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Effect of Nano-Zno_2 Finish on Reactive Dyed Organic Cotton

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Abstract
Main aim was to study the multi functional properties of the Reactive dyed and nano- ZnO_2 coated Organic cotton in terms of tensile strength, elongation, wettability, air permeability, and stiffness as well as the durability of the treatment for dye fixation, FTIR, SEM, UV protection, and light fastness. Application of nano-ZnO_2 on Organic cotton materials resulted in very good structural and functional properties. Nano-ZnO_2 treated samples showed lower values of warp and weft way count than the control samples. All Nano-ZnO_2 treated samples of 120's and 60's depicted higher values of cloth thickness and cloth weight than control samples. Highest tensile strength in warp and weft way and higher percent of elongation were observed for control samples of 120s and 60s. All dyed and nano coated cotton samples of different colours subjected to Sunlight test depicted lower values of Colourstrength (K/S) and Reflectance (RFL) than control samples. Higher protection against UV radiation provided by the ZnO_2 - treated Organic cotton samples. FTIR spectra of control and nano- ZnO_2 treated dyed cotton fabrics depicted peaks at different ranges of (cm^2) CH_2 and C-O bonding. SEM images confirm the good distribution and superior performance of the in situ synthesized ZnO_2 within the polymer matrix

I. Introduction

Nanotechnology, according to the National Nanotechnology Initiative (NNI), is defined as utilization structure with at least one dimension of nanometer size for the construction of materials, devices or system with novel or significantly improved properties due to their nano-size. The nanostructures are capable of enhancing the physical properties of conventional textiles, such as anti-microbial properties, water repellence, soil-resistance, antistatic, anti infrared and flame-retardant properties, dyeability, colour fastness and strength of textile materials.

ZnO_2 Nano Particles are mostly used as a UV light scattering additive in cosmetics such as sunscreens, toothpastes and beauty products. ZnO_2 Nano Particles are widely used in rubber manufacture, production of solar cells and LCDs, pigments (as a whitener), chemical fibers, electronics and textiles. ZnO_2 is an essential ingredient in almost all types of antifouling paints, and recently bulk ZnO_2 has been increasingly replaced by ZnO_2 nano Particles because of their enhanced antibacterial properties. Although metals and metal oxides are known to be toxic at relatively high concentrations and are not expected to be toxic at low concentrations.

The term ENM referred as nanoscale engineered particles with at least one dimension in the range of about 1 to 100 nanometer (nm). The use of ENM for textile products could lead in future to the widespread production of nano textiles with improved or novel functionalities or the combination of multi functions in one textile product.

In textile finishing field the washing durability of the finishing agent is very important factor depends on the affinity of the finishing agent or in the case of polymer coatings, on how well the polymers can bind with the textile surface. Theoretically, the chemical bond between the finishing agent and the textile surface is the best way to achieve durability**.** The wide range of applications is possible as ZnO_2 has three key advantages. First, it is a semiconductor with a direct wide band gap of 3.37 eV and a large excitation binding energy of 60 me V. It is an important functional oxide, exhibiting excellent photo-catalytic activity. Secondly, because of its non-central symmetry, ZnO_2 is piezoelectric, which is a key property in building electromechanical coupled sensors and transducers. Finally, ZnO_2 is bio-safe, biocompatible and can be used for biomedical applications without coating. With these three unique characteristics, ZnO_2 could be one of the most important nanomaterials in future research and applications.

This research study attempts to study the multi functional properties of the nano- ZnO_2 coated Organic cotton in terms of tensile strength, elongation, wettability, air permeability, and stiffness as well as the durability of the treatment for dye fixation, FTIR, SEM, UV protection, and light fastness.

Objectives

1. To find out the suitability of Nano ZnO_2 particles and reactive dyes on Organic cotton
2. To assess the functional properties of Nano ZnO_2 coated on Organic Cotton fabrics
3. To study the sustainability of nano-finish for colour fastness

II. Materials and Methods

2.1. Selection of raw materials

Suitable Nano ZnO_2 particles and Concentration, Organic cotton fabric, chemicals and reactive dyes were selected

2. 2 Laboratory Assessment

2.2. 1 Nano ZnO_2 treatment

The fabric is dipped in 0.5 M zinc nitrate solution for 30 min (1:10 MLR), followed by squeezing of excess solution in a padding mangle at a pressure of 10 lbs per square inch. Then dipped in 1.0 M Sodium hydroxide solution for 30 min. Subsequently the fabric is washed in cold water followed by hot water. The fabric pH is neutralized by dipping in 0.1% Acetic acid solution followed by cold water wash and air drying. Then the fabric is cured in hot air oven at 160^0 C for 5 min. The use of Sodium hydroxide helps in oxidation of Zinc nitrate to form Zinc oxide and the surface pores present on the fabric helps to control the size of the nano particles. (Ref: Applied surface science 390 (2016) 936-940)

The influence of the nano-$Zn0_2$ finish for general textile properties e.g. Tensile strength, elongation, Air permeability, Stiffness as well as the durability of the treatments were investigated (Dept Textiles, UAS, Dharwad)

ZnO_2 coated Organic cotton fabric samples were dyed with reactive dyestuff..Four colours were selected; Black Pantone solid coated 6c, Blue pantone solid coated 280c, Red Pantone 185-c and Yellow pantone solid coated 115c

Reactive Dyeing Recipe:

Dye Concentration	- 2 percent (OWM)
MLR (Material Liquor Ratio)	- 1:30
Turkey Red Oil	- 2-4 ml
Temperature	- 60^0- 80^0C
Sodium Chloride	- 60 gpl
Sodium Carbonate	- 2 percent (OWM)
Duration	- 90 min

The dyestuff is dissolved by pasting with cold water and few drops of Turkey Red Oil. Scoured and bleached Cotton material is entered in the cold dye bath and the temperature is gradually raised to 60^0- 80^0C. Initially the immersed sample was treated in the dye bath for 10 min. Subsequently dissolved Sodium carbonate and sodium chloride is added to the dye bath at two stages with 10 minutes intervals. The fabric sample is treated for 60 minutes. Finally the dyed sample is removed from dye bath, squeezed and spread it for 15-20 minutes, rinsed in cold water and shade dried.

2.2.2 Colour strength:

The colour strength (K/S) and reflectance (RFL) values for each dyed samples were obtained using the instrument *"Minolta CM- 600/700 d",* Colour Spectro Photometer

2.2.3 Colour fastness to sunlight (IS: 686-1985)

A test specimen of 1 x 6 cm was closely wrapped on a card and mounted in the exposure rack at an angle of 45º. The rack was exposed for 48 hours from 9 am to 3 pm (6hrs/day) for 8 days.

2.2.4 FTIR analysis

Fourier Transform Infrared Spectroscopy **(FTIR):** FTIR is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. The surface functional group of treated samples were examined using Perkins Elmer FT-IR spectrometer CC99589 spectrum two for assessing the functional properties.

2.2.5 UV light protection measurement

The UV light responses of the treated and untreated cotton fabrics were studied using a UV-Vis spectroscopy. The effectiveness in shielding UV radiation was evaluated by measuring the UV absorption and transmission. The transmission data were used to calculate the ultraviolet protection factor (UPF) and the percent of UV transmission

2.2.6 SEM
The Scanning Electron Microscope (SEM) allows visualization of surface features of a solid sample by scanning through an electron beam. The treated and untreated test samples were analysed under Scanning Electron Microscope JEOL JSM 5400.

2.2.7 Statistical Analysis
The results were analysed statisticaly for its significance using t test.The experimental data is analyzed and subjected to following statistical tests.

III. Results and Discussion

3.1 Geometrical properties
Table 1. Cloth count of Reactive dyed Nano-ZnO_2 treated Organic cotton fabric samples

Table Value 2.306004133

Sample	Warp Control (mean value)	Warp Nano-ZnO_2 treated (mean value)	t	Weft Control (mean value)	Weft Nano-ZnO_2 treated (mean value)	t
Cotton 120 s Control	43.6	44.2		36	39	
Black	43.4	43.8		37.8	37.4	
Blue	43.6	43.6		35.8	37.4	
Red	47.0	44.0		37.6	38.4	
Yellow	43.4	44.6	**0.2215395** NS	37.2	37.6	**-2.07081** NS
Cotton 60s Control	34	29.8		26.8	23.2	
Black	33.8	32.8		27.2	28.2	
Blue	34.6	33.6		27.8	27.6	
Red	32.4	31.4		28	21.8	
Yellow	34.2	34.6	**1.4754743** NS	27.8	28.4	**1.195132** NS

Table Value 2.306004133

SEM images confirm Cloth count is the number of ends and picks per unit area and is affected by the yarn count and compactness of the weave. From the Table 1 it is learnt that among all the fabric samples, warp way cotton 120's control red (47) obtained highest value followed by control and blue (43.6) and black & yellow (43.4). Warp way cotton 60s of all samples including control depicted lesser values of warp count than 120s. Almost similar trend was observed for weft way samples of 120s and 60s.

Overall Nano-ZnO_2 treated samples showed lower values of warp and weft way count than the control samples. Though nano coated samples attained lower values of warp and weft way count, there was no significant difference between control and nano treated samples. Weft way yarn count of all the samples was relatively coarser than warp way attained to its fiber content may be due to lower twist per inch and single yarn structure.

Table 2. Cloth thickness of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples (mm)

Sample	Control (mean value)	Nano-ZnO_2 treated (mean value)	t
Cotton 120 Control	0.242	0.278	
Black	0.28	0.306	
Blue	0.258	0.312	
Red	0.264	0.302	
Yellow	0.254	0.308	**4.7971623****
Cotton 60 Control	0.39	0.498	**4.4112619***

Black	0.402	0.460	
Blue	0.438	0.460	
Red	0.412	0.472	
Yellow	0.442	0.466	

Table Value 2.306004133 ** Significant at 1% level
* Significant at 5% level

It is always assumed that, thicker the fabric, properties such as drapability, abrasion, thermal insulation value etc are dependent on cloth thickness. It is inferred from the Table 2 that, cloth thickness of cotton 60's control and Nano-ZnO_2 samples were noticeably higher than the other set of cotton 120's control and Nano-ZnO_2 treated fabric samples. On the other hand all control samples recorded least values of thickness.

There was significant increasing trend in the cloth thickness among control and Nano-ZnO_2 treated fabric samples. All Nano-ZnO_2 treated samples of 120's and 60's depicted higher values of cloth thickness may be due to deposition of Nano-ZnO_2 material in the microfabrils of the fiber molecules and cellular fraction of the fiber which may lead to increase in the individual fiber bulkiness.

Table 3. Cloth weight of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples (GSM)

Sample	Warp Control (mean value)	Warp Nano-ZnO_2 treated(mean value)	t	Weft Control (mean value)	Weft Nano-ZnO_2 treated(mean value)	t
Cotton 120s Control	37.467	39.067		31.067	32.987	
Black	37.333	38.00		31.867	33.333	
Blue	39.600	43.067		35.733	38.040	
Red	39.333	42.533		32.133	33.200	
Yellow	38.000	40.000	-0.0672012^{NS}	32.267	33.733	**-0.52186^{NS}**
Cotton 60s Control	69.200	63.333		52.000	52.400	
Black	62.400	63.467		51.600	50.933	
Blue	66.000	66.667		53.067	49.467	
Red	63.600	68.668		48.667	47.067	
Yellow	71.333	71.200	2.938015*	50.533	51.600	**1.667998^{NS}**

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The weight of fabrics can be described as the weight per unit area i.e. grams per square meter. The specimens were tested as per the IS 1964:2001. Some of the factors like type of fibre, yarn threads per unit area, type of weave employed etc. contribute to greater extent in determining the weight of the fabric. Table 3 narrates the warp and weft way weight contributing to different sets of fabrics. It is revealed that the cloth weight per square meter of all the nano treated fabric samples was higher than control samples owing to the fiber content and the Nano coating might have contributed to certain per cent of weight to yarn structure with relatively coarse and heavyer weft yarns possessed less number. Further it is observed that there was no significant difference between two fabric samples and between control and Nano-ZnO_2 treated samples.

Table 4. Bending length of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples (cms)

Sample	Warp Control (mean value)	Warp Nano-ZnO_2 treated(mean value)	t	Weft Control (mean value)	Weft Nano-ZnO_2 treated(mean value)	t
Cotton 120s Control	2.13	1.80		1.87	1.57	
Black	2.13	1.63		1.77	1.67	
Blue	2.07	1.67		1.93	1.57	
Red	2.17	1.70		2.10	1.70	
Yellow	2.03	1.87	7.4833017**	2.13	2.07	**0.807372^{NS}**

Cotton 60s Control	2.13	1.87		2.10	1.63	
Black	2.33	1.83		2.17	1.93	
Blue	2.43	1.93		2.23	2.10	
Red	2.13	1.87		2.30	1.73	
Yellow	2.33	1.67s	**5.8797455****	2.07	1.83	**3.578457****

Table Value 2.306004133 ** Significant at 1% evel
* Significant at 5% level

Table 4 indicates cloth bending length of test samples. In general weft way values were greater than warp for all the coloured samples which may be because of surface coating and permeability of Nano ZnO_2 solution in the micro fabrils of fiber molecule due to amorphous region of weft yarns.

Among all the samples nano treated Organic cotton 60's blue (2.100) colour samples showed highest bending path followed by 120's yellow (2.067) which in turn depicted its stiffness, may be due to dye absorption and surface deposition of nano particles further resulted in greater cloth weight and thickness. Least was exhibited nano coated control 120's (1.567) attributed to least weight and thickness. Thus, was found to be soft and pliable. Except 120s weft rest all samples exhibited significant difference at 1 percent level.

Table 5. Cloth tensile strength of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples (kgf)

Sample	Warp Control (mean value)	Warp Nano-ZnO_2 treated(mean value)	t	Weft Control (mean value)	Weft Nano-ZnO $_2$treated(mean value)	t
Cotton 120s Control	17.10	14.80		16.20	9.90	
Black	13.80	11.30		13.50	2.80	
Blue	15.30	14.20		12.00	7.40	
Red	13.30	9.50		16.3000	3.80	
Yellow	14.10	3.20	**1.8775047**^{NS}	13.50	6.70	**5.335327****
Cotton 60s Control	18.40	15.20		19.40	6.20	
Black	19.10	15.60		18.30	6.30	
Blue	20.00	19.10		18.00	5.80	
Red	18.70	14.30		13.70	5.90	
Yellow	15.90	15.00	**1.4885108**^{NS}	18.00	5.80	**11.67235****

Table Value 2.306004133 ** Significant at 1% level
* Significant at 5% level

Tensile strength is the breaking strength of a sample i.e ability of the material to withstand the rupture induced by external force. It is usually expressed in units of force per unit of cross sectional area of the sample. Table 5 narrates about the cloth tensile strength of warp and weft ways of control and nano ZnO_2 treated samples. Highest tensile strength in warp way was observed for control samples of 120s and 60s . Similar trend was observed in weft way of 120s and 60s samples. Among the coloured samples 120s warp way blue (15.3 and 14.2) and 6os warp way of the blue (20.0 and 19.1) exhibited maximum value and 120s weft way blue (7.4) and 60s weft way black (6.25) showed highest values of tensile strength.

Statistical results revealed no significant difference in warp way on the contrary significant difference was observed in weft way cloth tensile strength between control and nano treated ZnO_2 samples.

In general warp tensile strength of control and nano ZnO_2 treated samples was higher than weft attributed to the fibre content and fine yarn where each constituents of fibre bear more load than the course weft yarn, thus increasing the breaking strength of the fibre. All warp and weft way control samples attained greater value than nano treated ZnO_2 sample which may be due to the reaction of nano ZnO_2 solution resulted in weakening of the fibres.

Table 6. Cloth elongation of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples (%)

Sample	Warp		t	Weft		t
	Control (mean value)	**Nano-ZnO_2 treated**(mean value)		**Control** (mean value)	**Nano-ZnO_2 treated**(mean value)	
Cotton 120s Control	6.67	5.2		7.17	2.65	
Black	6.55	4.05		6.1	2.10	
Blue	4.35	4.50		2.76	2.45	
Red	6.95	4.85		5.55	1.50	
Yellow	5.50	3.20	2.772277*	5.60	2.30	4.281772**
Cotton 60s Control	7.72	7.75		7.55	6.20	
Black	9.50	8.10		7.20	6.25	
Blue	9.90	9.45		6.80	5.80	
Red	9.45	7.60		5.50	5.90	
Yellow	8.50	8.10	0.3230042NS	6.75	5.80	2.136007NS

Table Value 2.306004133 ** Significant at 1% level
* Significant at 5% level

Table 6 narrates the per cent elongation of control and nano ZnO_2 treated samples. Irrespective of yarn counts and warp & weft directons, all control samples showed highest elongation where as least elongation was seen for warp way yellow samples and 120s blue and 60s red depicted least strength in weft way.

All nano ZnO_2 treated warp and weft way samples attained lower values of elongation per cent than control samples. On the other hand , there was no significant difference in warp and weft way cloth elongation for 60s cotton. Where as warp and weft way elongation of cotton 120s , was highly significant in warp way at 1 per cent and and 5 per cent level in weft way direction

Table 7. Cloth strength (K/S) and Reflectance value of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples

Sample	Wave length	K/S		t	RFL		t
		Standard (mean value)	**Nano-ZnO_2 treated**(mean value)		**Standard** (mean value)	**Nano-ZnO_2 treated**(mean value)	
Cotton 120s Control	400	109.486	91.463		0.332	0.315	
Black	610	131.809	76.5625		11.5045	8.8095	
Blue	670	124.7555	75.2255		17.9535	12.5185	
Red	510	123.738	80.8975		11.2765	9.119	
Yellow	400	96.1625	107.21	**3.539771****	3.7435	4.0455	**0.529012**NS
Cotton 60s Control	400	74.0575	135.0685		0.228	0.308	
Black	600	74.678	133.9095		17.049	13.4765	
Blue	670	91.599	150.5945		18.3205	9.253	
Red	510	65.091	153.9655		19.743	12.597	
Yellow	400	87.2355	115.7785	**0.55642**NS	4.1775	4.7905	**0.11816**NS

Table Value 2.306004133 ** Significant at 1% level
* Significant at 5% level

It is revealed from Table 7 that despite of different colours, control samples exhibited highest colour strength (K/S) values followed by nano coated samples. On the contrary nano coated samples depicted least reflectance (RFL) values. This may be due to the presence of nano coating of specimen reveals the density of dye molecules prominently.

The loss in colour strength (K/S) values were slightly higher in standard samples than nano finished samples which may be because of presence of metallic compounds ZnO_2 and dye molecules may interact with the bonding mechanism of cotton fibre leads to hydrolyses of the dye resulting in lower K/S values inturn indicates higher rate of absorption within the substrate.

Statistical results revealed that highest significant difference was observed between dyed and nano coated samples of different counts for colour strength and there was no significant difference between dyed and nano coated samples of 120s and 60s cotton samples for reflectance values.

Table 8. Colour strength (K/S) and Reflectance (RFL) values of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples subjected to Sunlight

Sample	Wave length	K/S		t	RFL		t
		Standard (mean value)	**Nano-ZnO_2 treated** (mean value)		**Standard** (mean value)	**Nano-ZnO_2 treated** (mean value)	
Cotton 120 Control	400	163.588	61.129		0.241	0.148	
Black	610	399.459	25.034		10.06	2.518	
Blue	670	192.495	51.949		11.366	5.905	
Red	510	800.961	12.485		9.187	1.147	
Yellow	400	829.831	12.051	**3.081124****	4.05	0.488	**2.110615**^{NS}
Cotton 60 Control	400	164.494	60.792		0.363	0.221	
Black	610	210.172	47.58		15.682	7.461	
Blue	670	213.231	46.898		8.269	3.878	
Red	510	304.568	32.823		18.244	5.99	
Yellow	400	432.219	23.136	**4.635202****	2.421	0.56	**1.411547**^{NS}

Table Value 2.306004133 ** Significant at 1% level

* Significant at 5% level

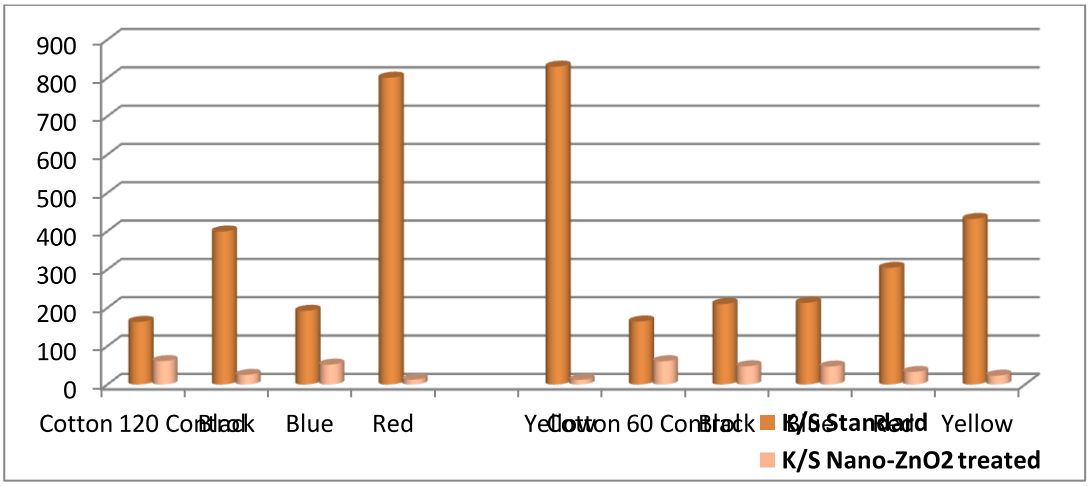

Fig 1 : K/S values of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples subjected to Sunlight

Colour strength (K/S) values of all dyed and nano coated cotton samples of different colours subjected to Sunlight test depicted (Table 8 and Fig1) lower values than standard and lower values of reflectance (RFL) than standard. Increase in percent of colour strength was seen highest in control for 120s and 60s (61.129 and60.792 %) followed by blue (120s-51.949,%) and (60s-47.58).This may be ascribed to the absorption of ultraviolet with higher energy vibrates the dye molecule to an electronically excited state and either degradation or change the status of chromogen due to photo oxidation or photo reduction.

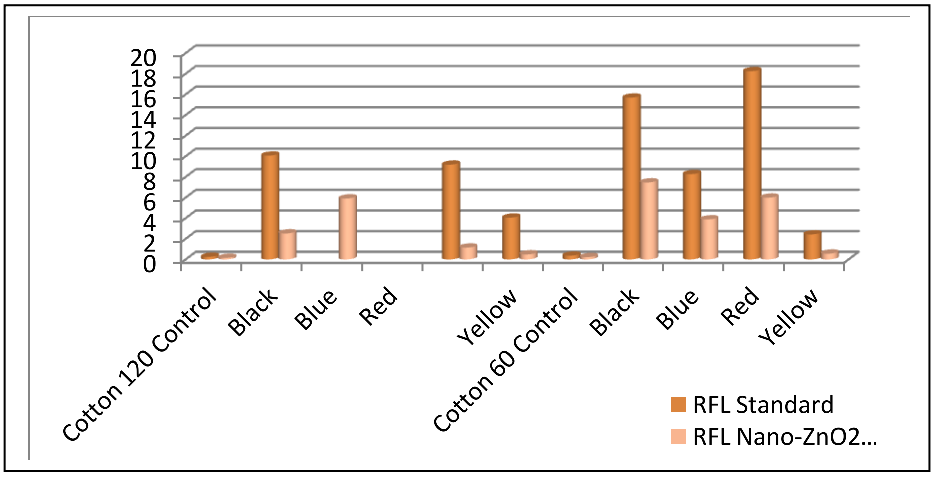

Fig 2 RFL values of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples subjected to Sunlight

Nano coated samples subjected to sunlight (Table8 and fig) depicted least reflectance (RFL) values. Among the nano coated dyed samples, 120s blue (5.905)and 60s black (97.461) depicted higher values followed by 120s (2.518)and 60s red (5.99) which indicates higher the K/S colour strength values lower the reflectance values.

However highest significant difference was observed between dyed and nano coated samples of different counts for colour strength. On the contrary no significant difference was found between dyed and nano coated samples of 120s and 60s cotton samples for reflectance values.

Table 9. UPF values of Reactive dyed Nano ZnO_2 treated Organic cotton fabric samples

Sample	Control (mean value)	Nano-ZnO_2 treated (mean value)	t
Cotton 120 Control	5.79	8.86	
Black	22.9	42.28	
Blue	20.6	38.91	
Red	25.7	44.10	
Yellow	18.8	44.30	0.5674159^{NS}
Cotton 60 Control	6.71	7.01	
Black	43.48	48.78	
Blue	41.24	61.51	
Red	42.18	45.03	
Yellow	26.34	45.40	0.6544557^{NS}

The data (Table9) reflect the higher protection against UV radiation provided by the ZnO_2 - treated fabrics, particularly for the Organic cotton samples loaded with zinc oxide nano particles. Although for 120s cotton fabrics, the calculated UPF is significantly lower than the standard values required for classifying the clothing as excellent in UV -shielding, these results confirm the protection against UV radiation by using the treatment with nano coated ZnO_2 on the fabrics.

All the treated samples showed the better UPF values, the low porosity and higher GSM of control cotton fabric 60s displayed the slightly lower values of UPF, which increased with the increase of nano - ZnO_2 pick up in treated fabrics. The reason for this was attributed to the blocking of the active sites by the dye molecules, which also prevent UV rays from reaching ZnO_2.. Though there was increase in UPF values after nano finish statically no significant difference was found between dyed and nano coated samples of 120s and 60s Organic cotton samples

It is found that the performance of ZnO_2 nanoparticles as UV-absorbers can be efficiently transferred to fabric materials through the application of ZnO_2 nanoparticles. The UV tests indicate a significant improvement in the UV absorbing activity in the ZnO_2-treated fabrics. Fibres provide optimal substrates where a large surface area is present for a given weight or volume of fabric. . The results imply that the effectiveness in shielding UV radiation is due to the UV absorption capacity of ZnO_2 nanoparticles on the fabrics surface. Nano ZnO_2maintained much higher UV protection because of their high specific surface area and refractive index and with the good adhesion between nano particles and textile substrates, which consequently improves the durability of UV protection.

Table 10. Air permeability values of Reactive dyed Nano ZnO2 treated Organic cotton fabric samples Kawabata Evaluation System (k.Pa.S/m)

Sample	**Control** (mean value)	**Nano-ZnO_2 treated** (mean value)	**t**
Cotton 120 Control	0.116	0.119	
Black	0.122	0.154	
Blue	0.126	0.139	
Red	0.126	0.127	
Yellow	0.140	0.155	1.60^{Ns}
Cotton 60 Control	0.066	0.070	
Black	0.182	0.189	
Blue	0.131	0.143	
Red	0.188	0.199	
Yellow	0.201	0.210	0.316^{Ns}

Cotton 120s Table t value: 1.89 Cotton 60s Table t value : 1.85

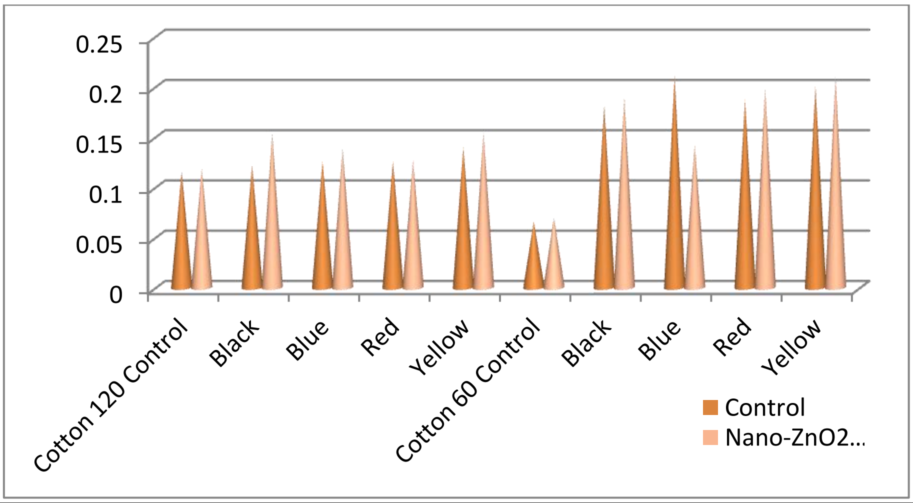

Fig 3: Air permeability of Reactive dyed Nano ZnO2 treated Organic cotton fabric samples

Air permeability values of the nano-ZnO_2 coated fabrics (Table 10) was slightly higher than the control, hence the increased breathability. In case of nano-ZnO_2 coated fabrics, due to its nano-size and uniform distribution, friction was significantly less for 120s than 60s. The nano porous structure and the high oxygen (ether and hydroxyl) density of the cellulose fibre constitute an effective nano reactor for in situ synthesis of metal ZnO_2 particles. It is observed that the air flow speed increased with nano ZnO_2 particle size. This may be because of the nano particles created finer capillaries in the fabric structure, allowing for faster air transport.

3.2 FTIR (Fourier Transform Infrared Spectroscopy) analysis

Fourier-transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. FTIR offers quantitative and qualitative analysis for organic and inorganic samples. **FTIR** identifies chemical bonds in a molecule by producing an infrared absorption spectrum. The spectra produce a profile of the sample, a distinctive molecular fingerprint that can be used to screen and scan samples for many different components.

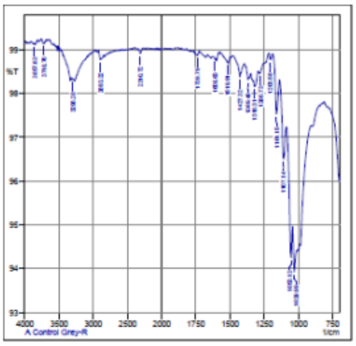

Fig 4 a1 -120s Control white

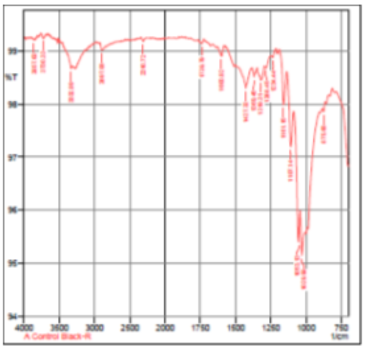

Fig 4 a2 -120s Control Black

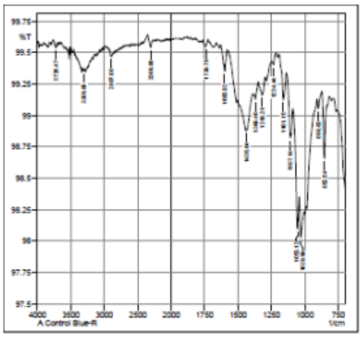

Fig 4 a3- 120s Control Blue

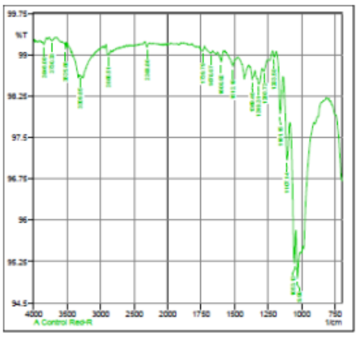

Fig 4 a4- 120s Control Red

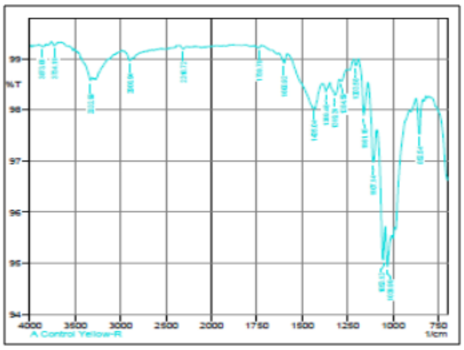

Fig 4 a5 120s Control Yellow

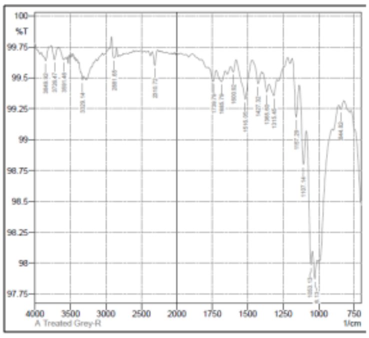

Fig 4b1- 120s Nano-treated White

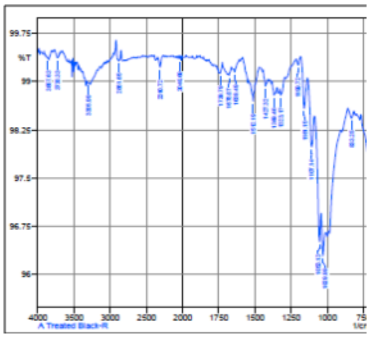

Fig 4 b2 - 120s Nano-treated Black

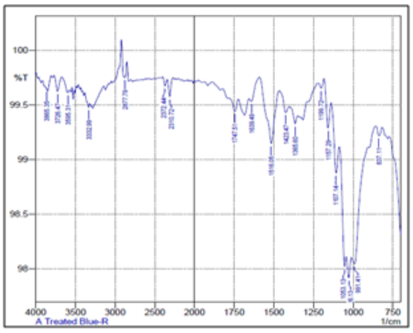

Fig 4b3 - 120s Nano-treated blue

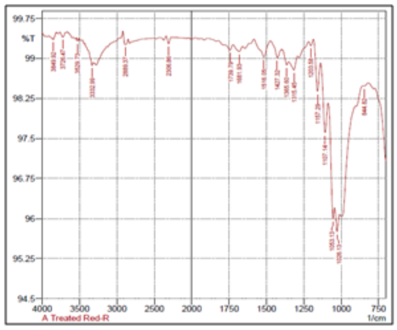

Fig 4b4 - 120s Nano- treated Red

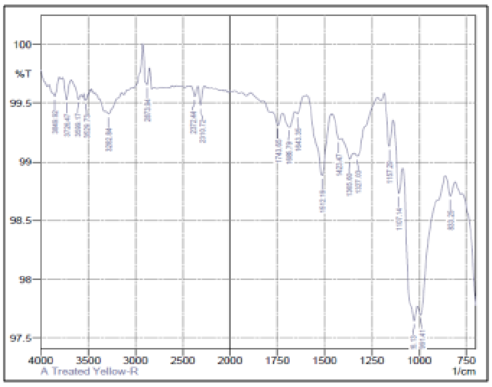

Fig 4b5 -120s Nano-treated Yellow

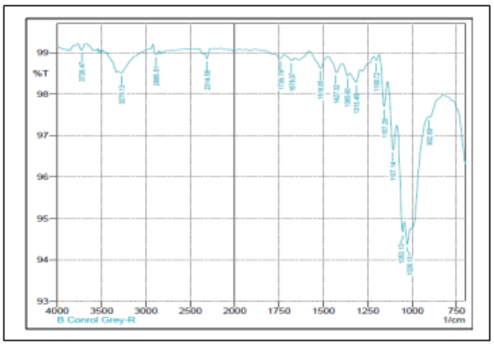

Fig 5a1- 60s Control White

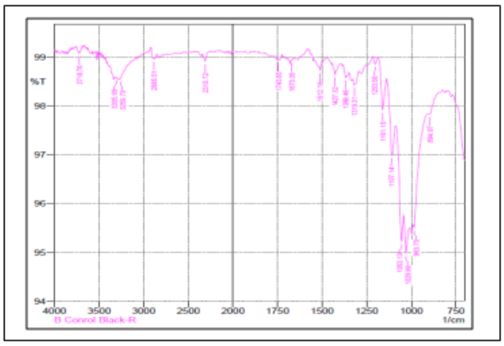

Fig 5a2- 60s Control Black

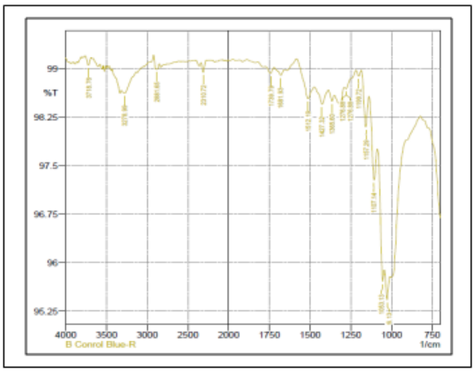

Fig 5a3- 60s Control Blue

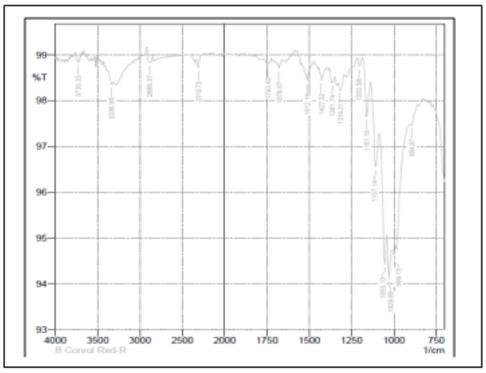

Fig 5a4 60s Control Red

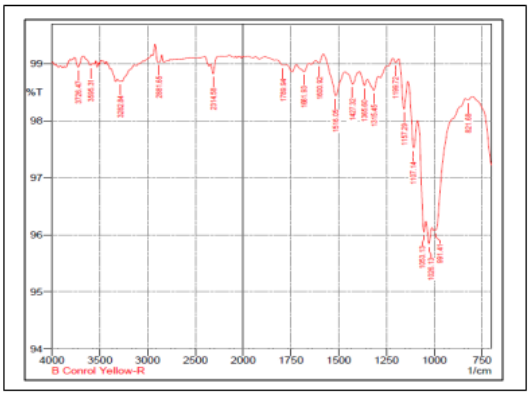

Fig 5 a5- 60s Control Yellow

This technique measures the absorption of infrared radiation by the sample material versus wavelength. The infrared absorption bands identify molecular components and structures. Infrared Spectroscopy is the analysis of infrared light interacting with a molecule. This can be analyzed in three ways by measuring absorption, emission and reflection.

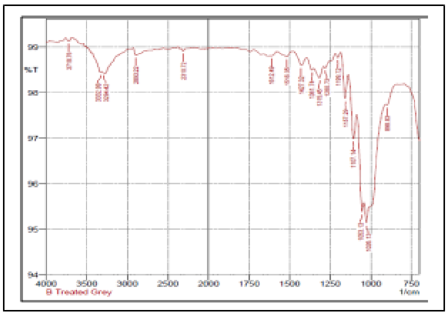

Fig 5b1- 60s Nano-treated White

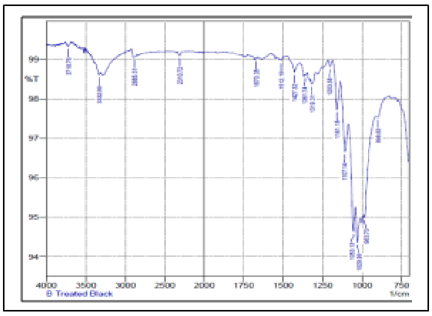

Fig 5b2 - 60s Nano-treated Black

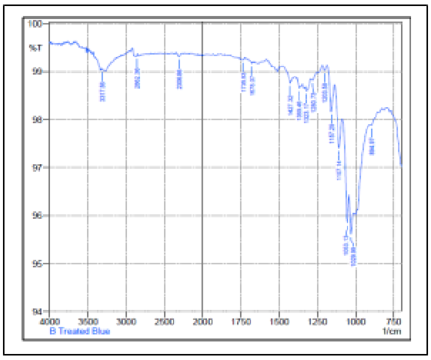

Fig 5b3 -60s Nano-treated Blue

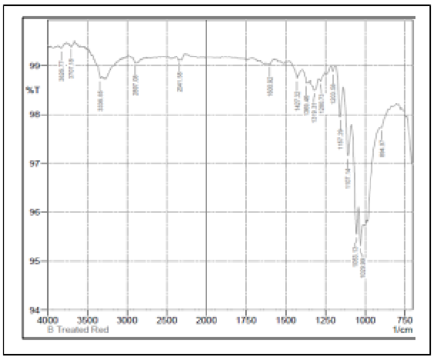

Fig 5b4 -60s Nano-treated Red

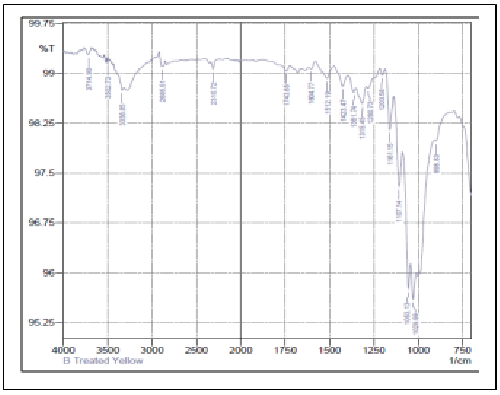

Fig 5b5 -60s Nano-treated Yellow

FTIR spectra of the synthesized nano materials is shown in the figures (Fig 4a1 – 5b5). IR spectroscopy is concerned with the study of absorption of infrared radiation, which causes vibrational transition in the molecule

Figures showed (Fig 4a1 – 5b5) the FTIR spectra of uncoated control and nano- ZnO_2 treated dyed cotton fabrics depicted peaks at different ranges of (cm^2) CH_2 and C-O bonding respectively. The peaks represent areas of the spectrum where specific bond vibrations occur.. The higher absorption number .indicated the presence of more specific bond numbers in a sample at a specific wavelength. Red is the lowest energy visible light and violet is the highest. A strong peak around 1450 cm^{-1} indicates the presence of methylene groups (CH_2), while an additional strong peak about 1375 cm^{-1} is caused by a methyl group (CH_3.Absorbance is used more often than percent transmittance because this variable is linear with the concentration of the absorbing substance, whereas percent transmittance is exponential.

The spectrum of the material obtained from 120s clearly shows the ZnO_2 absorption band near 430 crn'. The peaks at different ranges (cm^2) indicate the presence of -OH and C=O residues, probably due to atmospheric moisture and CO_2 respectively. IR (infrared) active molecules containing functional groups that "stretch" when the electric component of the electromagnetic irradiation "couples" with the electric dipole of the IR active group. In fact the exact frequency of the C=O absorbance, generally around 1720 cm-1, is highly sensitive to the R and R' groups attached to the carbonyl carbon. The basic property in a molecule that allows it to absorb infrared radiation is that the transition results in a deformation of the molecule so that the dielectric constant is different in the excited state from the ground state. An infrared active molecule or substance absorbs some frequency in the infrared spectrum. These absorptions are the result of changes in rotational or vibrational energy states in the molecule.

3.3 SEM analysis

Figures show the SEM micrographs of control and treated cotton fabrics. Deposition of nano- ZnO_2 particles on the surface of the treated cotton fibres is clearly seen, whereas control cotton is free from nano- ZnO_2 particles.

The surface of samples is more uniformly covered with nano - ZnO_2 than the control samples. It may be concluded that ionic liquid is acting as facilitating agent for exhaustion of nano-ZnO_2 during the exhaustion.

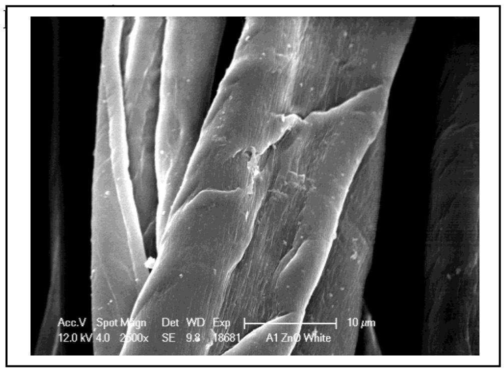

Fig 6a1 – **120s Control**

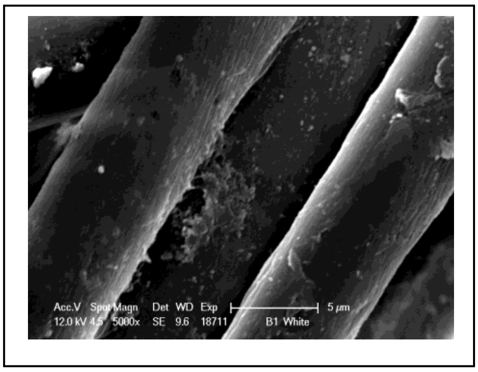

Fig 6b1- **60s Control**

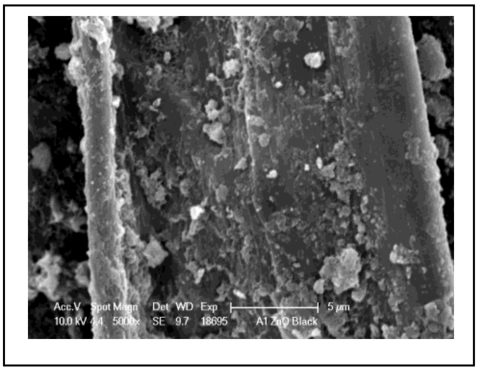

Fig 6a2- **120s Black**

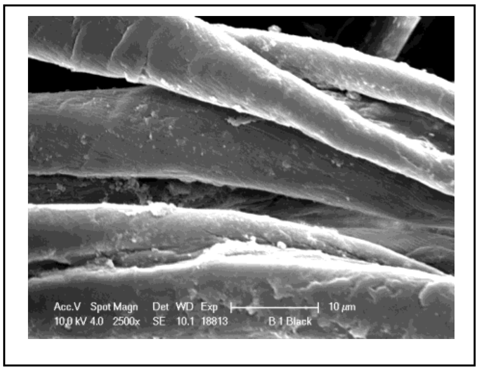

Fig 6b2 - **60s Black**

Fig 6a3- **120s Blue**

Fig 6b3- **60s Blue**

Fig 6a4- **120s Red**

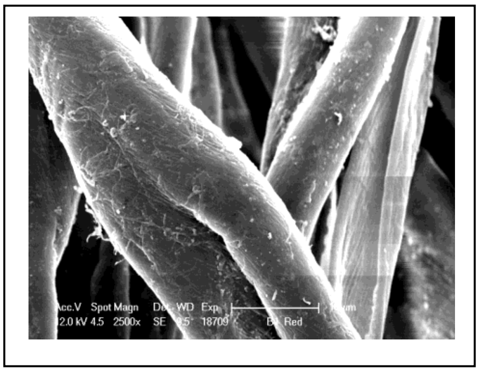

Fig 6b4- **60s Red**

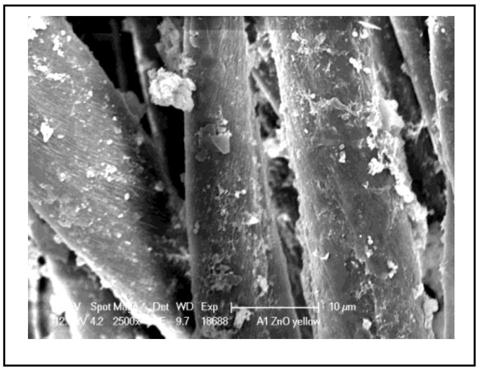

Fig 6a5- **120s Yellow**

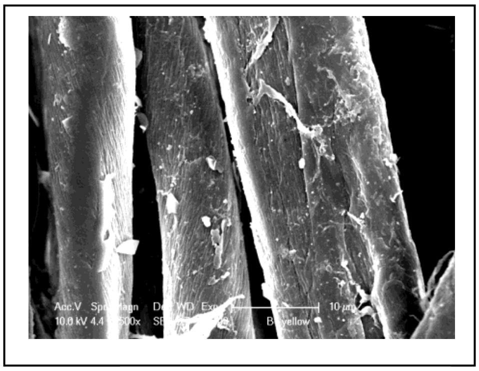

Fig 6b5- **60s Yellow**

The surface of the treated fabrics was observed by scanning electron microscopy. In the Fig. 6a1-6b5 the Uncoated and nanoscaled ZnO_2 particles are observed on Organic cotton samples. The nano particles are well dispersed on the fibre surface in both the cases, although some aggregated nano particles are still visible. The particles size plays a primary role in determining their adhesion to the fibres. It is reasonable to expect that the largest particle agglomerates will be easily removed from the fibre surface, while the smaller particles will penetrate deeper and adhere strongly into the fabric matrix. It is seen that the stability and retention of ZnO_2 depends on both size and concentration. The reason for this was attributed to the good distribution and superior performance of the in situ synthesized ZnO_2 within the polymer matrix. The SEM image analysis confirmed uniform and dense depositions of available on the surface of cotton fabric.

NPs.

IV. Conclusion

Application of nano-ZnO_2 on Reactive dyed Organic cotton materials resulted in very good structural and functional properties. Effectiveness of all properties of textile material depends upon the quantity of nano-ZnO_2 present in the material and its uniformity throughout the surface. Nano ZnO_2 will really enhance the UV – blocking property due to their increase surface area and intense absorption in the UV region.

Present results confirm that ZnO_2 is one of the most promising materials for the development of high-performance textile products and may be intensively investigated in the future. Future research in the field of ZnO_2-modified textile fibers will certainly follow the main directions in the fabrication of green, multifunctional, and smart textiles.

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