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Novel Method for CNTs Dispersion in Fluids

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ABSTRACT

Carbon nanotubes consist of rolled graphene sheets with common center. CNTs have diameter from about 0.4 nm for SWNT to 30 nm for MWNT and length even 3 mm. This allotropic form of carbon has unique properties: very high Young's modulus, high electric and thermal conductivity. Unfortunately, very high specific surface area makes CNT a filler with poor solubility in fluids. To improve dispersion of carbon nanotubes in solvent new method with combine dielectrophoresis and megasonification was developed.

Key words:t Carbon Nanotube, CNT, Dispersion

1. INTRODUCTION

One of the most interesting materials of the last two decades is allotropic form of carbon – carbon nanotube (CNT). It has unique physical, chemical and structural properties. Especially very high value of electrical and thermal conductivity (3000 – 6000W/mK [1,2]) make them a potential filler in the thermally conductive polymer composite. Effective use of carbon nanotubes as a filler in polymer composition require high degree of their dispersion in composite structure. Carbon nanotubes are introduced into composite as a dispersed suspension in liquid such as water, acetone, alcohols etc.

There methods of dispersion of nanomaterials with high aspect ratio such as carbon nanotubes, nanofibers etc are well known. One of them, widely used method for dispersion of CNTs is sonication [3-5]. Sonication is being subjected to vibration of the particle agglomerates caused by ultrasonics waves, which increase the efficiency of penetration of the agglomerates by the liquid solvent.

The main problem during the dispersion of CNTs in liquids is the formation of agglomerates with submicron size, which are difficult to break. Typical sonicator operate in the range from 20 kHz to 150 kHz. The use of ultrasounds with frequencies in the megahertz range enhances the effectiveness of the solvent interaction with submicron particles. [6-8].

There are known methods for the movement of CNTs by using dielectrophoresis phenomenon in an inhomogeneous electric field [9-12].

In the current paper, the authors propose a new equipment for dispersion of carbon nanotube. The equipment use combined alternating electric field together with mechanical wave from ultrasonic transducer.

2. METHOD AND DEVICE DESCRIPTION FOR THE DISPERSION OF CNTS

The scope of paper are procedure and construction of a system for controllable dispersion of carbon nanotubes in different fluids. However, not only dispersion, but also reverse phenomenon (aggregation) is easy to obtain.

In the Fig. 1 the chamber for efficient CNTs dispersion is presented. Full system consist of (1) the chamber made of stainless steel, (2) the cover made of polytetrafluoroethylene, (3) electrodes, (4) the power supply with controlled electric field intensity and frequency, (5) the ultrasonic/megasonic transducer, (6) the control/driver unit for transducer, (7) the fluid with carbon nanotube and (10) optional heater/-sink.

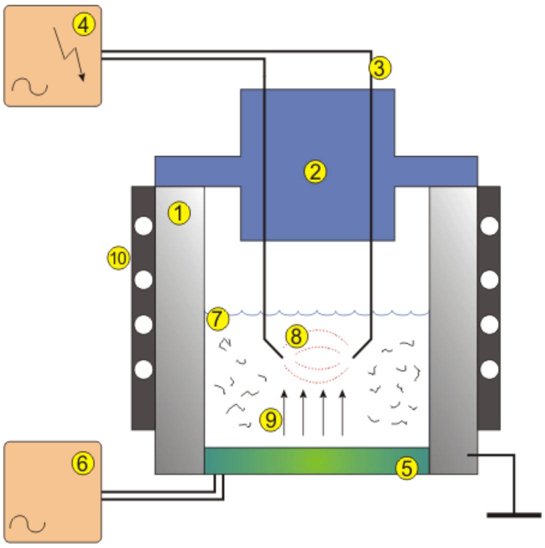

Fig. 1: Diagram of chamber for efficient CNTs dispersion, (1) the chamber made of stainless steel, (2) the cover made of polytetrafluoroethylen, (3) electrodes, (4) the power supply, (5) the ultrasonic/megasonic transducer, (6) the control/driver unit for transducer, (7) the fluid with carbon nanotube, (8) the electric field, (9) the acoustic wave from transducer, (10) the heater/heat - sink.

Combined alternating electric field together with mechanical wave from ultrasonic transducer leads to faster and better dispersion of thrads formulated from CNTs in presence of strong electric field. Both electric field and ultrasonic transducer have controllable frequency and power.
The use of megasonic transducer with shorter wavelength (resonance frequency is 1.65Mhz) rather than typical used (transducers which work in range from 20kHz to 150kHz) improves the dispersion of smaller agglomerates of carbon nanotubes.
Both dispersion and agglomeration of CNTs can be observed while the parameters of electric field are changed. Additionally, different fluids require different frequencies for optimal dispersion ratio.

3. EXPERIMENTS AND RESULTS

The same amount of CNTs (0,01 g) and liquid (10 g) was used in all cases for further comparison. Three different liquids were used: distilled water, acetone, and isopropyl alcohol. 1.65 MHz excitation frequency both for megasound transducer and high voltage power supply was used. To increase the electric field gradient, pair of independent, separated high-voltage-high-frequency (HVHF) converters were used and each one were stimulated in antiphase to another. The amplitude of voltage has been doubled this way and its estimated value was Vp-p= 30 kV. Due to high power density applied to only 10 ml of volume (c.a. 60W for dielectrophoresis and 20 W for megasonic transducer) the power was supplyied periodically to protect the sample from overheating. The dispersion ratio and stability of the solution was subject of evaluation.
For the evaluation of proposed method of dispersion CNTs in fluids the spectrophotometer was used [13].
In the Fig. From 2 to 4 the results of dispersion are presented. The best effect were obtained for distilled water, the worst for acetone. The shelf test for each liquid in the Fig. 5 to 7 are presented.

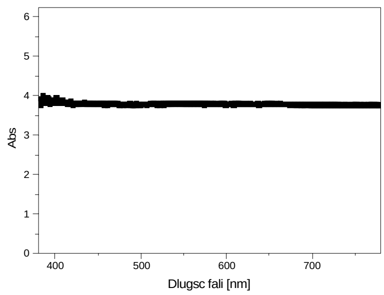

Fig. 2: Absorbance for distilled water in visible range of light.

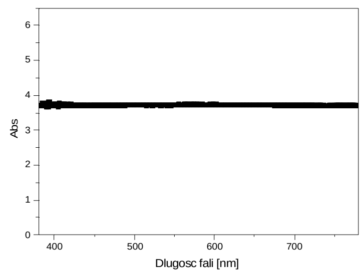

Fig. 3: Absorbance for isopropanol in visible range of light.

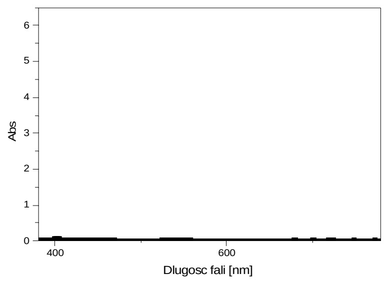

Fig. 4: Absorbance for acetone in visible range of light.

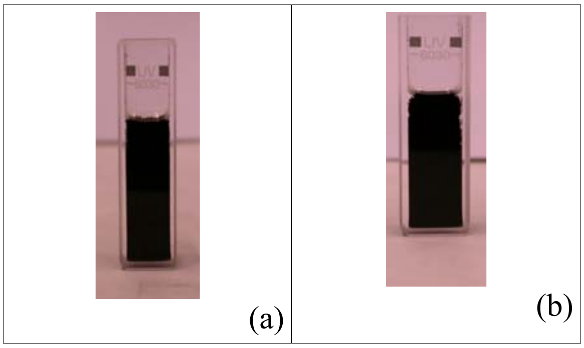

Fig. 5: Shelf test for CNTs dispersed in isopropyl alcohol; (a) just after preparation of suspension and (b) after thirty minutes on shelf.

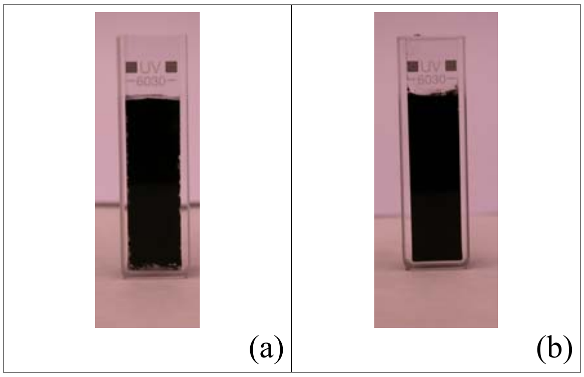

Fig. 6: Shelf test for CNTs dispersed in distilled water; (a) just after preparation of suspension and (b) after thirty minutes on shelf.

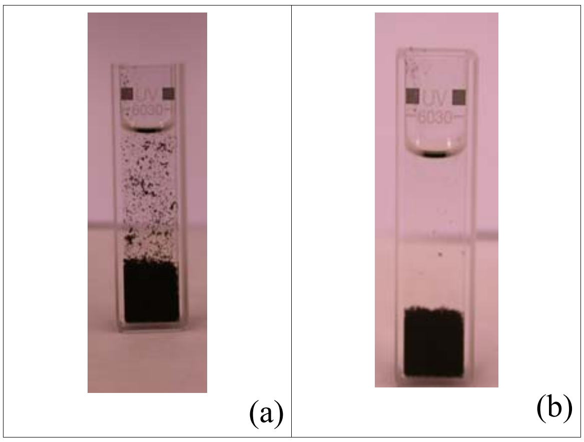

Fig. 7: Shelf test for CNTs dispersed in acetoner; (a) just after preparation of suspension and (b) after thirty minutes on shelf.

4. SUMMARY

The best results were obtained with distilled water - the solution was uniformly black and stayed stable (no sedimentation occurred) for more than thirty minutes. Isopropyl alcohol also gave good results while proposed procedure were used. Unfortunately, acetone which is very popular in preparation of polymers composites seems to be the worst solvent.

ACKNOWLEDGMENTS

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