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A Review on PDMS-CNT Nano-Composite Based Flexible Sensors

V. B. Shinde[1], M. R. Khodke[2]
[1, 2](Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune, India)

Abstract : *We review different preparation methods of percolation of carbon nanotubes (CNT) in polymer composites. We give a survey of different articles published on PDMS-CNT Nano composite. In present survey parameters like CNT types, preparation method, curing time, curing temperature and CNT concentration as well as polymer type are evaluated and determined their impact on maximum conductivity of the composite film. Advantages as well as limitations of these composite fabrication methods are evaluated. To investigate the effect of MWCNTs on the electrical properties of composites, we discussed different fabrication methods for CNT-PDMS Nano composite film. In this particularly for the mechanical mixing method polydimethylsiloxane (PDMS) mixed in a 1:10 ratio of curing agent and PDMS base because PDMS base is much more viscous than the curing agents. Physical characteristics with high electrical conductivity of the composite film are depends on the effective dispersion of MWCNTs.*

Keywords: *Carbon Nanotubes, Electrical conductivity, Flexible sensor, Nano composite, PDMS.*

I. INTRODUCTION

Carbon nanotubes are electrically conductive and useful for improving polymer properties. In recent years, many researchers have shown that carbon nanotubes have unique nanostructure and extraordinary physical and mechanical properties. They are widely used as Nano fillers to improve electrical, thermal and optical properties of polymer composites. However, the effective utilization of the properties of nanotube composites depends on the quality of their dispersion and the level of interfacial boxing of Nano composites. Uniform dispersion and distribution of carbon nanotubes throughout the matrix is difficult to obtain due to their tendency to form agglomerates during synthesis because of strong van der Waals attraction among individual tubes.

Conducting polymers like PANI, PTh, PPy, PDMS and PEDOT are widely used in various applications. Some of application fields are medicine, actuators, electronics, optics, energy devices, and composites. There is huge demand of conducting polymers for developing various flexible or wearable electronics, displays, and other devices. [1].

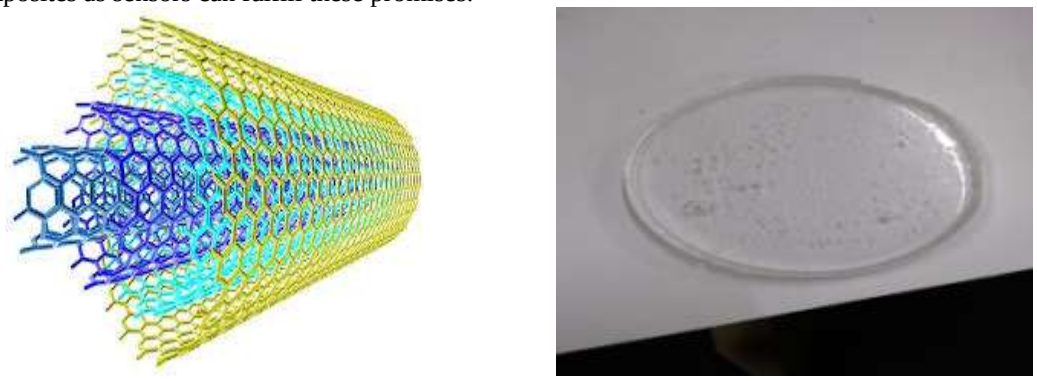
Conducting polymer composites typically consist of a polymer matrix into which conducting fillers are incorporated. These multifunctional materials have many potential applications that include electromagnetic interference shielding, electrostatic dissipation and heat dissipation. Carbon nanotubes are electrically conductive and useful for improving polymer properties. Carbon nanotubes widely used as Nano fillers to improve electrical, thermal and optical properties of polymer composites. However, the effective utilization of the properties of nanotube composites depends on the quality of their dispersion and the level of interfacial boxing of Nano composites. Uniform dispersion and distribution of carbon nanotubes throughout the matrix is difficult to obtain due to their tendency to form agglomerates during synthesis [2].

The percolation threshold of MWCNT is depends on proper dispersion of MWCNT in the polymer matrix. It also influences the mechanical sensitivity of the sensor and its measurement range. The viscosity of polydimethylsiloxane (PDMS) base polymer is 5.1 Pa-sec, for direct dispersion of MWCNTs nominal limit of ultra-sonication is exceeded [3]. When resistance changes in these Nano composites is exceptionally greater than that of metallic piezoresistive materials then electro mechanical coupling of pressure changes. The piezoresistive stress coefficient of a CNT-polymer Nano composite is approximately two orders of magnitude higher than that of a typical metallic piezoresistive. The maximum value occurs at a concentration just above the percolation threshold concentration because the piezoresistive stress coefficient is a function of the nanotube [4]. In the present study, we give a survey of Parameters like type of Carbon Nano Tubes, preparation method, curing temperature and curing time as well as polymer type and dispersion methods are discussed.

II. ORIGIN OF PROBLEM

If inorganic materials are not suitable then alternative option preferred is of conducting polymers with optical and mechanical properties are used [5]. Strain sensors based on metal foils and semiconductors are commercially available with a well-established technology and low cost of fabrication, but they possess very poor stretch ability. Hence there is need to develop sensors with higher sensitivity and which can be embedded

in the structure to offer additional functionality like structure strengthening and good stretch ability. Use of Nano composites as sensors can fulfill these promises.



(a) (b)

Fig.1. (a) Schematic of MWCNT and (b) PDMS Film

III. METHODS

The various methods are carried out with different preparation methods by few researchers. Researchers performed different methods like dipping method or two stage processes, composite of CNT Eco flex, Composite by mechanical mixing. To determine the physical characteristics of the Nano composite film various important factors are evaluated using different methods. Some methods are discussed below.

3.1 Dipping Method

This method is studied by Ji Eun Cha to investigate the Effect on Thermal and Mechanical Properties of Flexible Composite Film due to Continuous MWCNTs. In this he prepared MWCNT Bucky paper using dipping method as shown in Fig.3. Fig shows step to step process of dipping method.

In this Bucky papers are an entangled network structure of MWCNTs, fabricated by suspension filtration. To obtain excellent buckypaper structure and properties, a well-dispersed MWCNT aqueous suspension is prepared. Many factors affect the dispersion of the MWCNTs most important is moisture content.

To remove moisture, MWCNTs are dried at 1000C for 12 h. After this calculated amount of MWCNTs is mixed In this Bucky papers are an entangled network structure of MWCNTs, fabricated by suspension filtration. To obtain excellent buckypaper structure and properties, a well-dispersed MWCNT aqueous suspension is prepared. Many factors affect the dispersion of the MWCNTs most important is moisture content. To remove moisture, MWCNTs are dried at 1000C for 12 h. After this calculated amount of MWCNTs is mixed into a 50 mL dispersion medium and then MWCNTs are dispersed using a bath-type sonicator for 20 min. Using vacuum filtration different buck papers were produced, in order to investigate the effect of the MWCNT lengths,

types of dispersion medium Nano materials, the MWCNT contents in suspension, sonication time and types of filter on the resulting buckypaper structure. After the filtration, buckypaper was dried overnight in an oven at 1200C.

He concluded that, by forming the continuous MWCNT buckypaper there is improvement in the thermal conductivity and tensile strength of the buckypaper-filled composite film which is 76% and 275%, respectively[6] Fig.3. Dipping method of PDMS-CNT composite film fabrication

3.2 Composite of CNT– Eco flex

This method is studied by Morteza Amjadi and he developed a CNT- Eco flex Nano composite for super-stretchable, skin-mountable, and sensitive strain sensors. In this number density of the CNT percolation network is important factor to control the sensitivity of the strain sensors.

In this method simple three layers composite considered for the strain sensors. Out of three two layers of Eco flex and one is of CNT. Composite consist of CNT thin films laminated between the top and bottom layers of Ecoflex. Initial resistance of the strain sensors is increases when the strain sensors are stretched out and this result re-orientation and re-positioning of CNTs within network. Due to elastic force of Eco flex recovers the resistance and elastic force reestablish percolation network. The fabrication processes of the CNT–Eco flex Nano composite thin films are simple like a sandwich. Here, instead of dispersion of CNTs inside the polymer matrix for the fabrication of Nano composites. He used simple method and successfully fabricated the CNT–Ecoflex nanocomposite. This is fabricated in a controllable manner by the infiltration of the liquid polymer inside the thin film of porous CNT network.

He detected Skin motion for promising application. In this he mounts the strain sensors on various parts of the body. The maximum strains are measured by the bending of the finger, wrist, and elbow joint using strain sensors to be 42%, 45% and 63% respectively [7].

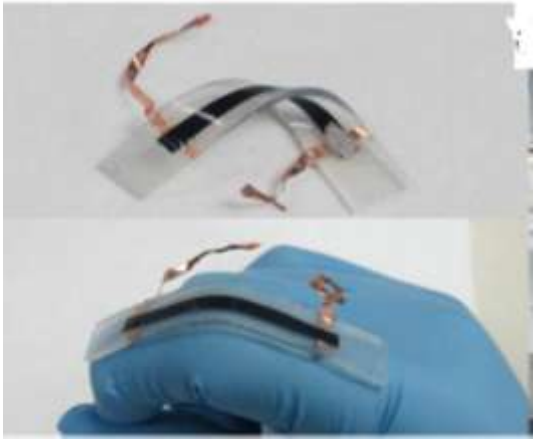


Fig.2. Flexible CNT– Ecoflex nanocomposite

3.3 PDMS and CNT composite by Mechanical mixing

Here is another method of composite preparation in which proposed amount of MWCNT is mixed by mechanical mixing. There are several samples with CNTs concentration varying range.

Calculated amounts of CNTs and S184 were placed into a beaker and stirred using mechanical mixer at 100 rpm for 1hr. Then a curing agent was added and subsequently stirred at 100 rpm for 5 min. After that, the mixture was filled into the vacuum flask which is connected to vacuum where air bubbles were removed. Finally, mixture was filled into the mold and placed into drying oven where mixture is cured at 70 °C for 12 hrs. [2].

Fig.4. shows composite after the drying in oven, here petri dish is mould for simplicity but we can take any mould as per requirement.

Fig.4. PDMS-CNT composite by Strirring process

IV. CONCLUSION

The purpose of the proposed paper is to review various methods of experimental work on proper percolation of carbon nanotubes (CNT) in polymer composites published in different articles. In this different methods are studied, composite of CNT Eco flex and dipping method are shows better results over PDMS-CNT composite by Strirring process. Strirring process is very complex and difficult method than other methods bacause it requires homogenous mixture of CNT/Polymer. Out of all three methods composite of CNT Eco flex method is simple and best because this method achieve structure strengthening and good stretch ability.

V. FUTURE SCOPE

Based on the literature review, it is evident that the parameters which are not studied so far are listed below and these parameters can be suggested as future scope of study.

i. Use of PDMS Nano composites as strain and pressure sensing material.
ii. Effect of CNT on physical properties of PDMS composite film
iii. Effect of curing time on composite film
iv. Effect of curing temperature is studied for limited range.

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