REPORT OF RESEARCH RESULTS

Exploration of carbon nanotube-cement composite fabricated for traffic safety application

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Summary

Carbon nanotubes (CNTs) are member of carbonaceous nanomaterials with unique properties of high mechanical strength, superior electrical and thermal conductivity. CNTs could be applied to cement composites for improving the electrical and mechanical properties. Which was used for the real-time monitoring and maintenance of infrastructure and roads to help reduce injuries and casualties due to traffic accidents. In this work, CNTs have been dispersed in water by adding different dispersing agents and characterized by UV-VIS spectrophotometer which was found the sika viscocrete-10TH (0.2% w/w) is the best among others dispersing agent. Prior to being mixed with cement paste with different percent weight ratio of CNTs to cement (0.2%w/w, 0.5%w/w, and 0.75%w/w). CNTs/cement composites would be analyzed by a scanning electron microscope (SEM) a universal mechanical testing machine, and an electro-resistivity meter respectively. SEM revealed the dispersion of CNTs in cement matrix with the usage of the dispersants. Meanwhile, the mechanical strength analyses showed a decrease in compressive strength of the CNTs/cement composites with the increase in the CNT weight ratio. On the other hand, electro-resistivity analyses could confirm the higher conductivity of CNTs/cement composites when the weight ratio of CNTs was increased.

Aim of Research

The main objective of this collaborative project between Chemical and Civil Engineering is to prepare CNTs/cement composites which different weight ratio of CNT and investigate the mechanical property and electrical property of CNTs/cement composites which will be complied with the focus of MSIWF for increasing traffic safety. Experimental works and analyses of resultant samples of the CNTs/cement composites has been conducted in Chulalongkorn University and in collaborative network.

Method of Research & Progression

1.Dispersion of CNTs in water

Carbon nanotubes (CNTs) were dispersed in water by a dispersing agent. 5 types of the dispersing agent which consist ethyl acetate (0.2% w/w), dimethylformamide (0.2% w/w), disodium laureth sulfosuccinate (0.5% w/w), sodium lauryl ether sulfate (SLES) (0.5% w/w) and sika viscocrete-10TH (0.2% w/w) were mixed with 2 g of CNTs in 300 mL of water and sonication for 30 minutes.

2.CNT solution characterization

Carbon nanotube solutions with different dispersing agents which were left for 24 hours in room temperature were characterized by UV-VIS spectrophotometer (SHIMADZU UV-2600) with a wavelength from 200-800 nm for observation of percentage transmission of solution.

3.CNTs/cement composites

CNTs/cement composites were produced by using different percent weight ratio of CNTs to cement (0.2%w/w, 0.5%w/w, and 0.75%w/w). First, CNTs and dispersing agents were added to 300 mL of water. After that, the solution was stirred for 10 minutes, sonicated for 30 minutes, and stirred again for 10 minutes. Next, ordinary Portland cement type 1 was mixed with CNTs solution by mechanical mixing which speeded 140 rpm for 30 seconds and 285 rpm for 150 seconds respectively. CNTs/cement composites paste was poured into mold size 5×5×5 cm^3 and covered by a plastic sheet for 24 hours.

4.CNTs/cement composites test

CNTs/cement composites were characterization by scanning electron microscope with elemental analysis (SEM, Hitachi, S-3500N) for observation of morphology and dispersion of CNTs in cement. Mechanical strength of CNTs/cement composites was measured via compressive machine (TMC 3000 MM) and electrical conductivity of CNTs/cement composites was measured via electro-resistivity meter (CD770 SANWA).

Results of Research

CNT suspension using different dispersing agents was analyzed by UV-Vis spectrophotometer. Degree of dispersion could be interpreted from signal transmittance (%T) as shown in Fig. 1. The transmittance (%T) of CNT suspensions with dimethylformamide and ethyl acetate were around 70-80 % due to settling of CNTs, suggesting the undesired dispersion of CNTs. However, the transmittance of CNTs with sodium lauryl ether sulfate (SLES) and sika viscocrete-10^{TH} were approached 30 % and 0 % respectively. Based on necked-eye observation, CNT suspension using sika viscocrete-10^{TH} exhibited homogeneity when compared to others. Therefore, sika viscocrete-10^{TH} was selected to prepare CNTs/cement composites for analyzing their electroconductivity and compressive strength.

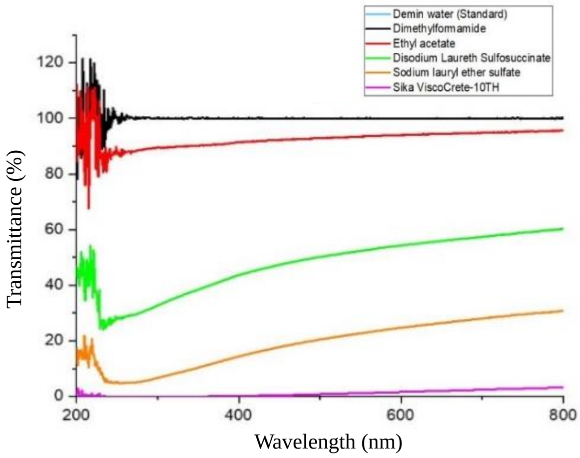

Figure 1 UV transmittance for analyzing dispersion of CNTs in water with different dispersing agents

Morphology and dispersion of CNTs in the resultant composites with different weight ratio of CNTs to cement was analyzed using SEM as shown in Fig 2. (a)-(c). Unless the weight ratio of CNTs were varied, typical SEM images reveals similar appearance of CNTs dispersed evenly in the cement matrix. These qualitative analyses would confirm that CNTs could be uniformly composited with cement by using specific dispersing agent, which was sika viscocrete-10^{TH}.

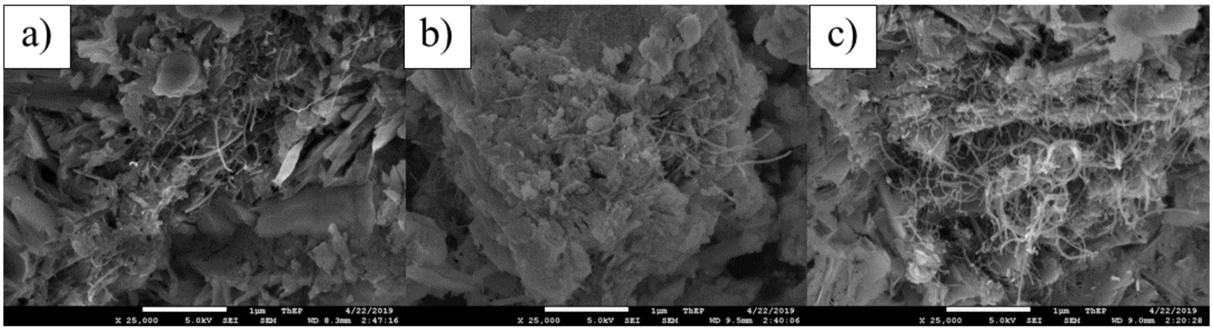

Figure 2 SEM images of CNTs/cement composites at different weight ratio of CNTs to cement a) 0.2%w/w, b) 0.5%w/w, and c) 0.75%w/w

Based on comprehensive analyses, a reversed correlation between compressive strength and electrical conductivity of CNTs/cement composites was confirmed as shown in Fig 3. The compressive strength of CNTs/cement composites became higher when the sample was aged for a longer time period due to the hydration reaction, resulting in lower porosity and higher density (Uddin et al., 2012). However, the compressive strength became lower when the weight ratio of CNTs was increased due to a decrease in cement density. On the other hand, the electrical conductivity of CNTs/cement composites became higher when the weight ratio of CNTs was increased, as the re-arrangement of CNTs in cement took place. When age of sample was longer, water content in the composite was lost due to the dehydration and evaporation from pores of the composite. As a result, the conductive pathway of electrons for current flow was disconnected. Therefore, the electrical conductivity of CNTs/cement composites was decreased due to such disconnection of CNTs (Doo et al., 2017).

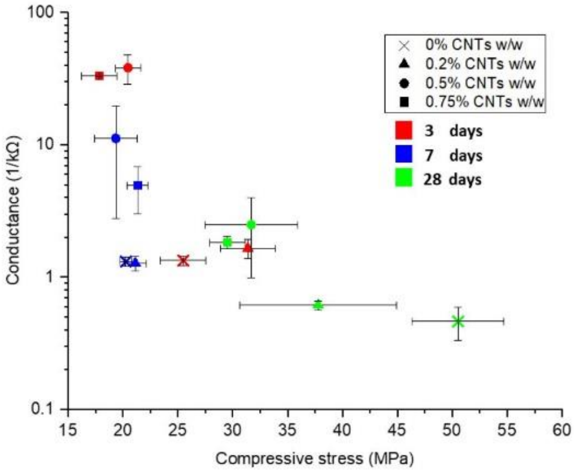

Figure 3 Relationship between compressive stress and electrical conductivity of CNTs/cement composites at different weight ratio of CNTs to cement

Future Areas to Take Note of, and Going Forward

In the future, further investigation on optimizing procedure to produce CNTs/cement composite will be conducted with a focus on finding other chemicals to enhance the conductivity and strength property of the CNTs/cement composite.

Means of Official Announcement of Research Results

Based on our present investigation, our team has been able to officially publish a research paper in *Construction and Building Materials*, which is a journal ranked in top 10% (Tier 1) in the field of Civil Engineering (please refer to the attachment). In this contribution, we found that the addition of 0.1% CNTs improved the compressive strength and permeability of the mortar. Furthermore, CNT/cement composite with a high fire resistance could be developed by adding 0.25% CNTs and 0.2% PP fibers. After being cured to 1,000 °C, the mortar produced with such optimal mix exhibited a residual compressive strength of approximately 40%, which was 19% higher than that observed using plain mortar. Microstructure observations indicated that bridging effect of CNTs and melting of PP fibers work together for improving the fire resistance of composite.

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