Characterizations of PVA composites based on recycled ultrafine cotton and wool powders

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ABSTRACT

Different percentages of cotton and wool micro particles (average size 20-80 m) were added to two different molecular weight of polyvinyl alcohol (22000& 145000 Da) during preparation of film (30 m) by casting technique. Morphological surface study of a prepared composite film was established by Scanning Electron microscopy (SEM). Many characterizations were investigated, thermally dynamics properties investigated by Differential Scanning Calorimetry (DSC), Thermal Gravimetric Analysis (TGA) and Mechanical properties. All the result support that the prepared composites film have a good distribution of the particles through the film and improve the thermal and mechanical properties of the PVA film. The ability of these composites to absorb water (moisture content) and formaldehyde from the environmental surrounding were examined and evaluated.   © 2015 Trade Science Inc. - INDIA

KEYWORDS

Polyvinyl alcohol (PVA);
Composite;
Cotton powder;
Wool powder;
DSC and TGA.

INTRODUCTION

During the last decade, there has been a growing interest in the use of biodegradable polymers in order to reduce the environmental pollution caused by plastic wastes. Therefore, there is an urgent need to develop renewable resource-based, environmentally benign materials, which will reduce the problem of plastic wastes and will be a solution to the uncertainty of the petroleum supply[1].

Polyvinyl alcohol (PVA) is the largest volume, synthetic, water-soluble resin produced in the world. PVA is very useful as precursor of the broad class of materials[1]. From the late sixties there has been a growing interest in hydrophilic polymer networks for applications as biomedical polymers[2]. The main areas of applications of PVA materials include drug delivery systems, wound dressings, injectable polymers, implants, stimuli-responsive systems and slow release of drug preparations[1-4].

Polyvinyl alcohol (PVA) blends have long been used with other natural polymers because of PVA's ability to form films. The performance properties of PVA are influenced by the molecular weight and the degree of hydrolysis. PVA has a planar zigzag structure like polyethylene. All PVA grades are readily

soluble in water, depending on factors like molecular weight, particle size and particle crystallinity[5]. As a hydrophilic polymer, PVA exhibits excellent water retention properties[6]. Optimum solubility occurs at 87% to 89% hydrolysis. For total dissolution, however, PVA requires water temperatures of around 100°C with a hold time of 30 minutes.

Recent work has shown that swollen PVA networks can serve as useful model membranes to elucidate various fundamental phenomena of mass transport[6-10].

Polymer micro-composites, also presently known as 'micro-structured materials', are materials in which micro particles, typically 10–100 µm in at least one dimension, are dispersed in an organic polymer matrix in order to dramatically improve the performance properties of the polymer[11].

The large amount of yearly wasted cotton and wool found on the market is always a target for recycling industry. The possibility of using micro-size particles of cotton in the polymer matrix for improving the moisture management were investigated. Polyvinyl alcohol used as matrix and its solutions are considered non-toxic.

This work is an application of our earlier work,[12]that is, we have reported the preparation and characterization of ultra-fine micro cotton and wool powder by freeze milling technique. The purpose of this study is to improve the ability of the PVA membrane to absorb moisture and formaldehyde by adding micro powder of recycled cotton or wool, which have ability for adsorption. Several characterizations of applied PVA membrane are covered by Scanning Electron Microscopy (SEM), Differential Scanning Calorimetry (DSC), Thermal Gravimetric Analysis (TGA) and Mechanical properties.

EXPERIMENTAL

Materials

Untreated cotton and wool fibres (from waste), the fibres length was 4–6 mm. Two molecular weights (22000 and 145000 Dalton)of polyvinyl alcohol (PVA) werepurchasedfrom Fluka Company-Germany, degree of polymerization was 2000 and 98% hydrolysed.

Preparation the pva cotton/wool film composites

Preparation of cotton and wool ultrafine powder

The fibres was milled under liquid nitrogen by freeze milling technique[12] using *Freezer/Mill 6800* machine, immersing and milling the samples completely in liquid nitrogen for certain time (T_2), milling for another time (T_1) and these cycle was repeated for several times completely under liquid nitrogen. The condition details for prepare samples powder described in list of tables

Preparation of 10 % and 15% PVA solution by conventional method

PVA solutions (M.wt. 22000 and 145000 Da) in water at concentrations of 10 % and 15 % were prepared. Heat onelitre of tap water to 88–90°C or just under the boiling point of water. It is recommended that tap water be used when making the polyvinyl alcohol solution because bacteria will grow much faster in a polyvinyl alcohol solution that contains distilled water[13]. Once the water is heated, lightly sprinkle the polyvinyl alcohol into the water while stirring continuously (a magnetic stirrer/hot plate works well to heat and stir the solution). It's important that the polyvinyl alcohol be added lightly and slowly since each grain of polyvinyl alcohol must be individually "wetted" for it to go into solution,[13, 14] then it was stirred and heated at 100C for 60 min. The beaker covered with a rubber plug, and periodically stirred. The resulting solution left overnight to allow the bubbles to disappear.

Preparation of PVA cotton/wool film composites

TABLE 1 : Freezing– millingcondition for cotton and wool fibres

Fibre	CycleAccount	T_1 (min)	T_2 (min)	Total Freezing Time(min)	Total Shaking Time (min)
Cotton	11	5	10	110	55
Wool	7		5	35	35

T_1: Shaking Time (min.) T_2: Cooling Time (min.)

TABLE 2 : Composition and abbreviation of PVA composites film with cotton or wool powders

	Powder %	Polyvinyl Alcohol			
		PVA 22000 (PVA_I)		PVA 145000 (PVA_II)	
		10 %	15 %	10 %	15 %
PVA	0	PVA_I_10	PVA_I_15	PVA_II_10	PVA_II_15
	3	CVC 110	CVC 140	CVC 70	CVC 40
Cotton	5	CVC 120	CVC 150	CVC 80	CVC 50
	10	CVC 130	CVC 160	CVC 90	CVC 60
	3	WVC 110	WVC 140	WVC 70	WVC 40
Wool	5	WVC 120	WVC 150	WVC 80	WVC 50
	10	WVC 130	WVC 160	WVC 90	WVC 60

Cotton or wool micro-particles were added to PVA solution (3, 5 and 10 % wt/wt) and then heated with stirring in a water bath at about 50C for 15 min, and then the solution was poured onto a glass plate mould with 0.35 µm, and left for 2 or 3 days. The PVA film carefully peeled off from the glass plate. The prepared film composition with abbreviation was illustrate in TABLE 2.

Characterization of the composite films

Scanning electron microscopy (SEM)

Surface morphology for composite films wasstudied by Scanning Electron Microscopy (SEM) analyser using HITASHI S–3000 microscope S, at 15–kV acceleration voltage, after gold coating to enhance the quality of the pictures.

DSC and TGA

In order to evaluation the thermal dynamic properties for composites film, Differential Scanning Calorimeter (DSC) and Thermal Gravimetrical Analysis (TGA) was performed on a NETZSCH DSC 204 under nitrogen flow (20 ml.min^{-1}) and NETZSCHTG 209, respectively.

For DSC analysis, PVA composite films with cotton and wool fibres (5–10 mg weighed to 0.1 mg precision) heated from –20 to 150C with heating rate of 10C min^{-1} and kept at high temperature for 2 minutes to erase any thermal history. Subsequently, it cooled till 0C using rate of 10°C min^{-1},after 2 minutes at the low temperature, a second heating run at a same heating rate of 10°C min^{-1} performed. The melting temperature *Tm* and enthalpy *DH* evaluated from the maximaofthefusionpeaks of second heating[15].

Thermo Gravimetric Analysis (TGA), performed on the NETZSCH TG 209C used samples of approximately 15 mg heated with 10C/min from room temperature to 600C, under dry nitrogen gas flow rate of 40 mL/min (to prevent oxidation process).

Tensile strength

The mechanical testing of these composites films was done using a tensile testing machine (Rheometric Scientific Minimat 2000) with a 20 N load cell at a crosshead speed of 0.1 mm/min at 22C and 55% of relative humidity. Three stripes from different places in each film were taken (0.9 5 cm), and then length, wide and thickness were measured after clamped in the machine using digital calliper. Due to the length limitation of Rheometric Scientific Minimat 2000 instrumental, the measurements of elongation at break were performed on a Zwick 1425 tensile tester with a 20 N load cell,the measurement condition remained the same. Three measurements were performed for each sample and the observed data were shown for the average.

Wettability measurements

Wettability time measured for the composites films byAATCC Test Method 39–1993, bymeasuring the needed time for one drop to complete absorbed through the film without any additional force[16, 17].

Composite films application

Moisture absorbance

Moisture absorbance for composites film occurred using NETZSCHTG 209 thermal gravimetrical analyser. The films sample kept in certain hu-

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TABLE 3 : DSC data for PVA and its composites film with cotton or wool powders

PVA	Sample	Peak 1		Peak 2	
		ΔH (J/g)	T_m (°C)	ΔH (J/g)	T_m (°C)
	PVA_I_10	145.7	97.1	77.42	226.1
	CVC 110	134.8	87.4	70.70	225.3
	CVC 120	129.6	85.4	40.86	224.5
PVA_I_10	CVC 130	127.2	80.3	44.64	223.7
	WVC 110	145.5	96.5	75.11	225.4
	WVC 120	143.2	86.3	70.92	225.1
	WVC 130	140.6	74.2	64.85	224.5
	PVA_I_15	144.2	106.9	75.99	226.6
	CVC 140	144.0	104.2	75.96	224.5
	CVC 150	143.4	104.1	74.01	224.3
PVA_I_15	CVC 160	140.3	103.8	74.59	224.1
	WVC 140	142.9	106.6	75.39	223.6
	WVC 150	135.2	106.3	74.32	223.5
	WVC 160	130.6	106.1	68.61	223.3
	PVA_II_10	157.2	88.2	74.23	226.3
	CVC 70	157.8	88.6	75.36	225.3
	CVC 80	159.9	89.9	76.39	219.6
PVA_II_10	CVC 90	165.7	91.9	78.18	221.7
	WVC 70	158.8	89.6	76.34	225.6
	WVC 80	165.3	91.2	78.23	224.7
	WVC 90	171.7	92.2	82.08	222.3
	PVA_II_15	155.4	97.2	68.06	228.1
	CVC 40	166.8	97.6	71.87	228.5
	CVC 50	170.1	99.3	75.80	229.9
PVA_II_15	CVC 60	176.3	101.2	77.65	230.1
	WVC 40	171.8	107.9	70.31	230.1
	WVC 50	174.6	109.6	75.30	232.2
	WVC 60	179.5	111.3	79.42	233.3

T_m = Melting Temperature, "H = Enthalpy

midity atmosphere 60 % for 5 days, then the sample placed into a platinum crucible (5–10 mg weighed to 0.1 mg precision) and closed using high pressure to keep the humidity, and then the pane holed and measured the amount of loss water percent using NETZSCHTG 209 thermal gravimetrical analyser. In addition, this method repeated 5 times with different samples from different position in the composites film.

Formaldehyde absorbance

The formaldehyde absorbance of PVA and its composites are measured by weight gain technique.

In this technique, a known weight (W_o) of each dry membrane were kept in a closed glass bottle and all the bottles were kept in a vacuumed closed chamber. The chamber was first connected with vacuum pump for one day. Then the chamber was saturated with a formaldehyde by adding formaldehyde solution in an open dish for two days. After that, one bottle were open and the sample were hang up for one day till completely saturated and then it's take off and kept in the bottle again. The saturation processwas repeated before each experiment for the sample. After that, all the samples were weighted again (W_f). The percent amount of the absorbed form-

aldehyde (%) were calculated by equation:

On the other hand, the formaldehyde concentration before and after absorption process of these composites films are determined using Z-300XP formaldehyde meter in order to compare both methods.

RESULT AND DISCUSSION

Different percentages of cotton and wool micro particles (average size 20-80 m) were added to two different molecular weight of polyvinyl alcohol (22000 & 145000 Da) during preparation of film (30 m) by casting technique. The films of PVA and its composites with cotton and woolpowders are characterized via SEM, DSC, TGA and wettability test. Mechanical properties of produced films were measured beside formaldehyde absorption of composite films.

Characterization of composite films

Scanning electron microscopy (SEM)

The SEM micrographs of both PVA polymer grades PVA_I and PVA_II and their composites film with different concentration of cotton and wool are presented in Figure 1. Scanning Electron Microscopy investigates the surface morphological structure of composites film of PVA_I_10 and PVA_II_10 with different concentration of cotton powders (3, 5 and 10 %), on the other hand, the composites films of PVA_I_15 and PVA_II_15 are represented with different concentration of wool powders (3, 5 and 10 %). From micrographs, some film characteristics can be observed, surface morphology of pure film of PVA grades under different concentration (10 & 15 %) appears smooth and flatted, and On the
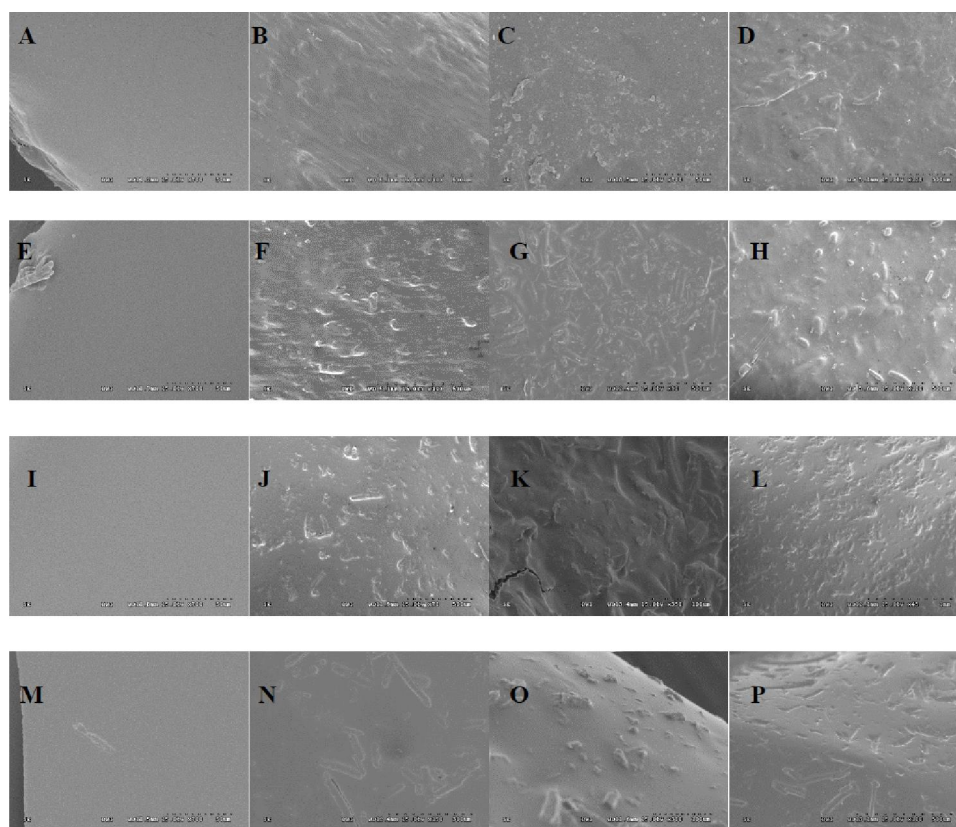

Figure 1 : SEM micrographs of PVA_I and PVA_II and thier composite films with cotton and wool nano-particles at different concentrations
A) PVA_I_10 B) PVA_I_10/Cotton 3% C) PVA_I_10/Cotton 5% D) PVA_I_10/Cotton 10%
E) PVA_I_15 F) PVA_I_15 / Wool 3% G) PVA_I_15/Wool 5% H) PVA_I_15/Wool 10%
I) PVA_II_10 J) PVA_II_10/Cotton 3% K) PVA_II_10/Cotton 5% L) PVA_II_10/Cotton 10%
M) PVA_II_15 N) PVA_II_15/Wool 3% O) PVA_II_15/Wool 5% P) PVA_II_15/Wool 10%

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TABLE 4 : TGA data for PVA and its composites film with cotton and wool powders

PVA	Sample	Peak 1		Peak 2		Peak 3		Mass residual (%)
		$T_{d\,DTG}$ (°C)	Mass loss (%)	$T_{d\,DTG}$ (°C)	Mass loss (%)	$T_{d\,DTG}$ (°C)	Mass loss (%)	
	PVA_I_10	73.9	4.80	269.6	77.05	411.9	11.93	6.22
	CVC 110	71.3	5.41	259.8	76.06	412.0	16.31	2.22
	CVC 120	63.1	5.29	261.5	79.68	415.1	14.69	0.34
PVA_I_10	CVC 130	67.9	4.81	260.8	79.41	414.5	12.82	2.96
	WVC 110	72.9	5.65	268.2	76.79	418.7	14.73	2.83
	WVC 120	81.8	6.59	303.9	72.40	445.2	17.87	3.14
	WVC 130	66.8	6.53	252.7	78.00	414.5	15.40	0.07
	PVA_I_15	75.3	4.23	264.6	75.15	421.2	12.12	8.41
	CVC 140	73.4	4.95	265.6	72.66	422.8	14.66	7.73
	CVC 150	58.40	5.43	258.26	80.66	425.9	11.85	2.06
PVA_I_15	CVC 160	75.87	5.08	292.79	70.86	439.1	15.16	8.90
	WVC 140	64.80	3.59	269.43	85.77	402.13	10.56	0.08
	WVC 150	73.7	4.51	271	77.08	410	14.56	3.85
	WVC 160	47.92	4.67	266.40	81.38	408.98	12.05	1.09
	PVA_II_10	65.2	5.24	346.7	67.25	419.0	26.12	1.39
	CVC 70	72.5	5.43	346.9	65.81	437.1	28.13	0.63
	CVC 80	74.1	5.26	352.5	63.71	439.9	30.57	0.46
PVA_II_10	CVC 90	67.7	5.01	316.3	69.12	431.3	22.11	3.76
	WVC 70	66.3	5.79	338.9	63.70	436.5	26.88	3.63
	WVC 80	66.5	5.62	205.1	63.94	346.0	29.30	1.14
	WVC 90	68.6	5.21	339.1	64.00	431.9	27.81	2.98
	PVA_II_15	80.6	4.62	339.7	65.59	437.6	26.54	3.25
	CVC 40	74.0	5.24	315.6	68.13	426.8	23.14	3.49
	CVC 50	68.0	5.69	309.8	69.89	429.5	22.57	1.85
PVA_II_15	CVC 60	75.0	5.58	316.0	66.84	434.7	23.93	3.65
	WVC 40	78.2	6.06	325.8	69.59	445.6	21.83	2.52
	WVC 50	79.5	6.33	337.0	66.58	441.7	27.01	0.08
	WVC 60	65.3	6.03	342.1	66.30	424.0	27.61	0.06

contrary, the surface of all composites looks heterogeneous and coarse. Depending on the powder type and its concentration the surface morphological changed, with another words, the surface become complete heterogeneousat higher concentration of powder and in composites of wool. It is also obvious that, no indication about any significant agglomeration following the adding of powders beside homogenous distribution of powder inside film matrix.

Differential scanning calorimetry (DSC)

The main thermal events for PVA films were reported by Lobo *et al.*[18] The DSC results of PVA and its composite films are illustrate in TABLE 3, and it can concluded that, PVA pure films I and II (10 and 15 %) has an important two exothermal peak, first peak which corresponding to evaporation of water ca. 100C, and second peak which corresponding to melting of the PVA crystallization. As mentioned in TABLE 3, peak temperature for both peaks of the two different molecular weights PVA is increase with increasing the percent of PVA in the film from 10 to 15%. In addition, enthalpy has opposite behaviour than peak temperature; meaning its decreasing with increasing the PVA concentration.

Furthermore, the main thermal events for wool and cotton composites film with PVA are an exo-

thermic peak due to water evaporation around 100C, an exothermic peak at 224–228C subsequentto melting of its crystallization, and above 300°C there is a decomposition peak extensive from thermal degradation (burning) of natural powders[12, 19].

Forlow molecular weight PVA,adding of cotton or wool nanoparticles causes decreasing in both enthalpy and peak temperature, also increasing addition percent cause more decrease in both enthalpy and peak temperature. Furthermore, the high molecular weightPVA has anopposite behaviour than low molecular weight; meaning that, adding of cotton or wool nanoparticles increase the enthalpy and temperature peak of the composites film.

From PVA chemical structure,it is noticed that, PVA has very short branching (hydroxyl group). As the average molecular weight of PVA increases the chain length of polymer increase, increasing the chain length increase the probabilityand intensity of London interactions (van der Waals forces) between polymer chains, which has a dominate effect of polymer thermodynamic properties. Hydrogen bonding is by far the dominant interaction in this particular polymer and goes some way into explaining its thermal behaviour. So, increasing the molecular weight cause increasing the thermal properties.

Thermal gravimetrical analysis (TGA)

Thermal stability characteristics of PVA and their composites were tested by TGA, the samples being heated from room temperature to 600°C with a heating rate of 10°C/min under a nitrogen flow. This analytical technique used to determine materials thermal stability and its fraction of volatile components by monitoring the weight loss of the sample in a chosen atmosphere as a function of temperature. Thermal decomposition temperature (°C), mass loss (%)and mass residual (%) results are given in TABLE 4.

The TGA data shows that all samples exhibited three distinct weight loss stages. The same pattern was found by Tudorachi *et. al.*[20] in their study on PVA and starch mixtures as biodegradable polymeric materials. The first stage presents the loss of weakly physical absorbed water while second stage exhibits the decomposition of side chain of PVA and the

third stage shows the decomposition of main chain of PVA. TGA of ultrafine cotton and wool powder have been investigated with Hassabo *et. al.*[12].

From TABLE 4, it can be seen that the major weight loss are observed at about 80-90 wt% in the range of 200-450C for all samples which correspond to the structural decomposition of PVA as well as pyrolysis of cotton and wool powder. A typical weight loss occurred at about 100C due to moisture escape aroundboiling point of water. The mass loss at 100C is related to the volatilization of water[21, 22]. At around 400C, a complete decomposition of the sample has been accrued.

Adding of cotton or wool powder to PVA matrix does not show any significant effect for the thermal stability of the composites. Increasing of cotton amount decreases the temperature of decomposition. This is due to the decomposition of cotton and wool powder, which starts normally at around 310°C[23] and 270°C[24]for cotton and wool respectively, and which is shortly delayed by the encapsulation of cotton particles in the PVA matrix, suggesting that cotton and wool powder at these ratios increases the thermal stability of PVA polymer. Mass loss of the polymer composites decreases by increasing the amount of powder to polymeric material. The pure PVA filmshave lower thermal stability than that of its composites with cotton or wool fine powders. In addition, a carbonaceous residue remains after all volatile products has presented in TABLE 4[25].

Tensile measurement

Tensile measurements were run to evaluate the mechanical properties of the resultant composites films and to establish the compatibly of composites materials to use in proposed applications.

Force at break

Force at break values were recorded for all composites films in Figure 2. Generally, all the composites films has broken atlower force of force at break than pure PVA film. Furthermore, both molecular weights PVA and their composites record high elongations and do not broken easily. Some film composites, like those based on cotton powder; require a force higher than those based on wool powder, indicates that the cotton powder has more mechani-
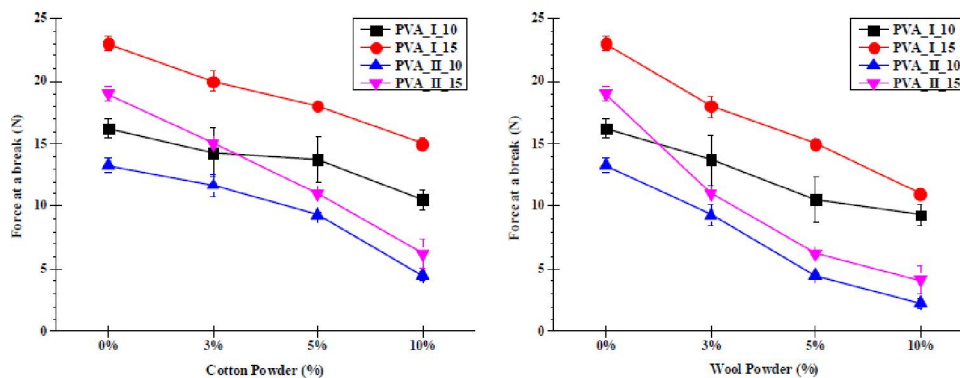
Figure 2 : Force at break for PVA and its composites films with ultrafine cotton and wool powder at different concentrations
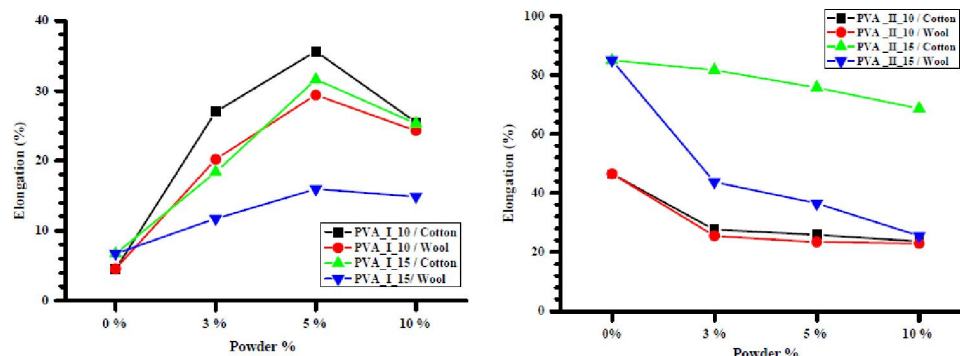

Figure 3 : Elongation (%) for PVA and its composites films with cotton and wool powders at different concentrations

cal compatibility with PVA than wool powder. One may also notice that the effect of particles is the same. Meaning that, increasing of cotton or wool powder concentration leads to decreasing of force at break. Furthermore, increasing the PVA concentration from 10 to 15 %, led to decreasing of the force at break for both PVA molecular weights.

Elongation at break

Figure 3 Showsthe evolution of elongation at break of PVA and its composites films with different amount and type of powders. It shows that, for low molecular weight PVA the elongation at a break increasing by adding cotton or woolpowders till 5 %, then by increasing the powder percent the elongation at a break was decreasing. This effect may be attributed to, adding of cotton or wool powderincrease the amorphous region of the film (the crystallinity ratio decreases). On the other side, the elongation at break for high molecular weight PVA decreasing by adding cotton or wool powders. Furthermore, PVA_I and its composite films shows lower elongation at a break than PVA_II and its composites.

Breaking modulus

The breaking modulus is a material property that describes its stiffness and is used for characterizing the textile fibres[26]. It is defined in a similar way with elastic modulus, but using the values of stress and strain at break:

$$BM = \frac{\text{Breaking stress}}{\text{Breaking strain}}$$

In this work, all the cross-section areas were kept constant, having a rectangular profile with a thickness of 0.2 mm and a width of 15 mm. So, in formula of breaking modulus we used the breaking force instead of breaking stress.

The breaking modulus of PVA_I and PVA_II composites films are shown in Figure 4. Comparing the effect of various powder concentration on the breaking modulus of PVA composites. It is observed that, as the concentration of cotton and wool powder increase, the breaking modulus also increase.

Composites application

Moisture absorbance
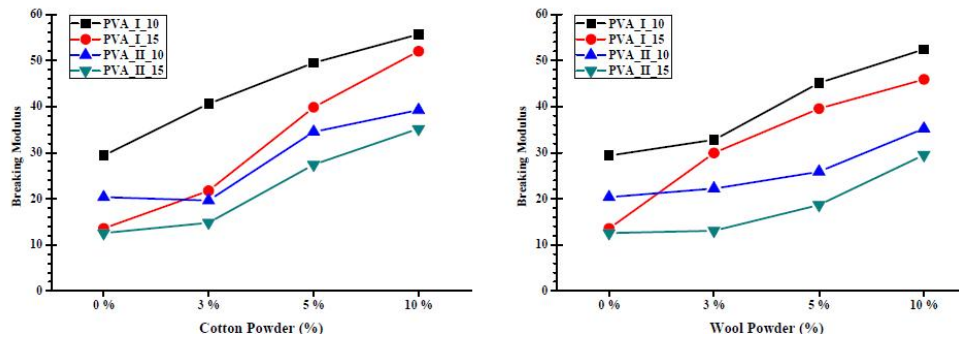
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Figure 4 : Breaking modulus for PVA and its composite films with cotton and wool powder at different concentrations
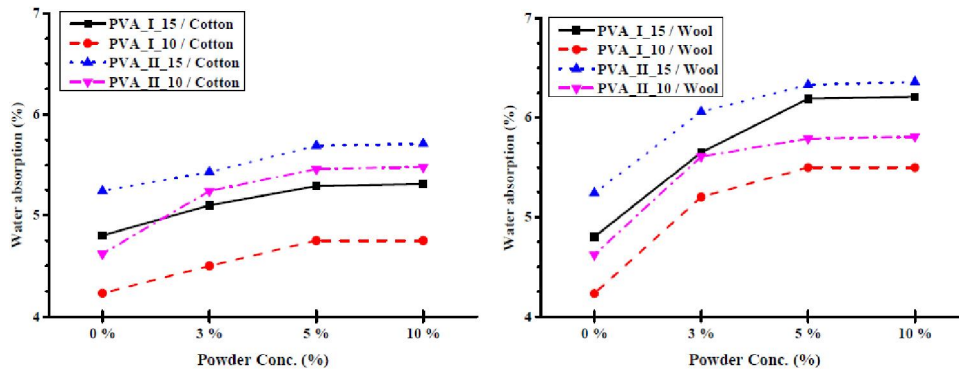

Figure 5 : Water absorption for PVA and its composites films with cotton and wool powders

The composites film of PVA was characterise to use as moisture absorbance which is necessary in some filter. The ability of textile fibre to absorb moisture and perspiration is an important property for providing the comfortable felling to the users. For this reason, we have investigated the moisture management of the resultant composites under different relative humidity conditions to screen out the suitability of each composite.

At a 100% relative humidity environment high molecular weight PVA absorbs moisture more than low molecular weight PVA, also, high concentration PVA film can absorb moisture more than low concentration. That may be attributed to, PVA creates hydrogen bond in presence of water molecule which changes its dielectric and conductive properties[27]. The moisture sorption characteristics of both PVApolymersand their composites with cotton and woolpowders were measured for the composites with 3, 5 and 10% powder (see Figure 5). The moisture uptake is improved by adding of wool powder much than cotton powder.

From physical view-point of cotton, the molecule is a ribbon-like structure of linked six-member rings each with three hydroxyl groups (OH) on the C2, C3 and C6 atoms projecting out of the plane of the ribbon. As well as providing structural stability the hydroxyl groups allow extensive intermolecular hydrogen bonding with many molecules, including water. The accessibility of water to these hydroxyl groups depends on the spacing between crystal lattice planes. From a completely dry state, water molecules will form hydrogen bonds with hydroxyl groups that are not already linked within crystalline regions[28].

The extra moisture absorption in both polymers is the contribution of the cotton particles. Overall, the adding of up to 5% cotton powder to the PVAmatrix improve the total moisture uptake, which is attributed to the corresponding amount of cotton powder added. In addition, more increase the amount of cotton powder till 10 %didn't have any significant change on the water absorption comparing with 5 % of cotton powder.

On the other hand, at 100% relative humidity wool takes moisture up to 33% of its weight[29]. Therefore, by adding wool powders to PVA matrix we expect that the moisture performances of the
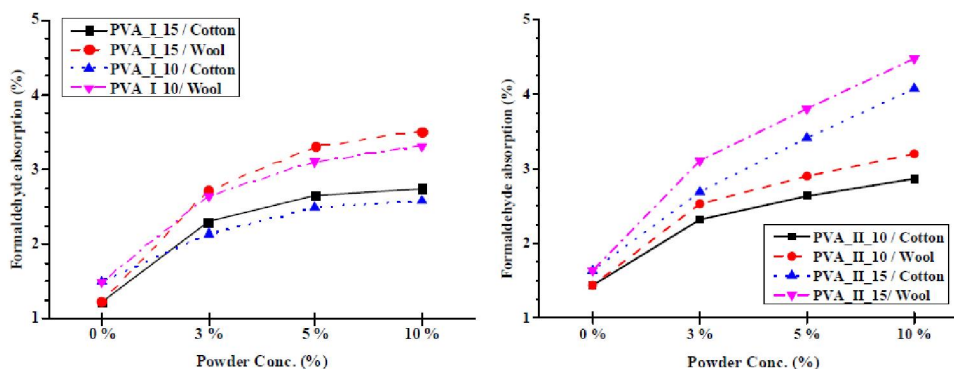
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Figure 6 : Formaldehyde absorption for PVA and its composites films with cotton and wool powders

composite film will be improved.

As shown in Figure 5, adding 5% of wool powder to the PVA film observes changing of the ability of the composite to adsorb moisture. The composite film can take 3% of its weight moisture when the surrounding environment has 95% relative humidity, which is more than what pure PVA adsorbs under the same conditions. The extra-amount fits practically the contribution of wool particles added to the film[30]. As it appears adding of wool particles to PVA matrix changes significantly the moisture properties making the composite film to behave closer to natural products.

Formaldehyde uptake

It is demonstrate that, the composite film could absorb formaldehyde from the environmental; Figure 6 shows the formaldehyde absorption (%) for PVA and its composites films with cotton and wool micro powders.

This result shows that,pure PVA film (low or high molecular weight at 10 or 15%) could be absorb formaldehyde with1.23,1.5, 1.44 and 1.64 % for PVA_I_10, PVA_I_15, PVA_II_10 and PVA_II_15 respectively. Furthermore, addition of both cotton and wool powders improve the ability of the composites films to absorb formaldehyde. In addition, composites with wool powderswere absorb the formaldehyde much more than those composites with cotton powders.

As the pure PVA absorb formaldehyde depending on the molecular weight and the concentration, (high concentration is better than low concentration and higher molecular weight is better than low one;

as the same behavior of water absorbance), it found that it is the same behavior for the composites with cotton and wool powder.

CONCLUSION

A new composites film based on polyvinyl alcohol (PVA) and micro-powders from cotton and wool were prepared using variousconcentrations; molecular weight of PVA (low 22000 and high 145000), concentration of PVA in water (10 and 15 %), concentration of additive powders (3, 5 and 10 %). All these mixtures were casting over glass plate with standard thickness.

The Surface morphology for composites films were examined using the scanning electron microscope (SEM). Differential Scanning Calorimeter (DSC) and Thermal Gravimetrical Analysis (TGA) was performedto evaluate the thermal properties of the composites film and mechanical properties was done. All these examinations support that, the distribution of the micro-powders in PVA matrix is homogenous and has no agglomeration sign. Physical and mechanical investigations of these composites film were improved. Uses of these composites film as a membrane to absorb water and formaldehyde is approved experimentally as shown in the result of composite applications section.

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