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Research Article

Analysis of Bagasse Cellulose-Based Hydrogel for Methylene Blue Removal from Textile Industry Wastewater

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The textile industry is one of the biggest water consumption production areas and its waste is essential to cause ecological contamination as they deliver questionable color, weighty metal, and degradable natural and inorganic results whenever arranged without treatment. The natural treatment strategy is not broadly drilled because of its intricate method. In the adsorption method, for example, actuated carbon was limited by prudence of its significant expense and low adsorption limit. This study has completed the combination and portrayal of bagasse cellulose-based hydrogel for the expulsion of methylene blue color from textile industry wastewater. The study furnishes a major critical contributing option for biodegradable adsorption material by supplanting the conventional color evacuation method with a nonconventional one that showsthe attainability of horticultural waste for a union of the hydrogel as opposed to noninexhaustible petrochemical based and show the capability of involving hydrogel for the expulsion of harmful contamination from the textile industry. The hydrogel was combined utilizing free extreme polymerization that can utilize acrylic corrosive (AA) and citrus extract as cross-connecting specialists and monomers individually. FTIR, XRD, and conduct metric titration are the primary hardware utilized for the portrayal of the hydrogel. The cycle boundaries that can influence the color evacuation proficiency of hydrogel, for example, pH, contact time, and temperature have been examined. A focal composite plan by rotatable component is the technique used to browse reaction surface strategies to control the tests with the communication of cycle boundaries.

1. Introduction

1.1. Background of the Study. In developing better life, industrialization is a crucial factor in fulfilling the gap in a socio-profitable sector of the world. The continuous artificial scale is growing with necessary product waste, which harms the atmosphere and health point of view [1]. Contamination fluently released from colorful product factors such as cloth assiduity, rubber, plastic, pulp, paper, and other affiliated assiduity has become a common problem in numerous countries because they produce an enormous quantum of varicolored wastewater and other dangerous poisonous adulterants [2]. According to [3], those product sectors were completed to attain further than a million-ton enthralled toxic color-to-color finished products, and around 7×10^5 tons of color was produced annually. Now a days, decolorization strategies for pollution had been turning into a concern. The chemical remedy approach got great attention and additionally eliminated dye becomes disposed of as sludge due to the breakdown of a compound of dye as it is tough to recycle it [2].

Since textile finishing goes through bleaching, dyeing, finishing, and publishing, various chemicals, colorings, and a huge amount of water were used in each finishing stage which is the reason for the generation of a high amount of toxic and dangerous effluent including color, heavy substance, and degradable organic and inorganic salts [4]. Recently, the textile industry has the potential to release 51% of sewage waste annually. From this, greater than 70 billion ton per year is discharged from the dyeing process [1]. Those

wastes were characterized by high values of BOD, COD, TSS, TDS, TS, high shifting pH, and strong colors which are the primary cause of mortal health and submarine life. Wastewater effluents with a high level of COD can be toxic to biological life [5]. The presence of BOD in textile wastewater leads to the rapid depletion of dissolved oxygen [5]. To a great extent, treatment options widely practiced in decolorization were the physical method, chemical method, and biological method [4] that can be applied. Among the raised mechanisms of dye elimination through adsorption, the method is simply eloquent and sensible because of it being cheap, getting rid of an extensive variety of compounds from the commercial wastewater, having an excessive floor region that allows adsorption, and time being powerful than different remedy methods [6]. A lot of researchers have done gel preparation but have not focused on the gel from bagasse cellulose [7].

Most of the time, hydrogel was synthesized via esterification, free radical polymerization, graft polymerization, cross-linking, and ionization radiation [8]. Cross-linking agents play a massive role in the equilibrium swelling degree and elastic modulus of the hydrogel; the nature of the agent can differ from residences of the adsorbent [9]. Hydrogel from cellulose is a superabsorbent that can absorb and retain huge amounts of water or aqueous solutions [10]. It has great industrial applications in addition to the textile industry such as (a) hygienic and bio-related uses (more specifically in disposable diapers); (b) agricultural uses (such as water reserving in soil, soil conditioning, and controlled release of agrochemicals); (c) pharmaceutical dosage forms; (d) separation technology; (e) paper industries (such as in wastewater treatment); (f) water-swelling rubbers; (g) soft actuators/valves; (h) electrical applications; (i) construction, packaging, and artificial snow; (j) sludge/coal dewatering; and (k) fire extinguishing gels [10]. This study covered the synthesis and characterization of bagasse cellulose-based hydrogel for the removal of methylene blue dye from textile industry wastewater.

Treatment of cation dye will become not an unusual placethat trouble over an extended duration of time, in addition, one million tons of cation dye such as methylene blue dye which is produced yearly and large cited for dangerous illnesses like carcinogenetic and mutagenic, growing heartbeat, vomiting, surprising, and any other not unusual place relative disease [2]. Hydrogels have been established to be tremendous dye-adsorbent substances with extraordinarily excessive quantities of methylene blue adsorption [2]. Synthesis of bagasse cellulose polymer-based hydrogel for the intention of dye removal has been taken into special consideration due to its abundance, renewability, biodegradability, and biocompatibility. More than 100 million tons of SB are produced worldwide annually.

Cellulose first abundant sustainable polymer natural resource introduced from the allure unbranched chain of the 3-hydroxyl group (OH) on each monomer presents the capability to form hydrogen bonds [11].

The ability of cellulose to form intra- and intermolecular hydrogen bonds by the hydroxyl group that is able to make linear cellulose straight chain and support it to bring together into crystalline, and morphological structures [11]. In agreement with [12], cellulose-based hydrogel was a suitable adsorbent for the removal of cation dye.

2. Method

Raw sugar cane bagasse becomes washed with the usage of distilled water till impurities and a small number of sugar constituents are left after juice extraction. Then, the moist bagasse allowed to dry by exposing it to daylight for one susceptible day and it is been grounded for an additional work.

2.1. Raw Material Preparation. Raw sugar cane bagasse turns into washed using distilled water until impurities and a small number of sugar parts are left after juice extraction. Then, the wet bagasse was allowed to dry by exposing it to sunlight for one week and it was grounded for additional work.

2.2. Proximate Analysis. Proximate analysis for sugarcane bagasse was conducted as per the standard ASTM method conducted by authors [13] at the Department of Bioenergy, Agricultural Engineering College and Research Institute. This proximate analysis includes moisture, ash, volatile matter, and fixed carbon contents reported in the result section.

$$\mathrm{MC}(\%) = \frac{W_i - W_f}{W_i} \times 100, \tag{1}$$

$$\begin{aligned} \mathrm{AC}(\%) &= \frac{W_2 - W_0}{W_1 - W_0} \times 100, \\ \mathrm{VM}\,\% &= \frac{W_L(g)}{W_m(g)} \times 100, \\ \mathrm{FC}\,\% &= 100 - (\mathrm{VM}\,\% + \mathrm{AC}\,\%). \end{aligned} \tag{2}$$

2.3. Component Characterization of Sugar Cane Bagasse

2.3.1. Lignin Determination. Lignin content in raw sugar cane bagasse was determined according to a procedure conducted by [14]. 2 gm of 2 mm mesh size bagasse was well mixed with 25 milliliters of 72 percent sulfuric acid at 20°C for 2 hours. The resulting mixture was transferred to a circular bottom flask and diluted with water to make a 3 percent acid solution and then boiled for 2 hours using a hot plate and condenser. The hydrolyzed residue was filtered with a vacuum filtration unit and washed free of acid utilizing hot water. The lignin content is calculated based on the oven-dry sample as follows:

$$\text{Lignin content}(\%) = \frac{\text{weight of dried sample}}{\text{the initial weight of the sample}}. \tag{3}$$

2.3.2. Determination of Water, Ethanol, and Extractives. Extractive determination was done by following the procedure applied by [13] that 10 g of bagasse powder with a particle size of 600 μm was taken and mixed in 200 ml of distilled water and kept in a boiling water bath of 80°C for 3 hours. Then, it was filtered using a vacuum filter. The filtered residue was dried at 105°C until a constant dry weight was obtained. Similarly, for the preparation of ethanol extractives, ethanol was diluted to 5% in 200 ml of distilled water and then extractives were prepared with the same procedure as water extractive preparation. Finally, the extractive percentage was determined as follows:

$$\text{extractive}(\%) = \frac{(W_I - W_e)W_w}{W_I} \times 100, \quad (4)$$

where W_I is the initial weight of the sample and W_e and W_w are the constant weights of the water and ethanol extractive.

2.4. Isolation of Cellulose. The residual was added to a 4% NaOH (w/v) solution (200 mL) and stirred for 2 h at 60°C using a magnetic stirrer; the ratio of residual to NaOH was 1 : 10 (w/v). The oxidation process by H_2O_2 was reported by [15], 24% H_2O_2 (v/v) (200 mL) was added to an alkalized residue with magnetic stirring at 60°C for 2 h to completely remove lignin and hemicellulose. Toward the finish of extraction, the buildup was separated and washed with refined water to arrive at neutrality. The ratio of the residue to H_2O_2 is 1 : 20 g/ml. Finally, a solution with white precipitate was filtered using a vacuum filter and washed with distilled water thoroughly and dried in an oven at 50°C overnight as observed in Figure 1 below.

2.5. Cellulose Yield Determinations. From the extraction process mentioned above, the amount of final cellulose product obtained was determined as follows:

$$\text{yield}(\%) = \frac{\text{weight of obtained cellulose product}(g)}{\text{weight of baggase powder used}(g)} \times 100. \quad (5)$$

2.6. Characterization of Cellulose Product

2.6.1. Purity Test. A purity test for extracted cellulose was conducted according to the procedure taken place by [16]. 2 g of extracted bagasse cellulose was mixed with 100 mL of ethanol and heated at 65°C, and then it was placed in a water bath adjusted at 60°C. After 10 min stirring, the undissolved matter was settled with the beaker in the bath. Then, the hot supernatant was decanted and filtered, and 100 ml of ethanol that was heated at 65°C was added to the undissolved matter and placed in the water bath.

After decanting the supernatant liquid, the insoluble matter was transferred to the crucible with the aid of ethanol at 65°C in a wash bottle. The insoluble residue was first washed with 100 ml of ethanol at 65°C followed by 50 mL of ethanol at room temperature. Then, the crucible was placed in an oven at 105°C for 1 hr and the contents of the crucible were stirred to break up the cake and facilitate complete drying and the crucible was placed in a desiccator. The crucible was dried for an additional 1 hr until the change in mass during drying becomes constant; finally, purity was calculated as follows:

$$\text{purity}(\%) = \frac{M_s \times 10000}{M_{\text{Sp}} \times (100 - M_{\text{OSP}})}, \quad (6)$$

where M_s, M_{sp}, and M_{osp} are the mass of dried residue, the mass of specimen used, and moisture in the specimen as received, respectively.

2.6.2. UV-Vis Spectrometer Analysis. The UV absorbance spectra of cellulose arrangement were estimated from 190 to 700 nm. The intensity absorbance peaks of extracted cellulose corresponding to this range validate the presence of cellulose content and the Origin Pro (8.5) version software was used to analyze absorbance versus wavelength.

2.6.3. Fourier-Transformed Infrared Spectroscopy (FTIR). Functional group changes between untreated sugarcane bagasse and extracted cellulose product during various treatment methods were analyzed by FTIR spectroscopy (L1600300 Spectrum TWO UTA) using potassium bromide (KBR) as reference material. The infrared spectra band was recorded by passing a beam of light through the solid sample at a resolution of 4 cm^{-1} in the spectral region between 4500 and 450 cm^{-1}. The disk was prepared from a powered sample of (0.001 g) and (0.045 g) of cellulose and potassium bromide using 400 kg/cm^2 for 10 min, respectively. The spectra offer qualitative and semiquantitative information suggesting the absence and presence of lignocellulosic compounds and whether the intensity of the absorption band has changed.

2.6.4. X-Ray Diffraction (XRD). An X-ray diffractometer (DW-XRD-Y7000 with cu kα radi ation) was used to estimate the change between the degree of crystallinity of untreated sugarcane bagasse powder and extracted cellulose. This equipment is recommended as a special technique for investigation of the degree of crystallinity of lignocellulosic materials including sugarcane bagasse. The scanning range was 2θ = 10 to 70 degrees at a scanning speed of 0.03 m/s using an acceleration voltage of 30 kv and 25 MA current. The diffraction pattern of bagasse and sugarcane bagasse was analyzed from the determined peak. The Crystallinity Index and crystal size of sugarcane bagasse and extracted cellulose were determined according to the equation used in the research work of the authors [17], and the result was compared with the literature value. Experimental analysis was done at the Chemical Engineering Department of Adama Science and Technology University.

$$(\text{CI in }\%) = \frac{\text{area of crystalline peak}}{\text{total area of all peaks}} \times 100\,(\text{CS}) = \frac{k\lambda}{\beta \cos\theta}, \quad (7)$$

where CI is the Crystallinity Index, CS is the crystal size, K is the correction factor and is usually taken to be 0.91, λ is the radiation wavelength, θ is the diffraction angle, and β is the

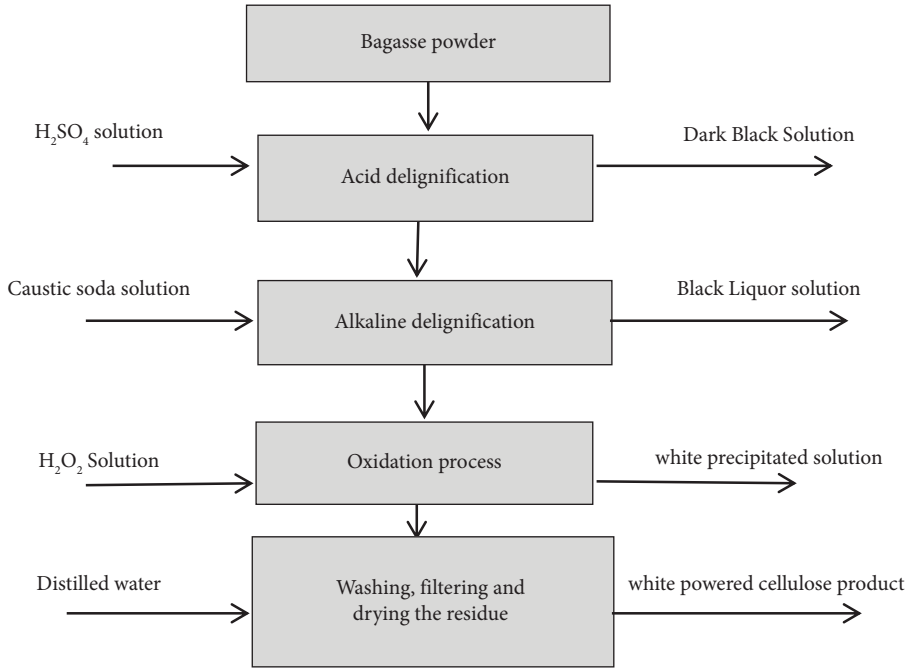

Figure 1: Flow sheet for extraction of cellulose from sugar cane bagasse.

corrected angular width (in radians) at half maximum intensity.

2.7. Synthesis of Bagasse Cellulose-Based Hydrogel. The hydrogel was synthesized from extracted cellulose according to a combination of procedures conducted by [18, 19]. Cellulose solution was prepared by adding 1.0 g of extracted cellulose powder into 20 ml of concentrated phosphoric acid to break down intra- and intermolecular hydrogen bonds [20]. Thereafter, using polyethylene glycol (PEG) for the production of hydrogels shows that synthesized hydrogels are responsive to external stimuli and hence these smart hydrogels are widely practiced for pollutant removal from west water as well as aqua solution [21]. Based on [12], an optimal degree of swelling for practical applications was achieved using low-citric acid concentration [22].

2.8. Reaction Mechanism. During the preparation of the citric acid solution, 10% (w/v) citric acid was dissolved in water at 70°C, which lead to citric anhydride; dissociation of a hydrogen ion from citric acid yields hydronium ion formation. Figure 2 shows the structure formation of citric anhydride during the dissolution of citric acid into the water in the presence of heat.

Figure 3 shows the esterification bond formation between cellulose.

Further esterification reaction with another cellulosic hydroxyl group produces a crosslink between cellulose chains which is shown in Figure 3. This system depends on an anhydride middle development. Figure 4 shows crosslinking reaction.

2.9. Characterization of Hydrogel

2.9.1. Swelling Study. The swelling ratio for hydrogel can be determined by the water-immersing method mentioned by [2]. 2 g of powder hydrogel was immersed in 100 ml of distilled water for two days until it reaches swelling equilibrium and is calculated using equation (1).

2.9.2. Gel Content Determination. Determination of gel content was done by the sole fraction removal method reported by [18]. 1 g of dried hydrogel was immersed in 100 ml of distilled water for 48 hours to completely remove the sol fraction. Then, the swelled hydrogel was taken out and dried at 50°C by using the oven drying technique; finally, gel content is determined as follows:

$$\text{gel content}\,(\%) = \frac{\text{weight of dry gel after swollen}}{\text{the initial weight of dried gel before swelling}}. \quad (8)$$

2.9.3. X-Ray Diffractometer Analysis (XRD). X-ray diffractometer for crystallinity analysis was carried out to show the crystallinity change that occurred during the esterification reaction. The scanning speed for the process was 0.03 m/s

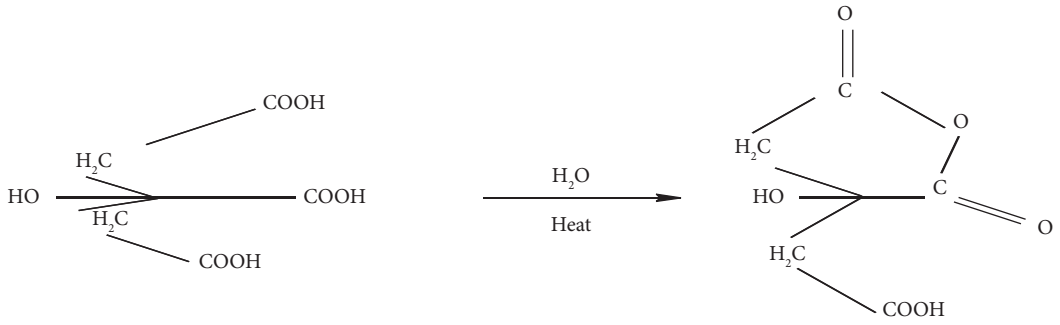

Figure 2: Dissociation (formation of citric anhydride).

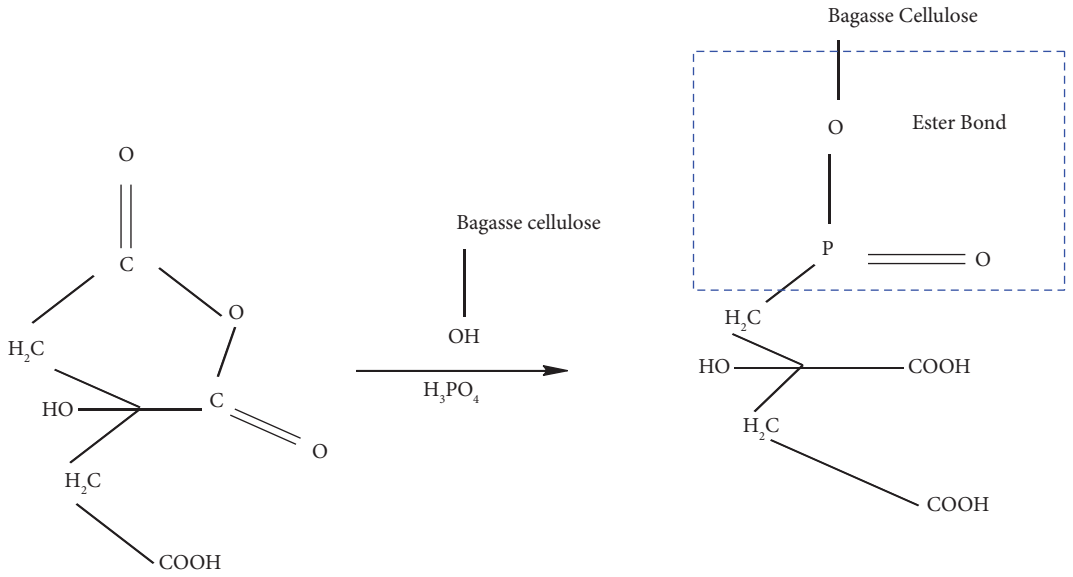

Figure 3: Esterification reaction between bagasse cellulose.

over 2θ in the range of 10–70 degrees using an acceleration voltage of 30 kv and a current of 25 mA. Finally, the Crystallinity Index and crystal size were calculated according to equation (7).

2.9.4. Fourier Transformed Infrared Spectroscopy Analysis (FTIR). Fourier transform infrared spectroscopy (FTIR, PERKIN ELMER, L1600300 Spectrum TWO UTA) was used to characterize functional groups and chemical structure of hydrogel synthesized by potassium bromide disk technique.

2.9.5. Particle Size Determination. Dynamic light scattering analysis is one of the well-known methods to determine the particle size distribution and average particle size of the material. The refractive indices are continually changing due to this motion, which is detected by a sensor, which uses the Stokes–Einstein equation to determine the size distribution of the adsorbent.

2.9.6. Adsorption Experiment. Four different batch mode experimental studies were carried out to study the effect of adsorbent dosage (0.6–1.6) g, initial pH of (4–9), initial contact time of (30–60) minutes, and initial pollutant concentration of (5–25) mg/L on removal efficiency of the synthesized hydrogel. Then, the adsorbent was removed by a watchman filter paper and the supernatant was analyzed by UV-visible spectrophotometer for the residual concentration of MB at a maximum wavelength of 665 nm and the final removal efficiency of hydrogel was determined according to the equation mentioned by [23].

$$\text{Removal efficiency}\,(\%) = \frac{C_O - C_e}{C_o} \times 100, \tag{9}$$

where C_o and C_e, are the initial concentration of pollutant in the sample (dye) of solution and equilibrium concentration of pollutant (dye) in the sample in mg/L, respectively.

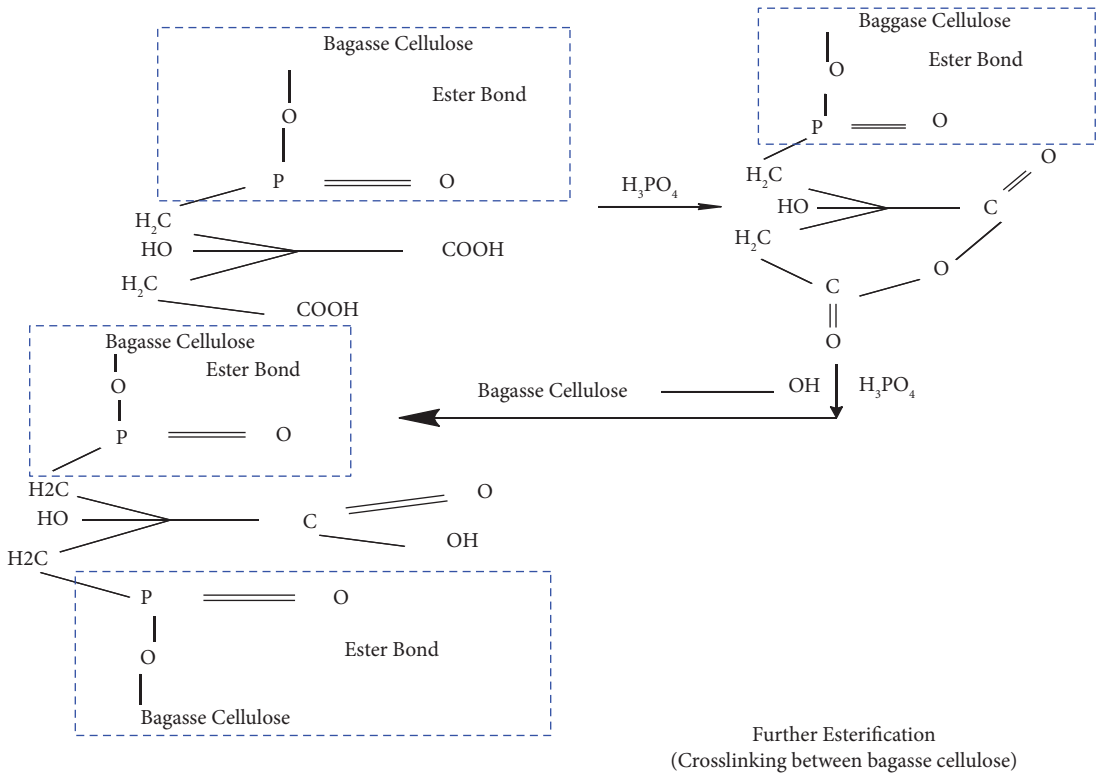

Figure 4: Further esterification reaction between cross-linking and cellulose.

Adsorption capacity will be studied under different operating conditions by using a UV-visible spectrometer, and the amount of adsorption capacity is calculated as follows: -

$$(Q_e) = \frac{C_O - C_{EQ}}{M} V, \tag{10}$$

where Q_e is the amount of dye adsorbed at equilibrium, C_o is the MBD concentration of the solution before the equilibrium, C_e is the MBD concentration of the solution in the equilibrium, and V is the volume of MBD solution.

2.9.7. Adsorption Kinetics. As per Mustapha, Ndamitso, and Sumaila, [24]. 1.2 g of hydrogel power was added to 100 mL of 20 mg/L of MBD concentration at room temperature and shaken vigorously at respective contact times (15, 30, 45, 60). The obtained residual hydrogel was used to calculate the pseudofirst-order and pseudosecond-order adsorption kinetics (K, Qe, and R^2) according to equations (9) and (10).

3. Result and Discussion

3.1. Proximate Analysis for Sugarcane Bagasse. Proximate analysis was performed for sugarcane bagasse adsorbent to analyze the different physicochemical characteristics such as moisture content, ash content, volatile matter, and fixed carbon.

The proximate analysis result of bagasse determines the distribution of its contents. It may be noted that the volatile matter present in bagasse contributes maximum to its contents. The moisture content present in the sample can also be considered water vapor when it is heated to high temperatures.

All of the tables' data are fittable with the literature value (Tables 1 and 2 below).

3.2. Component Characterization for Sugar Cane Bagasse

3.2.1. Cellulose Determination Result. About 42.35% of determined cellulose content is observed in this research work which also agreed with the literature value as observed in Table 3 below.

3.2.2. Yield Result. Yield determination for cellulose product was calculated according to equation (11), which is the ratio of the product obtained and total bagasse powder used multiplied by 100%. 120 g of bagasse powder was used in this work and 52.4505% of dried cellulose product was obtained.

$$\text{Yield}\,(\%) = \frac{\text{weight of cellulose}\,(62.9406g)}{\text{weight of baggase}\,(120g)} \times 100 = 52.4505\%. \tag{11}$$

Table 1: Summary of proximate analysis results.

	Value in %
Parameter	Raw bagasse
Moisture content	49.93
Ash content	2.45
Volatile matter	69.35
Fixed carbon	28.2

Table 2: Literature value obtained one for proximate analysis of raw bagasse.

Analysis carried out	Result recorded (%)	Literature value (%)	Remark
Moisture content	49.93	48.50–51.5	[25]
Ash content	2.45	1–4	[26]
Volatile matter	69.35%	58.50–71.30	[27]
Fixed carbon content	28.2	18.60–29.40	[28]

3.2.3. Purity Test Result. Purity test for extracted cellulose was common for the quality of synthesized hydrogel. Extracted cellulose in this work was 91.883% pure. The purity validates the percent of the active ingredients in the cellulose and the removal of unwanted polysaccharides during the treatment method which was used as the main raw material in the synthesis of the hydrogel. Numerous kinds of literature reported that the highest extracted cellulose purity recommended for the synthesis of hydrogel was $(71.04 \pm 0.78)\%$ to $99.16 \pm 0.15)\%$.

3.2.4. Absorbency Analysis Result. UV absorbance spectra of cellulose solution were measured from 200 to 700 nm and the corresponding results are shown in the Figure 5 below. The intensity absorbance peak of extracted cellulose was observed around 199 nm. In agreement with [17], absorbance spectra between 190 nm to 700 nm show the presence of cellulose product in the solution or removal of unwanted polysaccharides showing a component of the cellulose polymer.

3.2.5. Functional Group Analysis Result. The chemical constituent of sugarcane bagasse (untreated) and extracted cellulose product are shown in the figure below. The FTIR spectra of both samples indicate two main absorbency regions in the range of (800–1800) cm^{-1} and (2700–3500) $cm^{-1.}$ Graph analysis of untreated sugarcane bagasse 832 cm^{-1} is attributed to bending vibration of arenes C–H bond in lignin, even though wave numbers containing this peak are not found in the graph of cellulose extracted which is in agreement with [31]. The peak observed at 897 cm^{-1} shows the presence of β – glycosidi c linkage between glucose units in cellulose and hemicellulose. However, these characteristics of the peak are not found in the lignin structure; moreover, this peak is significantly presented in purified cellulose extracted [32].

The peak at 1042 cm^{-1} is related to C–O stretching in the plane due to aromatic C–H deformation of cellulose and lignin [33]. The peak at 1051 is ascribed to the C–O antisymmetric stretching vibration of the glucosidic ring in cellulose and hemicellulose, while this peak disappeared from extracted cellulose [34]. The peak at 1105 cm^{-1} can be assigned to C–O–C glucosidic ring vibration in cellulose and is agreeable with aromatic C–H in-plane deformation of lignin and also peak at 1160 cm^{-1} is related to pyranose ring C–O–C asymmetric stretching of cellulose and hemicellulose which confirmed with [35]. The absorption peaks at 1200 cm^{-1} are O–H deformation vibration mode of cellulose, while the absorbency peak at 1240 cm^{-1} shows C–O out-of-plane stretching vibrating in lignin; after the chemical treatment process, these peaks are disappeared from extracted cellulose in this work, which is the best suggestion for the removal of lignin [36].

The peak at 1320 cm^{-1} is assigned to the CH_2 wagging frequency of cellulose which appears to be both untreated sugar cane bagasse and extracted cellulose [37]. The peak at 1365 cm^{-1} corresponds to the C–H bending or polysaccharide aromatic C–O vibration and aliphatic C–H stretching mode of cellulose, hemicellulose, and lignin [33]. The peak observed at 1600 cm^{-1} only formed in untreated sugarcane bagasse due to the C=O stretching vibration of lignin does not appear in extracted cellulose products. The absorbance band located at 1634 cm^{-1} for both sugarcane bagasse and extracted cellulose is associated with absorbed water in the cellulose and sugar cane bagasse [17].

The peak positioned at 1728cm^{-1} is correlated to C=O stretching vibration of the carboxylic group of lignin and hemicellulose; this peak did not appear after the chemical treatment method showing complete removal of that polysaccharide from sugarcane bagasse [38]. The absorbency peak around 2900 cm^{-1} is due to the C–H stretching vibration of methyl and methylene groups in cellulose and hemicellulose as observed in Figure 6 below [38]. The broad peak around 3340 cm^{-1} is attributed to the O–H stretching of the intermolecular hydrogen bond of hydroxyl groups [34]. The FTIR spectra are shown in Figure 6.

3.2.6. Crystallinity Analysis Result. The presence of crystallinity in cellulose is one of the most important characteristics contributing to its physical, chemical, and mechanical properties [39]. The diffractometer peak analysis observed from XRD analysis scanned over 10 to 70 degrees with a scanning speed of 0.03 s^{-1} was done for untreated sample bagasse and extracted cellulose. The peak corresponds to the crystallinity nature of the materials and the background is corresponding to the amorphous nature of materials. Crystallinity change was observed between untreated sugar cane bagasse and chemically extracted cellulose. The intensity peak located at 22 for cellulose and sugarcane bagasse describes the crystalline nature of the material and the intensity value shows the amount of crystalline structure (2thetha value). High-intensity peaks shown for extracted cellulose show crystallinity change between cellulose and sugar cane bagasse.

Table 3: Comparison of this work with literature value for component characterization.

Analysis carried out	Result recorded (%)	Literature value (%)	Remark
Lignin content	18.35	18–24	[17]
Hemicellulose content	30.8	22.9–35.8	[29]
Cellulose content	42.35	40–50	(Naiyasit et al., 2014)
Extractive	8.5	2.7–14.1	[30]

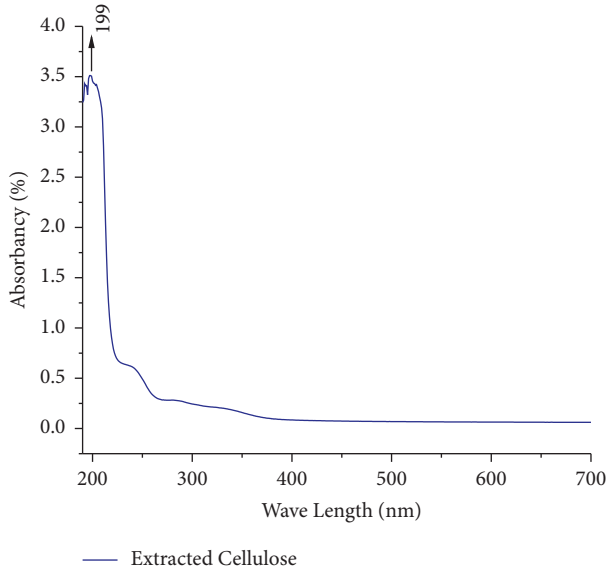

Figure 5: UV spectrometer analysis for extracted bagasse cellulose.

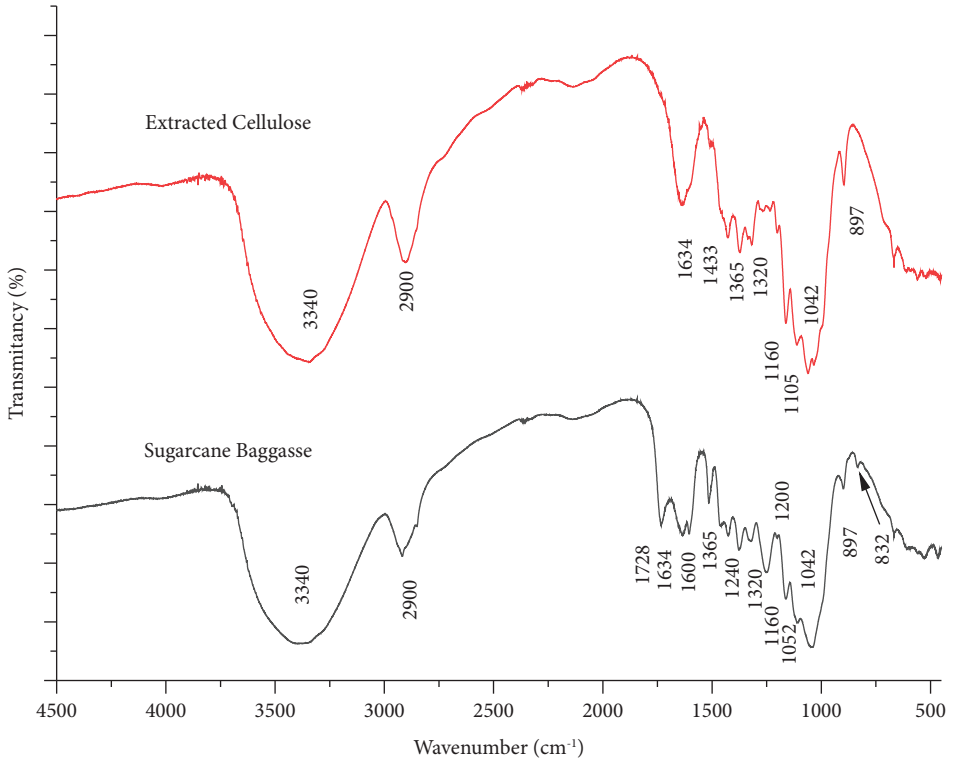

Figure 6: FTIR spectra of untreated sugarcane bagasse and extracted cellulose.

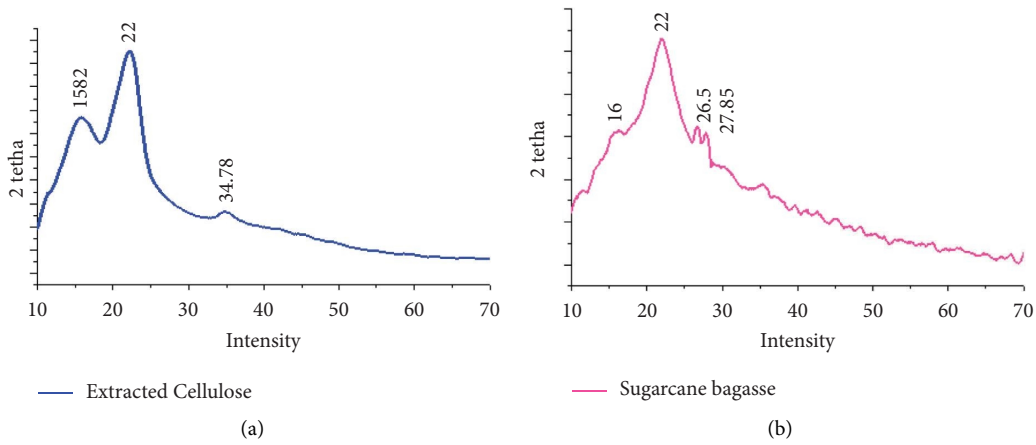

Figure 7: X-ray diffraction pattern of (a) extracted cellulose and (b) untreated sugarcane bagasse.

Table 4: Experimental analysis for gel content determination.

Run no	Weight of dry gel (g)	Gel content (%)
1	1.849	92.45
2	1.710	85.50
3	1.699	84.95
4	1.689	84.45
		Average = 86.8125%

Table 5: Literature-based study for mechanical property study for synthesized hydrogel.

Analysis	This work (%)	Literature value (%)	Remark
Swelling capacity	4182.5	(2146–5595)	[41]
Water absorbency test	96.919	(75 – 99.9 ± 0.1)	[19]
Gel content	86.8125	(70 – 100)	[40]

The Crystallinity Index was found to be 47.101% and 77.612% for bagasse and extracted cellulose, respectively. CI changes after the treatment method was increased by 30.511%, showing the Crystallinity Index change between sugarcane bagasse and cellulose which shows the removal of the amorphous part of lignin and hemicellulose from sugarcane bagasse. The experimental analysis discussion was in agreement with [17]. The average crystal sizes for sugarcane bagasse and extracted cellulose were 2.51 nm and 1.119 nm, respectively (Figure 7).

3.2.7. Swelling Study Result. During the swelling study, high weight increment of swollen hydrogel was shown after a two-day immersing period, which gains 4182.5% of the swelling degree of the synthesized hydrogel. Regularly. the meshes of the network in the rubbery phase started to expand, allowing other solvent molecules to penetrate the hydrogel network [40]. The properties of swelling of bagasse cellulose hydrogel were calculated using equation (1). This value was in agreement with the literature that highly swollen hydrogel achieves a high adsorption capacity of methylene blue dye pollutants from the textile industry [41].

3.2.8. Water Absorbency Test Result. Synthesized hydrogel in this work shows 96.919% water uptake capacity. As per [19], water content exceeding 95% of the total weight of gel makes it superabsorbent hydrogel; this means this hydrogel is an infinitely large molecule or super macromolecule having unique properties of maintaining the shape even upon swelling.

3.2.9. Gel Content Determination Result. The oven-dry method of the swollen gel was four times recorded until the constant was gained. Finally, the mean value of gel content was calculated as shown in Table 4. Literature-based study for mechanical property study for synthesized hydrogel is shown in Table 5.

4. Conclusions

Based on the proximate analysis result, sugar cane bagasse has maximum volatile matter and minimum ash content. Therefore, the analysis gives evidence for sugar cane bagasse as the precursor used for activated CarbonCript.

The study is focused on the analysis of hydrogel from bagasse cellulose and its application for dye removal from textile wastewater. As observed from crystal size analysis extracted cellulose is more crystal than not extracted cellulose. There is the β-glycosidic bond linkage between cellulose and the hemicellulose structure of the starch. The produced gel has a crystal matrix structure which can be helpful to trap small molecules. The water absorbance capacity of the hydrogel is high due to the more crystal structure of its structure which leads to swelling behavior.

Basicity based on cellulose purification results in a high-quality pure product. We want to recommend further studies to change the surface area of the produced gel for further efficiency of removal or trapping behaviors of the produced gel.

Abbreviations and Acronyms

AOP: Advanced oxidation process
BOD: Biological oxygen demand
COD: Chemical oxygen demand
CV: Crystal violet
EPA: Ethiopian Environmental Protection Authority
FRP: Free radical polymerization
HGB: Hydrophilic gels for biological use
ISPCH: Industrial Safety and Pollution Control Handbook
MBD: Methylene blue dye
SAP: Super adsorbent hydrogel
SB: Sugar cane bagasse
TDS: Total dissolved solid
TS: Total solid
TSS: Total suspended solid.

Data Availability

Supportive result for water absorbance taste is found at https://doi.org/10.1186/s13065-017-0273-5, functional group analysis supportive data are found at https://doi.org/10.4236/ajac.2018.96023, and absorbance taste result supportive result is found at https://doi.org/10.1063/1.5053181.

Disclosure

The latest version of this paper has been published as a preprint [42].

Conflicts of Interest

The authors declare no conflicts of interest.

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