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Research Article

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Investigate Manufacturing Hydrogel Nanocomposites Based on Carbon Nanotubes with Various Monomers

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ABSTRACT

The aim of this study is to determine and obtain the optimal amount of materials used in construction of nano-composite, manufacturing hydrogel nanocomposites with carbon nanotubes using different monomers, functionalization of carbon nanotubes for use in situ polymerization and investigate the results obtained of various tests on sample manufacturing. To this aim, the hydrogel nanocomposites were synthesized of polymer N ISO Propyl acrylamide Ku (PVP) using primers ammonium persulfate, methyl grid bis-acrylamide and different amounts of functionalized carbon nanotubes. In tests of inflation done by increasing the carbon nanotubes in the structure of the hydrogel, inflation of samples in water will be less double distilled water. Nano-composite hydrogel structure by FT-IR, SEM is confirmed.

Keywords: Hydrogel; Nanocomposites; Carbon nanotubes

INTRODUCTION

Hydrogels are polymers with high absorption power and three-dimensional network that due to having hydrophilic functional groups in their structure have water holding and absorption capacity and even aqueous solutions under pressure. General properties of hydrogels include amounts of water and aqueous solutions of ability to maintain and its release with improved mechanical and thermal properties, high modulus of rigidity in these nanocomposites causes to be used in various fields including agriculture, pharmaceutical and medicine (Weinand etal, 2006) Due to physical and chemical changes resulting from the increase of carbon nanotubes in the polymer network over their effect is only as a filling. Advanced infrastructures have been always the reliability to justify the effort and cost for finding modern sciences and exploration (Kuchak Zaiy et al., 2013). The progress of science and technology in various fields caused the emerging technology of nanotechnology. Production capabilities of lighter and stronger industrial materials and products, programmable and intelligent, reduce costs, increase service life, new tools and systems is used as wearable non-invasive tool in the hands of the real molecular levels (Liyaghati and et al., 2011). Tuberculosis is generally stable suspension of colloidal solid particles or polymers that are placed in liquid. These particles can be amorphous or crystalline. Solid colloidal nano-sized particles that are formed through two reactions, simply Tuberculosis is a mixture of solids with different sizes and between 1 and 100 nm in water that are not deposited (bmecenter.ir) Carbon nanotubes can act as metals or semiconductors, according to the structure have size and rotation of metallic or semiconducting properties. Set the size, structure and topology of nanotubes causes to create important mechanical and surface properties in these compounds. Carbon nanotube structure is made entirely of sp^2 hybrid carbons that considerably are stronger than sp3 hybrid carbons in diamond. In fact, carbon nanotubes have good chemical stability and have a unique tensile strength (100 times greater than steel and 10 times stronger than kelvar (brand for synthetic fibers of polyamide para.)) And high Young's modulus (modulus of elasticity: ratio of stress to strain of linear solid material on the bottom of the yield strength, yield strength: the tension that causes to start plastic deformation or flow of material to be 7 times more than steel). In addition, carbon nanotubes with a surface area to m^2g^{-1} 1500 is lighter than aluminum and at temperatures above 1000 ° C has thermal stability and its thermal conductivity is WmK^{-1}6000 that is double diamond (Bakshi, 2010) It is important that electrons move differently in the nanotube depending on the arrangement of the carbon nanotubes that creates a metallic or semiconductor properties in this material (Mittal etal, 2006) Considering above, the overall objective of this study is to determine and obtain the optimal amount of materials used in construction of nano-composite, manufacturing hydrogel nanocomposites with carbon nanotubes using different monomers, functionalization of carbon nanotubes for use in situ polymerization and investigate the results obtained of various tests on sample manufacturing. Given the excellent properties of nano especially carbon nanotubes and use in various combinations has created many applications in the field.

MATERIALS AND METHODS

For carrying out the synthesis and investigating the properties of nanocomposite hydrogels poly (N Iso Propyl acrylamide Kuo (PVP)) based on carbon nanotube, experiments have been conducted in several stages. The structure of Polyvinylpyrrolidone (PVP) is in a way that can be used as drug carriers in chemotherapy guided by magnetic (Agarwal et al, 2001). In this issue, first four hydrogel samples using different percentages of Polyvinylpyrrolidone (PVP) and Acrylic acid and methylene bis-acrylamide connection was made in situ polymerization method and using UV drug release aminophylline of the four hydrogels in PH = 7.4 was measured as well as the positive effect of polyvinylpyrrolidone (PVP) in the release were determined and then were able to obtain two kinetics models and a model of transfer mass to compare the penetration for these hydrogels that is well matched with the experimental data (etal, 1999 Carino). In this scheme, polymerization reaction was conducted by ammonium persulfate (APS).

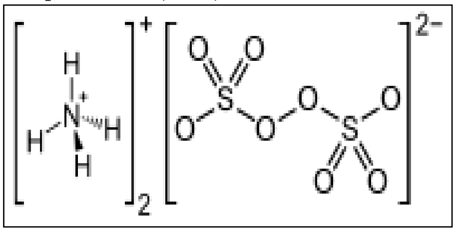

Figure 1: Ammonium persulfate structure (Macromo, 1994)

Also, in this project, a network of several vinyl called methylene bis-acrylamide is used. First, to get a better composition of the hydrogel, the experiments table were designed and change the inflation properties of the hydrogel due to change the materials were examined. In this study the properties of chemicals used for the manufacture of nanocomposite hydrogels based on carbon nanotubes in Table 1 are briefly mentioned.

Table 1: Ingredients used in tests for the manufacure of the hydrogel matrix

Chemical name	Chemical formula	Molecular mass (g / mol)	Appearance	Density (g / ml)	Manufacturer Company	Application in material
Carbon nanotubes	C	12	Black powder	-	Merck	Nanoparticles
Ammonium persulfate (APS)	$NH_4)_2S_2O_8)$	228.18	Yellowish-white crystals	1.98	Merck	primer
Methylene bis-acrylamide (MBA)	$C_7H_{10}N_2O_2$	154.17	White powder	1.235	Merck	Network construction
Poly-N- isopropyl acrylamide (PNIPAM)	$CHCONHCH(CH_3)_2$	113.16	White crystals	-	Merck	The main monomers
1 Vinyl 2 (PVP)	C_6H_9NO	111.14	Colorless liquid	1.043	Merck	The main monomers
Distilled water	H_{2O}	18.01	Colorless liquid	1	-	Base

In this study, various equipment and devices are used for testing that is explained briefly below: digital scale, magnetic stirrer, Ultrasonic bath (ultrasonic bath used in this research Parsonic 2600s and product of Iran's Pars Nahand), Avon, PH meter, infrared spectrometer (Spectrum Device) devices of infrared spectroscopy used in this research, including tuberculosis ATR Vector 33 model and made in Brussels Germany, vegetative electron microscope; For sample preparation put nano composites made in liquid nitrogen and fracture it and prepare surface of fracture to SEM test. To test the research, microscope used model VEGA TS 5166MM made in Tescan company of Czech Republic and device of deposition model DSR 1 DC SPUTTERING made in Company of nanostructured coatings is a the device of deposition.

Preparation of hydrogel and investigation of its related properties

The method of preparing hydrogel base (without CNTs):

Specified amount of each monomer should be solved in a certain amount of distilled water and transferred into the beaker and put it in the ultrasonic bath to obtain a homogeneous solution. After complete dissolution, a specified amount of the grid methylene bis-acrylamide added and given the time to it to be fully solved.

After complete dissolution of the material, a certain size of the solution 30% weight radical initiator of ammonium sulfate added to the reaction beaker and put it in a water bath at 70° C and hydrogel was formed after 20 to 30 minutes. To complete the polymerization, hydrogel remained in flux for 24 hours. Remove the hydrogel and was placed in distilled water for 24 hours to remove the unreacted monomers from it. Next, hydrogel for 2 days was placed in the oven with a temperature of 30 ° C to be dried completely.

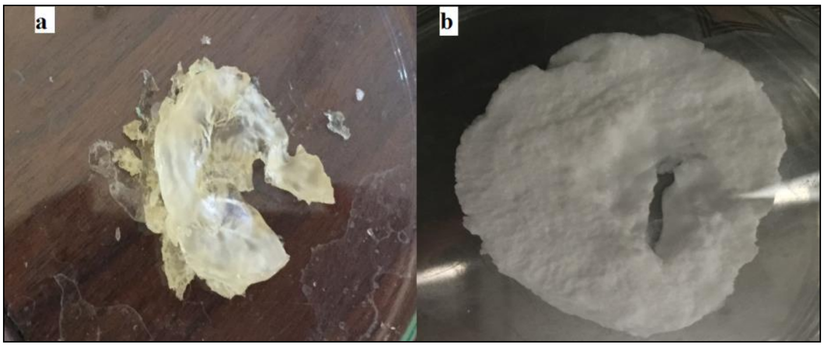

Figure 2: Basic hydrogel: (a) hydrogel after forming, (b) hydrogel after drying

Method of preparation of nanocomposite hydrogels

By selecting the best combination for the synthesis of the original matrix, according to the steps outlined for the preparation of hydrogel should be acted then carbon nanotube material functionalized added and the suspension is mixed for 20 minutes.

Functionalization of carbon nanotubes

2 g of crude carbon nanotubes with 30 ml of 60% nitric acid should be transferred in 100 mL balloons, balloon door be closed and inside the machine placed ultrasonic waves with a frequency of 40 kHz put for 30 minutes. After 20 hours of stirring and refluxing balloon with its contents on the heater, the contents should be smoothed onto the filter paper with mesh 0.22 micrometre and until PH sample to 7 washed with distilled water. The sample is placed for 24 hours at 60 ° C oven to be dried the sample.

We pour 1 g of dried sample with 20 ml of thionyl chloride poured inside ballon and we uniform for 24 h at 70°C, then smooth on the filter 0.22 micrometers using vacuum pump. Dry sample filtered should be poured into 100 ml balloon and with 40 ml of pure ethylene glycol for 48 hours at 120 ° C using a mixer be shacked.

At the end, from the filter paper with a mesh 0.22 micrometre, contents of balloon should be smoothed and washed with polar organic solvent THF.

Investigating inflation properties of hydrogel

Some of hydrogels dried using digital scales should be weighed and placed inside the beaker containing 30 ml of distilled water at 37 ° C.

At regular intervals, inflated hydrogel should be brought out of solution and using paper towel dried its surface moisture and we weigh it. In order to check inflation, measure was up to 5 hours. By repeating the measurement after 24 hours, the equilibrium inflation rate will be determined.

The following formula is used to calculate the inflation rate:

$$ESR = (W_{st} - W_d) / W_d$$

W_{st} and W_d, respectively, are inflated sample weight at time t and the initial weight of the dry sample.

RESULTS

The analysis of results of investigating inflation behavior of hydrogel

According to the chart (1) the tendency of water uptake by the hydrogel (without CNTs) increases over time, also according to the survey conducted in chart (2) the inflation behavior of hydrogel nanocomposite with carbon nanotube increases by passing time.

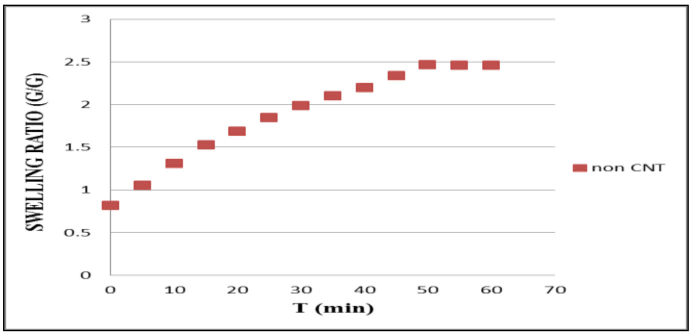

Chart 1: Investigating the inflation behavior of nanocomposite hydrogels without carbon nanotube

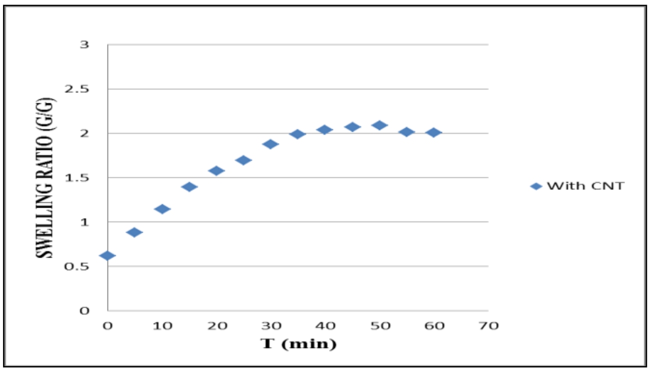

Chart 2: Investigating the inflation behavior of hydrogel nanocomposites with carbon nanotubes

Based on the drawn samples in Figures 1 and 2, hydrogel environment without the carbon nanotubes absorb more water from the hydrogel with Carbon Nanotubes, which shows the more inflation behavior of the hydrogels than hydrogel with carbon nanotubes.

Analysis of Infrared Spectroscopy (FT-IR)

Of all the physical properties of an organic compound, a property that alone provides the most information about the combination structure is the infrared spectrum. Change the vibrations of a molecule by absorption of infrared light, the light in the visible spectrum is after red (lower frequency, longer wavelength, lower energy) is indicative of a desired compound structure, in this study to approve the chemical structure of hydrogels synthesized FT-IR infrared spectrum was used.

Nanocomposite hydrogels infrared spectrum without CNTs

Infrared spectrum of nanocomposite hydrogels without carbon nanotube:

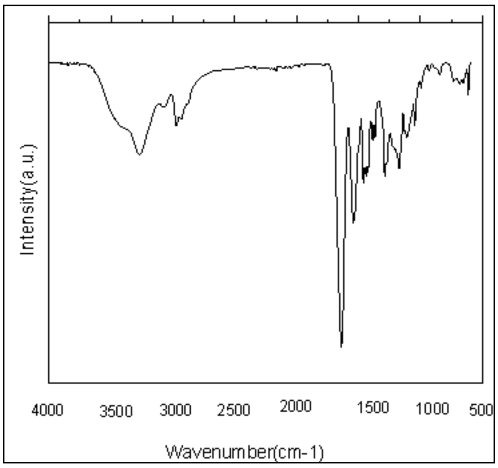

Figure 3: FT-IR spectrum of nanocomposite hydrogels without a carbon nanotube

Infrared spectrum of hydrogel nanocomposites based on carbon nanotubes:

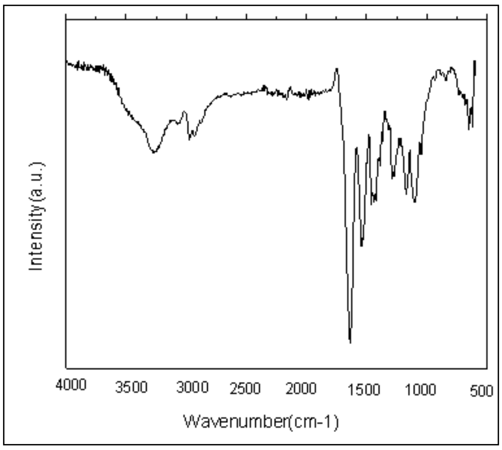

Figure 4: FT-IR spectra of hydrogel nanocomposite with carbon nanotube

In the infrared spectrum 2500 cm^{-1} peak carbonyl group and in the area of 2800 to 3000 cm^{-1} is related to the alkyl groups in the structure. In the area of 3100 to 3500 cm^{-1} related to amine groups grid.

Morphology of hydrogels synthesized

Morphology of four samples of prepared hydrogels was studied using electron microscopy which is as follows. Particle size in the following form states that the more the inflation rate of the hydrogel increases, the rate of water absorption into the hydrogel network is more and causes to increase the particle size. Network structure and its polarity is an important factor in determining the rate of inflation of network and water infiltration into the network. Figure 5 a in zoom of 500 nm shows that carbon nanotube well located in the hydrogel. Figure 5b shows the structure of the hydrogel formed which shows uniformity of structure.

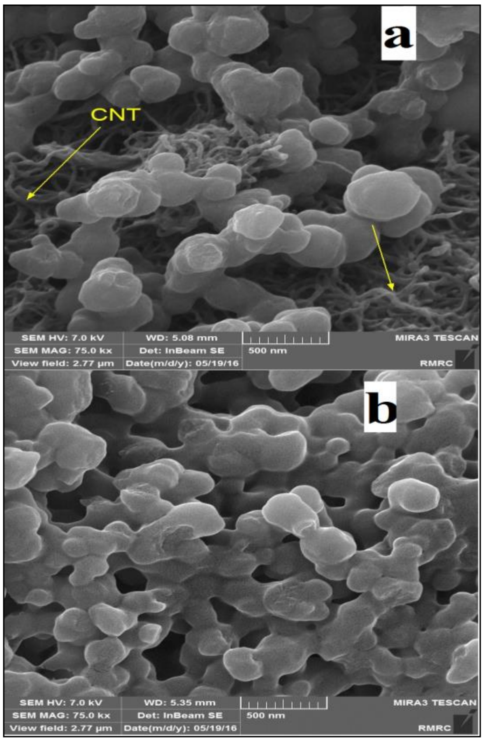

Figure 5: Morphology of the nanocomposite hydrogels at 500 nm (A) based on carbon nanotubes (b) without carbon nanotubes

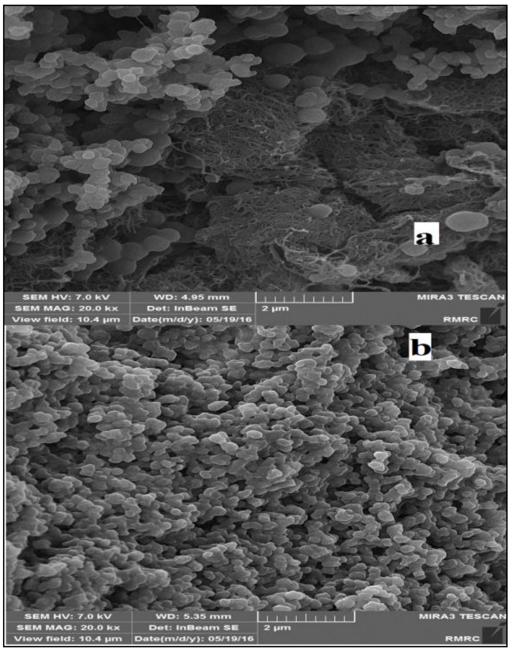

Figure 6: Morphology of the nanocomposite hydrogels in 2 micrometers (a) based on carbon nanotubes (b) without carbon nanotubes

As can be seen in Figure 6, the presence of carbon nanotubes in nano-composite hydrogel is evaluated in Zoom 2 micrometers. Uniformity of the structure and the presence of carbon nanotubes within the hydrogel indicate that nano-composite hydrogel is formed.

CONCLUSION

Hydrogels have porous sufficient space to absorb water. Since the hydrogel has a high porosity and very fragile structure and more inclined to state of powder, it is needed to use the carbon nanotube for the strength of the hydrogel.

Carbon nanotubes fill a part of empty space between the polymer tissues of hydrogel and reduce the number of polymer units among connections have an indirect effect on elastic property of chain and the free volume available for water molecules penetrate into the network is reduced. As a result, the presence of carbon nanotubes has great influence on the inflation behavior of network and absorbs less water.

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