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Studies Of Influence on Multiwalled Carbon Nanotubes (MWCNT's) Reinforced Epoxy Based Composites

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ABSTRACT: *In the present work, the Multiwalled Carbon Nanotube reinforced epoxy composites are fabricated with different weight fraction of the reinforcement and are subjected to hardness test as well as compression test. The mechanical properties of these composites are investigated and found posses increase in hardness test and young's modulus with increased weight fraction of the reinforcement compared to the based matrix fabricated using the same process.*

Keywords: *Epoxy resin, hardner, multiwalled carbon nanotube, nanocomposites.*

I. Introduction

Carbon nano-tubes is the form of carbon, multiwalled carbon nanotubes (MWCNT's) is rolled to a tubular shape with multiple layers. MWCNT's are to revolutionize several fields in mechanical and electrical engineering. This are a major component of nanotechnology. MWCNT have a wide range of unexplored potential applications in various technological areas antistatic behavior such as fuel filler caps, automotive fuel lines, fuel filter housings, fuel hoses, etc., housings such as mobile phones, coatings etc., Mechanical strengths such as electrostatic paintings, adhesives, aircraft parts, sports goods, coatings etc., electrical components, etc., Epoxy-based composite materials are being used as structural components not only in weight sensitive aerospace industry, but also in the marine, armor, automobile, railways, structural engineering to their excellent high-adhesion, low-weight, and good chemical/corrosion-resistance.

Over the years, many attempts have made to modify epoxy by adding either rubber particles or fillers to improve the matrix-dominated composite properties. The addition of rubber particles improves the fracture toughness of epoxy, but decreases its Young`s modulus and strength. The addition of fillers, improves the Young`s modulus and strength of epoxy.

These properties would enable us the exact application for which the specimens can be tailor-made. Applications are of conductive polymers & composites in electronic & automobile products, as sensors & instruments in applications like microscope probe tips, gas leak detectors, electromagnetic shielding sporting goods(tennis racket), as conductive coatings in printed circuit board, as catalysts in petrochemical applications, as textiles and fibers, in lithium ion batteries, lamps, semiconducting materials, advanced ceramics, microwave antennas, medical implants, drug delivery, aerospace etc.

II. Experimental section

2.1 Methods of Synthesizing MWCNT

The oldest method for the carbon nanotube production is the electric arc discharge. This technique was used already in the early sixties by R. Bacon for the synthesis of carbon fibers called whiskers. The same technique was adapted in 1990 by Kratschmer and Huffman to produce fullerenes in good yields, and later on this method was improved and applied for the synthesis of multiwall (MWNT) and single wall (SWNT) carbon nanotubes. Other methods such as the laser evaporation/ablation and chemical vapour deposition (CVD) were also successfully examined in the production of carbon nanotubes. The laser evaporation process is technically similar to the arc discharge method. The difference between these two methods is in the quality and purity of the obtained products. However, the arc discharge and the different types of CVD are the most promising and utilized techniques in the large scale production of carbon nanotubes and related materials. Here, we use Arc Discharge method.

2.1.1 Arc Discharge Method:

Nanotubes were observed in 1991 in the carbon soot of graphite electrodes during an arc discharge, by using a current of 100 amps that was intended to produce fullerenes. However the first macroscopic production of carbon nanotubes was made in 1992 by two researchers at NEC's Fundamental Research Laboratory. The method used was the same as in 1991. During process, carbon contained in negative electrode sublimates because of high-discharge temperatures. Because nanotubes were initially discovered using this technique, it has been the most widely used method of nanotube synthesis.

The yield for this method is up to 30% by weight and it produces both single-walled and multi-walled nanotubes with lengths of up to 50 micrometers with few structural defects.

The arc discharge technique generally involves the use of two high-purity graphite electrodes. The anode is either pure graphite or contains metals. In the latter case, the metals are mixed with the graphite powder and introduced in a hole made in the anode center. The electrodes are momentarily brought into contact and an arc is struck. The synthesis is carried out at low pressure (30-130 torr or 500 torr) in controlled atmosphere composed of inert and/or reactant gas. The distance between the electrodes is reduced until the flowing of a current (50–150 A).

The temperature in the inter-electrode zone is so high that carbon sublimes from the positive electrode (anode) that is consumed. A constant gap between the anode and cathode is maintained by adjusting the position of the anode. A plasma is formed between the electrodes. The plasma can be stabilized for a long reaction time by controlling the distance between the electrodes by means of the voltage (25–40 V) control. The reaction time varies from 30–60 seconds to 2–10 minutes.

2.2 Preparation of MWCNT/Epoxy Composite

2.2.1 Material

The polymer matrix consisted of bisphenol-A-based epoxy resin (Araldite GY LY556) with an amine-based hardener (Aradur HY 917), obtained from Huntsman Advanced Materials and Ethanol was the chosen solvent. Multi-walled carbon nanotubes produced by arc discharge were supplied by NANOSHELL Wilmington DE USA and its purity was higher than 98% (information taken from the supplier data sheet).

2.2.2 Preparation

MWCNT was mixed with ethanol and sonicated for 15 minutes in a beaker. The sonication helps disperse the nanoparticles uniformly and reduce lumps, thus countering the Vander wall`s forces set up. This procedure helps us in getting fine grained MWCNT. The above mixture (MWCNT & ethanol) is heated on an electric heater to evaporate ethanol in the same beaker. Care must be taken to not heat the MWCNT above 75`C. MWCNT taken in amounts of 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 1.75% and 2% weight fraction, epoxy resin and hardener were taken in appropriate weight standards (composition), with respect to the mould used. Only MWCNT and epoxy resin were thoroughly mixed for 30 minutes using sonicator. The sonication is carried out in a water bath thereby lowering the undesired heat which polymerizes the epoxy fluid. The sonication helps to disperse the nanoparticles uniformly throughout the epoxy polymer matrix. Hardener was added to the above mixture (MWCNT & epoxy resin) 10:1 and stirred for 5 minutes with a stirrer. The mixture is pre-heated in an electric oven up to 45'C after adding the hardener. The mixture is heated in a controlled environment in an electric oven and then poured into the die and placed in a Petri dish. It is kept in an atmospheric condition for 12 hrs to cure.

2.3 Characterization

XRD graphs of the samples were taken and thus the components of the samples were determined and verified. The phase purity of the MWCNT and epoxy resin were characterized by X-ray diffraction (XRD) on a X-ray Diffractometer with Cu Ka radiation (k = 1.5418 Å). The powdered samples of MWCNT and its composites (MWCNT/epoxy) were pressed into an appropriative glass mold with a pit for XRD characterization

III. Results and Discussion

3.1 Rockwell hardness test

The specimen was prepared according to the ASTM standard ASTM785.

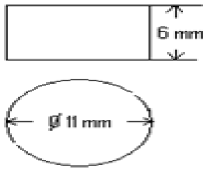
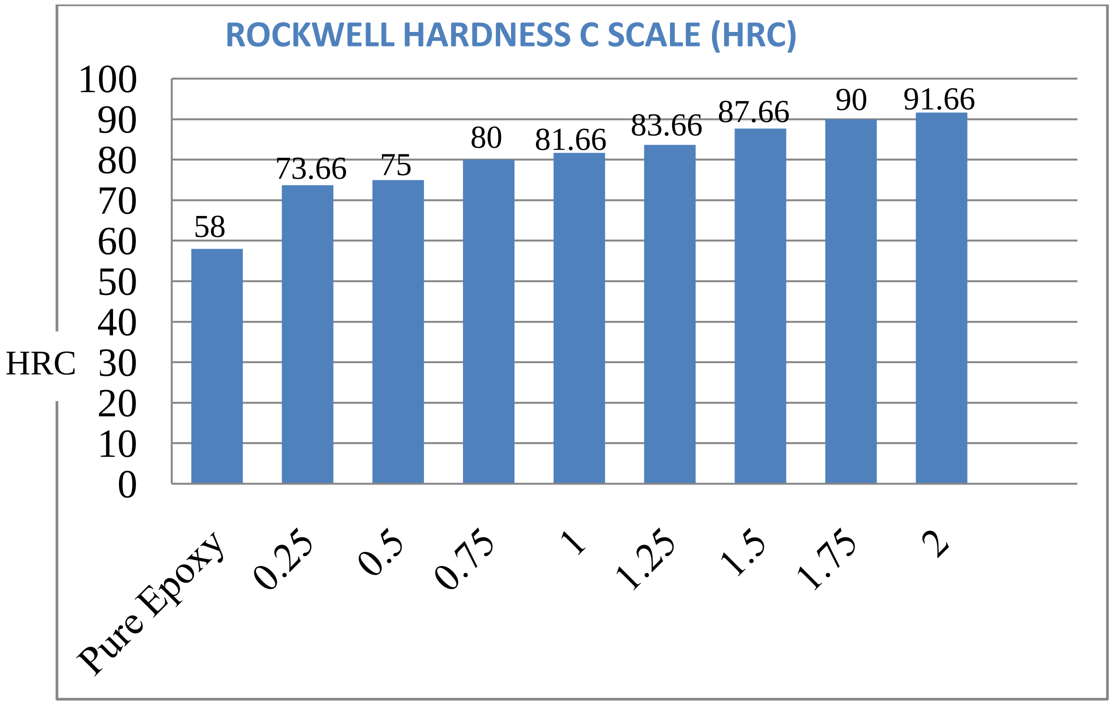


Figure 1: Specimen Dimension

3.2 Hardness Test



Graph.1 : % age of MultiWalled Carbon NanoTube

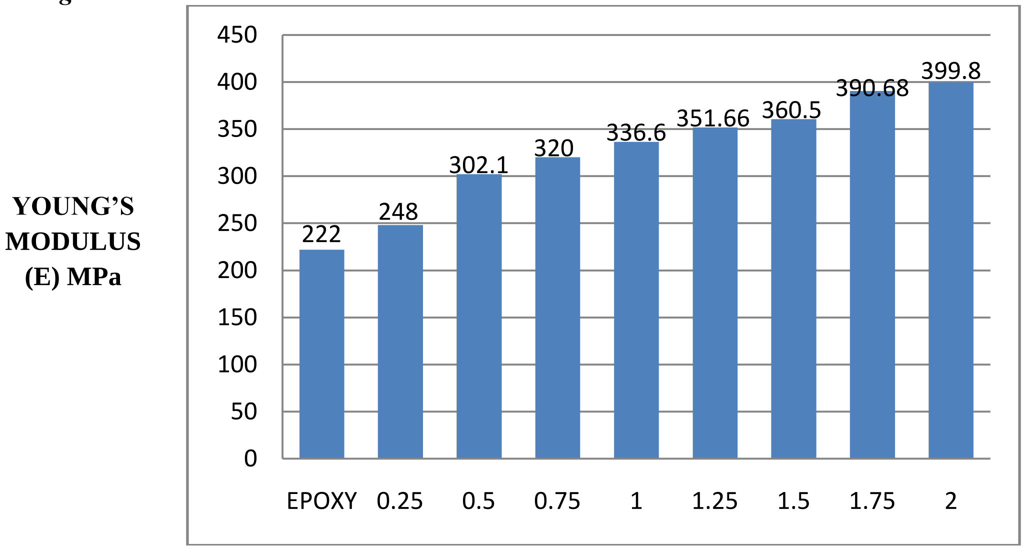
Graph-1 shows that as the percentage of multiwalled carbon tube increases, the hardness also increases.

3.3 Compression test

The specimen was prepared according to the ASTM standard ASTM695.

Each sample was a round solid cylinder with dimensions of length 40mm and diameter 15.5mm. The Load v/s Deflection and Stress v/s Strain graphs were obtained and hence Young's Modulus was determined for each of the samples. The bar graph of Young's moduli versus samples containing certain weight percentages of MWCNT's is as shown below.

Young's modulus v\s MWCNT%



Graph.2: Variation of Young's modulus for different %age of MWCNT

3.4 XRD Graphs

XRD Graphs of the polymer composite samples containing 0.25%, 0.75%, 1.25% and 2% by weight of MWCNT were taken to verify the composition of the prepared samples and are shown in below fig.2, fig.3, fig.4 and fig.5

XRD GRAPHS

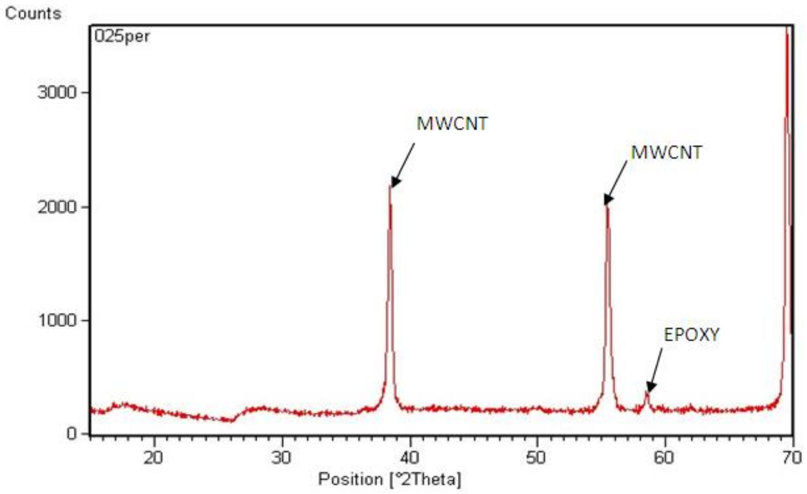


Fig.2 : 0.25 % MWCNT-Epoxy Composite

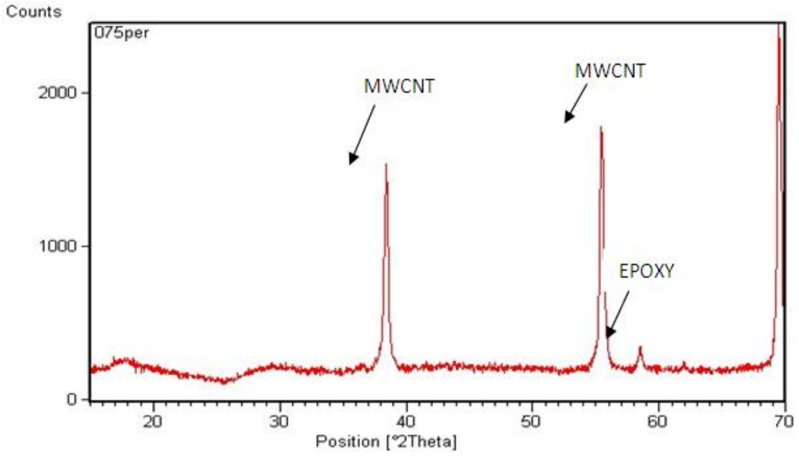


Fig.3: 0.75 % MWCNT-Epoxy Composite

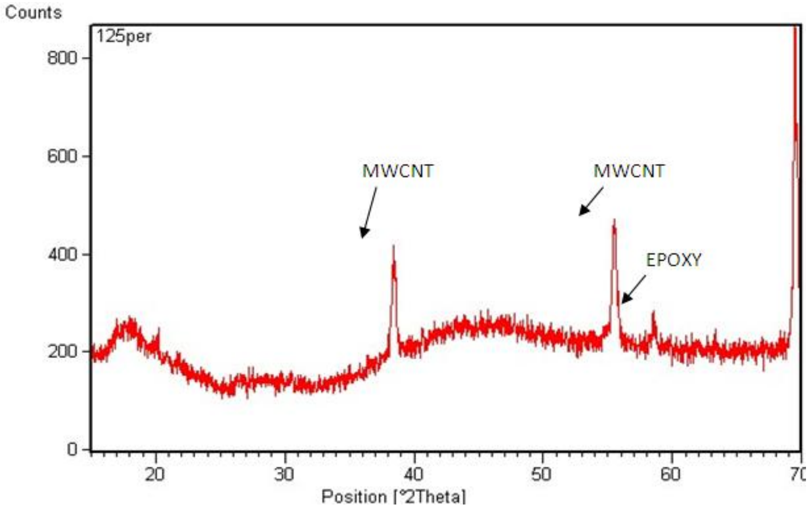


Fig.4: 1.25 % MWCNT-Epoxy Composite

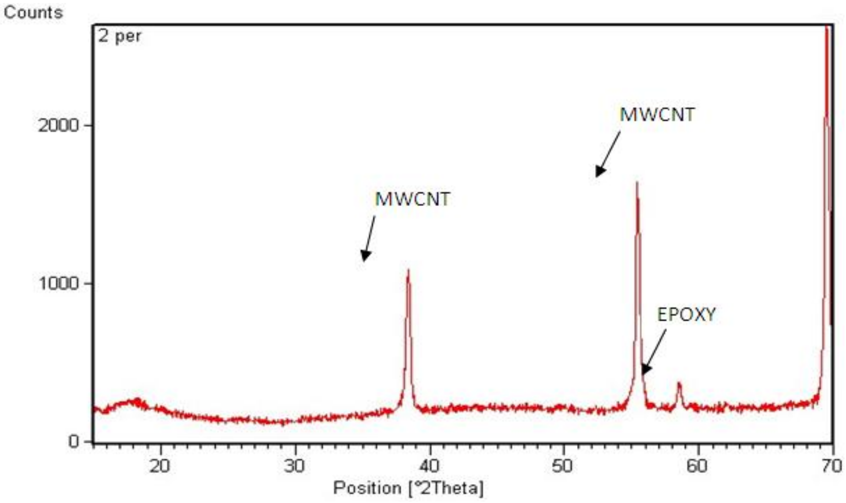


Fig.5: 2 % MWCNT-Epoxy Composite

IV. Conclusion

The MWCNT/epoxy nanocomposites have been fabricated and the reinforcing effect of MWCNT been investigated for enhancing the mechanical properties of the epoxy resin. It is shown that the blending of MWCNT a proper content of 0.25 wt.% into the epoxy matrix can simultaneously enhance the compression strength, Young's modulus and Hardness strength. The composite compression and hardness strengths reach the maximum with an improvement of 0.5%, 0.75%, 1.25%, 1.50%, 1.75% and 2.0% for the compression strength and hardness strength respectively. These are explained mainly in terms of the MWCNT–epoxy interfacial bonding at room temperature and the dispersion of MWCNT in the epoxy matrix. Consequently, MWCNT is a promising nano-modifier for enhancing the mechanical properties of epoxy resins.

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