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Study on the Performances of Polyethersulfone (PES)/Polyaniline (PANI)/Pectin (PEC) Blended Membrane in Textile Wastewater Treatment

Kartigesan Murugaya, Nor Faizah Razali*, Mohd Erwan Sanik and Ahmad Raqib Ab. Ghani
[1]Department of Chemical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia
kartig@uthm.edu.my, faizahr@uthm.edu.my, erwans@uthm.edu.my, raqib@ uthm.edu.my

ABSTRACT

Membranes play an important role treating the industrial wastewater for the benefit towards mankind, and the environment. The main purpose of this report is to study the performances of polyethersulfone (PES)/polyaniline (PANI)/pectin (PEC) blended membrane in treating textile wastewater. The synthesized membrane was used to treat wastewater from textile industry. The prepared membrane improved the quality of textile wastewater which contains many polluting substances that varies from inorganic compounds to polymers and organic products. The purpose of this study was extended to characterize the distinctive nature and features of the prepared mem-brane in order to compare the physical and chemical properties. This aids to study the structure of prepared membrane. Under the water permeability test, it is revealed that the membrane of PES/PANI/0.01 PEC membrane formed the best flux decline graph and its rejection performance is the best with 48.07% rejection. Besides, tensile test portrays that the membrane of PES/PANI/0.01 PEC has the best elasticity where its Youngs Modulus is 650.91 MPa while the membrane of PES/ PANI/0.1 PEC has the best ductility property where its percentage of elongation at break is 14.30%. The textile wastewater was tested via turbidity, pH, dissolved oxygen test, and total suspended solids (TSS) before and after the treatment with different composition of membrane to determine the efficiency and the performance of the membrane produced. The textile wastewater samples treated with PES/PANI/0.1 PEC membrane gives the highest pH and dissolved oxygen value which are 7.83 and 6.16 mg/L respectively. Moreover, the textile wastewater sample treated with PES/ PANI/ 0.01 PEC membrane gives the lowest and best readings when it comes to turbidity and total suspended solids (TSS) which are 0.60 NTU and 172 mg/L respectively. The characterization studies on different composition of PES/ PANI/PEC showed that the membrane composition of PES/PANI/0.01 PEC possess good membrane quality and effectively improve the quality of textile wastewater.

Key words : Polyethersulfone, Polyaniline, Pectin, Textile Wastewater.

1. INTRODUCTION

Ultrafiltration can be described as a vital membrane separation processes and has become an excellent separation equipment for many industrial applications. This must be owing to the membranes' outstanding separation potential and low energy usage [1]. Ultrafiltration utilizes a finely porous membrane to filter out water and micro solutes from macromolecules and colloids [2]. There are many researches on ultrafiltration membranes including polyethersulfone (PES) and polyaniline (PANI) in wastewater treatment. However, there are only limited studies on the modification of the membrane to improve the quality of wastewater. The aim of this study is to synthesize membrane from the combination of polymers and polysaccharide for textile wastewater treatment purpose. It is followed by the characterization the distinctive nature and features of the prepared membrane in order to compare the physical and chemical properties. The study also focuses on identifications the suitable ratio of polymers and polysaccharide compositions to attain the effective membrane for wastewater treatment. The scope of study covers on the fabrication of membrane by using polymers, PES, PANI, with the addition of different dosage of polysaccharide which is PEC to improve the quality of textile wastewater.

1.1 Polyethersulfone (PES)

Polyethersulfone (PES) can be said as one of the crucial polymeric materials and is widely used in separation fields [3]. Throughout previous fourth years of research, PES membrane has been extensively utilized in advanced separation technology, for instance microfiltration (MF) and ultrafiltration (UF). PES membranes are regarded to be highly tolerant to oxidants (>250,000 mg h/L for chlorine) and to a broad range of pH between 2 and 12 [4]. PES and PES-based membranes also can be said to depict excellence oxidative, thermal and hydrolytic stability as well as outstanding mechanical property [3]. PES also displays excellent membrane-fabricating characteristics. Yet, polyethersulfone PES normally has a hydrophobic surface that results in serious membrane fouling, which can cause worsening of membrane performance and lessen membrane life [1].

1.2 Polyaniline (PANI)

Polyaniline (PANI) has been the considerable contemporary preference due to their unique electrical behaviour, good environmental stability in doped and neutral states, ease of production and extensive applications in different fields. However, the main drawback of PANI is lack of solubility, which explains its limited processability due to a rigid backbone [5]. Commonly, PANI is produced by oxidative polymerization. PANI membranes are fabricated by solution blending with N-methyl pyrrolidone (NMP) and exhibited the high oxidation stability enough to adopt as dehydration membranes [6]. PANI possess properties, such as its ease of production, environmental stability, simple doping and dedoping chemistry, relatively modest cost, and solubility in highly aprotic solvents like N-methyl-2-pyrrolidone (NMP) [1].

1.3 Pectin (PEC)

Pectin is the ionic plant polysaccharides; whose major structural lineaments are the linear chains consisting more than 100 (1-4)-linked α-D-galacturonic acid residue [7]. Because of the similarity of pectin and alginate, such fruit materials are assuring biosorbents, their biosorption capability has only been studied to a restricted extent despite of their large availability at minimal cost [8]. Pectin is also known for its biodegradability. Being food processing industry wastes, pectin is therefore a very good candidate for eco-friendly biodegradable materials [9]. It cannot be denied that, pectin has flocculating activity and it can be utilized as novel and safe biopolymer flocculant, since it is biodegradable, edible and non-hazardous toward humans and the environment [10].

1.4 Textile wastewater

The textile industry is a very broad sector in terms of raw materials, processes, products and equipment and has very sophisticated industrial chain [11]. The textile industry utilizes about 10,000 pigments or dyes, but most of them are poisonous substances to human and aquatic life and it has been stated that up to 15% of the dyes in consumption are discharged into wastewaters [12]. Main pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, colour, acidity, and few more soluble substances [11].

2. MATERIALS AND METHODS

Upon synthesizing the membrane, the characterization of the membrane was conducted using water permeability measurement, flux decline test, contact angle, and field emission scanning electron microscope (FESEM), Fourier-transform infrared spectroscopy (FTIR) and tensile test. Besides, the fabricated membrane was used to treat textile industrial wastewater. The treated textile wastewater was tested via turbidity test, pH test, dissolved oxygen test, total suspended solid test to identify the efficiency of the membrane.

2.1 Fabrication of PES/ PANI/ PEC blended membrane

In order to synthesis the membrane, PANI nanoparticles (commercial; PANI; Aldrich), PES (Ultrason E1010 NAT; BASF Corporation, Mw = 58,000 g/mol) 1-methyl-2-pyrrolidone (NMP; Merck), Pectin (Sigma Aldrich) and RO water were required. The membrane was fabricated by the standard phase inversion method. The membrane was prepared by dissolving PES in NMP. The solution was then heated by utilizing a water bath and was stirred at the temperature of 80ºC for five hours to make sure of a complete dissolution of the polymer.

After attaining a homogeneous solution, the casting solutions were left overnight to let the complete release of bubbles. The blended membranes were synthesised by mixing PANI solution that was prepared separately from the PES solution. The PANI solution was prepared by dissolving PANI nanoparticles in NMP and stirred it for twelve hours. The solution was then filtered by utilizing a 0.45 mm syringe filter. This was done in order to curb agglomeration.

Later, the PANI solution together with the different dosage of pectin were mixed with the PES solution and were stirred mechanically for eight hours and then left overnight for deaeration. The prepared solutions then were casted on a sterilised glass plate with a film applicator of model SLT- 200 mm with 0.8 mm thickness. The membrane was exposed to the atmosphere based on the evaporation times before immersing the glass plate in a coagulation bath filled with RO water. Once immersed in the coagulation bath, the membranes that formed was pared off. This step was followed by immersing it in RO water for twenty-four hours to eliminate residual solvent and pore-forming agent. For every composition of PES/PANI/ PEC blended membrane, three different sheets of membranes were fabricated which were labelled A, B, and C respectively. The membrane specifications which includes different compositions of fabricated membranes are as shown in Table 1.

Table 1: Membrane casting specifications

Membrane	Casting specifications			
	Membrane Type	PES (g)	PANI (g)	PEC (g)
PES/ PANI	A	4.05	0.1	0
	B	4.05	0.1	0
	C	4.05	0.1	0
PES/ PANI/ 0.01PEC	A	4.05	0.1	0.01
	B	4.05	0.1	0.01
	C	4.05	0.1	0.01
PES/ PANI/ 0.05PEC	A	4.05	0.1	0.05
	B	4.05	0.1	0.05
	C	4.05	0.1	0.05
PES/ PANI/ 0.1PEC	A	4.05	0.1	0.10
	B	4.05	0.1	0.10
	C	4.05	0.1	0.10

2.2 Characterization of PES/ PANI/ PEC blended membrane

A. Water permeability test

Water permeability test was conducted as a way to study the fouling properties of PES/ PANI/PEC membrane of each composition. The fouling study was conducted by measuring the permeation of the membranes using RO water. This test was mainly conducted to choose the best membrane with anti-fouling property out of type A, B, C membranes from each different PES/ PANI/PEC composition. The apparatus that was 400 mL stirred ultrafiltration cells (model 8400) with a membrane surface area of 44.17 cm^2 connected to a nitrogen gas cylinder.

Different amount of pressure was exerted which are 1.5, 2.0, 2.5 and 3.0 bar. During the experiment, time taken for every 2 ml of permeate was noted down for each pressure. A graph of time in seconds against pressure (bar). The coefficient of determination, R^2 value for each graph was calculated and the membrane type with highest R^2 was chosen. The RO water flux was then calculated using the following equation:

$$J = \frac{V}{At} \quad (1)$$

where J is the RO water flux (L/m^2 h), V is the permeate volume (L), A is the membrane area (m^2) and t is the time (h). The chosen membrane was tested further for its fouling property via flux decline.

B. Flux decline

In order to investigate the anti-fouling properties of the chosen type of modified membranes, the membrane was used to treat the textile wastewater. The pressure 2 bar was used and for every two minutes, the volume of permeate was calculated. This test was conducted for 90 minutes where the membrane was usually foul by that time. Then the normalised flux decline behaviour of the membranes during the ultrafiltration was identified by plotting a graph of normalised flux decline against time (s). The normalised flux is the ratio of instantaneous solution flux (J_t) to the flux of buffer solution (J_0). The rejections were calculated based on Eq. (2) in order to study the fouling properties of membrane.

$$R = 1 - \frac{c_p}{c_f} \quad (2)$$

The C_p represents the concentration of the solute for the permeate, while C_f is the concentration of the solute in the feed stream.

C. Fourier Transform Infrared Spectroscopy (FTIR)

Basically, FTIR Perkin Elmer Frontier and Spectrum Two model is used to recognize the chemical structure of the membranes. Infrared spectra of the membranes and potassium bromide mixtures (KBr) are gained over the frequency range from 400 to 4,000 cm^{-1} at resolution of 4 cm^{-1} by utilizing FTIR [13].

For this experiment, FTIR, PerkinElmer Frontier and Spectrum Two model was utilized to determine the chemical structure of the polyethersulfone (PES)/ polyaniline (PANI)/ pectin (PEC) blended membrane. Infrared spectra of the membrane and potassium bromide mixtures (KBr) were obtained over the frequency range of 400 to 4000 cm^{-1} at resolution of 4 cm^{-1} via FTIR.

D. Tensile test

The mechanical properties of polyethersulfone (PES)/ polyaniline (PANI)/ pectin (PEC) blended membrane were measured by using tensile testing machine of model LR3OK by LLOYD Instruments at ambient temperature. The gauge length was 25 mm and the width at the centre of the specimen was 5 mm. The specimen thickness was about 0.8 mm. The cross-head speed was 10 mm/ min. After obtaining the result, the Young's Modulus of the membrane were calculated using the formula:

$$E = \frac{\sigma}{\varepsilon} \quad (3)$$

Where E is Young's Modulus and σ and ε stands for tensile stress and tensile strain respectively. Moreover, tensile strength of each compositions of membrane was calculated by using the equation (4):

$$\text{Tensile Strength} = \frac{\text{Maximum load}}{\text{Area}} \quad (4)$$

In addition to that, percentage of elongation at break was calculated too via equation (5):

$$\%\ \text{Elongation at Break} = \frac{\text{Extension} \times 100\%}{\text{Initial Length}} \quad (5)$$

2.2 Application of PES/ PANI/ PEC blended membrane in Wastewater Characterization of PES/ PANI/ PEC blended membrane

A. pH test

The pH test was conducted in order to detect the effect of membrane on the wastewater. The pH meter of Hanna Edge of model HI 3220 was used. The cap of probe of the pH meter was removed carefully. The probe of the pH meter was cleaned by immersing it in distil water to remove any particles that can disrupt the readings. Then the probe of the pH meter was inserted into the wastewater sample. The test was repeated three times to obtain average value. This was done in order get accurate result.

B. Dissolved Oxygen test

Dissolved oxygen test was carried out to evaluate the gaseous oxygen in water which is vital for good water quality [14]. The DO meter of Hanna Edge model H1764080 that was used. The dissolved oxygen was calibrated before using it. The probe of the DO meter was cleaned by immersing it in distil water to remove any particles that can disrupt the readings. Then, the probe was placed in the wastewater sample and wait for the meter to achieve equilibrium. The dissolved oxygen concentration was read directly from the scale. The test was repeated three times to obtain average value. This was done in order get accurate result.

C. Turbidity test

Turbidity test was conducted in order to evaluate water clarity and the amount of the material suspended in water reduces the passage of light through the water. The turbidity of textile wastewater was measured by utilizing turbidity meter which the sample was filled into a sample cell and kept into the cell holder for further measurement. It was measured by using turbidity meter which the sample was filled into a sample cell and put into the cell holder for measurement. The turbidity meter used was Eutech Turbidimeter TN-100.

D. Total Suspended Solids (TSS)

Total suspended solids (TSS) is the dry-weight of particles trapped by a filter. It is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant. In order to conduct the test, the filter papers were dried in the oven at 103℃ to 105℃ for 1 hour and was cooled in a desiccator. Later, the filter papers were weighed. These steps were repeated until the filter papers achieve constant weight. The treated wastewater samples were shaken to ensure homogeneity of the wastewater. Later, 25 ml of wastewater sample was pipetted onto centre of weighted filter papers in a Buchner funnel, using gentle suction.

The filter papers were washed carefully with 10 ml of distilled and dried at 103℃ to 105℃ for 1 hour and was cooled in a desiccator before weighing. The drying, cooling and weighing steps were continued until the filter papers achieve constant weight. For each wastewater sample treated by each different compositions of PES/ PANI/ PEC membrane, the test was repeated three times to obtain average value. This was done in order get accurate result.

3. RESULTS AND DISCUSSIONS

3.1 Water permeability test

Water permeability test was conducted to study the fouling properties of PES/ PANI/ PEC membrane of each composition. This test was mainly conducted to choose the best membrane with anti-fouling property out of type A, B, C membranes from each different PES/ PANI/ PEC composition. This was done by plotting graph of time (s) against pressure (bar). The graph with higher coefficient of determination was chosen as the best type of membrane for each different composition of membrane.

Coefficient of determination (R^2) is a commonly used measure of the goodness of fit of a function to a given set of data points [14]. A high R^2 value indicates a very good linear correlation between the two parameters which are time (s) and pressure (bar) with possible values ranging between 0 and 1. After choosing the best type of membrane from each different compositions of PES/ PANI/ PEC blended membrane, the RO water flux, J_0 was then calculated. Table 2 depicts the RO water flux, J_0 for each chosen membrane of different PES/ PANI/ PEC compositions.

Table 2: RO water flux, J_0 for each chosen membrane of different PES/ PANI/ PEC compositions

	Best Membrane	**Best Pressure (bar)**	**Area of membrane (m^2)**	**Time (h)**	**Volume (L)**	**RO water flux, J_0 ($L/m^2 h$)**
PES/ PANI (control)	Membrane B	2	0.0044	0.0008	0.002	568.18
PES/PANI/PEC 0.01	Membrane C	2	0.0044	0.0013	0.002	349.65
PES/PANI/PEC 0.05	Membrane B	2	0.0044	0.0007	0.002	649.35
PES/PANI/PEC 0.10	Membrane C	2	0.0044	0.0004	0.002	1136.36

3.2 Analysis of Flux Decline

The flux decline was calculated and plotted into a graph to study anti-fouling properties of the different composition of membranes. Figure 1 shows the normalized flux decline behaviour of the membranes during the ultrafiltration.

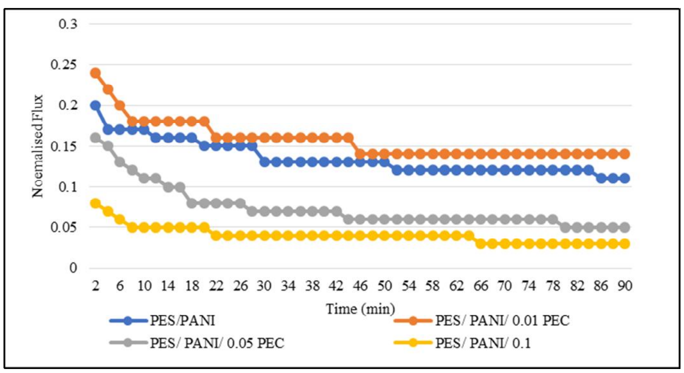

Figure 1: Normalized flux decline behavior of the membranes during the ultrafiltration.

It is clearly shown that the flux decline of the membrane PES/ PANI/ 0.1 PEC was higher than control and PES/ PANI/ 0.01 PEC membrane. This is followed by PES/ PANI/ 0.05 PEC membrane. This indicates higher fouling of the PES/ PANI/ 0.1 PEC and PES/ PANI/ 0.05 PEC. Membrane fouling caused the permeation flux to decline drastically. The membrane fouling is influenced by hydrodynamic circumstances, such as permeation drag and back transport, and chemical interaction between foulants and membranes [1].

3.3 Analysis of Tensile Test

The tensile test was conducted in order to study the mechanical properties of the fabricated membrane with different PES/ PANI / PEC compositions to study anti-fouling properties of the different composition of membranes. Table 3 shows the Young's modulus and percentage elongation at break of the tested membranes.

Table 3: The Young's modulus, tensile strength and percentage elongation at break of the tested membranes

Membrane	**PES/ PANI**	**PES/ PANI/ 0.01 PEC**	**PES/ PANI/ 0.05 PEC**	**PES/ PANI/ 0.10 PEC**
Stress (MPa)	13.143	16.901	11.074	15.588
Young's Modulus (MPa)	212.86	650.91	134.51	108.98
Elongation at break (%)	6.17	2.60	8.23	14.30

It is clear that Young's Modulus for the membrane of PES/ PANI/ 0.01 PEC is the highest among all other membranes. On the other hand, PES/ PANI/ 0.1 PEC shows the least value of Young's Modulus and it was followed by the membrane of PES/ PANI/ 0.05 PEC. Young's modulus is a measure of the ability of a material to withstand changes in length when under lengthwise tension or compression. It describes the elastic characteristics of a solid experiencing tension or compression in only one direction. Thus, as the value of Young's Modulus increase, the elasticity of the membrane is high.

In this case, the membrane of PES/ PANI/ 0.01 PEC shows the highest elasticity. The membrane of PES/ PANI/ 0.1 PEC and PES/ PANI/ 0.05 PEC shows the lowest elasticity property compare to control membrane. This justifies that just small amount of pectin is needed to improve the elasticity of the membrane. If the dosage of pectin is higher than the desirable level, the elasticity of the membrane might be greatly reduced.

Elongation at break depicts the intensity of bending and shaping a material can withstand without breaking. The measured elongation at break values define ductility of a polymer. It is shown in the Table 3 that the percentage of elongation at break for membrane PES/ PANI/ 0.1 PEC is the highest, followed by the membrane of PES/ PANI/ 0.05 PEC.

This depicts that these membranes possess some good ductility. Yet, PES/ PANI/ 0.01 PEC shows the least value of percentage of elongation at break, which is even lower than the control membrane. It portrays that the PES/ PANI/ 0.01 PEC has the lowest ductile property. The membrane of PES/ PANI/ 0.05 PEC and PES/ PANI/ 0.1 PEC indicates that the presence of pectin in the membrane increases the ductility.

3.4 Analysis of FTIR

All the synthesised membrane with different compositions of PES/ PANI/ PEC were tested with FTIR for the characterization of the membranes. Figure 2 through Figure 5 show the FTIR spectrum obtained from FTIR analysis software for the membrane PES/ PANI, PES/ PANI/ 0.01 PEC, PES/ PANI/ 0.05 PEC and PES/ PANI/ 0.1 PEC, respectively.

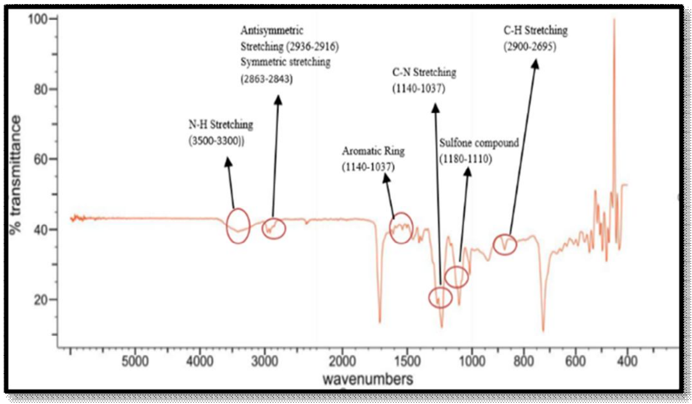

Figure 2: FTIR spectrum for the membrane PES/ PANI

Referring to Figure 2, there are C-N where it was proved by the corresponding stretching vibrations in the range of 1140 cm^{-1} to 1097 cm^{-1}. This justifies the presence of PANI in the PES/ PANI membrane. There is also sulfone compound present within the band of 1180 to 1110 cm^{-1}. This verifies the presence of PES in the PES/ PANI membrane.

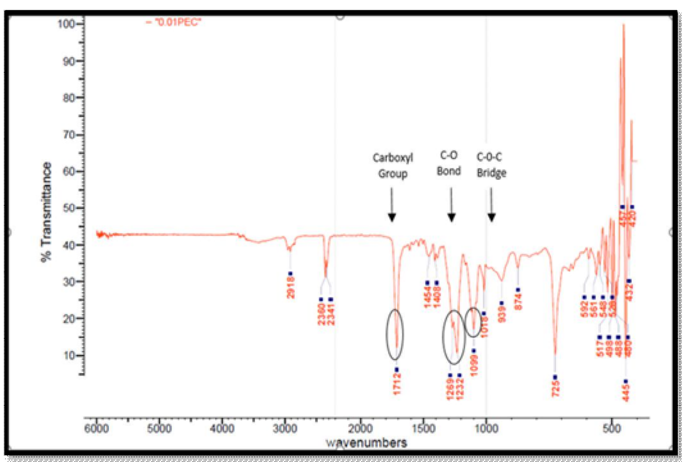

Figure 3: FTIR spectrum for the membrane PES/ PANI/ 0.01 PEC

Referring to Figure 3, there are C-O where it was proved by the corresponding stretching vibrations in the range of 1320 cm^{-1} to 1211 cm^{-1}. Stronger bands, occurring between the range 1725 cm^{-1} and 1700 cm^{-1} indicates the presence of carboxyl group, C=O in stretching mode. The absorption bands of C-O-C bridge can be observed within the band of 1175 to 1038 cm^{-1} in stretching mode. The presence of these chemical bonds and groups justifies the presence of pectin in the PES/ PANI/ 0.01 PEC membrane.

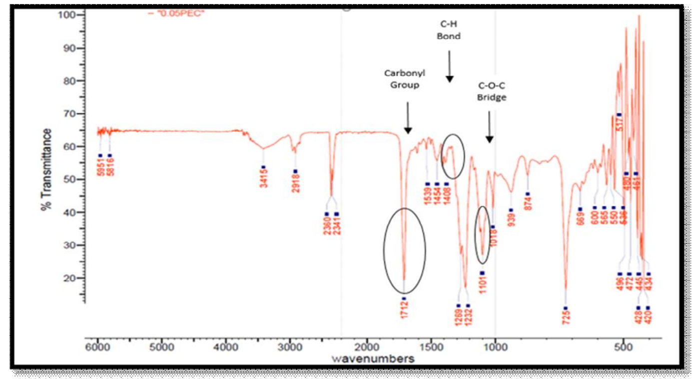

Figure 4: FTIR spectrum for the membrane PES/ PANI/ 0.05 PEC

Referring to Figure 4, there are C-H where it was proved by the corresponding deformation mode in the range of 1370 cm^{-1} to 1365 cm^{-1}. Stronger bands, occurring between the range 1805 cm^{-1} and 1735 cm^{-1} indicates the presence of carboxyl group, C=O in stretching mode. The absorption bands of C-O-C bridge can be observed within the band of 1175 to 1038 cm^{-1} in stretching mode. The presence of these chemical bonds and groups justifies the presence of pectin in the PES/ PANI/ 0.05 PEC membrane.

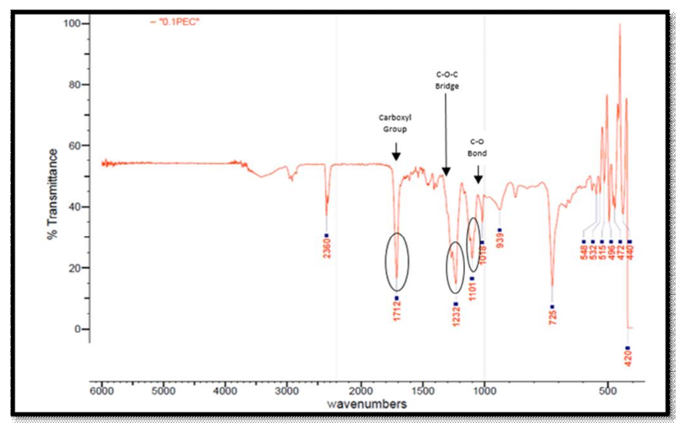

Figure 5: FTIR spectrum for the membrane PES/ PANI/ 0.1 PEC

Referring to Figure 5, there are C-O where it was proved by the corresponding stretching mode in the range of 1320 cm^{-1} to 1211 cm^{-1}. Stronger bands, occurring between the range 1725 cm^{-1} and 1700 cm^{-1} indicates the presence of carboxyl group, C=O in stretching mode. The absorption bands of C-O-C bridge can be observed within the band of 1175 to 1038 cm^{-1} in stretching mode. The presence of these chemical bonds and groups justifies the presence of pectin in the PES/ PANI/ 0.1 PEC membrane.

3.5 Analysis of pH test

The pH readings were recorded for the textile wastewater which had been treated using membranes of different compositions of PES/ PANI/ PEC blended membrane. Figure 6 shows the graph of pH value against different textile wastewater samples.

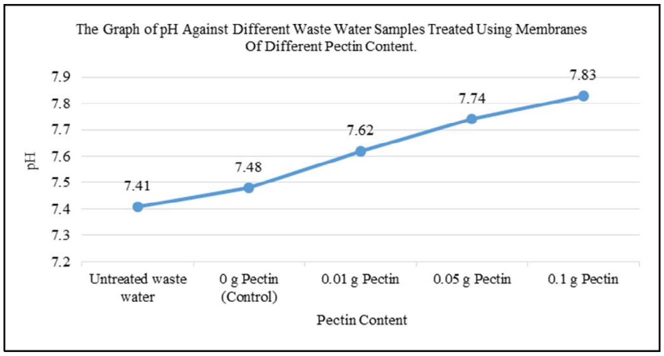

Figure 6: Graph of pH against different wastewater samples treated using membranes of different pectin content

Referring to Figure 6, the original pH value of textile wastewater is 7.41 which is slightly alkaline. The control membrane, which is PES/ PANI blended membrane shows a very small increase in pH. It is an obvious pattern that as the dosage of pectin in membrane increases, the pH value of treated wastewater increases gradually. The only clear explanation for this phenomenon is that pectin must have a negatively charged group which neutralises the H^+ ions in textile wastewater. Pectin molecules in raw, uncut fruit have an alkaline negative charge, which causes them to repel each other and to bond with water [15].

3.6 Analysis of Dissolved Oxygen test

The Dissolved Oxygen was recorded for the textile wastewater which had been treated using membranes of different compositions of PES/ PANI/ PEC blended membrane. Figure 7 shows the graph of pH value against different textile wastewater samples.

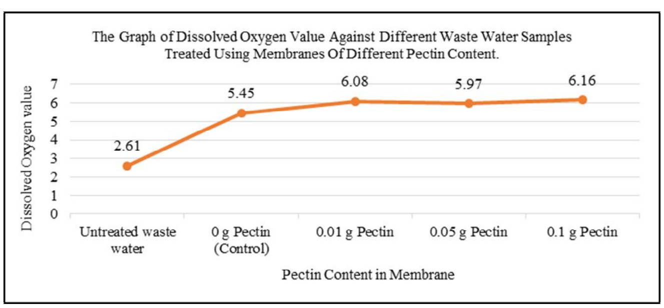

Figure 7: Graph of Dissolved Oxygen value against different wastewater samples treated using membranes of different pectin content

Referring to Figure 7, it is shown that the original DO value of textile wastewater is 2.61 which is very unhealthy. The control membrane, which is PES/ PANI blended membrane shows a very small increase in Dissolved Oxygen value. It is an obvious pattern that the presence of pectin in membrane causes gradual increase the DO value of textile treated wastewater. Yet, the highest DO value was recorded for the wastewater sample which has been treated by the membrane of PES/ PANI/ 0.01 PEC followed by the membrane PES/ PANI/ 0.10. However, the differences are very small to the point where it seems insignificant. The uneven distribution of pectin throughout the membrane is the only logical explanation for the membranes PES/ PANI/ 0.05 PEC and PES/ PANI/ 0.1 PEC to treat with textile wastewater that yield low DO value compare to PES/ PANI/ 0.01 PEC. The increase in DO is indirectly due to the bio flocculation activity of pectin. Presence of pectin leads increase in flocculating activity. This greatly reduces turbidity of water samples.

3.7 Analysis of turbidity

The turbidity was recorded for the textile wastewater which had been treated using membranes of different compositions of PES/ PANI/ PEC blended membrane. Figure 8 shows the graph of turbidity, NTU value against different textile wastewater samples.

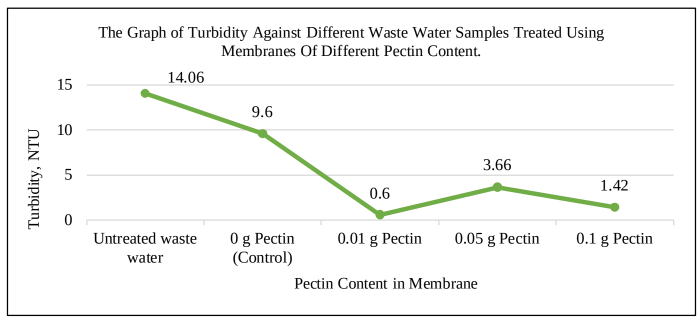

Figure 8: Graph of turbidity value in NTU against different wastewater samples treated using membranes of different pectin content

Referring to Figure 8, it is shown that the original turbidity value of textile wastewater is 14.06 NTU is which is very high. The control membrane, which is PES/ PANI blended membrane has able to slightly reduce the turbidity of water. It is crystal clear that membrane PES/ PANI/ 0.01 PEC reduced to the turbidity of textile wastewater to a very low and healthy point. This is followed by the membrane PES/ PANI/ 0.1 PEC. Membrane PES/ PANI/ 0.05 PEC seems to be less effective compare to other pectin blended PES/ PANI membrane. This might be due to the phenomenon that the pectin might has not fully or evenly mixed with membrane while fabrication which reduces its performances in curbing turbidity. However, the presence of pectin effectively reduces the turbidity of wastewater as its role as an effective bio-flocculants [10]

3.8 Analysis of Total Suspended Particles (TSS)

The test to identify total soluble solids (mg/L) in treated textile wastewater that was treated using membranes of different compositions of PES/ PANI/ PEC blended membrane was conducted. Figure 9 clearly depicts the graph of total suspended solids value mg/L against different wastewater samples treated using membranes of different pectin content.

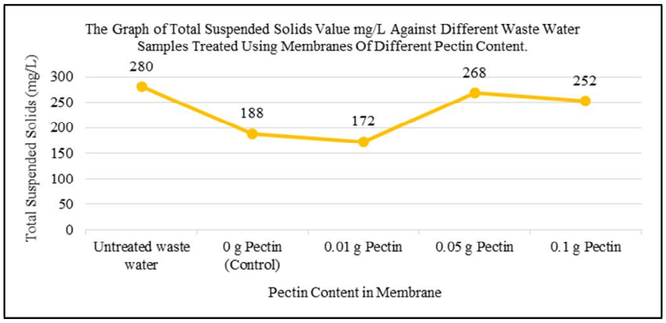

Figure 9: The graph of total suspended solids value mg/L against different wastewater samples treated using membranes of different pectin content.

It can be observed from Figure 9 that the membranes reduce the total suspended solids in treated wastewater. The untreated wastewater possessed total suspended solids of 280 mg/L. The membrane of PES/ PANI/ 0.01 PEC successfully reduced the total suspended solids of the textile wastewater to the very lowest point compare to other membranes. Yet, membrane of PES/ PANI/ 0.05 PEC shows the poorest performance in reducing total suspended solids in textile wastewater. This is followed by the membrane of PES/ PANI/ 0.1 PEC. It should be noted that control membrane which is PES/ PANI can reduce the total suspended solids better than PES/ PANI/ 0.05 PEC and PES/ PANI/ 0.1 PEC. It can be said that the only lowest dosage of pectin can improve the membrane performances to an excellent point.

The ability of the membrane in reducing the total suspended solids can be related to the bio-flocculants activity of pectin. It aggregates small particles into larger-sized particles and assist the retaining of total suspended solids via membrane. It also must be noted that, during turbidity test, the PES/ PANI/ 0.05 PEC and PES/ PANI/ 0.1 PEC membranes reduced the turbidity better than control membranes. But, when it comes to total suspended solids tests, the exact opposite phenomenon had occurred. It can be said that the uneven homogeneity of treated textile wastewater led to this occurrence. The container should had been shaken vigorously for the suspended solids to disperse evenly in treated wastewater.

4. CONCLUSION

The results obtained from the conducted experiments depicts that the objectives have been successfully achieved. Based on the first objective, a membrane of PES/ PANI/ PEC was successfully synthesized for textile wastewater treatment purpose. The second objective was also successfully achieved where the prepared membranes were characterized to identify the distinctive nature and features in order to compare the physical and chemical properties such as water permeability measurement, flux decline test, rejection performance, tensile test, Fourier-transform infrared spectroscopy (FTIR) and field emission scanning electron microscope (FESEM). The membranes of different were successfully compared by using the data from the tests. The third objective of this study was achieved when the effective ratio of PES/ PANI/ PEC was determined via several tests for better treatment of textile wastewater. The PES/ PANI/ 0.01 PEC shows the best ratio as it shows best performance throughout all the tests such as water permeability measurement, tensile test, pH, Dissolved Oxygen, turbidity and total suspended solids. It shows good anti fouling property and mechanical strength. For the fourth objective, the overall cost of the polyethersulfone (PES)/ polyaniline (PANI)/ pectin (PEC) blended membrane was estimated and compared with the commercial ultrafiltration membrane.

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