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Effect of Phenolic Compounds and Water Repellents Combination on Performance Properties of Cotton/ polyester Blended Fabric

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A NEWLY prepared stearyl alcohol / poly (N-vinyl-2-pyrrolidone) (SA/PVP) hybrid emulsion was used, as a water repellent finish, alone or in combination with some phenolic compounds namely tertiary butyl hydroquinone (TBHQ), curcumin and vanillin, in easy care finishing formulations. The results obtained reveal that: i) finishing fabric samples with different concentrations of the hybrid emulsion in absence of the aforementioned phenolic compounds, significantly enhances fabric weight, tensile strength, stiffness, water repellency, antibacterial, water vapor resistance and thermal resistance properties along with a gradual decrease in the resilience, surface roughness and air permeability of treated fabric, ii) using the hybrid emulsion with the above phenolic compounds efficiently enhances the storage life of the emulsion and upgrades the antibacterial properties of treated fabric, iii) addition of vanillin provides the finished fabric with pleasant scent, curcumin upgrades the UV protection property of treated fabric and TBHQ slightly enhances tensile strength, surface roughness, air permeability, water vapor resistance and thermal resistance along with a reduction in the resilience of treated fabric, and iv) the prepared hybrid emulsion, whether in absence or presence of TBHQ, can be used as extender for fluorocarbon textile finishes.

Keywords: Phenolic compounds, Hybrid emulsion, Cotton/polyester blend, Textile finishing, Functional finishes.

Nowadays, the role of textiles exceeds the traditional function of dressing to textiles of multi-functions that provide the wearers with comfort and protection in abnormal environments [1]. Many functional properties such as softness, anti-microbial, UV-blocking, wrinkle resistance, stain-resistance, hydrophilicity, anti-static charges, etc can be imparted for textiles [2-15]. According to the consumer needs, some of these functional properties can be imparted individually or simultaneously to achieve a textile of multi-functional properties by means of chemical finishes [1].

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Repellent finishes are that finishes which repel water, oil and dry dirt from textiles surfaces. Water repellency is achieved using different materials such as paraffin repellents, stearic acid–melamine repellents, silicone water repellents, fluorocarbon-based repellents [1], nano-structured materials such as silica, silver and calcium carbonate nano-particles [13], and sol–gel coatings such as modified SiO_2 nano-particles [13]. Generally, the repellent finishes achieve their function by reducing the free energy at fiber surfaces [1,13,15]. In order to obtain water and/or oil repellent textiles with reasonable comfort properties, the air as well as water vapor permeability of these finished textiles should not be significantly reduced and their tactile and performance properties are good [1,16]. On the other hand, textile materials can be attacked by microbes (bacteria, fungi, algae) during production, usage or storage. Bacteria infect textiles with fiber damage; unpleasant odors and a slick, slimy feel [1]. Thus, antimicrobial finishing of textiles is performed to protect both the textile substrate from microbes as well as the human beings from the bacterial infection. Many chemical finishes can be used to achieved antimicrobial finishing for textiles such as metal salts, Ag, TiO_2 and ZnO materials, chitosan, triclosan, quaternary ammonium salts, etc [17-22]. Moreover, the phenolic compounds such as tertiary butyl hydroquinone (TBHQ), vanillin and curcumin are known with their antioxidant and antibacterial properties.

TBHQ is a synthetic antioxidant and antimicrobial food additive and therefore it finds applications in healthcare setting [23-25]. Vanillin is a pleasant scent phenolic compound that is naturally found in vanilla beans. It is vastly used as a flavoring additive for food products and as an aromatic additive for other products such as fragrances, perfumes, and air fresheners. Furthermore, it has antioxidant activity as well as antimicrobial activity against some pathogenic bacteria such as E. coli [26,27].

Curcumin is a hydrophobic polyphenol extracted from the plant turmeric (Curcuma longa). It is not toxic to humans and has antioxidant, anti-inflammatory, antiviral and antimicrobial properties [28,29]. Previous studies reported that curcumin can be used as a natural dye to impart dyeing as well as antibacterial properties to wool, silk and cellulosic textiles [30,31].

In our previous work [32], a water repellent finish was prepared by reacting of PVP with SA in presence of ammonium persulphate as initiator to form SA/PVP hybrid. Homogenization of that hybrid in an aqueous medium produced a stable emulsion of nano sized particles. The present work aims to illustrate the effect of treating cotton/PET fabric with that hybrid emulsion alone or in combination with some phenolic compounds on the functional and comfort properties of the treated fabric.

Experimental

Materials

Bleached cotton/polyester (50/50) blended fabric of plain weave structure 1/1, weight of 125 g/m^2, count (Ne) of 30/1 and thickness of 0.31 mm was supplied by Misr Spinning and Weaving Co., Mehalla EL-Kobra, Egypt. Poly (N-vinyl-2-pyrrolidone) (PVP) of molecular weight 40000 Dalton, supplied by Research-Lab Fine Chem Industries, India, was used. Arkofix® NG, aqueous solution of dimethyloldihydroxyethylene urea (DMDHEU), as a crosslinker, as well as Nuva® FB,as a water/oil repellent, kindly supplied by Clariant, Egypt, was used. Egyptol®, a nonionic detergent produced by the Egyptian Company for Starch, Yeast and Detergents, Alexandria, Egypt was used. Stearyl alcohol (SA) of purity 95% and ammonium persulphate (APS) as initiator, tertiary butyl hydroquinone (TBHQ), vanillin and curcumin as phenolic compounds were all of laboratory grade chemicals.

Preparation of SA/PVP hybrid emulsion

The SA/PVP hybrid was prepared as follows [32]: a specific weight of stearyl alcohol was melted at 60 ^{O}C in 250 ml round flask equipped with a condenser in a thermo stated water bath. To that melt, thermostatic aqueous solution of PVP of weight ratio to SA (20%) and concentration of 60% was added with stirring. After that, an aqueous solution of ammonium persulphate of specific concentration and weight ratio to PVP (50%) was added to the reaction medium then the reaction medium was left at 80 ^{O}C for 55 min. At the end of the reaction, specific volume of hot distilled water at 70 ^{O}C was added to the reaction products followed by stirring the mixture, using a strong homogenizer, for 3 minutes to form homogeneous oil in water emulsion. To enhance the storage life of the prepared emulsion up to 3 months, some phenolic compounds such as TBHQ, vanillin or curcumin were added as antioxidants in specific concentrations listed in the text to the freshly prepared hybrid emulsion followed by stirring the mixture for extra 3 minutes.

Fabric treatment

Fabric samples of 30X30 cm^2 were padded in a finishing baths containing 60 g/L of DMDHEU, $(NH_4)S_2O_8$ as a catalyst and the hybrid emulsion alone or in combination with the phenolic compound to a wet pick up of Ca 100 %. The padded samples were dried at 100 ^{O}C/3 min then cured at 150 ^{O}C for 3 min in Wenner Mathis AGCH-8155 oven. The finished samples were then washed at 50 ^{O}C for 15 minutes, thoroughly rinsed, and finally dried for testing.

Testing and analysis

- Fabric weight (W) was determined according to ATSM (D 3776 – 79).
- Dry wrinkle recovery angle (WRA) was determined according to ASTM (D-1296-98).
- The tensile strength (TS) of the finished fabric sample was tested in the warp direction according to ASTM (D-2256-98).

- Water repellency rating (WRR) was evaluated according to the spray test, AATCC Test Method 22-1989. This test method determines the water-repellent efficacy of finishes applied to textile fabrics. In this test, a specimen of size 180 × 180 mm was conditioned at 65 ± 2% RH and 21 ± 1 ^{O}C for 4hr prior to testing. This specimen was fastened firmly to a 152.4 mm diameter hoop so that the taut surface of the specimen will be sloped with an angle of 45^{O} and exposed to the water spray of a special funnel filled with 250 ml distilled water at 27 ^{O}C. The distance between the funnel and the test specimen center was 150 mm. The water sprayed test specimen was compared with the wetted pattern with pictures on a standard chart.
- The antimicrobial activities of the untreated control and water repellent fabric specimens were determined according to the disc diffusion method, AATCC 147-2004. It is a qualitative method for evaluating the antibacterial activity of fabrics against Gram positive and Gram negative bacteria. Fabric specimen of diameter 1 cm was placed in sterilized Petri dishes containing solid sterilized nutrient agar that was streaked with test bacteria. After incubation at 37 ^{O}C/24 hours, the antibacterial activity of the fabric specimen was evaluated visually by determining of the clear zones of inhibition per millimeters around that specimen. The used test bacterial species were:

  Gram-positive bacteria: Staphylococcus aureus (SA).

  Gram-negative bacteria: Escherichia coli (EC).
- Ultraviolet-protection factor (UPF) values were calculated according to the Australian/New Zealand standard (AS/NZS 4366-1996) with a UV-Shimadzu 3101 PC spectrophotometer.
- Surface roughness (SR) was assessed using a Surfacoder 1700a.
- Stiffness (S) was determined in the warp direction according to ASTM (D 1388-96) using Jika (Toyaseiki) apparatus.
- Air permeability (AP) was evaluated according to ATSM (D 737-96). The air permeability of a fabric is the air flow passing through that fabric under a given air pressure.
- Water vapor resistance (WVR) was measured on Permetest instrument working on similar skin model principle as given by the ISO 11092.
- Thermal resistance (TR) was determined according to ASTM (D 1518-85).
- Durability to wash was determined by subjecting the finished fabric to 1 and 5 laundering cycles. Each laundering cycle was performed by washing the fabric at 50 ^{O}C for 10 min in presence of 2 g/L nonionic surfactant followed by rinsing and air drying at ambient conditions.
- The particles size of the hybrid emulsion samples were determined by transmission electron microscope (TEM) using a JEOL, JEM 2100 F electron microscope at 200 kV after sonication for 10 min.
- Scanning electron microscope (SEM) images of the treated and untreated fabric samples were obtained using SEM Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 30 kV, magnification 14× up to 1,000,000 and resolution for Gun, FEI company, Netherlands.

●Thermogravimetric analysis (TGA) was performed at a temperature starting from 25 to 600 ^{O}C under inert nitrogen atmosphere with heating rate of 10 $^{O}C/min^{-1}$ using the instrument: SDT Q600 V20.9 Build 20, USA.

Results and Discussion

Factors affecting performance, functional and comfort properties of cotton/PET finished fabric

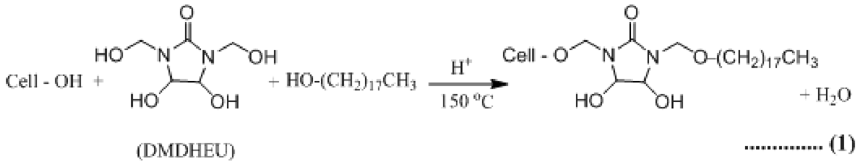
Effect of SA/PVP hybrid emulsion concentration

TABLE 1. Effect of emulsion concentration on some performance, functional and comfort properties of treated fabric.

Emulsion conc. (g/L)	W (g/m^2)	WRA (W+F) ^{O}	TS (Kg)	WRR	ZI (mm)		SR (µm)	S (mg)	AP ($cm^3/cm^2.s$)	WVR (m^2PaW^{-1})	TR (Clo)
					G +ve	G -ve					
Untreated	125.01	187	49.12	0	0	0	17.75	498	47.34	3.6	1.436
30	129.74	246	43.3	0	2	1	16.85	534	37.23	4.3	1.442
40	132.33	239	43.7	50	3	1	16.41	640	34.61	4.9	1.451
50	133.84	234	44.2	70	5	2	16.17	712	32.74	5.3	1.463
60	135.15	229	44.8	80	7	5	15.93	748	31.42	5. 6	1.471
80	137.26	223	45.4	80	8	7	15.79	854	27.97	5.9	1.484

Fabric finishing conditions: [DMDHEU], 60 g/L; [hybrid emulsion], 30-80 g/L; wet pick up,100 %; drying, 100 OC/5 min; curing, 150 OC/3 min. WRA: wrinkle recovery; TS, tensile strength; WRR: water repellency rating; ZI: zone of inhibition; G+ve: S. aurous; G−ve: E. coli; SR, surface roughness; S, stiffness; AP: air permeability; WVR: water vapor resistance; TR: thermal resistance.

Table 1 shows the effect of hybrid emulsion concentration on some physico-mechanical, functional and comfort properties of the treated fabric. It is clear that increasing the hybrid emulsion concentration up to 60 g/l results in an increasing in fabric weight, tensile strength, water repellency rating; from 0 up to 80, antibacterial properties, softness degree, stiffness, water vapor resistance and thermal resistance along with a reduction in the resiliency as well as air permeability of treated fabric samples. Further increase in the hybrid emulsion concentration, up to 80 g/L, has no effect on water repellency rating with a marginal increase or decrease in extents of the above mentioned properties of treated fabric samples. The variation in fabric weight, resilience, tensile strength, softness and stiffness properties of treated fabric samples is a direct consequence of the role of some DMDHEU in either binding the dispersed unreacted SA, as one of the hybrid emulsion ingredients, to fabric structure or crosslinking of it via its labile hydrogen of hydroxyl groups as illustrated by equations 1 and 2 respectively [15,16,32,33].



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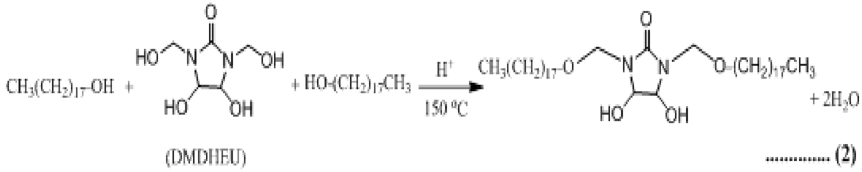

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On the other hand, coating the fiber surface with a low surface energy layer/film impedes the air penetration as well as water vapor transmission through the fabric structure that ultimately enhances the thermal insulation of coated fabric. The higher the hybrid concentration, the higher is the deposition of its ingredients on the fabric surface and consequently the enhancement in extents of such above properties will be [34,35]. Moreover, such hydrophobic layer/film forms a barrier against the bacterial growth as a result of the antibacterial activity of the long-chain fatty alcohols [36,37]. In addition, increasing of the hybrid emulsion concentration in the finishing bath with constancy of the crosslinker concentration may cause a libration of unbound entrapped antibacterial fatty alcohol species from the finished fabric surface resulting in upgrading of the antibacterial properties of that fabric**.**

Effect of adding of some phenolic compounds to the SA/PVP hybrid emulsion

TABLE 2. Effect of some phenolic compounds on storage life of the SA/PVP hybrid emulsion and the functional properties of the finished fabric.

Phenolic compound type	Phenolic compound concentration (g/L)	Functional properties of finished fabric					
		WRR		ZI (mm)		UPF	Scent intensity
		Before storage	After storage (3 months)	G+ve	G-ve		
0	0	80	50	7	5	8	-
TBHQ	1	80	70	11	8	8	-
	2	80	80	15	12	9	-
	3	80	80	16	14	12	-
Vanillin	3	80	70	12	10	10	+++
	6	70	70	16	13	14	++++
Curcumin	0.5	80	70	15	13	18	-
	1.0	80	80	17	13	26	-
	1.5	80	80	18	15	31	-

Fabric finishing conditions: [DMDHEU], 60 g/L; [hybrid emulsion], 60 g/L; wet pick up, 100 %; drying, 100 ^{O}C/5 min; curing, 150 ^{O}C/3 min. WRR: water repellency rating; ZI: zone of inhibition; G+ve: S. aurous; G−ve: E. coli; UPF: ultraviolet-protection factor.

Table 2 shows the impact of the type and concentration of some phenolic compounds namely TBHQ, Vanillin and Curcumin on the storage life of the SA/PVP hybrid emulsion, expressed as WRR values, as well as the functional properties of treated fabric samples. It is clearly seen that increasing of TBHQ

(0-3 g/L), vanillin (0-6 g/L) or curcumin (0-1.5 g/L) concentration in easy care finishing bath along with 60 g/l of the hybrid emulsion results in an enhancement in the storage life of the emulsion up to 3 months, compared to the freshly prepared emulsion, reflecting their effect as antioxidants [23-29]. Meanwhile, increasing the vanillin concentration in the aforementioned emulsion, either before or after storage the emulsion, negatively affect the WRR of treated fabric and lowering it to the value of 70, probably due to the hydrophilic carboxyl groups of vanillic acid [38]. On the other hand, Table 2 reveals also that inclusion of TBHQ, vanillin or curcumin in easy care finishing of cotton/polyester fabric in presence of the freshly prepared hybrid emulsion significantly affect the functional properties of the finished fabric. Thus, increasing the concentration of TBHQ (0-3 g/L) in the finishing bath brings about an enhancement in the antibacterial properties along with preserving WRR of treated fabric. Moreover, as far the vanillin concentration increases (0-6 g/L), it upgrades in one hand the antibacterial properties of treated fabric but on the other hand it impairs WRR of treated fabric. Curcumin is unique; it imparts the finished fabric with the highest antibacterial as well as UV protection properties, compared with the above mentioned phenolic compounds, but the dyed fabric suffer from inhomogeneous color drawback resulted from aggregation of the water insoluble curcumin molecules onto the fabric structure [39]. However, the improvement in the antibacterial properties of the aforementioned phenolic compounds treated fabric may be associated with liberation of physically entrapped or bonded phenolic compounds species from the finished fabric surface. Indeed, the variations in chemical structure as well as solubility of such phenolic compounds influence the antibacterial activities of treated fabric samples.

Effect of Tertiary butyl hydroquinone concentration and washing cycles

TABLE 3. Effect of TBHQ concentration on some performance, functional and comfort properties of treated fabric.

TBHQ (g/L)	WRA $(w+f)^O$	TS (Kg)	WRR	ZI (mm)		SR (µm)	S (mg)	AP ($cm^3/cm^2.s$)	WVR (m^2PaW^{-1})	TR (clo)
				G+ve	G-ve					
0	229	44.8	80(70)	7(4)	5(1)	15.93	748	31.42	5.6	1.471
1	228	44.8	80(50)	11(7)	8(3)	15.91	748	30.87	5.6	1.473
2	226	44.9	80(50)	15(10)	12(6)	15.87	748	30.02	5.7	1.476

Fabric finishing conditions: [DMDHEU], 60 g/L; [hybrid emulsion], 60 g/L; [TBHQ], 0-2 g/L; wet pick up,100 %; drying, 100 ^{O}C/5 min; curing, 150 ^{O}C/3 min. Values in parentheses indicate retained functional properties after 5 washing cycles. WRA: wrinkle recovery; TS, tensile strength; WRR: water repellency rating; ZI: zone of inhibition; G+ve: S. aurous; G−ve: E. coli; SR, surface roughness; S, stiffness; AP: air permeability; WVR: water vapor resistance; TR: thermal resistance.

To avoid the drawbacks of vanillin and curcumin as antioxidants in that study, TBHQ was selected as an efficient antioxidant as it enhances the storage life of the hybrid emulsion, preserves the WRR and improves the antibacterial properties of the finished fabric. Accordingly, different concentrations of TBHQ, 0-2 g/L, were incorporated in easy care finishing formulations containing 60 g/L of SA/PVP hybrid emulsion and 60 g/L of DMDHEU and the performance, functional as well as comfort properties of the treated fabric are monitored in Table 3. For a given set of finishing conditions, the data in Table 3 signify that increasing of TBHQ concentration in the finishing bath brings about: i) a significant enhancement in the antibacterial properties of treated fabric, ii) a slight increasing in TS, WVR and TR along with a slight decreasing in WRA, SR, and AP properties of treated fabric, iii) unchanged WRR and S properties of treated fabric. The upgrading in the antibacterial activities of treated fabric, compared to fabric treated in absence of TBHQ additive, may be associated with the inhibition of the bacterial growth as a result of a leaching of physically entrapped TBHQ species, with its phenolic groups, from the finished fabric surface. The preserving of WRR of the treated fabric at the value of 80 reflects the hydrophobic aromatic structure of the TBHQ [23-25]. The slight variation in the other performance and comfort properties, i.e. WRA, TS, WI, SR, S, AP, WVR, and TR properties of treated fabric is predictable and can be attributed to the fixation of a low concentration of TBHQ onto/within the fabric structure. On the other hand, the data in Table 4 reveal also that the retention in the antibacterial properties of treated fabric was still high after 10 washing cycles. Furthermore, a gradual detraction in the WRR of treated fabric was observed upon laundering. It seems that despite of the aromatic structure of such antioxidant, that may preserve the WRR of treated fabric, it may interact through its phenolic groups with some of the emulsion ingredients, *i.e.* these species containing PVP, forming hydrophobic film that is not tightly bounded to the surfaces of the treated fabric and thus can be swept away after 10 washing cycles leaving the fabric to have WRR of zero.

TABLE 4. Water and oil repellency rating of fabric samples treated with Nuva® FB alone or in combination with the SA/PVP hybrid emulsion.

Nuva FB (g/L)	**Hybrid emulsion (g/l)**	**WRR**	**ORR**
Untreated	0	0	0
20	0	70	70
	30	70	7
	40	80 (90)	8 (8)
	60	80	8
30	0	80	8
	30	80(90)	8(8)
	40	90	8
	60	90	8

Fabric finishing conditions: [DMDHEU], 60 g/L; [hybrid emulsion], 60 g/L; [Nuva® FB], 20-30 g/L; wet pick up, 100 %; drying, 100 ^{O}C/5 min; curing, 150 ^{O}C/3 min. Values in parentheses indicate water repellency rating (WRR) and oil repellency rating (ORR) of fabric samples treated with the same finishing formulation in addition to 2 g/L of TBHQ.

Fluorocarbons are widely used to impart textiles with water and oil repellency properties. These compounds provide fabric surface with the lowest surface energies than other repellent finishes. The most important disadvantages of the fluorocarbon repellents are their high cost and the needing for special treatment for the waste water resulted from their application. Thus, to minimize such disadvantages, wax emulsions are used as extenders for fluorocarbons repellent finishes [1,4,6]. In that step of our research work, the SA/PVP hybrid emulsion was examined to be as an extender for a commercial fluorocarbon finish namely Nuva® FB of Clarient. In this regard, different concentrations of both the hybrid emulsion and Nuva® FB were combined and WRR as well as ORR of their treated fabric samples were determined and listed in Table 4. It is clear that: i) treating fabric samples with Nuva® (FB), 0-30 g/L, in absence of the hybrid emulsion, imparts that samples with hydrophobic as well as oleophobic properties, that is a characteristic of fluorochemical finish [1,4,6], ii) combining 40-60 g/L of the hybrid emulsion with 20 g/L of Nuva® FB in different finishing formulations, in absence of TBHQ, raises WRR and ORR of treated fabric to reach 80 and 8 respectively, iii) combining 40-60 g/L of the hybrid emulsion with 30 g/L of Nuva® FB in different finishing formulations, in absence of TBHQ, enhances only WRR of treated fabric to reach 90, and iv) inclusion of 2 g/L of TBHQ in finishing formulations containing 40 g/L of the emulsion as well as 20 g/L of Nuva® FB or 30 g/L of the emulsion as well as 30 g/L of Nuva® FB, enhances only WRR of the treated fabric from 80 to 90 while keeping the ORR unchanged at the value of 8. Accordingly, the hybrid emulsion, whether in absence or presence of TBHQ, can be used as an extender for the fluorocarbon finish Nuva® FB.

Characterization of SA/PVP hybrid treated fabric

TEM Image

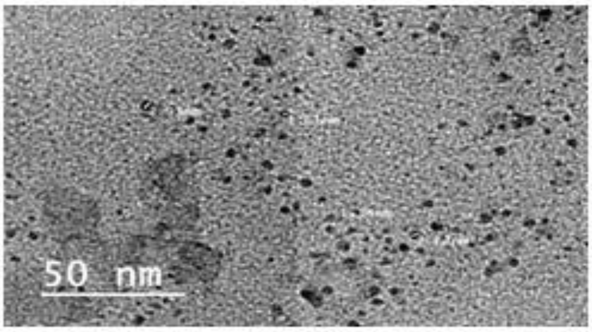

Fig. 1. (a): TEM image of SA/PVP hybrid emulsion.

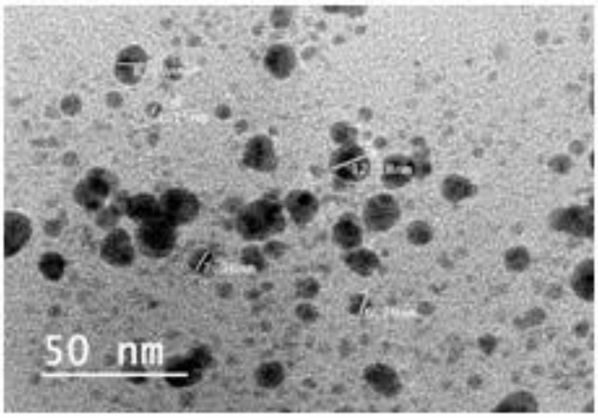

Fig. 1. (b): TEM image of SA/PVP hybrid emulsion loaded with TBHQ.

Figure 1 shows the particles size of freshly prepared SA/PVP hybrid emulsion in absence and presence of 2 g/L of TBHQ determined by the transmission electron microscope (TEM). It is clear that the emulsion particle size ranges approximately from 2 to 5 nm (Figure 1(a)), then after inclusion of TBHQ in the aforementioned emulsion the particles still maintain the nano size that reaches approximately to 13 nm (Figure 1(b)). It seems that TBHQ partially deactivates the stabilizing effect of PVP for the emulsion nano-particles [39].

Thermal gravimetric analysis

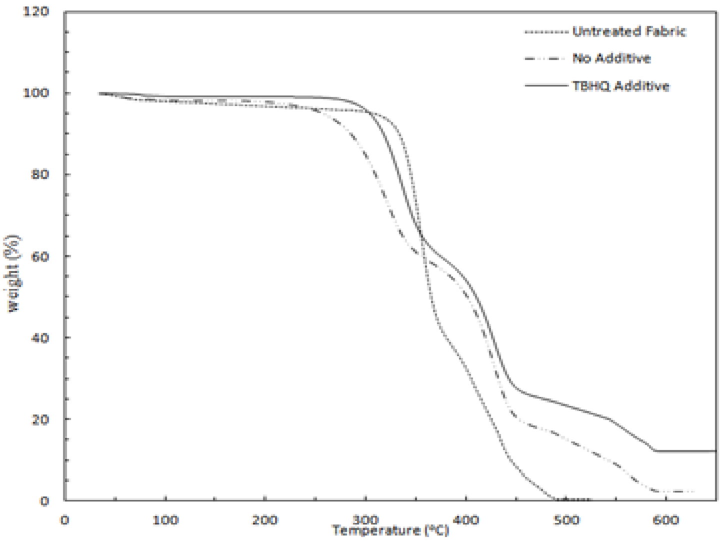

Fig. 2. TGA of untreated and water repellent fabric samples.

For comparison, an untreated sample as well as SA/PVP hybrid emulsion and its TBHQ loaded form treated fabric samples are examined using the thermal gravimetric analysis (TGA). Figure 2 shows three curves representing the thermograms of untreated, water repellent and TBHQ loaded water repellent fabric samples. It is obvious that the thermogram of the untreated sample consists of three regions; the first one represents a dehydration stage that locates between 30 and 110 ^{O}C and accompanied with a weight loss of 3.26 %. The second region represents the main degradation stage as a result of pyrolysis [42-44]. It locates in the range of 330 and 390 ^{O}C with a weight loss of about 44.55 %. The third region represents the stage of conversion of the remaining materials to carbon residue [42-44]. It locates in the range of 394 to 476 ^{O}C with a weight loss of 31.48 %. On the other hand, the first stage of the thermal degradation of the water repellent and TBHQ loaded water repellent fabric samples shows a weight loss of 2.26 and 1.22 % respectively in the range of 30 and110 ^{O}C. The other two stages of the thermal degradation consist of three peaks which may be attributed to coating these samples with the SA/PVP hybrid. The first peak is characterized with a weight loss of 38.24 and 37.93% in the region of 272 and 376 ^{O}C whereas the second peak is characterized with a weight loss of 42.07 and 35.77 % in the region of 389 and 465 ^{O}C for water repellent and TBHQ loaded water repellent fabric samples respectively. Finally, the weight loss of such samples at the third peak is 15.11 and 13.15 % respectively in the range of 501 to 593 ^{O}C. Thus, the percent weight loss of the aforementioned samples at such above temperatures may reflect the relative thermal stability of TBHQ loaded water repellent sample compared with that of the untreated and water repellent fabric samples.

Conclusion

The impact of utilization of the water repellent finish SA/PVP hybrid emulsion alone or in combination of with some phenolic compounds in different easy care finishing formulations on the performance, functional and comfort properties of treated cotton/PET fabric samples is summarized as follows: i) finishing of fabric samples with easy care finishing formulations containing the hybrid emulsion results in increasing the fabric weight, tensile strength, stiffness, softness, water repellency, antibacterial properties, water vapor resistance and thermal resistance along with a noticeable reduction in the resilience and air permeability of treated fabric, ii) treating fabric samples with finishing baths containing 60 g/L hybrid emulsion, 60 g/L DMDHEU as well as different concentrations of TBHQ, vanillin or curcumin results in an enhancement in the antibacterial properties accompanied with the preservation of the imparted water repellency of treated fabric, iii) beside the antibacterial properties imparted by such phenolic compounds, curcumin imparts its treated fabric with UV protection properties whereas vanillin provide a pleasant smell to its treated fabric, iv) in addition to the improvement in the antibacterial properties, TBHQ slightly enhances tensile strength, surface roughness, air permeability, water vapor resistance and thermal resistance along with a reduction in WRA of treated fabric, and v) the hybrid emulsion, whether in absence or presence of TBHQ, can be used as extender for fluorocarbon textile finishes.

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تأثير استخدام بعض المركبات الفينوليه مع هجين الكحول الستيريلى/ عديد فينيل البيروليدون على الخواص الوظيفيه و خواص الراحه الملبسيه لأقمشه القطن / بوليستر

هشام مصطفي فهمي ، آمال أحمد علي ، أحمد السيد عمرو ، شيماء محمود سيد و عبد الجواد محمد ربيع[1]
شعبة بحوث الصناعات النسجية - المركز القومي للبحوث و[1] قسم الكيمياء- كلية العلوم - جامعة عين شمس - القاهرة - مصر .

تم فى هذه الدراسة استخدام مستحلب هجين الكحول الستيريلى/عديد فينيل البيروليدون وحده أو بالاشتراك مع بعض المركبات الفينولية ثالث بيوتيل الهيدروكينون و الكركومين والفانيليا ضمن خلطات تجهيز العناية السهلة لأقمشه القطن / بوليستر لبيان تأثير مستحلب هذا الهجين مع هذه المركبات الفينوليه على الخواص الوظيفية و خصائص الراحة الملبسيه للقماش المعالج. و قد أكدت النتائج أن: أ) تؤدى معالجة عينات أقمشه قطن / بوليستر في حمامات تجهيز تحتوي على تركيزات مختلفة من مستحلب الهجين و رابط العرضى (مستغلا فى ذلك فوق كبريتات الأمونيوم المتبقى فى وسط تفاعل من تحضير الهجين كعامل حفاز) الى تحسن فى الخواص المقاومة للماء و قوة شد و تصلب و مقاومة البكتريا ومقاومة نفاذية بخار الماء و الحراره مع انخفاض طفيف في مرونة و خشونة سطح و نفاذية الهواء لعينات الأقمشه المعالجة، ب) تؤدى معالجة عينات الأقمشه في حمامات تجهيز تحتوي على 60 جرام / لتر من مستحلب الهجين و 60 جرام / لتر من الرابط العرضى و تركيزات مختلفة من أي من المركبات الفينوليه المذكورة أعلاه الى زيادة كبيره فى فترة تخزين و ثبات مستحلب الهجين مع زياده فى خواص الأقمشه للمقاومة البكتريا ، ج) بجانب الزياده فى خواص مقاومة الأقمشه المعالجه للبكتريا فقد أدى اضافة الفانيليا الى حمام التجهيز الى اكساب القماش المجهز رائحة زكيه كما أدى اضافة الكركومين الى حمام التجهيز الى اكساب القماش المجهز خصائص الحماية ضد الأشعة فوق البنفسجية ، د) أدى اضافة ثالث بيوتيل الهيدروكينون الى حمام التجهيز الى اكساب الأقمشه تحسن في خواص الأقمشه لمقاومة البكتريا مع زياده هامشيه فى قوة شد ومقاومة نفاذية بخار الماء و الحراره مقترنا ذلك بانخفاض طفيف في مرونة و خشونة سطح و نفاذية الهواء و ثبات كلا من خواص مقاومة الماء و تصلب العينات المجهزه. كما أثبتت النتائج أن مستحلب الهجين يمكن استخدامه سواء في غياب أو وجود ثالث بيوتيل الهيدروكينون كمادة تجهيز يمكن اضافتها الى مواد التجهيز الفلوروكربونيه لتقليل التكلفه الناشئه عن استخدام هذه المواد الفلوروكربونيه لتجهيز الأقمشه ضد الماء و الزيوت. و قد تم دراسة أثر اضافة مادة ثالث بيوتيل الهيدروكينون الى مستحلب الهجين على حجم جزيئات مستحلب الهجين باستخدام محلل حجم الجزيئات حيث أثبت الدراسه ان حجم جزيئات هذا المستحلب قد زادت بنسبه بسيطه من متوسط حجم 5 الى 13 نانومتر بعد اضافة مادة ثالث بيوتيل الهيدروكينون الى هذا المستحلب (و ذلك بعد اعادة تشتيت المستحلبين مرة أخرى باستخدام الموجات فوق الصوتيه لنفس الفتره الزمنيه). كما تم أيضا توصيف سطح الأقمشه المعالجه بهذا المستحلب باستخدام التحليل الحرارى.