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Synthesis And Characterization of Smart Cloth Using Carbon Nano Tube Reinforced Nano Composites

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ABSTRACT

The main scope of our project is to prepare nano composite coated cotton yarn. With excellent electrical and mechanical properties of carbon nanotubes (CNTs) proves to be a versatile nano material findings its role in almost all science and technology fields. In this work we considered MWNTs for preparing nano composites. We expect Bullet Proof cloth made using this CNT coated cotton yarn may climinate broken bones and blood clotting leading to severe damage to the body, because it has been observed that sheets made up of CNTs can effectively stops the bullet from penetrating the body. Moreover, using CNT coated cotton yarn for manufacturing parachute and sail cloth may give light weight and high strength cloth.

KEYWORDS

Cotton yarn, Carbon nano tubes, Multiwalled carbon nano tubes

I INTRODUCTION

At present the world military using Kevlar fiber made bullet proof cloth having the disadvantage of broken bones and blood clotting when injured. Bullet proof cloth made using this CNT coated cotton yarn may eliminate the above said problems, because CNT effectively stops the bullet from penetrating the body.

Parachute and sail cloth manufacturing companies searching for new light weight and strength materials. Manufacturing these cloths with CNT coated cotton yarn may fulfil the above purposes.

Smart clothes are used in several areas like military, medical, industries, aeronautics, ship building, entertainment purpose etc[1][2]. These smart clothes are manufactured in different methods and raw materials, according to the need. For over 30 years, the synthetic fiber Kevlar

has been the go-to material for making bullet-resistant vests and bullet proof clothes. This Kevlar made bullet proof material could stop Bullet Velocity upto 425 m/sec at a range of 4 meter and also stops all types hand beld gun bullets. But they have some disadvantages in cost aspects and safety aspects, because of these researchers are looking for new ideas and novel materials to make a truly bullet proof vest and clothes. The main disadvantage with present Kevlar and other bullet proof cloth is the broken bones and blood clotting leading to severe damage to the body.

Another interesting area of application is in the design of parachute and sail cloth, that needs light weight and tear proof materials, Currently, the parachute and sail clothes are manufactured by using finer combed cotton single yarn. For special purpose they are using carbon fibers to manufacture light weight parachute clothes. In parachute and sail cloth manufacturing industries, they are trying for manufacturing light weight and low cost parachute clothes.

Mutliwalled carbon nantubes are available in fair rate. It has good electrical properties than any other materials. It is also used to manufacture lithium ion batteries [3]. Yarn made of carbon nano tubes has good impact strength that are used than coated yarn [4]. In this project to coat the MWCNT over cotton yarn a nano fluid has to be prepared. This nano fluid coated uniformly on the surface of the yarn [5] [6] [7]. To prepare the nano fluids the MWCNT is uniformly mixed with a polymer matrix. This polymer matrix helps to bind with the cotton yarn [8] [9]. The nano fluids are prepared using different methods like electro spinning and sonication [10]. MWCNT has superior buckling property to bind with the cotton yarn and this special property of MWCNT helps to given superior strength to the cotton yarn [11].

In this work we considered MCWNTs for preparing nano composites [12] [13] [14]. We expect Bullet proof cloth made using this CNT coated yarn may climinate above said problems to large extent, because it has been observed that sheets made up of CNTs can effectively stops the bullet from penetrating the body [15]. The coating of MWCNT above the surface of the cotton yarn improves the sensing and electrical property also [16] [17] [18][19] [20] [21]. The main scope of our project is to prepare nano composite coated cotton yarn. With excellent electrical and mechanical properties carbon nanotubes (CNTs) proves to be a versatile nano material findings its role in almost all science and technology fields.

Moreover, using CNT coated cotton yarn for manufacturing parachute and soil cloth give light weight and high strength cloth.

II PERFORMANCE BASED ANALYSIS

Carbon Nano tubes

Carbon nanotubes, also known as CNTs, are molecules that are cylindrical in shape and are made up of rolled-up sheets of graphene, which is a single-layer carbon atom. Single-walled carbon nanotubes (SWCNT) have a diameter of less than one nano meter (nm), while multi-walled carbon nanotubes (MWCNT) are composed of many nano tubes that are interwoven in a concentrically interconnected manner and have sizes that exceed one hundred nano meters (nm). It is possible for their length to even exceed millimeters or even several micrometers.

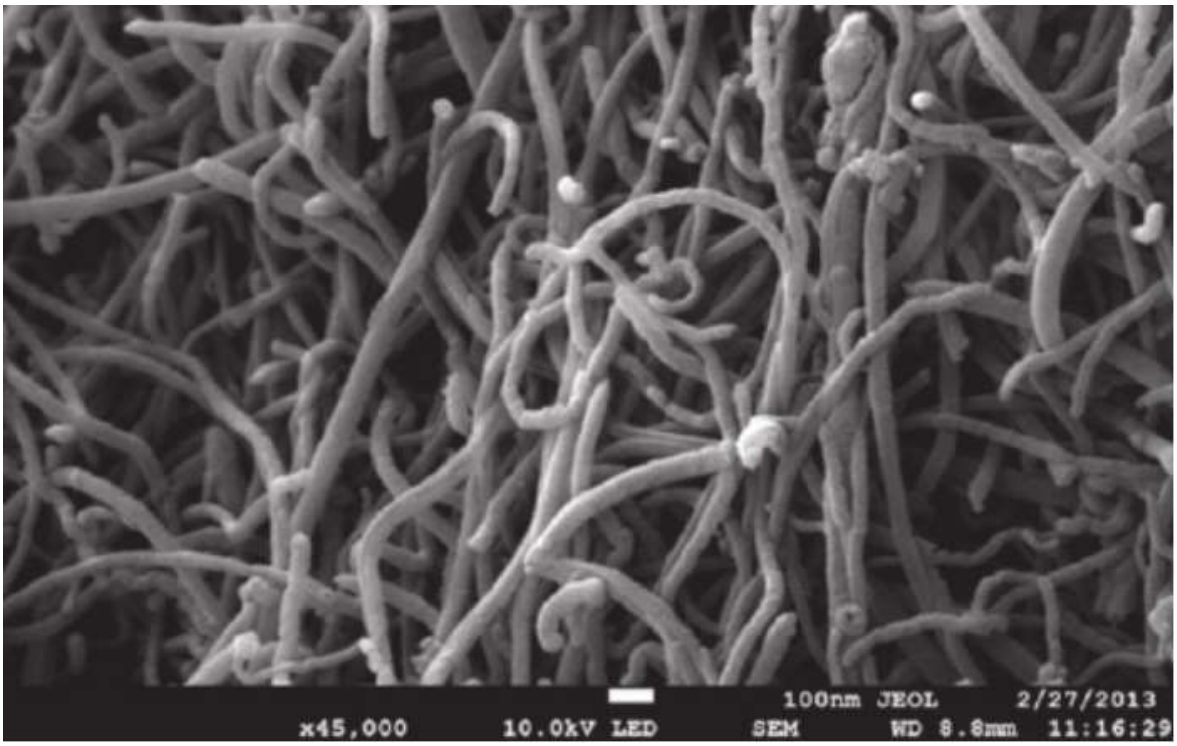

Figure 1SEM image of MWCNT

1. Cotton yarn (for example 10s, 20s, 60s, and 80s).
2. Multiwalled Carbon nano tubes.

3. Suitable polymer like PMMA and PEG.

Cotton yarn

The most common plant fiber is cotton, which is typically spun into fine yarn for mechanical weaving or knitting into cloth. Normally cotton yarn is available in the form of lea (120 yards) or in cone form. Cotton is a natural fiber abundantly available on our country. If the bullet proof cloth made of cotton yarn gives good characteristics to mix with any other material or fibers.

Figure 2 Cotton Yarn cone

For preparing CNT coated cotton yarn, first we have to choose best polymer for binding (CNT) purpose.

Initially we prepared the nano composite with help of PMMA with a solvent (Acetone) and Multiwalled carbon nano tubes is added by hand stirring [22] [23] [24]. About 10 cm of yarn is immersed in the solution. We found that uneven coating above the surface of the yarn.

To reduce the stirring time and cost, we tried for the following liquid stage polymers.

1. Polyvinyl alcohol
2. Polyethylene glycol

For our experimental convenience we preferred Polyethylene glycol (PEG-600)

For nano composite preparation and coated on cotton yarn (10s OE yarn) using the experimental set up shown below. The following difficulties faced by us after coating.

1. Improper coating due to poor mixing of polymer with CNT.
2. Drying time is more.
3. Required rate of coating could not be achieved.
4. Binding of CNT and yarn not smooth.

To overcome with these difficulties we preferred PMMA as a polymer and DMF as a solvent.

Coating set up also redesigned. The picture shows the old and new coating set up.

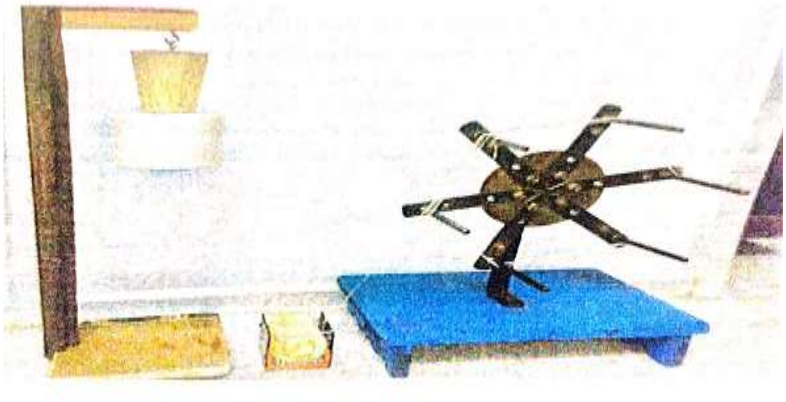

Figure 3 Coating of MWCNT on yarn

Yarn Conditioning Process

NUMBER OF CYCLES REQUIRED -2

			Cycle – 1		Cycle - 2
1.	Temperature	-	85 degree	-	90 degree
2.	Pressure	-	350 mbar	-	350 mbar
3.	Time	-	5 mins.	-	20 mins.

Cycle -1

a. Vacuum fill up inside the boiler
b. Water supply.
c. Heating up to 85 degree C.
d. Steaming (5 minutes).

Cycle – 2

a. Vacuum fill up inside the boiler
b. Water supply
c. Heating up to 90℃
d. Steaming (20 minutes).

Final vacuum

a. Time 30 seconds and 750 bar to 600 mbar.

Aeration (Drying and Freshening)

a. Nominal – 1001 mbar

Final time

a. Time 30 seconds

III PERFORMANCE EVALUATION OF CARBON NANO TUBES COATED YARN

As discussed in Method -1. We have studied the nano coated cotton yarn both in conditioned and unconditioned stage. It is observed visually that the strength of the yarn improved a lot in both type of yarn. In addition to that the samples were given for testing to investigate the tensile strength, elongation % and RKM properties. We observed considerable increase in the tensile strength, elongation% and RKM (unconditioned yarn) compare to uncoated raw yarn. But, we observed that in conditioned yarn the tensile strength and RKM improved and Elongation % is decreased compare to raw conditioned uncoated yarn. To improve elongation % in conditioned yarn. we adopted new method that are shown earlier. The test results are shown below.

Lab Test results : - (Method - 2)

Table No. 1 Mechanical Properties comparison of Raw Cotton yarn and CNT coated yarn for unconditioned yarn.

10s OE yarn	Raw cotton yarn	PMMA & CNT coated yarn
Tensile strength	491.30 grams	787.07 grams
Elongation %	5.41	8.42
RKM	8.32	13.33

Summary of CNT coated yarn : -

1. Increased Tensile strength in Percentage - 37.57%
2. Increased Elongation % - 55.63%
3. Increased RKM % - 37.58%

Table No. Mechanical Properties comparison of Raw Cotton yarn and CNT coated yarn for conditioned yarn

10s OE yarn	Raw cotton yarn	PMMA & CNT coated yarn
Tensile strength	484.18 grams	679.84 grams
Elongation %	7.72	8.70
RKM	8.20	11.57

Summary of CNT coated yarn : -

1. Increased Tensile strength in Percentage - 28.78%
2. Increased Elongation % - 11.26%
3. Increased RKM % - 41.09%

Summary of the test results :-

Table No. 2 Test results comparison of both methods for unconditioned yarn.

10s OE yarn	**Method – 1**	**Method - 2**
Tensile strength	32.16%	37.57%
Elongation %	9.42	55.63
RKM	32.13%	37.58%

Table No. 3 Test results comparison of both methods for unconditioned yarn.

10s OE yarn	Method – 1	Method - 2
Tensile strength	28.01%	28.78%
Elongation %	23.83% (decreased)	11.26% (increased)
RKM	40.01%	41.09%

Estimation of CNT coated cotton yarn diameter

Estimation of yarn diameter using Travelling Venire Microscope

1. Fringes are formed with air wedge method using Travelling microscope.
2. We could observe uniform fringes implying the homogeneous coating.
3. By taking fringe width of 16, we were averaged out the diameter.
4. Observed value works out the diameter of 0.005 inches.

As per SITRA norms formula for finding yarn diameter : -

1. Standard Formula from SITRA norms for calculating the yarn diameter = 1/28 x √ count .
2. For 80s count =1/28 x √ 80
   = 0.004 inches
3. Improvement in yarn diameter after coating = 0.005 inches
4.
5. Increased diameter = 0.001 inches

Conclusion

1. Based on test results it is concluded that in method -2 the tensile strength is increased in unconditioned and conditioned coated yarn than method-1.

2. The Elongation in method -2 is increased drastically from 9.42% to 55.63% in unconditioned coated yarn compared to method -1.

3. In conditioned yarn the elongation is 23.83% decreased in method -1, but in method-2 the elongation is increased up to 11.26%

4. The RKM also increased in method-2 both in conditioned and unconditioned coated yarn.

5. From our results, we conclude that unconditioned yarn give better performance than conditioned yarn.

6. From the analysis of the results, we conclude method -2 is best suited for nano coating.

7. Coating thickness of about 25% of yarn diameter could improve the mechanical properties drastically.

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