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Research Article

Influence of Carbon Nanotubes on Mechanical Properties of Polyurethane Composites

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ABSTRACT

The main purpose of this work is to investigate the influence of carbon nano tubes (CNTs) on mechanical properties of polyurethane composite. Synthesis of carbon nano tubes (CNTs) was done by solution processing method using N-methyl-2-pyrrolidone (NMP) and tetrahydrofuran (THF) solvents. The small compact particles of polyurethane was converted into blend polyurethane by heating at 100°C in tetrahydrofuran solvent (THF).Samples were prepared using different wt%ages of carbon nano tubes (CNTs) i.e. (i= 0, 0.1, 0.5, and 1) and Polyurethane (PU) i.e. (i=100, 99.9, 99.5, and 99) in respective order. These samples were characterized by stress strain curve, modulus of elasticity (E) and percentage elongation by using universal testing machine (UTM).The addition of 1wt% of carbon nano tubes showed the higher stress in 19.2551 N/mm^2 and respective strain in 700.2294. Maximum elongation and modulus of elasticity is 140.0459mm, 0.26N/mm^2. Hence, results show that increase in stress strain, E, and percentage elongation is direct relation with nano particles.

Keywords: Liquid exfoliation method; Mechanical properties; Carbon nano tubes; Tetrahydrofuran

INTRODUCTION

The materials are playing an important role in industrial applications. The demand for high-quality and multifunctional nano materials in different industrial applications is increasing day-by-day. The study on carbon nano tubes based polymer has been increasing in recent years[1].Different industries is doing a big effort on research in nano technology for advanced nano materials[2].Carbon nano tubes have got much attentation due to its amazing mechanical, electrical and thermal properties. Introduction of carbon nano tubes into different types of polymer holds the likely improve the host material's mechanical, electrical and thermal properties[3-6].There are two main classification of carbon nano tubes i.e. multiwall and single wall carbon nano tubes.MWCNTs were produced by different method i.e. chemical vapour decomposition method, arc discharge method or laser ablation method[7].The diameters of multiwall carbon nano tubes vary from 1.4 to 100nm and 0.4 to 3nm for single wall carbon nano tubes. The modulus of elasticity for multiwall and single wall carbon nano tubes vary from 270Gpa and 1Tpa respectively. The electrical properties of single wall carbon nano tubes are better than multiwall carbon nano tubes [8-9].The two major problems occur during the preparation of such composites are agglomeration and poor interaction. To overcome these problems different techniques have been introduced [10,11].

MATERIAL AND METHOD

Solvents

Tetrahydrofuran and N-methyl-2-pyrrolidone were the sol- vents, which are used for preparation of CNTs and they are purchased from LABSCAN Ltd.Ireland.

Multiwall carbon nano tubes and polyurethane

Multiwall CNTs was purchased from Sentron Asia international laboratory, processed for preparation of polyurethane and carbon nano tubes samples.

Experimental procedure

In this experimentation, two types of synthesis are involved first is synthesis of CNTs and second one is solution casting technique for preparation of samples, following steps were carried for the making of CNTS/PU membrane is given below [12].

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a) Dispersion of layered material

b) Sonication

c) Centrifugation

d) Filtration and drying

e) Fabrication of specimens

a. Dispersion of layered material

Dispersion of bulk graphite in to small layers was done by using N-Methyl-1, 2-Pyrrolidine solvent [13].

b.Sonication

Bath sonication process (where high frequency waves broke the bulk material) was done by with DSA50-Sk1 having 1.8l capacity and range of frequency up to 45 KHz was followed at 10 °C for 2 h [14].

c.Centrifugation

After sonication process, centrifugation is needed to pure the solution. Gradient ultra-centrifugation and differential ultra-centrifugation [15] are the two methods which are used to separate the impurities. After Centrifugation process we got nano particle of CNTs without impurities [16]. The solution of NMP and CNTs at speed of 500 rpm was centrifuged for 60 min at room temperature in ZK100 ultra centrifuge to separate surfactant from solution [17].

d.Filtration and drying

Vacuum filtration assembly was used to separate NMP form layers of CNTs.For this purpose 0.22 micro meters thick nylon paper was used. After this the filter paper was dried at temperature of 150°C at microwave oven for NMP's evaporation. After this, the filter paper was weighed. After weighted the filter paper, 82.7mg CNTs was obtained and dissolved in 100ml THF solvent.

e.Fabrication of samples

Samples were made with the solution casting method according to the requirements of the samples.

CHARACTERIZATIONS

Mechanical properties

Samples having dimensions 60 mm × 10 mm × 0.06mm (length ×width thickness) at rate of feed 10mm/min were examined by UTM. UTM used in this research has 100 KN force and connected with Trapezium-X interface; steps are represented in Figures1 and 2.

RESULTS AND DISCUSSIONS

To investigate the influence of carbon Nano tubes on the mechanical properties of polyurethane mechanical test are performed. Following properties were investigated from the mechanical testing performed on pure polyurethane and its composites with MWCNTs. Stress strain diagram of CNTs/PU composite certainly reflects that variation in mechanical properties was function nano filler.

1) Stress & Strain

2) Young's modulus

3) Elongation

Figure 3 shows that pure polyurethane as shown in red line strain% and stress values are 5.5 % and 14.11N/mm^2, respectively; the exposed increasing trend in orange ,blue and green line with increasing values of filler as (i.e., 0.1,0.5,1). Ultimate tensile strength (UTS), modulus of elasticity (E), and percentage elongation at break would determine with reference above curves of stress strain. Values of all samples are given in Tables1 and 2.

The fig 4 consists of four bars from which each bar is representing elongation w.r.t amount of MWCNTs present in that sample. From the Figure 4 it can be clearly seen that as the amount of MWCNTs is increasing in pure polyurethane, the elongation of Nano-composite also increasing. It starts rising from 107.53mm and goes up to 140.04mm. From Tables3 and 4, elongation of each sample can be easily identified.

Figure 5 shows that Young's modulus or modulus of elasticity is the measure of the resistance of an object against the deformation when a stress is applied to it. Values of modulus of elasticity of

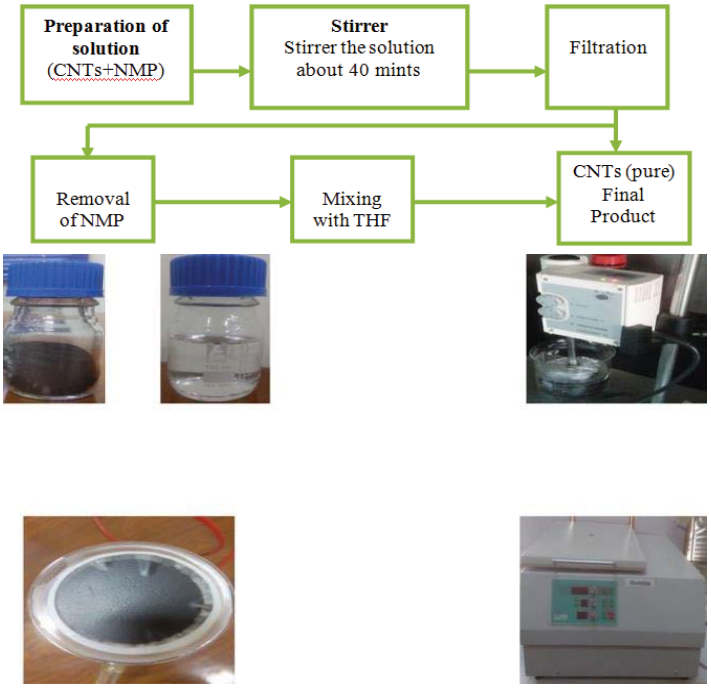

Figure 1: Experimental setup for synthesis of CNTs.

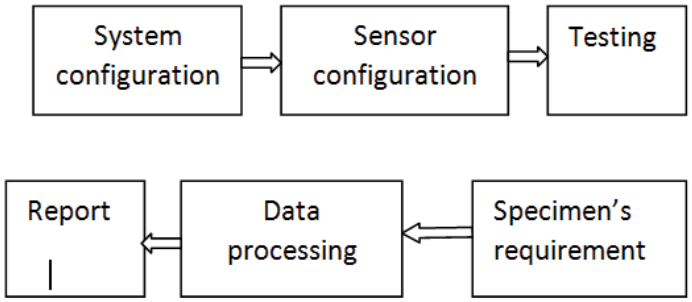

Figure 2: Trapezium-X interface procedure.

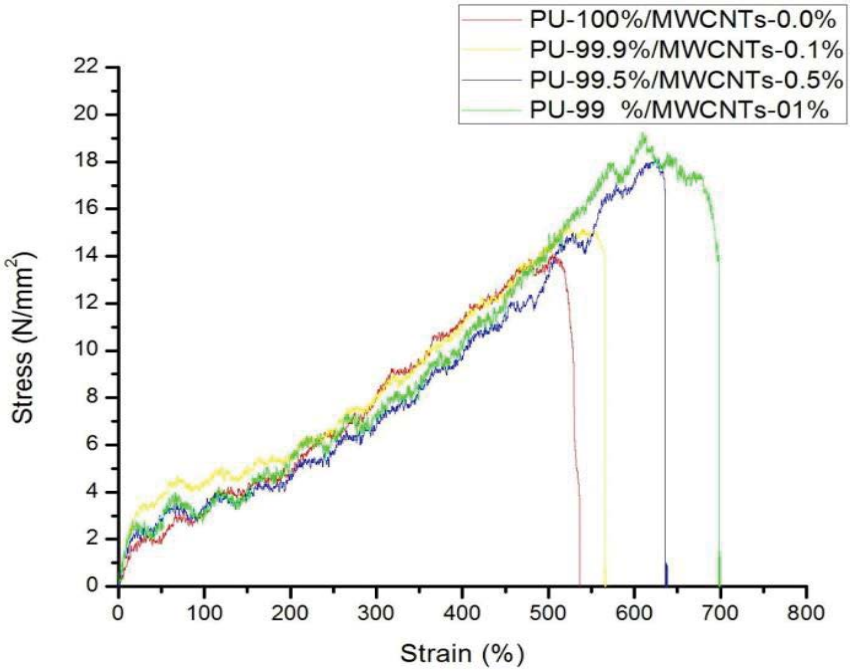

Figure 3: Stress strain diagram of PU/MWCNTs Nano composites.

Table 1: Wt. % age of samples.

Sample NO	CNTs Wt.% age	Polyurethane Wt.% age
Sample 1	0	100
Sample 2	0.1	99.9
Sample 3	0.5	99.5
Sample 4	1	99

Table 2: Stress-Strain values.

Specimens	Line color	Stress (N/mm^2)	Strain (%)
PU/MWCNTs	Red	14.1197	504.455
PU/0.1%MWCNTs	Yellow	15.201	553.223
PU/0.5% MWCNTs	Blue	18.1516	623.989
PU/01%MWCNTs	Green	19.2551	700.2294

pure polyurethane and its Nano composites shows that modulus of elasticity is not significantly changing as the percentage of MWCNTs increases. As the stress increases the strain also increases and thus the ratio remains constant. Modulus of elasticity is taken on y-axis and wt. % of MWCNTs is taken on x-axis.

CONCLUSION

MWCNTs were mixed with NMP to make a homogeneous mixture. After keeping this solution in magnetic stirrer MWCNTs were filtered from NMP. Then different concentrations of filtered MWCNTs were mixed with polyurethane blend to obtain MWCNTs/PU nano composites. Mechanical testing was done under UTM on filtered MWCNTs/PU composites. A visible change in values of stress, strain and elongation was calculated. Stress increases from 14.1197MPa to 19.2551MPa, elongation increases from 107.5309 mm to 140.0459 mm as the concentration of MWCNTs increase. Mechanical properties of polyurethane enhanced as the concentration of MWCNTs increases. Hence, there is direct relation between mechanical properties of polyurethane and concentration of MWCNTs.

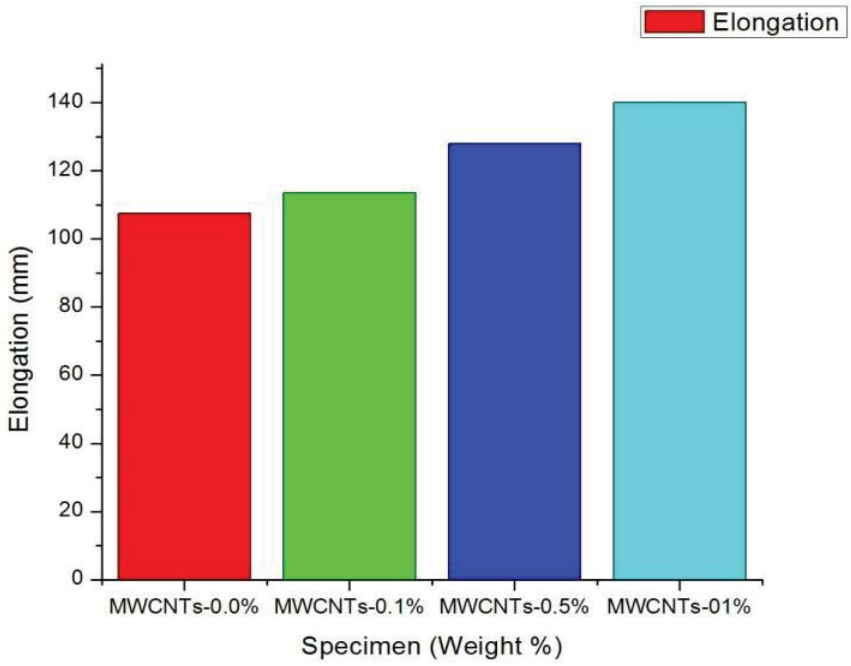

Figure 4: Graph of Elongation (mm) Vs. Weight % of MWCNTs.

Table 3: Elongations values.

Specimens	Elongation (mm)
PU/MWCNTs	107.5309
PU/0.1%MWCNTs	113.5241
PU/0.5% MWCNTs	128.0739
PU/01%MWCNTs	140.0459

Table 4: Young's modulus values.

Specimens	Young's modulus(N/mm^2)
PU/MWCNTs	0.02412
PU/0.1%MWCNTs	0.02315
PU/0.5% MWCNTs	0.02514
PU/01%MWCNTs	0.026

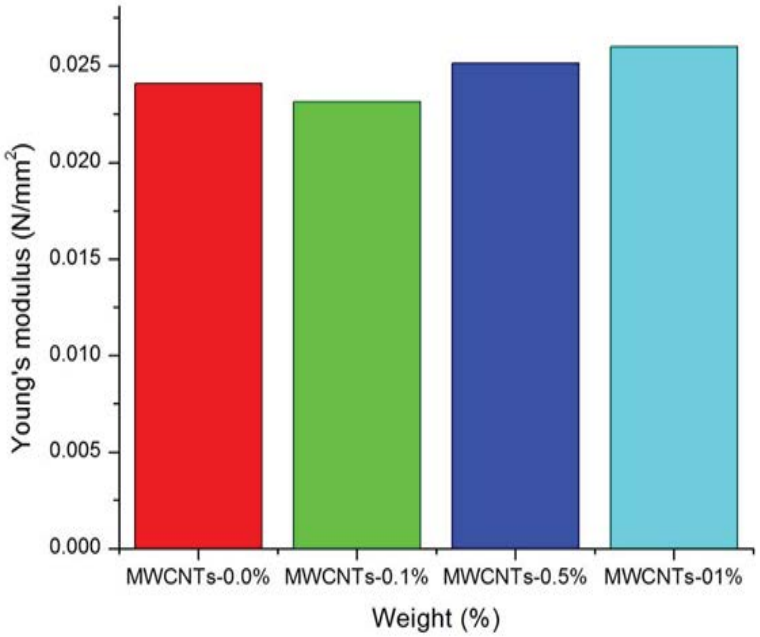

Figure 5: Graph of Young's modulus (N/mm2) Vs. Weight % of MWCNTs.

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