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Design and Development of Composite Nonwoven Filter for Pre-filtration of Textile Effluents Using Nano-technology

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Abstract

The main aim of this study is to test the feasibility of using composite membrane of nonwovens and Nano-fibre for the pre-filtration treatment of reactive dye bath effluent from the textile industry. The results of ultraviolet spectrophotometer of filtered and non-filtered sample show that the cleaning efficiency of effluent water will be achieved in the range of 70-80%. Cleaning efficiency of the Nano-filter filter remains around 70%. But a composite nonwoven filter made up of polyester fibre needle punched nonwoven and Nano-fibre web; the cleaning efficiency can reach as high as 90%.

Keywords: Nano technology; Nonwoven; Needle punched; Textile effluent; Filtration

Introduction

Textile industry is the largest industry in the world. Textile industries produce waste like contaminated water which has different type of metals and other hazards particle. These particles are very harmful for the human and nature. Textile industry use different type of dyes which produced metals like Cu, Zn, As and Ar [1,2]. This is directly and indirectly harmful for the mankind.

The removal of these types of metals and other particle is done with the help of ETP (effluent treatment plant). Effluent treatment plants are capable of removing particle from the water. These types of plant have four stage of treating the effluent. These are Preliminary, Primary, Secondary and tertiary treatment [3,4].

Preliminary treatment process, in textile wastewater treatment, is the removal of suspended solids, excessive quantities of oil and grease and gritty materials [1] The Secondary treatment process is mainly carried out to reduce the BOD, phenol and oil contents in the wastewater and to control its colour [5]. In tertiary process several technologies used in treatments including electro dialysis, reverse osmosis and ion exchange etc. [6].

Pressure-driven membrane filtration processes such as microfiltration (MF), ultra filtration (UF), nano filtration (NF), and reverse osmosis (RO) provide opportunities for the textile industry to purify water by separating its components based on size. However, widespread adoptions of some of these processes are yet to be realized due to membrane fouling. Membrane fouling is the accumulation of soil, or foulant, on the surface or within the pores of a membrane [7,8]. Fouling increases processing times, energy and cleaning costs, decreases separation efficiency. In severe cases, it may lead to irreversible clogging of the membrane.

So this research work aims to develop composite filters (Nonwoven and Spreading Nano-fibre over it) for pre-filtration of textile effluents. Nano woven fabric is mostly used for filtration process of water for due to its messing structure [9-11]. Applying nano-fibre over it, give control over the pore size. This gives even better filtration results. Nano-fibre of PES (Polyether Sulphone) has been produced and used in this research work because it has high thermal and chemical resistance and also has appropriate mechanical properties [12-16]. If the pre filtration of textile effluent is good the next process results will improve.

Materials and Methods

Preparation of non-woven sample

In this research work, nonwoven samples have been manufacture using recycled polyester fibre of circular cross-section (staple length 51mm and fineness 1.5 denier) at lab model machine (model- Trytex) (Table 1).

Deposition of nano-fibre over nonwoven sample

Polyethersulfone (PES) (Mw= 58000 and density of 1.37 g/cm^3) was from DMSRDE lab. As the sub layer of the membrane a technical polyester non-woven was used. The chemical structure of PES and DMF is shown in Figure 1. The solvents *N,N*-dimethylformamide (DMF) were obtained from DMSRDE lab. Solution viscosity was kept 0.52 and PES% was 15 (Tables 2 and 3).

Total filter is produced is six with two different nonwoven GSM and three different Nano-fibre spraying time. Each Filter is content two layer, first layer is nonwoven produced from polyester fibre 51 staple length and second layer is formed by PES Nano-fibre spraying over nonwoven (Figure 2).

Sr. No.	Parameters	Sample A (Each 3 Sample)	Sample B (Each 3 Sample)
1	Sample Size	10 × 25 inch	10 × 25 inch
2	GSM of sample	130	198
3	Thickness	2.1 mm	3.5 mm
	Machine parameter		
1	Feed mm/Stroke	10	10
2	Punches/min	35	35

Table 1: Machine parameters and sample details.

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Characterization of nano-fibre film: Characterisation of Nano film is done by scanning electron microscope (SEM). During the study, the morphology of the nano-fibers was found smooth surface, no beads and droplets. Diameter of the nanofibers was 260 ±110 nm.

Formation of waste water sample for filtration: A sample waste water was prepared with Medium shade Using Salt Concentration 20g/l Nacl, 8g/l Na_2CO_3 and Dye 50 mg/l.

Result and Discussion

UV results

UV test was done at the DMSRDE lab Kanpur with the spectrophotometer (model no V-630) with 800-200 wavelength with cell height 10 mm. The results show the promising filter with increasing cleaning efficiency (Table 4).

130 GSM and 198 GSM sample absorption in different UV value (comparison): Table 4 and Figure 3 clearly shows that the composite nonwoven filter with Nano-fibre layer improve the absorption values hence better filtration efficiency. This is possible due to improved surface of the filter. The Nano-fibre coating on the filter surface is the main reason behind this (Tables 5 and 6).

Table 6 and Figure 4 clearly shows that the composite nonwoven filter with Nano-fibre layer improve the flux permeability values hence better filtration efficiency. This is possible due to improved surface of the filter. The Nano-fibre coating on the filter surface is the main reason behind this.

Conclusion

Results show that the ion and other particle concentration will decrease in all filtered sample from main sample. Result Show that the flux permeability value and permeate flux will decrease simultaneously according to thickness of nonwoven fabric and also Nano fibre.

The removal efficiency of composite sample is 75% and we know

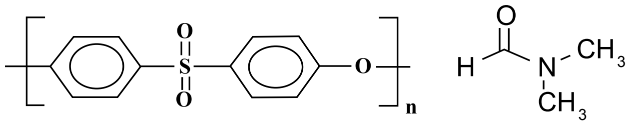

Figure 1: (a) Polyethersulfone (PES); (b) *N,N*dimethylformamide.

Sr. No.	Parameter	PES nanofibrous Membrane(first)	PES nanofibrous Membrane (Second)	PES nanofibrous Membrane (third)
1	PES Concentration	15 wt%	15 wt%	15 wt%
2	Applied voltage	20 kV	20 kV	20 kV
3	Feed rate	25 μl/min	25 μl/min	25 μl/min
4	Spinning distance	25 cm	25 cm	25 cm
5	Collection time	2 h	3 h	5 h
6	outer diameter of the injector	15 mm	15 mm	15 mm

Table 2: Electro spinning condition.

Sr. No.	Sample no.	Sample details
1	S1	130 GSM+2 Hour spreading
2	S2	130 GSM+3 Hour spreading
3	S3	130 GSM+5 Hour spreading
4	S4	198 GSM+2 Hour spreading
5	S5	198 GSM+3 Hour spreading
6	S6	198 GSM+5 Hour spreading

Table 3: Details of composite filter fabric samples.

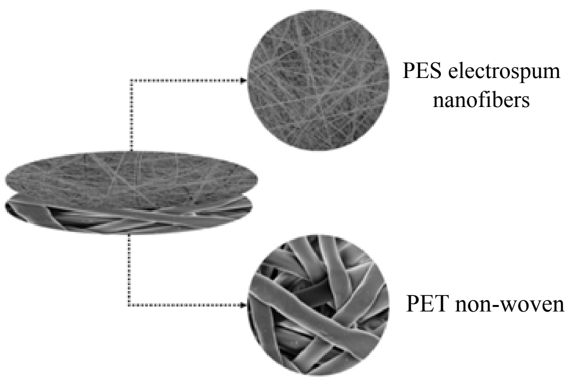

Figure 2: Details of the filter design.

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UV Value	Absorption Value						
	Before filtration		After filtration				
	Main Sample	130 Hours	130 GSM+3 Hours	103 GSM+5 Hours	198 GSM+2 Hours	198 GSM+3 Hours	198 GSM+5 Hours
800	1.71591	0.520248	0.490538	0.460582	0.343146	0.281131	0.109926
799	1.71545	0.519843	0.49034	0.45977	0.343158	0.281105	0.110076
700	1.63816	0.482494	0.462668	0.393183	0.320951	0.273147	0.106418
600	1.5975	0.462997	0.446871	0.367181	0.307864	0.26762	0.108035
500	1.72512	0.601857	0.61504	0.501424	0.446751	0.423599	0.300661
462	4.48165	2.59514	2.95018	2.43993	2.39472	2.36918	2.60564
461	7	2.69383	3.03568	2.53488	2.49018	2.46368	2.68427

Table 4: Absorption value.

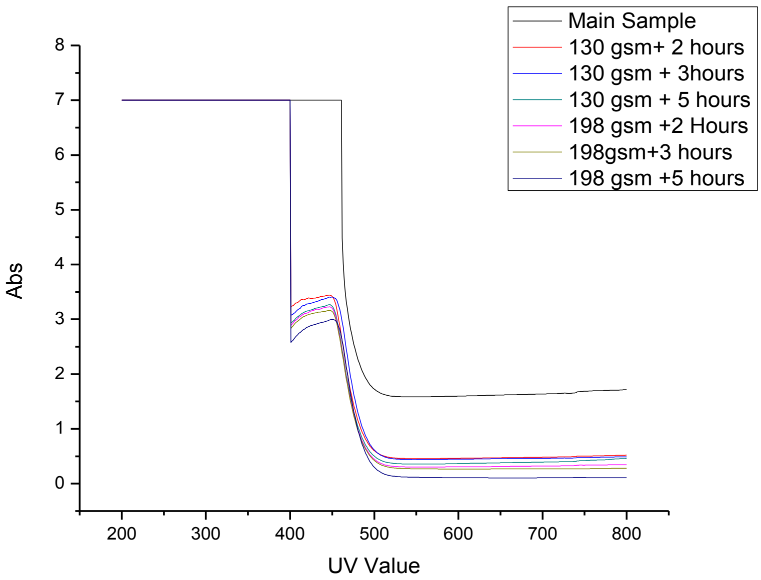

Figure 3: Change in absorption value with different GSM and time.

Sr. No.	Sample Classification	Flow Rate	Flux Rate
	Non-Woven(GSM)+Nano Fibre Time For Spreading (Hours)	Lit/hour	L/m²/hr
A.	Without sample for apparatus flux permeability	81.81	28981.86
B.	With Sample		
1	130+2	78.26087	27673.57
2	130+3	76.14213	26924.37
3	130+5	63.82979	22570.65
4	198+2	58.25243	20598.45
5	198+3	48.49138	17146.88
6	198+5	41.3413	14618.56

Table 5: Flux permeability through water.

Sr. No.	Sample Classification	Flow Rate	Flux Rate
	Non-Woven(GSM)+Nano Fibre Time For Spreading (Hours)	Lit/hour	L/m²/hr
A.	Without sample for apparatus flux permeability	81.81	28981.86
B.	With Sample		
1	130+2	14.4	5091.938
2	130+3	12.65	4474.462
3	130+5	10.76	3806.772
4	198+2	7.901	2794.083
5	198+3	7.380	2609.644
6	198+5	6.531	2309.478

Table 6: Flux permeability through waste water.

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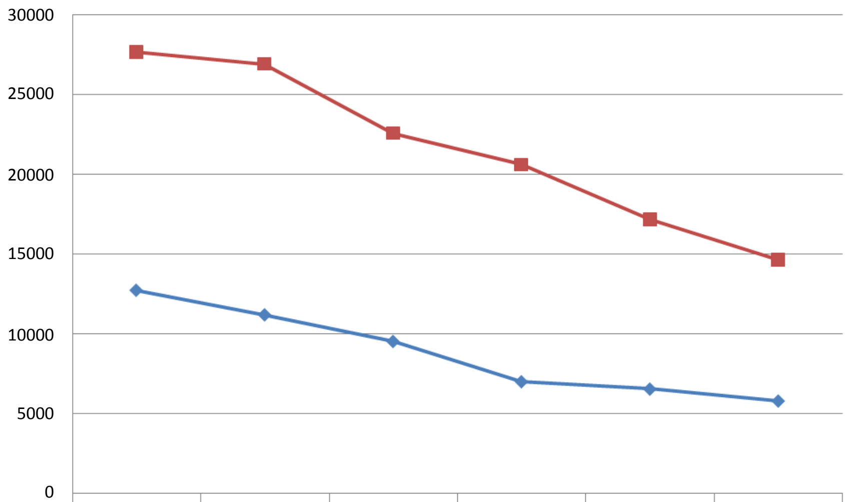

	130 GSM + 2 Hour	130 GSM + 3 Hour	130 GSM + 5 Hour	198 GSM + 2 Hour	198 GSM + 3 Hour	198 GSM + 5 Hour
Flux rate (L/m2/h)- Dye waste water	12729.84	11186	9516	6985	6524	5773
Flux rate (L/m2/h)- Water	27673.57	26924.37	22570.65	20598.45	17146.88	14618.56

Figure 4: Flux rate of different type of sample through dyeing waste water and fresh water.

the Microfiltration cleaning efficiency is 70%. So, by using this type of composite nonwoven for pre-filtration of microfiltration process, cleaning efficiency around 91% can be achieved. Achieving this much high cleaning efficiency, improves the efficiency of further cleaning process.

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