Dispersion of Multi Wall Carbon Nano Tubes Using Hybrid Surfactants.

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Abstract

Carbon Nano Tubes adhere together due to strong Vander wall forces, so it is inevitable to disperse Carbon Nano Tubes before using them in the cement matrix. In this paper, the dispersion of MWCNTs with Arabic gum, Polycarboxylate ether (PCE) based superplasticizer and both acting concurrently are described. The initial sonicated suspensions were too concentrated; they were diluted according to Lambert beer law to molarity of 0.18, 0.14 and 0.1mg/ml. Ultra Voilet-Visible spectrophotometry technique was used to check the dispersion of diluted samples. The peak absorbance values of Arabic gum, superplasticizer, and their synergistic suspension were measured respectively and a graph of these different surfactants was plotted according to Lambert beer law which depicts maximum dispersion in case of synergistic suspension of both surfactants.

Keywords: Multi-walled carbon nanotubes, Ultraviolet-visible spectrophotometry, Dispersion, Surfactants, dilution.

Introduction:

Carbon nanotubes are held by high Vander wall forces making it inferior soluble in water or organic solvent, resulting in difficulties in the preparation of stable carbon nanotube dispersions. There are many methods used to achieve dispersions like mechanical dispersion (Elias et al., 2005), ultrasonic dispersion (Liang & Li, 2015), chemical modification (Ou et al., 2009), dispersants (Yurekli, Mitchell, & Krishnamoorti, 2004), polymer coating method (Star et al., 2001), and metal coating method (Lordi, Yao, & Wei, 2001), of which the chemical treatment and ultrasonic process will cause damage to the structure of carbon nanotubes (Lu et al., 1996). Depending on the available equipment and needs, the researcher may use any one or combinations of any prior mentioned methods for dispersion of carbon nanotube. Furthermore, any kind of surfactant may be used to help in breaking the pi-pi bond between each layer and keep the individual layer stable.

A homogenous suspension of carbon nanotubes is inevitable for the reinforcing action of carbon nanotubes in the cement mortar. However due to strong van der wall forces in the carbon nanotubes due to its high surface area causes the CNTs to agglomerate together and adhere to form bundles in the matrix, originated from there polarizable extended pi-electron systems. Different techniques are used to disperse carbon nanotubes in the aqueous medium, such as the use of solvents, surfactants, functionalization with acids, amines, fluorine, plasma, microwave, moieties, and non-covalent functionalization. CNTs form agglomerates due to the adhesion between them which is caused by strong Vander wall forces in between the tubes. Surfactants have two characteristic features they adsorb on the interface of the CNTs and self-accumulation into a supramolecular structure.(Vaisman, Wagner, & Marom, 2006).In contrast to covalent sidewall functionalization, the noncovalent can immobilize the organic molecules on the sidewalls of the nanotubes without destroying the geometric and electronic structure of the carbon nanotubes(Zhao, Lu, Han, & Yang, 2003).

The most common method of dispersion employed these days is the use of chemicals in the form of surfactants in conjuncture with ultrasonic energy (Parveen, Rana, & Fangueiro, 2013). However, these chemicals must be very carefully selected as they may sometime interfere with hydration kinetics of cementitious matrices. Various cationic, anionic and non-ionic surfactants have been explored to evaluate their influence on the dispersion of functionalized and unfunctionalized MWCNTs.Arabic gum has also been effectively used as a surfactant to disperse the CNTs. W.Rashmi (Rashmi et al., 2011) reported in his work that significant dispersion of the CNTs can be achieved by the use of Arabic gum as a dispersing agent. They used CNTs 0.01-0.1% by weight of water and Arabic gum in the concentration of 0.25-5% by weight of water. Dispersion can also be achieved by the use of chemical admixtures. Superplasticizer (polycarboxylate based) is commonly used to achieve enhanced workability can also act as an effective dispersant of carbon nanotubes (Collins, Lambert, & Duan, 2012). Ultraviolet-visible spectroscopy (UV-vis spectroscopy) shows a clear difference in dispersion capability of different surfactants. The behavior of dispersion may be governed by the chemical interaction of CNTs and surfactants and electrokinetic properties (Parveen et al., 2013). The phenomenon of proper dispersion of CNTs with the help of a surfactant is also reported by (Sasmal, Bhuvaneshwari, & Iyer, 2013). It is evident from the above discussion that not much work has been done on the dispersion of CNTs in the combination of two or more surfactants. In this research, we try to evaluate the different suspensions containing surfactant individually and their synergistic effect based on their UV-vis spectra.

1. MATERIALS:

The CNT was purchased from SAT nanotechnology material CO. LTD. The properties of carbon nanotubes are listed in Table1. Arabic gum was purchased from the local grocer and later on, was passed through sieve # 200. Similarly, Polycarboxylate ether based superplasticizer (master polyheed 996) conforming to ASTM C-494 and acacia gum was used for dispersion mechanism. The detail properties of acacia gum and superplasticizer are listed in Table 2 and Table 3.

Table 1: Properties of CNTs.

Test items	**Diameter**	**Length**	**Appearance**	**Surface Area**	**Ash**	**Fe**	**Al**	**M**
Test results	10-20nm	10-30um	Blackpowder	90-350m2/g	<2%	0.4%	0.5%	0.2%

Table 2: XRF of Arabic Gum

Analyte	CaO	K_2O	Fe_2O_3	SO_3	MnO	F_2O_5	CuO	TiO_2	ZnO	SrO	Rb_2O
Result(%)	49.748	28.114	8.441	5.108	5.001	1.088	1.009	0.679	0.403	0.258	0.150

Table 3: properties of SP.

Form	**color**	**density**	**PH value**	**Chloride content**
Light	Light Yellow	1.08± 0.02	≥6	Chloride free

3.1 Sample preparation.

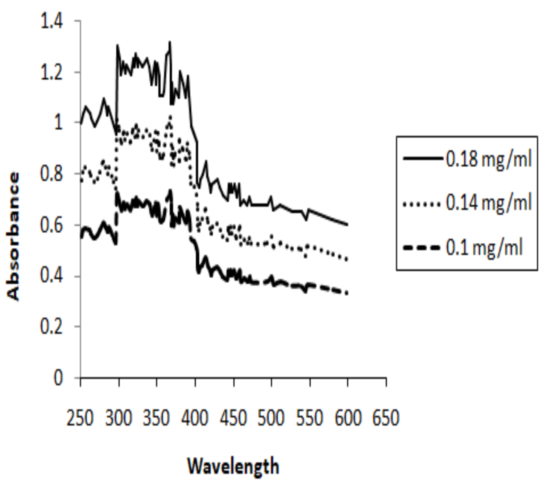
To measure the comparative dispersion of two different surfactants and the combination of these surfactants. Three different composites were made, MWCNTs to water ratio was 0.2% in every composition. In the case of Arabic gum and superplasticizer individual compositions, the ratio of MWCNTs to surfactant was 1:4, while in the case of the combination of both surfactants the ratio was 1:4:4. In which 1 represent MWCNTs and 4 represent Arabic gum and superplasticizer consecutively. The compositions were placed on a magnetic stirrer for 10 minutes. After dispersing the samples with a magnetic stirrer, further dispersion was carried out with the help of a bath sonicator. The samples were placed in the bath sonicator for 1 hour. After sonication, the samples were diluted, and the diluted samples were placed in a spectrophotometer in quartz cuvette to check the absorbance value. The detail process of mixing can be seen in Figure 1.

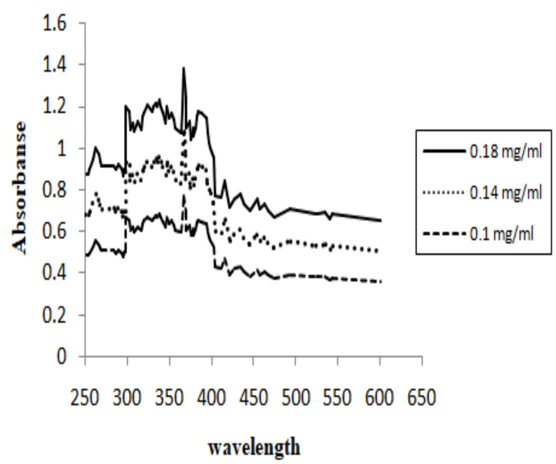
Figure 1: (a) Stirrer mechanism; (b) Bath sonicator

2. Results and discussions:

2.1. Effects of dilution:

The comparative degree of dispersion MWCNTs in an aqueous medium can be judged by the measurements of the UV-Vis spectra of the dispersions since multiwall CNTs show characteristic bands in the UV region(Miyata, Mizuno, & Kataura, 2011; Saito, Fujita, Dresselhaus, & Dresselhaus, 1992). In Ultra Violet-Visible spectrophotometry, the measured absorbance at a specific wavelength can be related to the degree that how much Carbon Nano Tubes are dispersed (Grossiord, Regev, Loos, Meuldijk, & Koning, 2005; Grossiord, van der Schoot, Meuldijk, & Koning, 2007). the three different suspensions after the sonication process were taken for the Ultra Violet-Visible spectrophotometry. The composites were too concentrated that's why they were diluted according to Lambert beer law. Each sample was diluted to get the molarity of 0.18, 0.14 and 0.1mg/ml. quartz cuvette was used because plastic and glass cuvettes don't give significant results in the UV region. The results are shown in Figure 1.





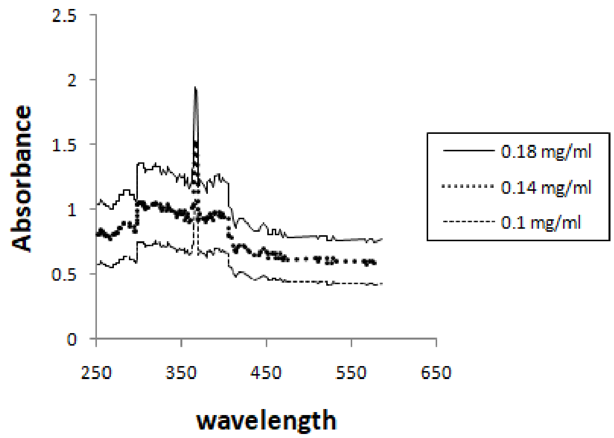


Figure 1: Absorbance spectra of the aqueous solution of CNTs in the presence of, (a) Arabic gum, (b) superplasticizer and (c) Combination of Arabic gum and superplasticizer.

2.2. Effect of surfactants:

From the Lambert beer law equation, the graph for each sample (Arabic gum, superplasticizer, and their combination were plotted). This graph shows the absorbance at 0.18, 0.14 and 0.1mg/ml. The straight line of Arabic gum and superplasticizer is showing maximum slope and depicts maximum absorbance.

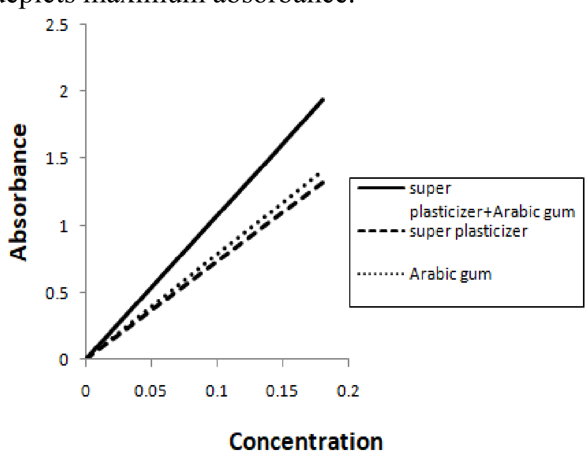


Figure 2: Absorbance spectra at different concentration.

In this study, different surfactants individually and there combined action on the dispersion of MWCNTs in aqueous medium was monitored using the technique of UV-, Visspectrophotometry. From the results, it is quite evident that when both of the surfactants, Arabic gum and superplasticizer were used concurrently the absorbance value was maximum which is a sign of thorough dispersion in comparison to individual action of both surfactants. It can be because of the reason that both surfactants rigorously disperse the MWCNTs, overcoming the Vander wall force. Moreover, the relation between dilution and absorbance in the spectrophotometry is also shown which shows the direct relationship between the concentration and absorbance

Conclusion:

To the authors' knowledge, both of these surfactants had not been used together to disperse carbon nanotubes. The current findings do not only add up to the growing body of the literature on multiwall carbon nanotubes dispersion but also confer the opportunity to perform further extra functionalization steps due to the carboxylate reacting group facing the surface. further, this study concludes that, the peak value at 362 nm wavelength and molarity of 0.18 mg/ml depicts that on comparison synergic composition of both surfactants gives maximum dispersion.

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