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Effect of Gamma Radiation on Cotton Fabric with Chitosan to Improve the Mechanical Properties

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Abstract In this investigation modification of cotton fabric with chitosan was done by the application of gamma radiation to improve the mechanical properties of cotton fabric. From the prawn shell chitin is prepared. Chitosan is prepared from deacetylation of chitin and dissolved in 1% acetic acid solution and radiated at 30KGy Co-60 gamma radiation. Radiated chitosan solution is cross-linked with scoured cotton fabric with the help of citric acid and $NaHPO_4$ used as catalyst. Cross-linked chitosan-cellulose solution is radiated at 1kGy through Co-60 gamma radiation. FTIR analysis was carried out for radiated cross-linked chitosan-cellulose for the improvement of the functional group of cotton. In order to augment the tensile strength and elongation percentage of pure cotton, irradiated chitosan cotton fabric and radiated chitosan cotton fabric was also evaluated and results showed that significantly improved their properties.

Keywords Gamma radiation, Cotton fabric, Chitosan, Tensile strength, Elongation

1. Introduction

The development of era in the fabric marketplace has led scientists and researchers to expand novel finishes to feature excessive cost on different fabric substances. It changed into a brand new window for researchers to advent and explore new research fields which consist of geotextiles, flame retardant textiles, insect repellent textiles, aroma textiles, medical textiles, smart textiles, antibacterial textiles, and nano textiles. Latest traits in the fabric industry are particularly targeted on bodily and chemical changes on floor of fibers and fabrics. One of a kind chemical and organic techniques were used electively to improve or impart everlasting functional traits at the surface of fabric substances. However, some of these chemicals are poisonous and once in a while high priced [1].

Chitin and chitosan are extensively flexible and promising bio materials. The deaectylated chitin spinoff, chitosan is more useful and bioactive polymer. In spite of its biodegradability, it has many reactive amino aspect corporations, which offer opportunities of chemical modifications [2]. There isn't always a sharp boundary inside the nomenclature distinguishing chitosan from chitin, when chitin is deacetylated over about 60% it turns into soluble in dilute aqueous acids and is referred to as chitosan. Chitin is the primary element inside the shells of crustaceans, along with shrimp, crab, and lobster. It is observed in exoskeletons of mollusks and bugs, and in the cell walls of some fungi [3]. Deacetylated spinoff of chitin is called chitosan. It is the second maximum ample polysaccharide discovered on the planet next to cellulose. There isn't a pointy boundary within the nomenclature distinguishing chitosan from chitin [3]. Chitin is a polysaccharide of animal origin located abundantly in nature and characterized by way of a fibrous structure. It bureaucracy the premise of the main constituent of the outer skeleton of bugs and crustaceans like shrimp, crabs and lobster [4]. Chitin and chitosan are naturally occurring ß-1,4-linked linear polysaccharides much like cellulose as proven in **Figure 1**. Chitin has the same backbone as cellulose, however it has an acetamide organization on the C-2 function rather than a hydroxyl group and its molecular weight, purity, and crystal morphology are depending on their assets [2]. Chitosan is a vulnerable base and is insoluble in water, but soluble in dilute aqueous acidic solutions underneath its pKa (~6.3), wherein it is able to convert glucosamine devices ($-NH_2$) into the soluble protonated shape ($-NH^{+3}$). The solubility of chitosan depends on its biological beginning, molecular weight and degree of acetylation [5]. Chitosan is found in

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some fungi, but its quantity is so constrained that it's far particularly produced commercially by means of alkaline deacetylation of chitin [6]. Huge quantities of crab and shrimp shells were abandoned as wastes via global seafood groups. This has led to vast medical and technological hobby in chitin and chitosan as try to utilize those renewable wastes. Chitosan has become the favored business form of those substances, as it's miles more tractable to solution tactics than chitin. The fabric enterprise maintains to search for eco-friendly tactics that substitute for poisonous fabric chemical substances and decrease dyes in dye house wastewater. The use of chitosan as a textiles chemical may be substantially beneficial inside the view of the usage of deserted seafood wastes. The major issues of chitosan are its loss of the antimicrobial pastime below alkaline conditions due to its lack of the cationic nature and its negative durability, whilst applied to fabric fabric, due to its loss of robust bonding with fabrics [3].

Cotton fibre is a cellulosic fibre. Cellulose is the most abundant certainly occurring polymer. Land flowers produce cellulose as one of the predominant structural units, the mobile wall. Cellulose has confirmed beneficial as a raw fabric for plenty business products. The textiles enterprise makes use of many sorts of cellulosic materials: Cotton, Flax, Hemp, Jute and Regenerated cellulosic fibers which include Rayon, Tencel & Lyocell [7]. Cotton is a gossypium vegetation produce seed hair. All through the world there are many species of cotton produced for their very own particular properties. Species versions can encompass staple duration, energy, and elongation at spoil, uniformity ratio, fineness (microniare), color & trash content. In the year 2000, it was determined that ~42% of all textile uncooked materials were derived from cotton [8]. Cotton fibres are the seed hairs of the plant Gossypium. They may be generally off-white in shade even though a few sorts have been bred to include a natural coloration. Each fiber is formed by means of the elongation of a single mobile from the floor of the seed. Cotton fiber include 85.5% cellulose [9], 0.5% oil and wax, 5% proteins, pectoses & coloring substances, 1% mineral material, 8 % moisture. It will likely be apparent that it cotton is nicely purified before bleaching it should lose 6.5% in weight [10].

Radiation technology concerning low electricity use, no chemical substances, ease to handling, and high treatment speed can alter the surface of textiles and improve dye uptake, printing, fastness houses, adhesion of coatings, and adsorption of used chemical substances [11]. Moreover a few preceding research show that gamma irradiation in textiles processing have promising effects since it is able to facilitate shrinking and wrinkling the resistance of fibres, improve the rate of dye uptake, fix extra dye onto the cloth as well as advanced the shade of the dyed material [12, 13]. It increases the capability to uptake dye onto fabric, and it is able to upload price in colouration at low temperature and does now not change the morphology of dye in addition to physical structure of fabric [14]. The role of gamma irradiation upon the stableness of dyeing cloth and fabric shape has additionally been investigated via colour strength, brightening in addition to fading of shades earlier than and after radiation remedy [15]. However effect of gamma radiation on cotton material to enhance its mechanical traits has not reported yet. The aim of this study to modify and cross link of cotton fabric with chitosan to identify its chemical bond through FTIR after deposition of gamma radiation .In this modification on cotton fabric not only enhance its tensile strength but also facilitates its elongation properties.

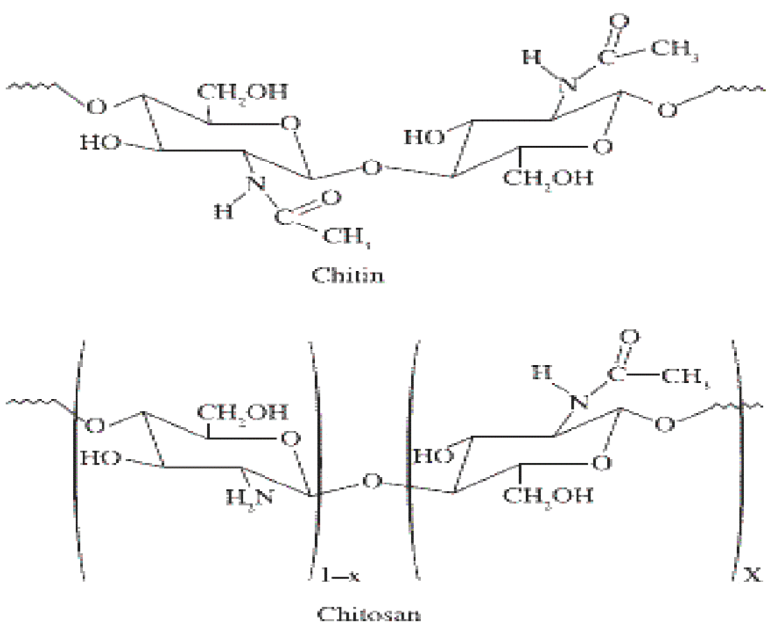

Figure 1. Schematic representation of the chemical structure of the chitin and chitosan

2. Experimental

Materials

Prawn shell was supplied from Bangladesh Atomic Energy Commission. Chitosan prepared from it. NaOH, HCl was used for the preparation of chitosan. Acetic Acid used to dissolve the chitosan. For cross-linking chitosan with cotton fabric citric Acid and $NaHPO_4$ was used. Mymun fabric confined DBL institution, Bangladesh provides the cordial guide with the aid of providing 100% scoured cotton fabric of GSM 120.

3. Methods

Preparation of chitosan solution

Firstly 1% Acetic Acid solution was made. 0.5% Chitosan dissolved in 1% Acetic Acid solution. For the uniformity of solution it is stirred for 30minutes and heated at 50°C. Prepared solution is radiated by Co-60 gamma ray at 30KGy.

Fabric Sample Preparation

Scoured fabric was dried at 60°C for 5min. Cotton fabric was cut with the scissor in a rectangular form and each pieces of fabric weight was 2.8gm.

Cross-Linking of Chitosan with Cotton fabric

Chitosan is cross-linked with cotton fabric by using Citric Acid and $NaHPO_4$ used as catalyst. For cross-linking fabric is soaked into chitosan solution for 30min. Fabric is soaked into both irradiated and non-irradiated chitosan. After soaking fabric was squeezed and dried at 80°C. Dried sample was radiated by Co-60 gamma radiation at 1 kGy. In case of cross-linking two samples are cross-linked with radiated chitosan and another four sample is cross-linked with non-radiated chitosan.

Analysis of functional Group using Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR spectrum of cotton fabric without radiated chitosan and after treatment of radiated chitosan was recorded by using fourier transform infrared spectroscopy (Brukar vertex 100, Germany) to identify the functional group of cotton fabric after radiated chitosan deposition and without chitosan treatment. A thin pallet of potassium bromide containing magnesium peroxide and the spectrums were recorded over 4000- 400 cm^{-1}.

Test Procedure

Tensile strength of cotton fabric, radiated chitosan cotton fabric, irradiated chitosan cotton fabric was measured by following ASTM-D-5035(1995) method using Instron tensile tester (Model No. 5565) [14]. According to ASTM D5034-09(2013) method elongation of cotton fabric, radiated chitosan cotton fabric, irradiated chitosan cotton fabric was done.

4. Results and Discussion

Analysis of functional Group using Fourier Transform Infrared Spectroscopy (FTIR)

FT-IR transmission spectra of pure cotton fabric, radiated chitosan cotton fabric was studied. In transmission mode the spectra were measured by KBr pellets made of finely cutand ground fabric. As a result the spectra showed only characteris-tic peaks of cellulose which is the major component of cotton fiber. But raw cotton also contains some impurities such as waxes, pectins etc. which are not detectable by transmission mode [16] (Figure 2). The spectrum of pure cotton extract showed peaks at 2918 and 2849 cm^{-1} corresponding to the asymmetric and the symmetric stretching of methylene (CH_2) groups in long alkyl chains. This finding supports the work done by Chung et al. [17]. These peaks are responsible for the presence of waxes. Other impurities such as pectins showed characteristic peak in the region 1600-1800 cm^{-1}. The spectrum obtained from pure cotton fabric and radiated chitosan cotton fabric was different. Figure 2 shown that in the peak of 3400 cm^{-1} there was a medium stretch which indicates that in this position amino group was present and in the peak of 1665cm^{-1} and 3332 cm^{-1} corresponding to the C=O vibrations groups in the carbonyl structure and O-H stretching vibrations.

Figure 3 demonstrated that at the peak of 3500-3400 cm^{-1} there was strong broad stretch which indicated that there was amino group in this position and in the peak of 1668cm^{-1} and 3333 cm^{-1} corresponding to the C=O vibrations groups in the carbonyl structure and O-H stretching vibrations. In the **Figure 3** it was obvious that radiated chitosan cotton fabric showed higher carbonyl, hydroxyl content rather than pure cotton fabric. E. Takacs studied the FTIR spectra for gamma-irradiation and alkali treatment on cotton and cellulose fabric. In that study revealed that in the FTIR spectra the increase of the absorbance at 1740 cm^{-1} (C=O stretching vibration) is the consequence of the degradation. Dose dependence of the ratio of absorbances at 1740 and 2924 cm^{-1}. The absorbance at 2924 cm^{-1} is due to the C-H stretching band [18]. Gamma radiation on cotton fabric enables the initiations of chemical reaction and leads to alteration of chemical composition of the cotton fabric i.e. increase of hydrophilic groups such as –OH, -C=O, and –COO. This mainly attributed to the number of polar groups formed and bonded on the fabric polymer in which transmittance is inversely proportional to concentration of the corresponding groups [19].

Tensile strength analysis

The **Figure 4** presents the results of tensile strength of pure cotton fabric, irradiated chitosan cotton fabric, radiated chitosan cotton fabric. The results shows that radiated (1 kGy) chitosan cotton fabric tensile strength was comparatively higher than the cotton fabric that was irradiated cotton fabric (1kGy) and pure cotton fabric. When gamma radiation (1KGy) was applied on chitosan cotton fabric, due to gamma ray chitosan cotton fabric get high energy electromagnetic radiations whose energies above 100 keV and wavelengths less than 10 picometers. Gamma radiation-precipitated grafting has been considerably carried out as a competitive technique to develop new purposeful substances. A smooth method to functionalize the material surfaces with the aid of γ-ray irradiation grafting become stated. The functionalization became a greater uniform as compared with the conventional electrochemical technique. The interfacial strength of the composites had a dramatic increase. A pre irradiation induced emulsion effect by using AN and AA onto PE nonwoven fabric through co graft polymerization method was studied by Liu and his co workers. The hydrophilicity of the modified fabric is improved for the application of AA. Heavy metal ion extraction was done for the modification of nonwoven fabric [20]. For the consequences gamma ray modify the surface of cotton fabric to enhances the tensile strength of chitosan cotton fabric [21].

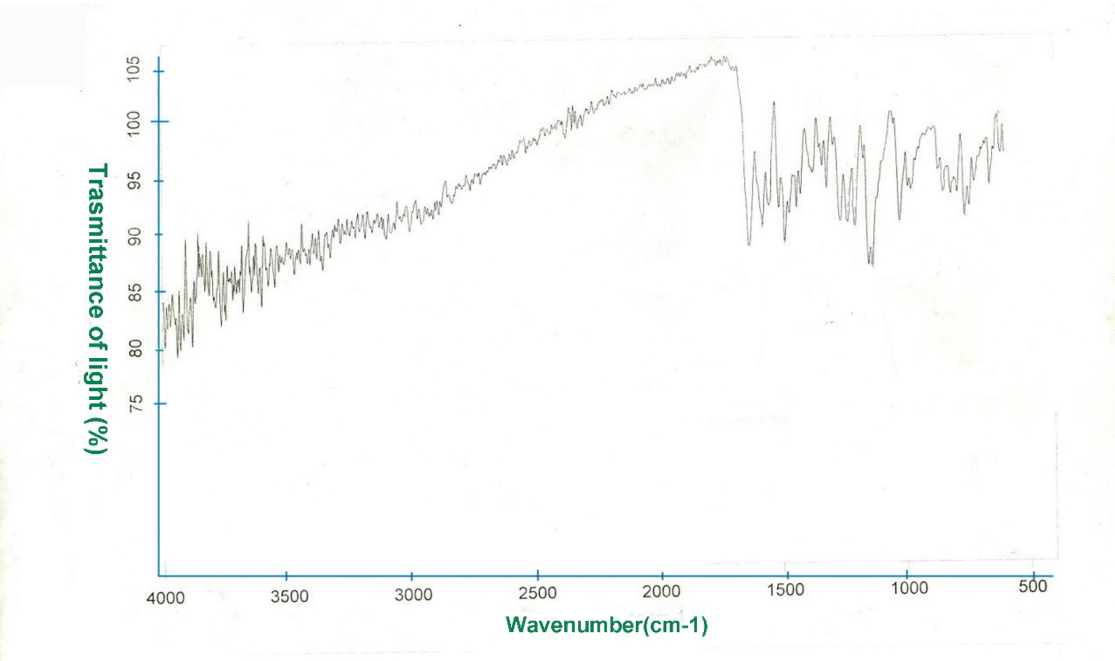

Figure 2. Analysis of functional group of pure cotton fabric from FTIR *test*

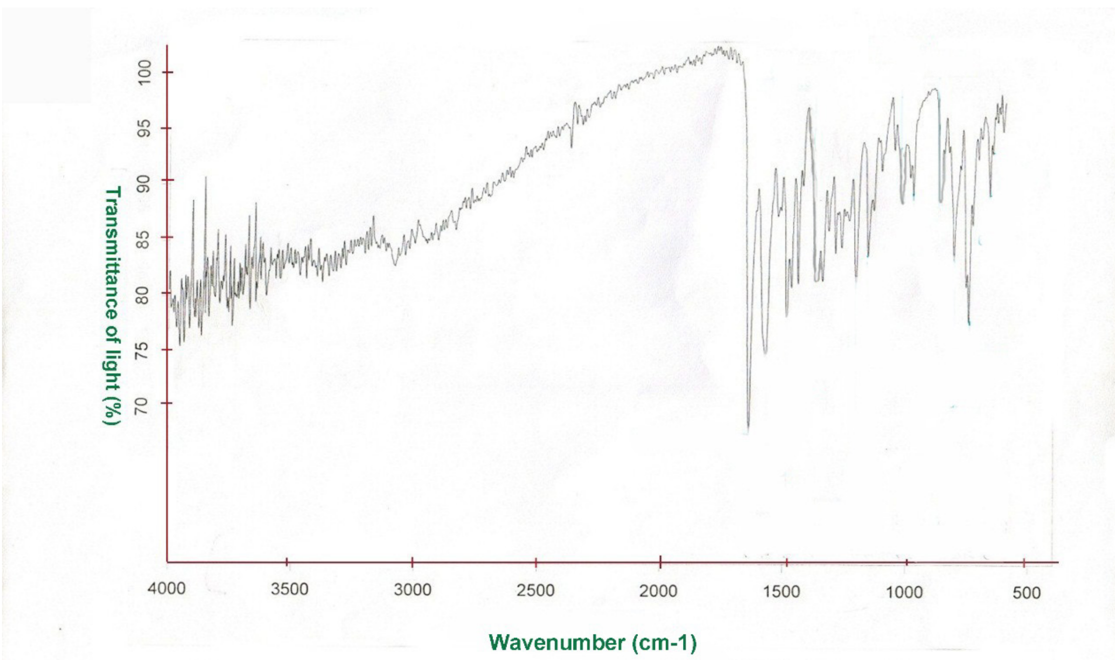

Figure 3. Analysis of functional group of radiated Chitosan treated cotton fabric by FTIR *test*

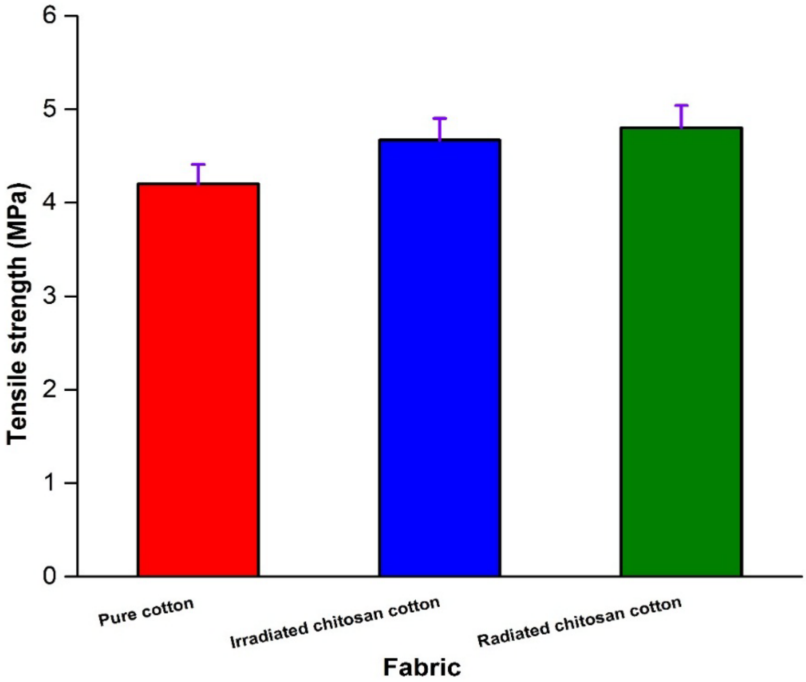

Figure 4. Tensile strength of pure cotton fabric, irradiated chitosan cotton fabric (1 kGy) and radiated chitosan cotton fabric (1 kGy)

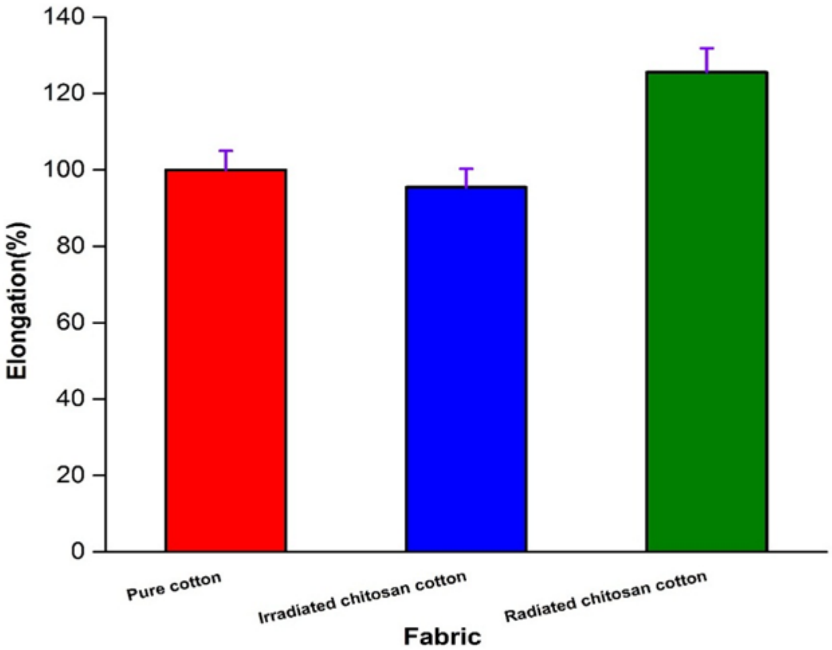

Figure 5. Pure cotton fabric, irradiated chitosan cotton fabric (1 kGy) and radiated chitosan cotton fabric (1 kGy) elongation%

Elongation (%) analysis

Gamma radiation give significant effect on chitosan cotton fabric [22]. **Figure 5** shown that Radiated (1 kGy) chitosan cotton fabric elongation (%) was comparatively higher than the cotton fabric that was irradiated cotton fabric (1KGy) and pure cotton fabric. The high electromagnetic energy of gamma ray improves elongation percentage of chitosan cotton fabric. Gamma ray has the ability to modify the surface of the fabric by improving bursting strength and extension which was studied by M. Mahbubul Bashar. In that study when total absorbed dose and concentration of hydrogen peroxide increased bursting strength of fabric was also decreased. In each option the sample which was not soaked with hydrogen peroxide showed comparatively higher bursting strength and lower strength are found for higher doses and higher amount of hydrogen peroxide concentrations. Gamma radiation was responsible for the higher extension of fabric because higher radiation creates more free radical on fabric surface that attacked polymer chain molecule more effective way [23].

5. Conclusions

Cotton fabric was subjected to gamma radiation which was prepared by using solution of chitosan to investigate mechanical properties of cotton fabric. FTIR analysis showed that intermolecular interactions exist between cotton and chitosan. Cross-linking is increased between cotton and chitosan by gamma radiation. For the influence of gamma radiation chitosan cotton fabric not only exhibits significant change in the tensile strength but also reveals magnificent elongations properties.

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