Luminaries and Ascophyllum are obtained from Northern Europe. The choice on
73   which seaweed to method commercially is based totally upon the price of the uncooked cloth and its
74   alginate content. Every other important criterion is the type of alginate contained inside the
75   seaweed, since the structure of the alginate determines its overall performance (see I.A.2). At the
76   same time as seaweed is the principle supply of alginates, several microbial assets have additionally
77   been observed, like Azotobacter vinelandii and Pseudomonas aeruginosa. Unlike seaweed alginates,
78   bacterial alginates are acetylated. Despite the fact that they're no longer at gift broadly used,
79   bacterial alginates might end up a possible opportunity as a marine pollutant has produced
80   instability within the long-time period seaweed alginate supply (Ott & Day, 1995).

81   1.1.2. Manufacturing process

82   For commercial utility alginate fibers want a few special purification because of its inner
83   morphology have a few inherent residences that needs special care to make alginate fibers suitable
84   for software level .the economic production system of alginate fiber changed into represented
85   (Siviello, 2016).
86   In phrases of the producing process, calcium alginate fiber can be made thru one of the
87   maximum simple spinning processes. The spinning solution can be made through dissolving
88   sodium alginate powder in water and, after degassing to get rid of the bubbles within the answer, a
89   focused sodium alginate solution may be extruded thru best spinneret holes right into a calcium
90   chloride tub, whereby sodium alginate is precipitated out in filament form as a calcium alginate fiber

91 (the latter being insoluble in water). The as-made fibers can then be stretched, washed and dried to
92 provide calcium alginate fibers. Figure 2 suggests schematically a small wet-spinning manufacturing
93 line. It have to be talked about that answers of sodium alginate can react with many di- and trivalent
94 cations to form gels; hence it's far viable to apply a ramification of metal ions to precipitate sodium
95 alginate answer at some stage in the wet-spinning technique. Within the production of alginate
96 fibers, calcium has observed greatest recognition as the divalent ion for gel formation, especially
97 because its salts are cheap, without difficulty to be had and non-toxic. Zinc chloride has also been
98 used for the manufacturing of zinc alginate fibers (Qin, Agboh, Wang, & Gilding, 1996).

99 Figure 3 shows the egg-container model for alginate gel formation (Grant, Morris, Rees, Smith,
100 & Thom, 1973) all through the extrusion process where sodium alginate is extruded right into a
101 calcium chloride tub, the buckled chain of guluronic acid gadgets acts as a two-dimensional
102 analogue of a corrugated egg-container with interstices wherein the calcium ions may % and be
103 coordinated, and even as calcium ions assist to maintain the alginate molecules together, their
104 polymeric nature and their aggregation bind the calcium ion greater firmly, resulting in a company
105 gel structure.

106 Previous study revealed that the shape of the guluronic acid block gives distances among
107 carboxyl and hydroxyl organizations which permit a high degree of coordination of the calcium ion.
108 At some point of the production of calcium alginate fibers, calcium ions from the coagulation
109 bathtub diffuse into the fiber to form a swollen fibrous gel. (Thomas, Gilson, & Ahmed, 1995)
110 studied the diffusion of calcium ions at some point of the wet-spinning technique. Their
111 consequences showed that the gelling time of calcium alginate fiber numerous linearly with alginate
112 attention, extended markedly with fiber radius and reduced with increasing calcium attention. Its
113 miles thrilling that the gelling time is independent of the guluronic acid and mannuronic acid
114 contents.

2. Materials and methods

2.1. Materials

117 Natural dyes rhubarb with different degrees of staining on the alginate fiber, were selected in
118 this study. They were purchased from the Changzhou Mel sheng Biomaterials Co. Ltd, China. Acetic
119 acid and Sodium acetate which were used without any purification to adjust the dyeing bath pH
120 were supplied by Sino pharm Chemical Reagent Co. Ltd, China. For surface modification of alginate
121 fiber cationic agent EPTAC (2, 3-Epoxypropyl Trimethyl Ammonium Chloride), ferrous sulphate,
122 copper sulphate, sodium hydroxide was used and sodium hydroxide supplied from Shanghai
123 ZhuoRui Chemical Co. Ltd, China. All these chemicals were analytical grade. Lab dyeing machine
124 was used to dye the alginate fiber which was purchased from Guangdong province. A vacuum
125 woven dryer was used which was purchased from Yu Ming Instrument co. ltd. of Shanghai.

2.2. Methods

2.2.1. Cationic treatment of alginate fiber

128 Cationic treatment of alginate fiber was done by using 3g/l cationic agent EPTAC (2,
129 3-Epoxypropyl Trimethyl Ammonium Chloride) at temperature 60° C for 30 min. Later alginate fiber
130 was dried at vacuum woven dryer.

2.2.2. Mordanting method

132 In case of dyeing of natural dyes, different types of mordant are used at pre-mordanting
133 method. Here, ferrous sulphate, copper sulphate mordant, was used during the dyeing process to
134 find out the best result for alginate fiber with rhubarb dyes. 40 g/l ferrous sulphate, copper sulphate
135 solution was made and further it was used in together with the dyes solution. When mordant was
136 used together with rhubarb dyes, it increased the affinity of the dyes to the alginate fiber. During

137   dyeing process, mordant were applied in different conical flax with the dyes solution to find out the
138   best dyeing results. Every conical flax will be marked with different numbering sticker to identify
139   the beakers after the dyeing process (Vankar, Shanker, & Verma, 2007).

140   2.2.3. Dyeing of alginate fiber with rhubarb dye

141   Dyeing Recipe: Alginate fiber =2-4 gm; pH = 4-8; Temperature = 40°to 90°C; Time =40-90 min;
142   Rhubarb dye =5% (o.w.f); M: L=1:10-1:40

143

144   After preparing the alginate fiber, dyes solution and mordant dyeing process was started. At
145   first dyeing solution of rhubarb dye (5% o.w.f) were taken in different 5 conical flax. Then 40 g/l
146   mordant was given in different flax by using a pipette. One flax was without mordant for checking
147   the different dyeing result with other samples. Finally, alginate fiber was placed in the conical flax
148   solution and shaken for sometimes for a proper mixing of dye solution with the fiber (LIU & GAO,
149   2010). The laboratory dyeing machine temperature was set at different temperature from 40° to 90°C
150   for dyeing process. It takes some time to reach the required temperature and when the temperature
151   reached at required temperature, the conical flax given to the machine and run the machine for
152   different duration from 40-120 min at various concentrations from 1:20-1:45 for different pH 5-12
153   .The machines was shaken by setting a proper rpm in the machine. After different time duration the
154   conical flax was taken out from the machine.

155   2.2.3. After treatment

156   After dyeing process, the dyed samples were taken out from the flax and kept in a bowl. Hot
157   wash treatment was done for 2-3 minutes to remove the unfixed dyes from the surface of the dyed
158   alginate fiber. After hot wash, soaping was done. 5 gm. /l detergent was used to make the soap
159   solution. 1000ml water was taken in a beaker and 5 gm. detergent was weighted. Then mixed
160   together in the beaker and soap solution was ready for the soaping treatment. The soaping process
161   was done in a 1:30 ratio and 120 ml soap solution was taken in every conical flax. Every conical flax
162   again set into the dyeing machine and run the machine at 60°C for 10 minutes. After soaping, the
163   samples were washed by using cold water. After cold wash, every sample were properly rinsed.
164   After rinsed, the samples were given to the vacuum dryer. The samples were dried in oven dryer at
165   80°C for about 20 minutes

166   2.2.4. Testing and analysis

167   FTIR Analysis

168   The FTIR spectrum of rhubarb dye particle was recorded by using FTIR spectrophotometer
169   (Brukar vertex 100, Germany). Fourier Transform Infrared Spectroscopy uses infrared light to scan
170   test samples and observe chemical properties like organic, inorganic and polymeric materials. FTIR
171   analysis accomplished by Attenuated Total Reflectance (ATR), Nujol and thin film. Solid samples are
172   usually prepared by shaving some material off of the sample that is thin enough to obtain a good
173   spectrum. The spectrum was recorded in transmittance mode by using ATR sampling technique
174   (Skoda, Astier, Pajonk, & Primet, 1994). The KBr plate containing dye particles were prepared and
175   the spectrums were recorded over 4000-400 cm-1 wavelength. The average reading of 40 scans were
176   recorded in 1cm interval.

177   2.2.5. Scanning Electron Microscope Infrared Spectroscopy of Rhubarb dye (SEM)

178   The surface morphology of Rhubarb dye particles was investigated by using scanning electron
179   microscope (phoenix 5000, shanghai). Gold Nano particle sputtering was applied on dye particles to
180   ensure the opacity caused by electron beams. The sample was scanned by using 5 kv electron
181   intensity and samples were examined with magnifications ranging from 1000 to 5000X times.

182 Scanning Electron Microscope gives the electronic image which reflects the morphology of the
183 sample surface. Scanning Electron Microscope was performed at high magnifications, generates
184 high-resolution images and precisely measures very small features and objects.

185 2.2.6. Evaluation of color strength

186   Color strength of the Rhubarb dyed alginate fiber was evaluated by using the
187 spectrophotometer machine. A data color machine of 110 TM was purchased from Shanghai used to
188 measure the color strength of the dyed samples.   At first the cotton dyed sample was placed in the
189 data color and different values of the dyed sample was found like lightness, value, hues and color
190 strength of the dyed sample was measured by (K/S) value. The CIELAB color space.
191   The color difference is expressed by the following equation 1

$$DE \text{ *}= (DL \text{ *}) \, 2 + (Da \text{ *}) \, 2Db \text{ *}) \tag{1}$$

192   Here DE* is the CIELAB color difference between batch and standard. Here DL*, Da*, Db.* and
193 hence DE* are in commensurate units. DL* denotes the difference between lightness (where L* = 100)
194 and darkness (where L* = 0), Da* the difference between green (`a*) and red (+a*) and Db.* the
195 difference between yellow (+b*) and blue (-b*) (fig). All measured samples showed a maximum
196 absorption.

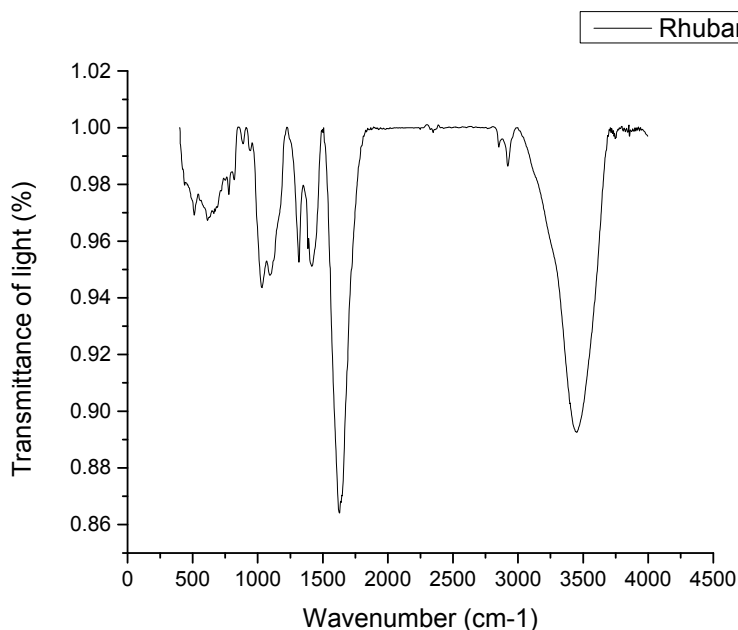
197 2.2.7. Color fastness to wash test

198   ISO-105-C06 standard washing fastness test method was applied in case of dyed alginate fiber.
199 A washing fastness machine was used for wash fastness test which was purchased from Shandong
200 province. At first, 4 gm. Detergent, 1 gm. Na-par borate and 1000 ml water were mixed together in a
201 beaker to make the washing solution. The alginate dyed fiber was cut according to the size 10cm × 4
202 cm. Multi-fiber fabric was also cut according to the same size & attached with the dyed sample.
203 Every sample were marked with different markings to find out the washing fastness results. Then 50
204 ml washing solution was taken in different conical flax. The attached dyed sample with multi fiber
205 fabric was placed in the conical flax & 25 steel balls were given in every conical flax. After this, the
206 conical flax was given to the washing machine from Shangdong Company at 60°C for 30 minutes.
207 After 30 minutes, washed samples were taken out from the machine & cold wash was done. After
208 washing rinsing was done & given to the dryer. After drying the samples were checked with the
209 help of grey scale.

210 2.2.8. Breaking strength of rhubarb dyed alginate fiber

211   After cat ionization treatment and pre-mordanting process breaking strength of rhubarb dyed
212 alginate fiber was investigated according to ASTM D3822M method (Properties, 1996).

213 **3. Results and discussions**

214 *3.1. FTIR analysis*

In addition to Fourier Transform, Infrared Spectroscopy was used to analyze and identify polymer, dye functional group with respect to different wavelengths that generate the transmittance of light spectra which exhibit the unique chemical bonds and the molecular structure of rhubarb dye at **Figure 1**. Furthermore, transmittance of light spectrum demonstrates zenith and peak that schematically represent components in higher concentration. Additionally peaks on the spectrum indicate functional groups for instance alkanes, ketones, acid chlorides, alcohol, carboxylic acids, esters, ethers group. However due to various bonds and different functional groups dye molecule absorb different infrared radiation wavelengths. Moreover, functional groups of rhubarb dye were investigated from the graph according to the standard characteristics of IR absorptions. However within the wavelength range 515-690 cm-1 there is a medium stretch in the graph which indicates that in this position alkyl halide group (C-Br) is present. Moreover in the wavelength of 850–550 cm-1 there is a medium stretch in the graph which represents that in this position alkyl halide group (C-Cl) is exist. In addition to the wavelength range of 950–910 cm-1 there is a medium O-H bend in the graph which shepherd that in this position carboxylic acids are extant. In the wavelength range 1000 -1320 cm-1 there is a strong stretch which usher that alcohols, carboxylic acids, esters, ethers group (C-O) are present there.

According to the graph, 1150-1300 cm-1   there is a medium wag which escort that alkyl halide group (–CH2X) is alive in dye molecule. Moreover, aromatic groups (C-C) were identified by a medium stretch in the wavelength 1500-1400 cm-1. In the case of wavelength, 1580-1650 cm-1 medium bend of the figure indicates that 10 amine group (N-N) is present there.

In the wavelength range 3200-3500 cm-1 there is a strong broad stretch which shows that those alcohols and phenols groups (O–H group) are present there. In the wavelength range 3610-3640 cm-1 there is a strong sharp stretch which indicates that there are free hydroxyl alcohols and phenols group (O–H group) is present in sappon wood. Thus, different functional groups of sappon wood were investigated with respect to standard characteristics of the infrared spectroscopy. In a nutshell hydroxyl group and alkyl halide are a dominating group among the various functional groups by analyzing the morphology of rhubarb dye.

245   *3.2. Factors affecting dyeing properties*

246   3.2.1. Temperature

247   Alginate tries to dye at low temperature move again a few years. It's been diagnosed for
248   decades that fiber harm as a result of dyeing is reduced markedly while alginate is dyed at boiling
249   temperature. On this research work emphasis on saving power through dyeing of cationised
250   alginate fiber with mordant and dyeing of alginate fiber with mordant lowering the fundamental
251   issues resulting from excessive temperature dyeing of alginate fiber. Previous study revealed that
252   alginate dyeing is the one of the primary problems of sometimes uneven dyeing. If the alginate
253   cuticle is damaged via localized chemical attack or by using abrasion. At higher temperature, the
254   extra polar the dye is greater strongly its miles absorbed by the damaged fibers. But this absorption
255   is very choppy and at better temperature the unevenness is even greater seen than at lower
256   temperature. But the depth of colour achieved is extra at better temperatures compared to lower
257   temperatures. At excessive temperature, alginate fiber has a tendency to become worse in energy
258   and turns into yellow and offers harsh sense/handle. The influence of temperature on alginate fiber
259   during dyeing with rhubarb dye was presented at **Figure 2**. Color strength of alginate fiber
260   increased from 40° to 80°C temperature. When temperature was above 80°C color strength of was
261   decreased due the physical and chemical nature of alginate fiber and dye molecule. Cationic
262   treatment of alginate fiber improves the color strength as well as exhaustion and fixation of dye
263   molecule.

264   3.2.2. Time

265   The influence of time on alginate fiber during dyeing with rhubarb dye was presented at
266   **Figure 3**. It was seen from that, the color strength increased with increasing time. The absorption of
267   the dye molecules commenced on the much less ordered surfaces of the fibers after which
268   proceeded underneath favorable situations into the interlinking place among elementary
269   crystallites, penetrating into them from each ends. Simplest water-swollen intermicellar areas and
270   regions of decrease order of the fibers have been reachable to massive acid dyes molecules. The
271   molecular chains in amorphous vicinity exhibited disorderly packing and could circulate
272   effortlessly to provide a big free extent, permitting dye molecules to diffuse effortlessly into and out
273   of the chains. Equilibrium between adsorption and desorption was accordingly displaced. As the
274   dye attention extended, the probability of touch among the dye molecules and fibers' surface
275   multiplied. But, increasing the attention improved the aggregation of the dye molecules inside the
276   dye tub, and that turned into prejudicial for dye molecules to penetrate into the fibers. And an
277   excess of dye concentration would reason the waste of the dyes and water pollution.

278   3.2.3. pH

279   pH play vital role in the field of wet processing specially in dyeing different type of fiber and
280   fabric. In textile dyeing pH keep the fiber properties by maintaining the exhaustion between fiber
281   and dye molecule. The influence of pH on alginate fiber during dyeing with   rhubarb dye was
282   presented at **Figure 4**.Color strength of alginate fiber increased from 3 to 7 pH due to the nature and
283   structure of alginate fiber .Alginate fiber alter its insoluble stage into soluble stage when goes into
284   water. Hydrogen bond and van der Waals forces facilitates the dyeing process by making reaction
285   between fiber and rhubarb dye .However alginate fiber make ionic bond with rhubarb dye that
286   contain anion . Uneven dyeing was occurred at lower pH and higher pH increased the depth of
287   shade .However higher pH reduced the rate of dyeing .The positive impact of this higher pH is that
288   the improving the level of dyeing.

289   3.2.4. Dye concentration

290　　　　The influence of dye concentration on alginate fiber during dyeing with rhubarb dye was
291　　presented at **Figure 5**. It was seen from that, the color strength increased with increasing dye
292　　concentration. The absorption of the dye molecules commenced on the much less ordered surfaces
293　　of the fibers after which proceeded underneath favorable situations into the interlinking place
294　　among elementary crystallites, penetrating into them from each ends. Simplest water-swollen
295　　intermicellar areas and regions of decrease order of the fibers have been reachable to massive acid
296　　dyes molecules. The molecular chains in amorphous vicinity exhibited disorderly packing and
297　　could circulate effortlessly to provide a big free extent, permitting dye molecules to diffuse
298　　effortlessly into and out of the chains. Equilibrium between adsorption and desorption was
299　　accordingly displaced. As the dye attention extended, the probability of touch among the dye
300　　molecules and fibers' surface multiplied. But, increasing the attention improved the aggregation of
301　　the dye molecules inside the dye tub, and that turned into prejudicial for dye molecules to
302　　penetrate into the fibers. And an excess of dye concentration would reason the waste of the dyes
303　　and water pollution.

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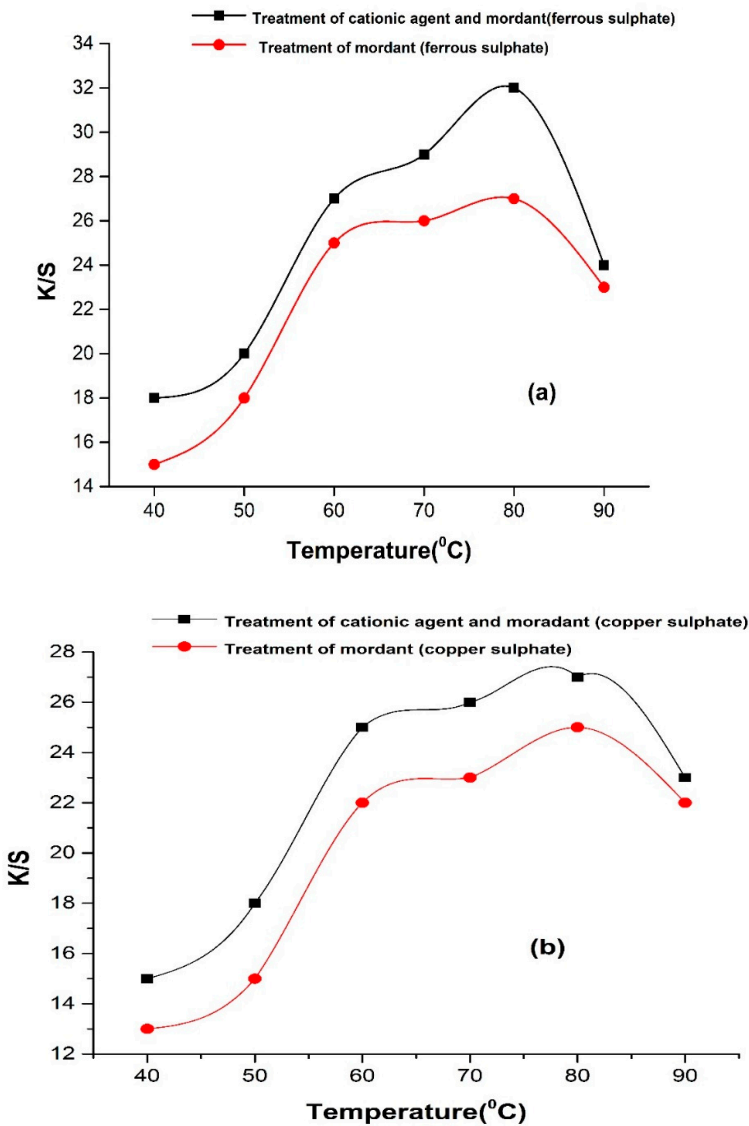
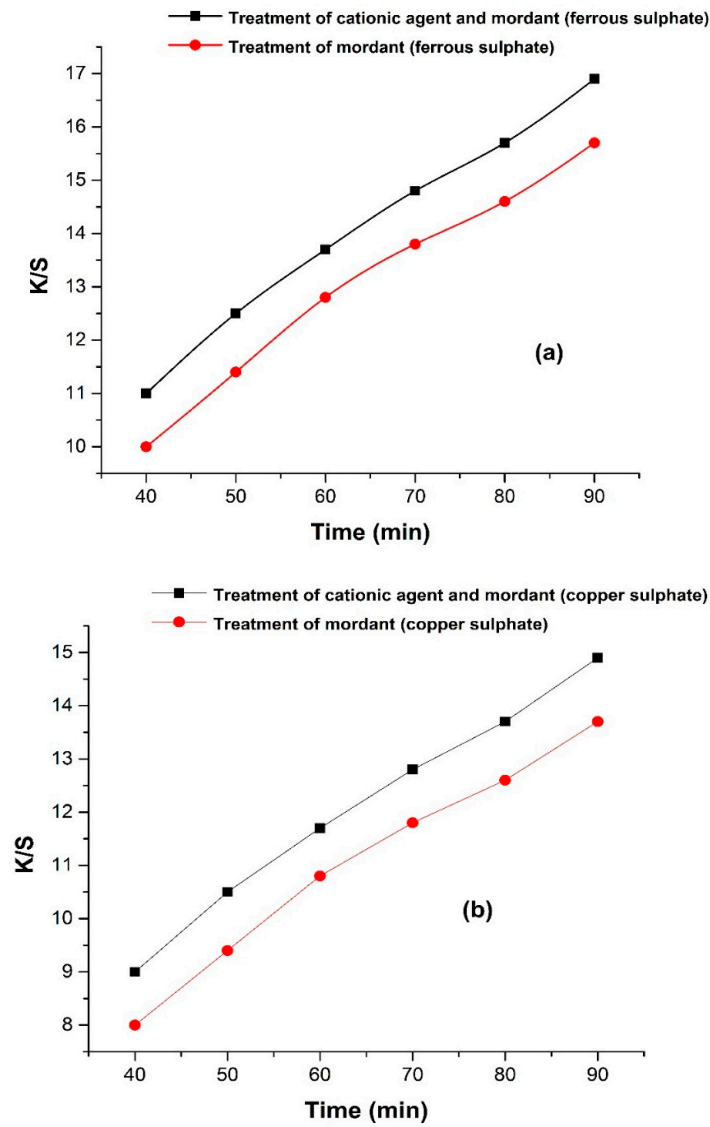
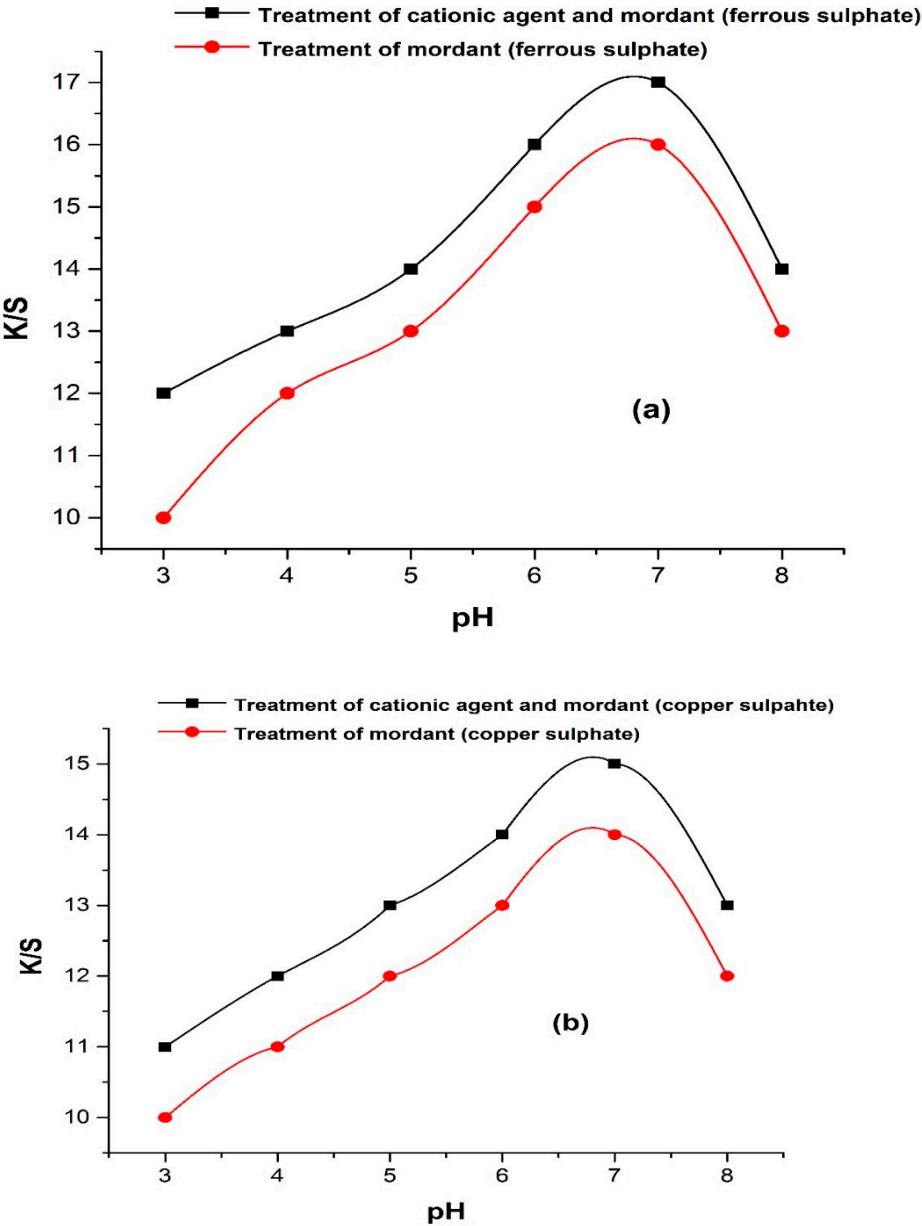

305   **Figure 2:** Effect of dyeing temperature on the color strength of alginate fiber with (a) cationic agent
306   and ferrous sulphate treated, (b) cationic agent and copper sulphate treated during pre-mordanting
307   process(dyeing condition: time 90 min, M:L=1:40,pH=7)

308

309   **Figure 3:** Effect of dyeing time on the color strength of alginate fiber with (a) cationic agent and
310   ferrous sulphate treated, (b) cationic agent and copper sulphate treated during pre-mordanting
311   process(dyeing condition: temperature 80ºC, M:L=1:40,pH=7).

312

313   **Figure 4:** Effect of dyeing pH on the color strength of alginate fiber with (a) cationic agent and
314   ferrous sulphate treated, (b) cationic agent and copper sulphate treated during pre-mordanting
315   process(dyeing condition: temperature 80ºC, M:L=1:40,time=90 min).

316

317   **Figure 5:** Effect of dyeing dye concentration on the color strength of alginate fiber with (a) cationic
318   agent and ferrous sulphate treated, (b) cationic agent and copper sulphate treated during
319   pre-mordanting process(dyeing condition: temperature 80ºC, pH=7,time=90 min).

320   *3.3. Effect of mordanting and cationisation process on alginate fiber*

321   Comparative analysis between surface treatment by cationic agent and without any
322 modification of alginate fiber for mordanting process was described at table 3. Brilliant and in depth
323 colorations with good fastness are wanted for packages in a fabric dyeing method. Especially, the
324 use of numerous mordants leads to good sized color difference and in the main effects in a
325 coloration shift towards darkish sunglasses(Jung & Bae 2014). For increasing the natural attraction
326 between material contributions of natural dye was not meager .In previous study revealed that
327 different metallic mordant did a lot protect the material from devastating effect of environment
328 (Chairat , Bremner, & Chantrapromma, 2007).

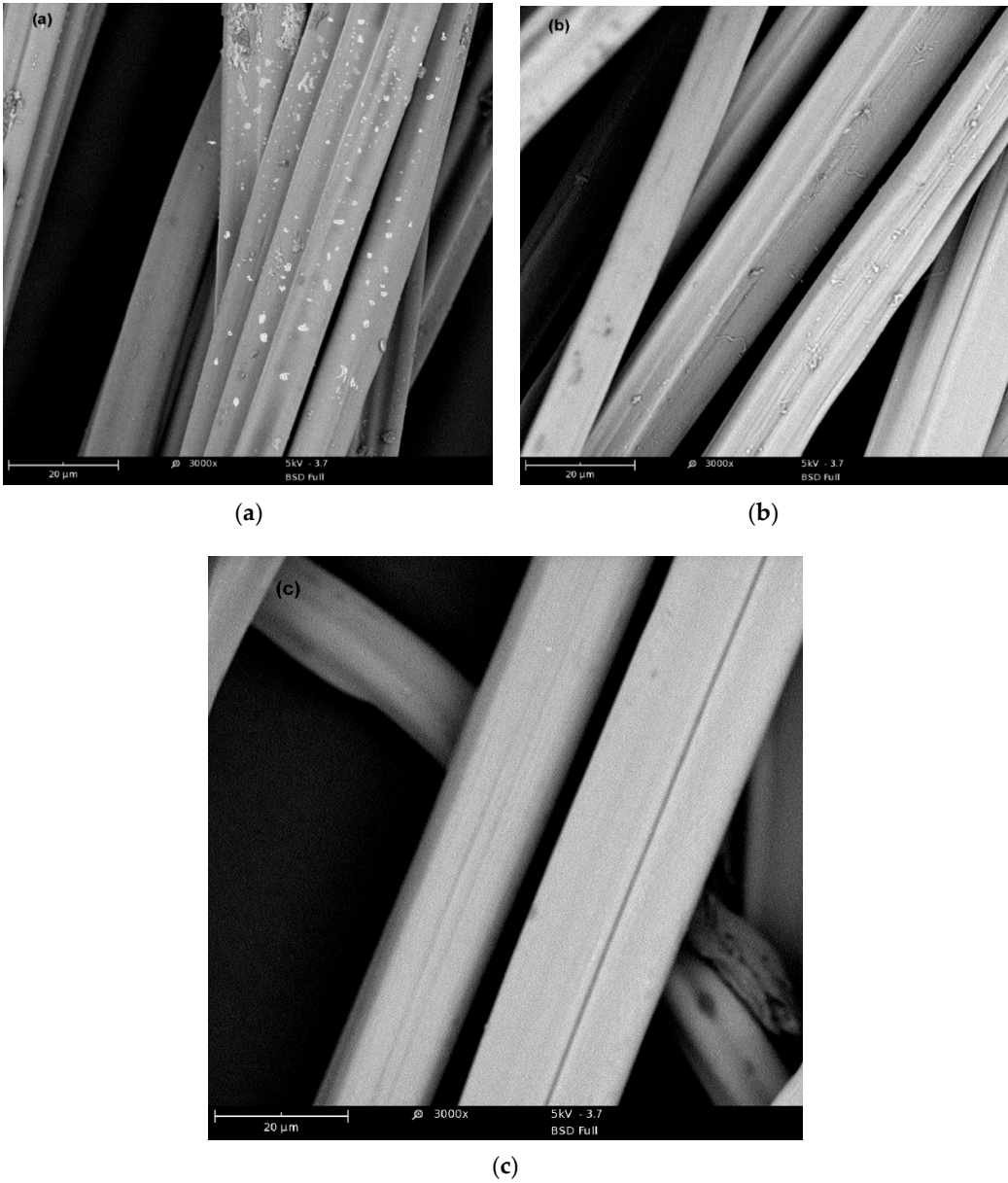
329   **T**able 1: Effect of mordanting and cationisation process on alginate fiber

Mordant	Effect of cationisation					Effect of Mordant				
	L^*	a^*	b^*	c^*	K/S	L^*	a^*	b^*	c^*	K/S
$FeSO_4$	64.08	-1.54	54.24	54.26	11.85	65.48	-2.96	51.07	51.15	9.01
$CuSO_4$	66.60	-1.70	57.25	57.28	11.57	63.52	-0.36	48.55	48.55	8.95
Without mordant	59.36	0.20	47.49	47.49	11.09	69.09	-3.12	53.32	53.41	7.94

330   *****Pre-mordanting

331   On this take a look at, mordants are used to various the coloration appearances. The utility in a
332 standardized dyeing manner was examined to estimate the ability of dyes from inexperienced
333 rhubarb dye. The technical capability of the extracted materials in regards to the coloration strength
334 and fastness houses of dyeing turned into checked**.**
335   The color strength of the alginate fiber dyed with rhubarb dyes was investigated by the data
336 color at **Table 1**. From different parameters samples we found degree of lightness (L^*), degree of
337 depthless (a^*), degree of brightness (b^*), Finally, K/S value was calculated to compare the color
338 strength pre-mordanted ,meta mordanted and post mordanted samples which is given at table . We
339 can see that, that samples which were treated with cationic agent with $FeSO_4$ mordants during pre
340 mordanting method give better results than the mordant treated dyed fiber. From the above result
341 table, it has been found that cationised alginate fiber dyeing with $FeSO_4$ mordant gave the k/s value
342 11.85. On the other hand, alginate fiber dyeing with $FeSO_4$ mordant gave the k/s value 09.01.
343 Moreover cationised alginate fiber dyeing with $CuSO_4$ mordant gave the k/s value 11.57. On the
344 other hand, alginate fiber dyeing with $CuSO_4$ mordant gave the k/s value 8.95. Moreover cationised
345 alginate fiber dyeing without any mordant gave the k/s value 11.09.Furthermore cationised alginate
346 fiber when dyeing with mordant   improves the color strength value of sample when compared to
347 alginate fiber when dyeing with mordant .The physiochemical reaction behind this tremendous
348 change was explained by jothi D who look over that the ionization of the hydroxyl groups and alkyl
349 halide in the dye molecules under the alkaline condition of the standard detergent solution not only
350 responsible for   dramatic color change but also   the decomposition of the dye itself, resulting in a
351 colorless or a differentially colored compound attributed to dramatic color change (Jothi 2008).There
352 was an inverse relationship existing between natural dye and water soluble properties.

353 *3.4. SEM analysis*

354   In case of rhubarb dye SEM shows the surface morphology of the dyed alginate fiber in 3000 X
355 magnifications. From the above SEM micrograph of the **Figure 6**, it shows that the micrograph at
356 3000 X in **Figure 6 (a)** is more smooth in surface than micrograph at 3000X in **Figure 6 (b)** and
357 **Figure 6 (c).**Due to cationisation of alginate fiber after dyeing, there is significant change in the
358 surface.
359   Surface of alginate fiber at 3000X as shown in **Figure 6 (a).**For the consequence dye particle
360 evenly distribute to the surface of alginate fiber as shown in figure **Figure 6 (a).**On the other hand
361 surface of mordanted alginate fiber after dyeing is not smooth as compared to cationised alginate
362 fiber as shown in **Figure 6 (b).**

363   **Figure 6 :** SEM Micrograph of (a) cationised and mordanted alginate fiber, (b) mordanted alginate
364   fiber and (c) raw alginate fiber dyed with rhubarb dye.

365   *3.5. Breaking strength*

366   Table 2: Breaking strength of alginate fiber

Mordant	Alginate fibers (cN/dtex)	Effect of Cationisation with dyed alginate fiber(cN/dtex)	Effect of mordant with dyed alginate fiber(cN/dtex)
$FeSO_4$	2.35	2.02	2.02
$CuSO_4$	2.35	2.05	2.05
Without mordant	2.35	2.01	2.01

367   *Pre-mordanting

368   Breaking strength of dyed alginate fiber was analyzed on the basis two methods such as
369   cationisation and mordanting method which was shown at Error! Reference source not found.. It
370   was seen from the table that generally alginate fiber breaking strength was respectively 2.35
371   cN/dtex, 2.35 cN/dtex, 2.35 cN/dtex when mordanting was done by using metal mordant
372   respectively ferrous sulphate, copper sulphate without any mordant .When alginate fiber treated
373   with cationic agent and mordant before
374   Dyeing it was obvious that breaking strength of alginate was decrease as compared to original
375   alginate fiber .The reason for this scenario was due to the effect of natural dye that destroyed the
376   high packing density of fiber .However the dyeing parameter of alginate fiber   had no tremendous
377   influence on the mechanical property of alginate fiber

378   *3.6. Wash fastness*

379   Table 3: Wash fastness of alginate fiber

Mordant	Effect of cationisation		Effect of mordanting	
	Color Stain	Color change	Color Stain	Color change
FeSO$_4$	3-4	4	2-3	4
CuSO$_4$	3	4	3	4
Without mordant	3-4	4	3	4

380   *Pre-mordanting

381   In this experiment, we done washing fastness test on rhubarb dyed alginate fiber dyeing with
382   different mordant that was shown at Error! Reference source not found.. Different samples color
383   fastness to wash was done with multi fiber fabrics and the samples staining were invested on cotton
384   part of the multi-fiber fabric after washing.   In case of cotton part, we have found that, cationized
385   alginate fiber dyed with rhubarb dyes solution using different mordant in dyeing machine gave the
386   best fastness grade as compared to pre-mordanted dyed fiber. In case of solution of cationized
387   alginate fiber dyed with rhubarb dyes solution using ferrous sulphate mordant in dyeing machine
388   gave the best (3-4) fastness grade as compared to dyed fiber with ferrous sulphate mordant which
389   are shown in **Table 3**. Cationized alginate fiber dyed with rhubarb dyes solution using copper
390   sulphate mordant in dyeing machine gave the higher (3) fastness grade as like to dyed fiber with
391   copper sulphate mordant. Moreover Cationized alginate fiber dyed with rhubarb dyes solution
392   without any mordant in dyeing machine gave the similar (3-4) fastness grade when compared to
393   dyed fiber without metal mordant through the assessment of grey scale.

394   **4. Conclusion**

395   Alginate fiber was modified by using cationising agent and mordant during dyeing with
396   rhubarb dye that is decent method. The alginate fiber was dyed by following two approach at one
397   approach cationised and mordanted alginate fiber dyed with rhubarb dye at temperature 80°C, form
398   90 min at pH 7 by maintain liquor ration 1:40. On the other approach mordanted alginate fiber dyed
399   with rhubarb dye at temperature 80°C, form 90 min at pH 7 by maintain liquor ration 1:40. The
400   method of cationisation improves the dyeing performance of alginate fiber with rhubarb dye. The
401   test results like Fourier Transform Infrared Spectroscopy (FTIR) of the extracted powder form and
402   SEM of alginate fiber was good. After dyeing, different tests of the dyed sample was done like color
403   strength test (k/s), color fastness to wash to check the fastness properties of alginate fiber. According
404   to the test results of the different dyed sample, washing fastness of the all pre-mordanted and
405   cationised dyed fiber was good as compared to post-mordanted dyed fiber. Color yield value for
406   dyes solution used in dyeing for cationised alginate fiber was evaluated by (k/s) value that was good
407   for pre-mordanted fiber. Finally, cationising method of alginate fiber with Rhubarb dyes is
408   comparatively good in comparing with different test results rather than the other traditional

409 methods. Its fastness property was good; process is simple, high colour yield than other
410 conventional methods and can be used for the further commercial use.

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