

Preparation of a Bagasse-Based Anion Exchange Fiber for Sugar Decolorization

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ABSTRACT: Sugar bagasse was converted into an anion-exchanger through grafting acrylamide using $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2/\text{H}_2\text{O}_2$ as initiator in an aqueous system, followed by reacting with ethylenediamine and hydrochloric acid. The effects of the grafting conditions such as monomer concentration, temperature, reaction time on the degree of grafting were investigated. The ion exchange capacity of the sugar bagasse base anion-exchange fiber (SB-IEF) was up to 3.70 mmol/g. Application of the SB-IEF in sugar decolorization was evaluated. Compared with commercial strong basic anion exchange resin (AIER) and strong basic anion exchange fiber (AIEF), SB-IEF showed the highest static decolorization capacity for sugar colorants (decolorization degree 71.40%), followed by AIEF (decolorization

degree 68.74%) and AIER (decolorization degree 31.40%) at the same operating conditions. The dynamic decolorization results indicated that SB-IEF showed larger processing volume than AIER and AIEF. SB-IEF with higher grafting degree would have a higher decolorization degree. When 200 mL 2% brown granulated sugar solution was treated with 1 g SB-IEF (grafting degree 82%), 80% decolorization degree could be achieved. The research results may provide a recyclable route for the comprehensive utilization of by-products of sucrose industry. © 2012 Wiley Periodicals, Inc. *J Appl Polym Sci* 000: 000–000, 2012

Key words: biofibers; graft copolymers; ion exchangers; adsorption

INTRODUCTION

Among all the technical difficulties in sucrose industry, decolorization craft is one of the most crucial problems. Bone carbon and activated carbon are classic decolorizing agents; however, they have been replaced by the highly developed ion exchange resins (IER) for their heavy equipment investment and material cost.^{1–3} Most of the current manufacture of refined sugar applies ion exchange resin to decolorization and purification.^{4–6} When used directly in sugar decolorization, ion exchange resin can be easily polluted by gel. Moreover, the accumulation of calcium ions is easy to plug the resin, which results in ion exchange resin's short using life and difficulty

in regeneration.^{2,7} Ion exchange fiber (IEF) is a fibrous ion exchange and adsorption material. It shows excellent adsorption performance due to the larger effective specific surface area, higher exchange rate, shorter transit distance, stronger adsorption ability, and longer using life. In addition, it's more easily to be regenerated, compared with the traditional ion exchange resin.⁸

As one of the by-products of sucrose industry, sugarcane bagasse is one of the most abundant renewable natural polymers on the earth. However, large quantities of bagasse have been burned as fuel in sugar refinery or abandoned for a long time. The comprehensive exploitation of bagasse resource would be of great significance in enhancing the economic benefits of sucrose industry. Modifying bagasse cellulose materials through graft polymerization to prepare ion exchange materials could be considered as a good way to better utilization of bagasse resource. Ion exchangers made from sugarcane bagasse could be used as efficient adsorbents for removal of heavy metal ion from wastewater.^{9–11} Nianfang Ma¹² developed an amidoximated bagasse (Am-B) by grafting copolymerization of acrylonitrile onto sugarcane bagasse. The equilibrium adsorption of Am-B for mercury ions amount could be as high as 917.4 mg/g, and the removal percentage of

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mercury ions can achieve 99%. The removal of Cr^{3+} ion from the wastewater of a local tannery by using a phosphosulfonated bagasse was performed by Nada A. M. A.¹³ The prepared phosphosulfonated bagasse can pick up $171.2 \mu\text{mol/g}$ from original Cr^{3+} concentration of $370 \mu\text{g/mL}$. Osvaldo Karnitz Jr.¹⁴ proposed in his work that a sugarcane bagasse chemically modified with succinic anhydride can be employed to treat heavy metal waters. The adsorption capacity of the modified bagasse for Cu^{2+} , Cd^{2+} , and Pb^{2+} were 139, 164, and 189 mg/g, respectively. There are also some researches on color removal: Clarke and Roberts¹⁵ modified agricultural residues including bagasse with diethylaminoethyl chloride under strong base solution and evaluated the application of the products DEAE-bagasse in sugar decolorization, under similar decolorization conditions, its color removal percentage could reach around 85%. Mane et al.¹⁶ have also reported the modification of bagasse with 3-chloro-2-hydroxypropyltrimethylammonium chloride (CHPTAC bagasse) and 53.49% color reduction could be achieved when CHPTAC bagasse whose N content is 2.5% was used to treat spentwash.

In this article we explored a new and practical way to add value to bagasse, a low-value by-product in sucrose industry. A basic anion exchange fiber (SB-IEF) was prepared through grafting with acrylamide followed by reacting with ethylenediamine and hydrochloric acid. The reagents used to prepare SB-IEF were easily available and the reaction conditions were relatively mild while no strong base was needed. The removal efficiency of sugar colorants by the anion exchange fibers was evaluated. The technique reported in this paper provided a recyclable route for the comprehensive utilization of by-products of sucrose industry.

EXPERIMENTAL

Materials and reagents

Sugarcane bagasse (SB) and brown granulated sugar were provided by Guangzhou Sugarcane Industry Research Institute (China). And SB was ground to 20–30 mesh size before use. Acrylamide (Am), ethylenediamine (EDA), NaOH, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$, and H_2O_2 were analytic reagent grade, and purchased from Guangzhou Reagent Company, Guangdong Province. A commercial strong basic anion exchange resin (AIER, ion exchange capacity 2.81 mmol/g) obtained from Wandong Resin Factory, Anhui Province, and a PVA-based strong basic anion exchange fiber (AIEF, ion exchange capacity 2.16 mmol/g) from Guangzhou Sugarcane Industry Research Institute were used as reference. Deionized water was used to prepare all solutions in the study.

Preparation of bagasse-based anion exchange fiber

Sugarcane bagasse (10 g) was immersed in 200 mL of NaOH aqueous solution (20 wt %) at 25°C for 24 h. The alkali-treated bagasse was then filtered and washed with deionized water till the pH of filtrate was neutral. The alkali bagasse fiber was dried at 60°C and stored in a desiccator for future use.

Graft polymerization of acrylamide (Am) onto NaOH-treated SB was conveniently carried out in an aqueous system using $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2/\text{H}_2\text{O}_2$ as initiator. One gram alkali-treated bagasse, 0.0645 g $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$, 0.5 mL 30% H_2O_2 , and 70 mL certain concentration of Am (14.3–85.7g/L) were transferred into a 100 mL three-neck flask. The system was purged with nitrogen during reaction to eliminate oxygen. The grafting reaction was carried out at a preset temperature (30–80°C) under nitrogen atmosphere for a certain time (1–5 h). The resulting product, polyacrylamide-grafted sugarcane bagasse (SB-Am), was washed with deionized water at 80°C to remove the residual monomer and homopolymers, and then dried at 60°C under vacuum. The degree of grafting was calculated according to the following eq. (1):

$$G = \frac{W_g - W_0}{W_0} \times 100\% \quad (1)$$

Where W_0 and W_g are the weights of the NaOH-treated sugarcane bagasse and grafted fibers.

One gram SB-Am was then refluxed with 25 mL ethylenediamine (EDA) for 8 h at 120°C in a 100-mL flask. The aminated fiber was washed with deionized water and dried at 60°C, then immersed in 0.1M HCl solution for 4 h. After that, the fiber was washed thoroughly with deionized water and dried at 60°C. The obtained anion exchange fiber was denoted as SB-IEF.

The reaction rate of Am converted to $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ was calculated according to the following eq. (2):

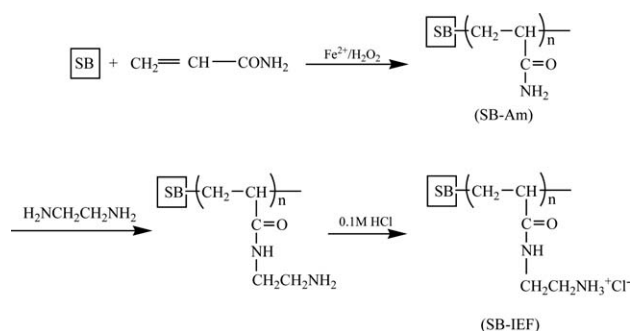
$$R = \frac{M_{\text{Am}}(W_a - W_g)}{(M_{\text{EDA}} - M_{\text{NH}_3})W_g \times \frac{G}{1+G}} \times 100\% \quad (2)$$

Where W_g and W_a are the weights of the SB-Am and SB-IEF, M_{Am} , M_{EDA} , and M_{NH_3} are the molar mass of Am, EDA, and NH_3 , respectively. And G is the grafting degree of SB-Am.

The $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ density was calculated according to the eq. (3):

$$\rho = \frac{(W_a - W_g)}{(M_{\text{EDA}} - M_{\text{NH}_3})} \div W_a \times 1000 \quad (3)$$

where ρ is the $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ density (mmol/g SB-IEF), W_g and W_a are the weights of the



Scheme 1 Reaction scheme of anion exchange fiber SB-IEF.

SB-Am and SB-IEF, M_{Am} and M_{EDA} are the molar mass of Am and EDA.

The preparation scheme of bagasse-based anion exchange fiber is showed in Scheme 1.

Measurement of sugar colorant removal

International Commission for Uniform Methods of Sugar Analysis (ICUMSA) is the only international organization concerned solely with analytical methods for the sugar industry. According to the ICUMSA Method GS 2/3-9 (2005), measurement of color of sugar solution at pH 7.0 was used to determine the percentage of decolorization degree of sugar solution by the anion exchange fiber.¹⁷

Sugar decolorization by continuous process

The sugar solution (2% brown granulated sugar aqueous solution) was introduced by a peristaltic pump to a fixed bed adsorption column packed with certain amount of SB-IEF ($\Phi = 6$ mm, $X = 150$ mm). Effluent solutions were collected at certain time intervals, and the color of the effluents was measured at 420 nm using a UV-7504C model UV-Vis spectrophotometer (Shanghai Xinmao Instruments, China). The decolorization degree E was calculated by the following eq. (4):

$$E = \left(1 - \frac{\text{IU}_1}{\text{IU}_0}\right) \cdot 100\% \quad (4)$$

where IU_0 and IU_1 are the ICUMSA (International Commission for Uniform Methods of Sugar Analysis) color of the initial and treated sugar solution. ICUMSA color measured at 420 nm is commonly used in defining the degree of whiteness of refined sugars.

$$\text{IU} = \frac{A}{bc} \times 1000 \quad (5)$$

where IU is ICUMSA color, A is absorbance tested by UV-7504C, b is the thickness of cuvette (cm), and c is the concentration of the sugar solution (g/mL).

Decolorization amount is used to evaluate the removal capacity of the adsorbents for colorants in sugar solution, which was calculated according to eq. (6):

$$Q = (1 - C)/M \quad (6)$$

where $C = \text{IU}_0/\text{IU}_1$; M is the weight of adsorbent (g).

Sugar decolorization by batch process

Totally, 0.5 g of SB-IEF fiber was added into 50 mL of 2% brown granulated sugar aqueous solution in 100-mL Erlenmeyer flasks. Then the flasks were sealed and shaken for 1 h at 60°C. Refractive index and the brix of the sugar solution before and after the decolorization were measured. Decolorization degree and decolorization amount of the prepared ion exchange fibers was studied.

Regeneration of anion exchange fiber

After decolorization, The spent SB-IEF was immersed into the sodium chloride solution (10 wt %) for 24 h to desorb the colorants. Then the regenerated SB-IEF was washed with deionized water for several times and dried at 60°C.

Structure characterization

Infrared spectra were obtained with FTIR Analyzer (Nicolet /Nexus 670, USA) equipped with a continuum microscope and Attenuated total reflection (ATR) objective. FTIR measurements were carried out at a range of 4000–650 cm^{-1} .

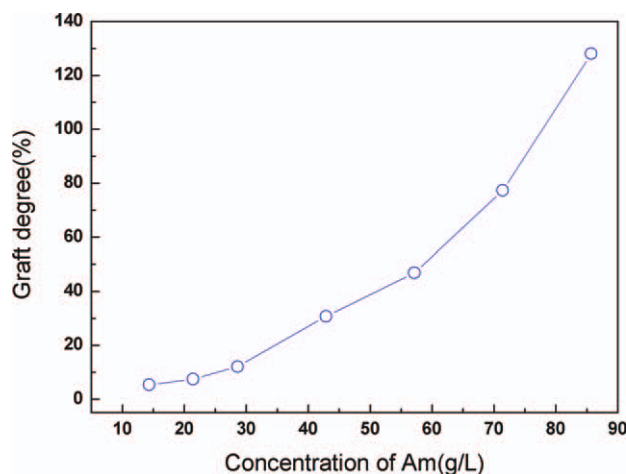


Figure 1 Effect of Am concentrations on the grafting degree of NaOH-treated SB (temperature, 70°C; time, 4 h). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

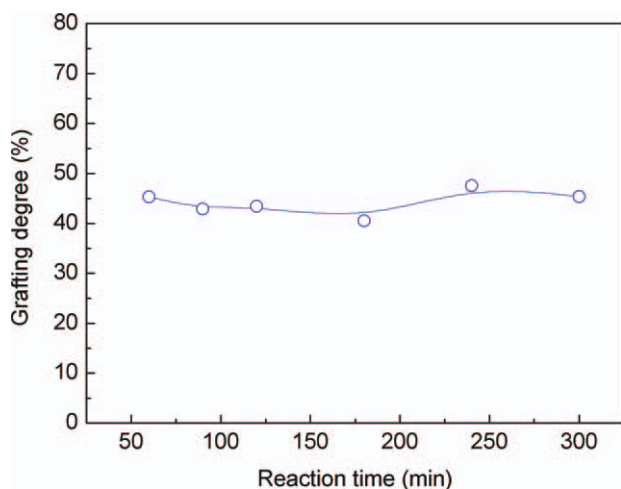


Figure 2 Influence of reaction time on grafting degree (Am concentration, 60 g/L; temperature, 60°C. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.])

SEM micrographs were obtained with a field emission scanning electron microscope (JSM-6330F, Japan). All samples were sputter coated with Au.

Nitrogen, hydrogen, and carbon content of samples were determined by Perker-Elmer Elemental Analyzer CHNS/O (Vario EL, Elementar, Germany).

Thermal stability of SB-IEF

Thermogravimetry (TG) Analyzer (Netzsch TG-20, Germany) was used to determine the thermal stability of all samples. The thermograms were obtained under a nitrogen atmosphere at a uniform heating rate of 20°C/min from ambient temperature to 600°C.

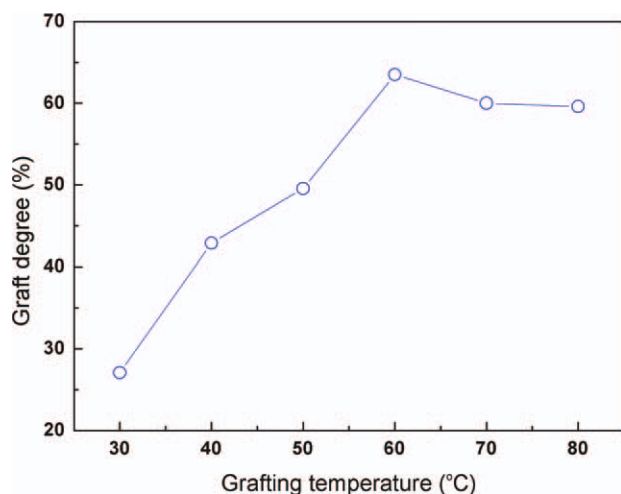


Figure 3 Influence of reaction temperature on grafting degree (Am concentration, 60 g/L; time, 1.5 h). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

TABLE I
Elemental Analysis of SB, SB-Am, and SB-IEF

	Elemental content (wt %)		
	C	H	N
SB	44.14	7.02	0.210
SB-Am	42.21	7.18	9.82
SB-IEF	42.49	7.61	11.57
AIEF	51.67	8.36	6.18

Ion exchange capacity

The static ion exchange capacity (IEC) of the anion exchange fiber was determined by using the conventional titration methods as described in Ref. ¹⁷.

RESULTS AND DISCUSSION

Graft copolymerization of acrylamide onto sugarcane bagasse

The effect of the concentration of monomer on the grafting degree is shown in Figure 1. The tendency showed grafting degree increased with the increase of the monomer concentration. Higher acrylamide monomer concentration could increase the probability for monomer to contact and react with the grafting sites. However, higher monomer concentration could also facilitate the formation of homopolymers of acrylamide, resulting in the purifying problem and the wasting of monomers. Considering the grafting degree and the postprocessing of removing homopolymer from bagasse-Am, 71 g/L of the monomer concentration would be most suitable.

Figure 2 showed the effect of reaction time on the grafting degrees of NaOH-treated SB. Grafting degrees varied from 40 to 45% when the grafting reaction time was between 1 and 5 h at 60°C, which

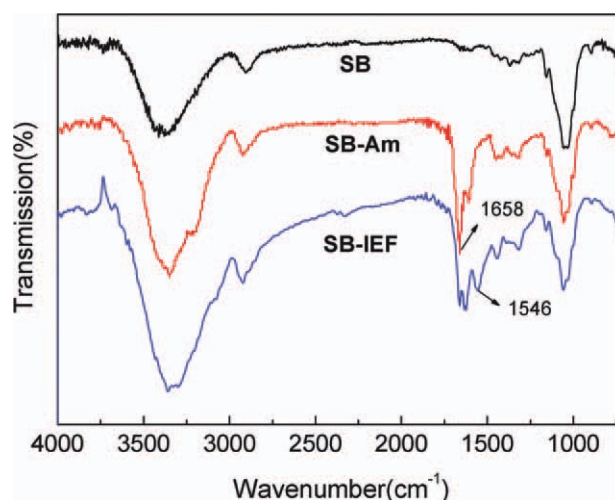


Figure 4 FTIR spectra of NaOH-treated SB, SB-Am, and SB-IEF. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

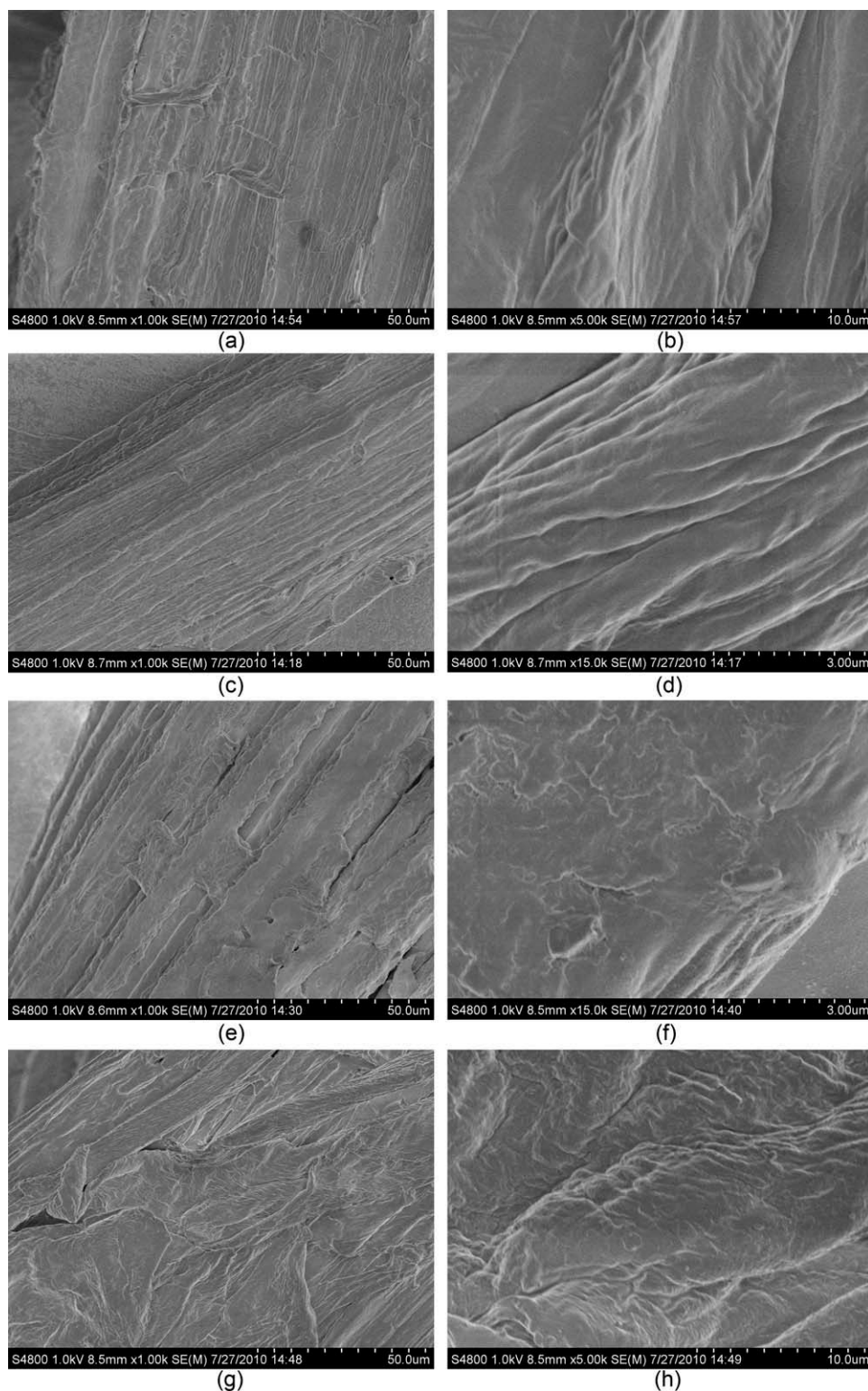


Figure 5 SEM photographs of the SB (a,b), NaOH-treated SB (c,d), SB-Am(e,f), and SB-IEF(g,h).

indicated that the graft copolymerization initiated by the $\text{Fe}^{2+}/\text{H}_2\text{O}_2$ system could be very fast, and finished in a short time. One-hour reaction time is enough to finish the graft copolymerization.

Many researches indicated that grafting degree was usually affected by the reaction temperature.¹⁸

Figure 3 showed the effect of reaction temperature on the grafting degrees of NaOH-treated SB. The grafting degree obviously increased from 27 to 65% when the reaction temperature was elevated from 30 to 60°C, and then it decreased when the reaction temperature is higher than 60°C. Higher

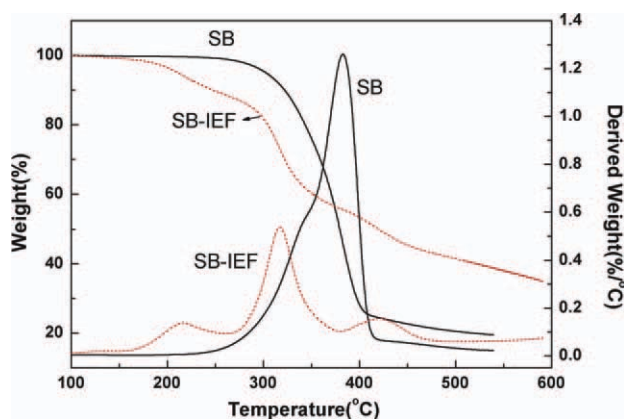


Figure 6 Thermogravimetric analysis and derivative thermogravimetric curves of the SB and SB-IEF. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

temperatures could enhance the diffusion of the monomer to the grafting sites, causing a higher grafting degree. However, when the temperature was over 60°C, elevating temperature would also accelerate the decay of the free radicals and the formation of homopolymers, thus decrease the grafting degree. The highest grafting degree was achieved at 60°C, which would be the most suitable reaction temperature in this study.

Chemical structure and the thermal stability of SB-IEF

Table I showed the elemental analysis results of NaOH-treated SB, SB-Am with 128% grafting degree and SB-IEF. The trace nitrogen of NaOH-treated SB came from a small amount of vegetable protein. After NaOH-treated SB reacting with acrylamide, the nitrogen content of SB-Am increased to 9.82 wt %, which confirmed that Am had been grafted onto NaOH-treated SB. And the hydrogen and nitrogen contents in SB-IEF were higher than those in SB-Am, which indicated that SB-Am had reacted with EDA.

The FTIR spectra of NaOH-treated SB, SB-Am, and SB-IEF are shown in Figure 4. The spectrum of SB-Am changed considerably compared with the spectrum of the NaOH-treated SB fiber. The SB-Am showed a new absorption peak at 1658 cm^{-1} due to

the C=O stretching. The absorption bands at 3200–3400 cm^{-1} corresponding to N–H bonds in $-\text{NH}_2$ were enhanced. Peak at 1610 cm^{-1} in spectrum of SB-Am was corresponded to scissoring vibration of $-\text{NH}_2$ of primary amide, and it disappeared in the IR spectrum of SB-IEF. When SB-Am reacted with EDA, a new absorption at 1546 cm^{-1} appeared, which could be assigned to C–N–H bending vibration of secondary amine. These demonstrate the reaction between SB-Am and EDA did occur successfully.

The surface morphologies of SB (a, b), NaOH-treated SB(c, d), SB-Am (e, f) and SB-IEF (g, h) are compared in Figure 5. In comparison, no significant difference between SB (a, b) and NaOH-treated SB(c, d) was observed. Compared with NaOH-treated SB(c,d), the surface of SB-Am (e, f) became obviously rougher. Membranous grafting layers polyacrylamide formed and enwrapped the surface of NaOH-treated SB. Unlike SB-Am (e, f), more dense grafting layers were observed in the images of SB-IEF (g, h), which may be due to a cross-linking reaction occurring between EDA and SB-Am.

TGA was undertaken in a nitrogen atmosphere to study the thermal stability of the NaOH-treated SB and SB-IEF (Fig. 6). The NaOH-treated SB showed only one platform at a mass loss. As shown in Table II, the decomposition of SB was found to be fast at around 272°C and till 434°C, at which near 75% of SB was decomposed. In the case of SB-IEF, the onset decomposition temperature of the product remained about 166°C. Two main decomposition stages were observed in the DTG curve and the onset decomposition temperatures were 166, 264, and 384°C, respectively. It was believed that the first stage of degradation mainly involves grafted molecules in easy degradation nature, such as Am and EDA. And the second decomposition platform might be attributed to the decomposition of SB. The third degradation step at 384°C might corresponds to the further pyrolysis of SB residues at about 264°C. It can be seen in Figure 6 that there was higher weight residual about 35% at 600°C. As thermogravimetry were analyzed under a nitrogen atmosphere, at a higher temperature, the carbonization process proceeds, which would involve thermal decomposition of the

TABLE II
Weight Losses of SB and SB-IEF at Different Thermal Stages

Material	First thermal stage			Second thermal stage			Third thermal stage			Weight of char (%)
	Temperature range (°C)	Weight loss (%)	T_{max} (°C)	Temperature range (°C)	Weight loss (%)	T_{max} (°C)	Temperature range (°C)	Weight loss (%)	T_{max} (°C)	
SB	272–434	75.0	382	—	—	—	—	—	—	19.5
SB-IEF	166–258	9.2	215	264–373	31.5	317	384–473	12.4	422	34.9

T_{max} , peak temperature.

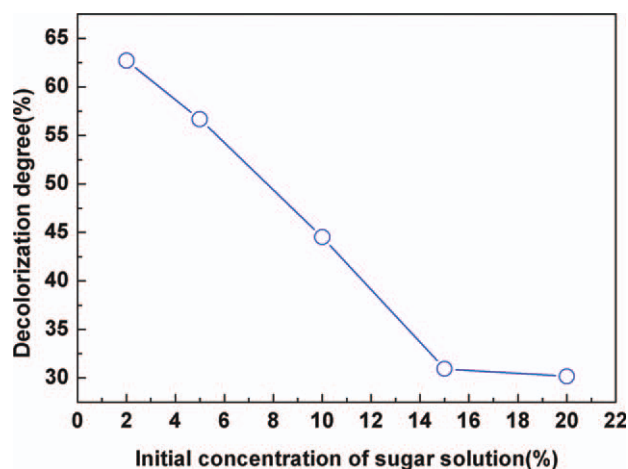


Figure 7 Static decolorization degree of sugar solution with different initial concentrations by SB-IEF. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

carbonaceous material, eliminating noncarbon species and producing a fixed carbon mass (char). As well known ammonium compounds can improve the thermal stability of carbonaceous materials,^{19–21} the cross-linking structure in SB-IEF can also enhance its thermal stability, which explains why SB-IEF had a higher char yield (35%) than SB.

Static decolorization

The absorbencies of brown granulated sugar solution at 420 nm linearly increased as sucrose concentration increased in the range from 0 to 30 g/L, corresponding with the Beer-Lambert law very well with mass extinction coefficient $0.03939 \text{ L g}^{-1} \text{ cm}^{-1}$.

The percentage of decolorization is an index for an adsorbent to adsorb coloring matter, especially sugar colorants. Results in Figure 7 indicated that the decolorization degree increased when the concentration of sugar solution decreased. Higher concentration of sugar solution meant higher concentration of sugar colorants, thus the decolorization degree would be lower at higher concentration of

sugar solution when the SB-IEF adsorbent employed was kept in a fix amount.

Decolorization capacities of SB-IEF, AIER, and AIEF were evaluated by batch adsorption process and compared (Table III). The results indicated that the SB-IEF showed the greatest ability to remove sugar colorants. At the same experimental conditions, decolorization degree of SB-IEF was 71.40%, those of AIEF and AIER were 68.74% and 31.40%, which may be due to the higher ion-exchange capacity of SB-IEF. Ion-exchange capacities of SB-IEF, AIER, and AIEF were determined to be 3.70 mmol/g, 2.81 mmol/g, and 2.16 mmol/g, respectively.

Dynamic decolorization

Figure 8 presented the dynamic decolorization of brown granulated sugar by various materials. The decolorization degree of AIER and AIEF is 74 and 42%, respectively. And with the increase of grafting degree of Am on SB-Am, SB-IEF showed better decolorization effect. SB-IEF ($G = 77\%$) achieved highest decolorization degree. It is believed that SB-Am with higher Am grafting degree would provide more amide groups to react with EDA and generate more ion exchange groups. By comparing the curves of SB-IEF with different grafting degree, the decolorization degrees were 82, 63, 37, and 14% for SB-IEF (77%), SB-IEF (60%), SB-IEF (44%), and SB-IEF (12%) when the elution volume was 240 mL.

To illustrate the effect of $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ on decolorization, $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ density (molar content of $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ group) on SB-IEF with different grafting degrees was calculated and listed in Table IV. On the basis of the results in Figure 8, their decolorization capacities were also presented, and compared with that of SB-Am. The results indicate that SB-IEF showed better decolorization effect with the increase of $\text{CONHCH}_2\text{CH}_2\text{NH}_3\text{Cl}$ density. However, SB-Am without reacting with EDA was proved to be poor decolorization ability, which indicating the

TABLE III
Decolorization Performance of Different Ion Exchangers for Brown Granulated Sugar Solution (0.50 g Sample; 50 mL 2% Brown Granulated Sugar Solution; 60°C; 60 min)

Material	IEC (mmol/g)	2% brown granulated sugar solution			
		ICUMSA color (IU)		Decolorization degree (%)	Decolorization amount (%/g)
		Initial	Final		
SB	–	21,262	20,386	4.10	0.08
SB-Am	–	21,262	19,220	9.60	0.19
SB-IEF	3.70	21,262	6,081	71.40	1.42
AIER	2.81	21,262	14,585	31.40	0.63
AIEF	2.16	21,262	6,647	68.74	1.36

TABLE IV
CONHCH₂CH₂NH₃Cl Density of SB-IEF and Reaction Rate of Am Converted to CONHCH₂CH₂NH₃Cl

Material	Grafting degree	R	ρ (mmol/g SB-IEF)
SB-Am	60%	–	–
SB-IEF	77%	66%	3.44
SB-IEF	60%	69%	3.18
SB-IEF	44%	71%	2.70
SB-IEF	12%	73%	1.06

functional group for decolorization is CONHCH₂CH₂NH₃Cl other than CONH₂.

Higher decolorization degree of SB-IEF was attributed to its higher contents of amine groups and its fibrous form. SB-IEF has a larger external specific surface area and shorter transit distance compared to AIER. In addition, SB-IEF can be tightly packed without gaps in an adsorption column where sugar decolorization process was conducted, which may greatly improve the adsorption efficiency of IEF for colorants.

The better adsorption results of SB-IEF compared with AIEF would be also due to the higher IEC and different functional groups of SB-IEF. AIEF is a PVA-based strong basic anion exchange fiber, consists mainly of quaternary ammonium groups, which may show strong adsorption for polar adsorbates. Whereas SB-IEF has amide, primary amine, secondary amine groups, which may prefer to adsorb weak polar colorants. On the other hand, SB-IEF has higher *N* content (11.57%) and higher ion exchange capacity (IEC = 3.70 mmol/g) than AIEF (*N* content = 6.18 %, IEC = 2.16 mmol/g); thus has higher adsorption capacity, and showed higher decolorization degree when same amount of adsorbents are compared.

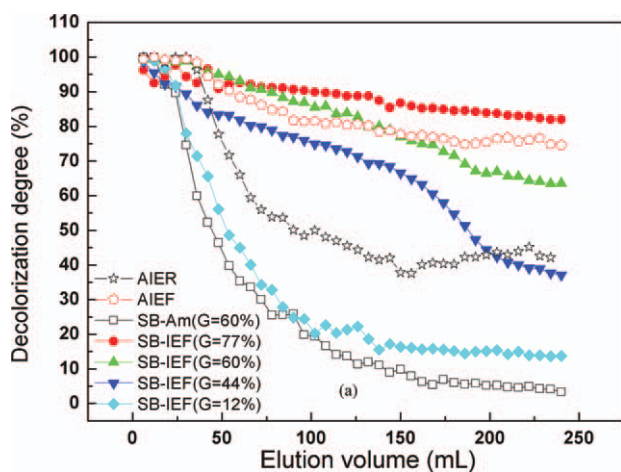


Figure 8 Dynamic decolorization curves of brown granulated sugar solution by various ion exchangers (1.00 g sample; 2% brown granulated sugar solution; 3 mL/min). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

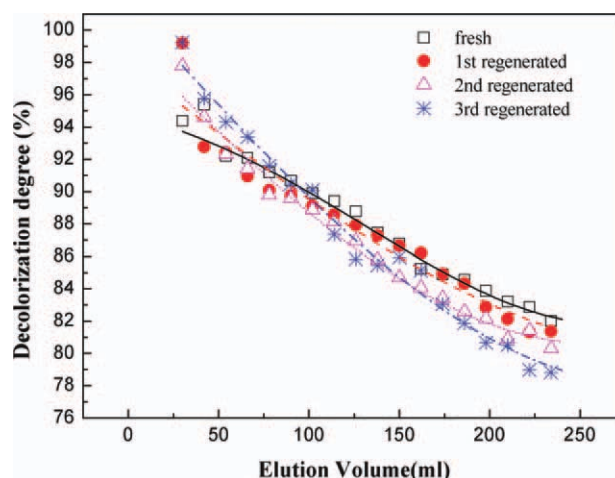


Figure 9 Decolorization curves of regenerated SB-IEF (1.00 g sample; 2% brown granulated sugar solution; 3 mL/min). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Regeneration

Figure 9 showed the decolorization curves of fresh and regenerated SB-IEF fibers. The results indicated that the spent fiber could be completely regenerated with 10% NaCl solution. The regenerated fiber showed almost the same decolorization performance as the fresh fiber. 1g SB-IEF packed in a fixed bed, after three adsorption–desorption cycles, could still remove over 80% colorants from the solution when 200 mL of 2% brown granulated sugar solution was treated with it.

CONCLUSIONS

A basic anion exchange fiber was effectively prepared through grafting acrylamide onto sugarcane bagasse fiber and sequentially ammoniating with ethylenediamine. The grafting degree was considerably affected by monomer concentration, reaction time, and temperature.

The static ion exchange capacity of the bagasse-based anion exchange fiber was as high as 3.70 mmol/g. The bagasse-based anion exchange fiber possessed better ability to remove sugar colorants than commercial strong base ion exchange fiber and commercial strong base ion exchange resin. The dynamic decolorization experiment indicate that SB-IEF showed larger processing volume, over 80% decolorization degree could be achieved when 200 mL 2% brown granulated sugar solution was treated with 1 g bagasse-based anion exchange fiber. The spent fiber could be completely regenerated with 10% NaCl solution.

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