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Multifinishing of Cotton using reduced Graphene Oxide

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Abstract - *Graphene is worth evaluating for anti-microbial and UV protection due to its outstanding physical and chemical properties. Graphene, which has abundant availability in nature, is currently under research phase for its functional application in the field of textile. The sp^2 hybridized 1-atom-thick planar sheet has been under consideration for its unique properties of strong cytotoxicity towards bacteria. In this work, reduced graphene oxide was applied on the cotton textile substrate and the evaluation of anti-microbial and UV protection finish is carried by a standard test of American Association of Textile Chemist and Colorists (AATCC). The following work also contains SEM and FTIR results of reduced graphene oxide.*

Key Words: **Reduced Graphene Oxide (rGO), Graphene Oxide (GO), Titanium dioxide (TiO_2), AATCC 100:2004, ASTM D6544.**

1.INTRODUCTION

Graphite oxide was first prepared by Oxford chemist Benjamin C. Brodie in 1859, by treating graphite with a mixture of potassium chlorate and fuming nitric acid. He reported the synthesis of "paper-like foils" with 0.05 mm thickness. In 1957 Hummers and Offeman developed a safer, quicker, and a more efficient process called Hummers' method, using a mixture of sulfuric acid (H_2SO_4), sodium nitrate ($NaNO_3$), and potassium permanganate ($KMnO_4$), which is still widely used, often with some modifications. Largest monolayer graphene oxide with highly intact carbon framework and minimal residual impurity concentrations can be synthesized in inert containers using highly pure reactants and solvents. Graphene is the new material of the future that will revolution in all sectors including the textile sector, both from the technical point of view and form the design of the intelligent cloth, various textile finishes and many more. In the last few years, the popularity of graphene in high-performance conductive textile as the fabric increases because of its outstanding features. The bulk material disperses in basic solutions to yield monomolecular sheets, known as graphene oxide by analogy to graphene, the single-layer form of graphite. Graphene oxide sheets have been used to prepare strong paper-like materials, membranes, thin films, and composite materials.

1.1 Material

An average thickness 1-4mm, lateral dimensional (X and Y) 5-10µm, 1-3 number of layer, 220 m^2/g surface area, >99% purity reduce graphene oxide purchased from Ad-Nano Technologies Private Ltd, Karnataka, India. Bleached and scoured (100%) Cotton fabric (200 GSM) supplied from Swadeshi Bleaching and Dyeing mill Pvt. Ltd. Ichalkaranji, India Titanium dioxide (TiO_2) was purchased from Balaji Chemical, Kolhapur, India.

1.2 Preparation of Antimicrobial and UV protection finish

The rGO is mixed with distilled water followed by probe sonication for 30 minutes at room temperature for getting dispersed aqueous rGO solution. The dispersed rGO was then mixed with TiO_2 solution followed by magnetic stirring at 50 rpm at different proportion. Application of the finish on Cotton was carried out by using padding, drying and curing technique. The padding expression was 80%, drying temperature was 80°C and curing temperature was 120°C for 3 minutes.

1.3 Characterization technique

The surface morphology was carried out using a scanning electron microscope (SEM; 6510LA). Fourier-transform infrared (FTIR) with wavenumber range of 500-4000cm-1, X-ray diffraction (XRD) with a monochromatized AI KR X-ray source at a constant dwell time of 100ms and pass energy of 40eV. The evaluation of the functional properties of antimicrobial and UV protection finish was carried out using standard test method AATCC 100:2004 for antimicrobial and ASTM D6544 for UV Protection finish.

1.4 Testing of Anti-Microbial Finish

The antimicrobial test was carried out by the suspension method. Here gram positive and gram negative bacteria that is Escherichia Coli and S. Aureus respectively.

Specimens treated with the non-releasing ti-bacterial agent under dynamic contact conditions. Antimicrobial activity is calculated in percentage (%) reduction of bacteria in the specimen (R%)

$$R\% = \frac{A-B}{A} \times 100$$

Where A and B are a number of bacteria colonies on untreated and treated fabric respectively.

1.5 Testing of UV protection property

The American Association of Textile Chemist and Colorists (AATCC) has developed a test for testing the UV ray reflection by fabric named American Society of Testing and Material ASTM D6544. To check the UV property of the fabric, it is necessary to have UPF (UV Protection Factor). Actually, it is the ratio of potential ery-thermal effect to the actual erythemal effect transmitted through the fabric by the radiation and calculated from the spectroscopic meter.

2. Result and Discussion

2.1 Morphology and structure of rGO material

The characterization of the rGO material was illustrated and typical SEM of the rGO material is shown in fig 1. in which layer by layer Graphene edges are observed and the flat sheet has lateral dimensions in the order of 5-10µm. It also shows fully exfoliated graphene material, some crumple on rGO is detected due to its atomic thickness in the range 1-4 nm. Furthermore, the XRD was analyzed to identify the surface chemical composition and variation of rGO in which at 2θ was between 10-15 and the potter acute angle 2θ was 11.4^0 of the reduced graphene oxide fig 2. The peak of the graphite was observed as 26.4^0. In addition, the FTIR of the rGO was also presented fig 3., which consisted of five different chemically shifted components that could be deconvoluted into OH groups (3400 cm^{-1}), C=O (1740 cm^{-1}), OH deformation peak (1420 cm^{-1}), C-OH (1220 cm^{-1}), C-O (1050 cm^{-1}) and 1620 cm^{-1} assigned to the vibration of absorb water molecules.

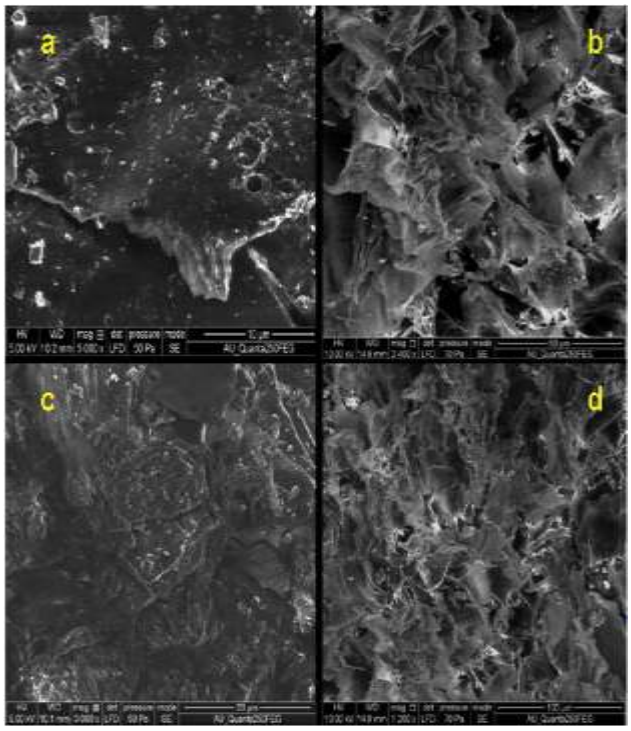

Fig -1: SEM of rGO

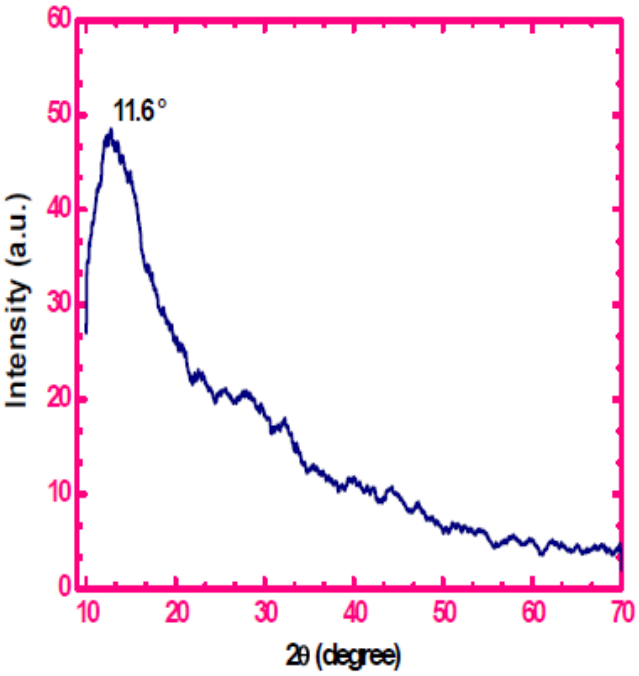

Fig -2: XRD of rGO

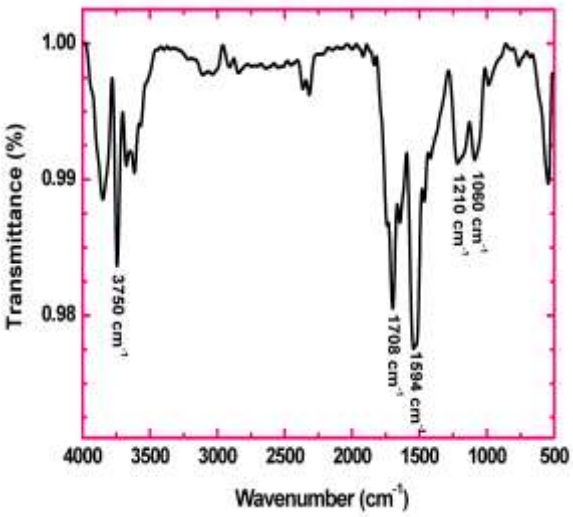

Fig -3: FTIR of rGO

2.2 Testing of samples for Antimicrobial finish

To explore the antibacterial activity of the samples, impregnation was carried out with a prepared mixture of TiO_2 and rGO nanoparticles utilizing pad dry cure method. The antibacterial test was completed with S. Aureus (Gram-positive microbes) and Escherichia Coli, (Gram-negative microscopic organisms). The Quantitative evaluation was finished by a standard test method (AATCC 100-2004). The samples were tried for antibacterial action and the consequences of the equivalent are given in Table 1.

Table -1: Antimicrobial activity testing

Sample	Antimicrobial Activity (% reduction)	
rGO/TiO_2 Sample (Average)	Staphylococcus Aureus	Escherichia Coli
	99	99

From the estimations of the antimicrobial function, it is clear that the antibacterial action of the treated samples is because of the treatment of rGO/TiO_2 nanoparticles. Further, it is also observed that the antimicrobial activity of the sample treated with rGO and TiO_2 mixture shows better performance and durability compared with individual nanoparticles.

2.3 Testing of samples for UV Protection finish

Table -2: UV Protection finish testing

Sr.No	rGO (gm)	TiO_2 (gm)	E% Under Sunlight
1	0.02	3	66.47
2	0.04	3	77.23
3	0.2	3	83.13
4	0.5	3	91.27

3. CONCLUSION

From the above result, it is evident that the production of cotton fabric with Anti-microbial and UV protection property is possible through rGO and TiO_2 while TiO_2 act as nucleation between the cotton fabric and rGO. The optimum combinations that yield the best performance in term of UV Protection and Antimicrobial is 0.5 gm of rGO. This proved that as the concentration of rGO increase the better will the result obtain. This combination can be used for various application like garment making, home textile, etc.

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