

The investigation of functionalization role in multi-walled carbon nanotubes dispersion by surfactants

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Abstract

Dispersibility and stability of chemical functionalized multi-walled carbon nanotubes (f-MWCNTs) in aqueous solution by using small amount of a cationic ionic liquid (IL), 1-tetradecyl-3-methylimidazolium Chloride, [C₁₄mim]Cl, was investigated and was compared with unfunctionalized MWNTs. The surface modification of MWCNTs was done by acid treatment. The f-MWCNTs are extensively characterized by using FT-IR spectroscopy. Using UV-vis spectroscopy was proved that the presence of functional group on the side wall of MWCNTs significantly affected their dispersibility in an aqueous solution which contains a small amount of imidazolium based IL as dispersing agent.

Keywords: Multi Walled Carbon Nanotubes, functionalized Carbon Nanotubes, Dispersion, Imidazolium based Ionic Liquid

1. Introduction

Since their discovery by Iijima in 1991[1], CNTs have attracted a lot of attention to themselves, due to their unique electrical, thermal and mechanical properties [2-4,11]. However, Because of

the strong intrinsic van der Waals forces, CNTs tend to aggregate and entangle together spontaneously [5], which is the major limitation to their practical applications. So it seems that dispersing CNTs as individual tubes being a sufficient solution for overcoming to this problem and using the unique properties of CNTs. The important issue is attempting to have a homogeneous dispersion of CNTs. For dispersing CNTs in aqueous media usually two approaches are used: Firstly, chemical functionalization of CNTs by introducing polar groups such as carboxyl groups in order to achieve better dispersibility in water [6,10]. Second, physical functionalization of CNTs by adsorption of surfactants and polymers to decrease the van der Waals interaction and improve the dispersibility of the CNTs [7,10].

Recently Room Temperature Ionic Liquids (RT-ILs) with unique physicochemical properties such as wide liquid temperature range, high thermal stability, negligible vapor pressure, high viscosity, negligible vapor pressure, non flammability, increased electrochemical window, and relatively high ionic conductivity have attracted considerable attention as novel materials to dispersing CNTs [8]. So ILs are a kind of surfactant and were used for physical functionalization of CNTs to disperse them in aqueous solutions. In this paper, we use both physical and chemical functionalization of nanotubes simultaneously to investigate the dispersibility and stability of f-MWNTs in comparison with unfunctionalized ones in aqueous media containing cationic ILs.

2. Experimental

2.1. Functionalization and preparation of suspensions

1-tetradecyl-3-methylimidazolium Chloride was synthesized by Dr. Sharifi in Chemistry and Chemical Engineering Research Center of Iran. Multi walled Carbon Nanotubes (MWCNTs)

were purchased from Arkema. The pristine MWCNTs were chemically functionalized with a 3:1 mixture of concentrated sulfuric acid and nitric acid. After that, the sample was washed with distilled water, then filtered and dried overnight. Finally MWCNTs-COOH was characterized with FT-IR measurements on a Shimadzu S8400 Fourier transform infrared spectrometer.

The suspensions of MWCNTs were prepared by adding equal amounts of pristine CNTs and f-MWCNTs into 1-tetradecyl-3-methylimidazolium Chloride IL aqueous solution. These were sonicated by probe sonicator (UP 400S, Hielscher Ultrasound Technology, Germany). The resulting suspensions were centrifuged to sedimentation of bundles. Then the suspensions were characterized by UV-vis (UV mini, 1240, Shimadzu, Japan).

3. Results and Discussion

Fig. 1 shows the FT-IR spectra of pristine MWCNTs and the f-MWCNTs. A peak around 1714-1726 cm^{-1} appears in the spectra of MWCNTs-COOH that can be attributed to the C=O stretching of carboxylic acid group. Peaks at 1034 and 3435 cm^{-1} were observed that can be assigned to C-O and OH stretching vibrations of carboxylic acid group, respectively [9]

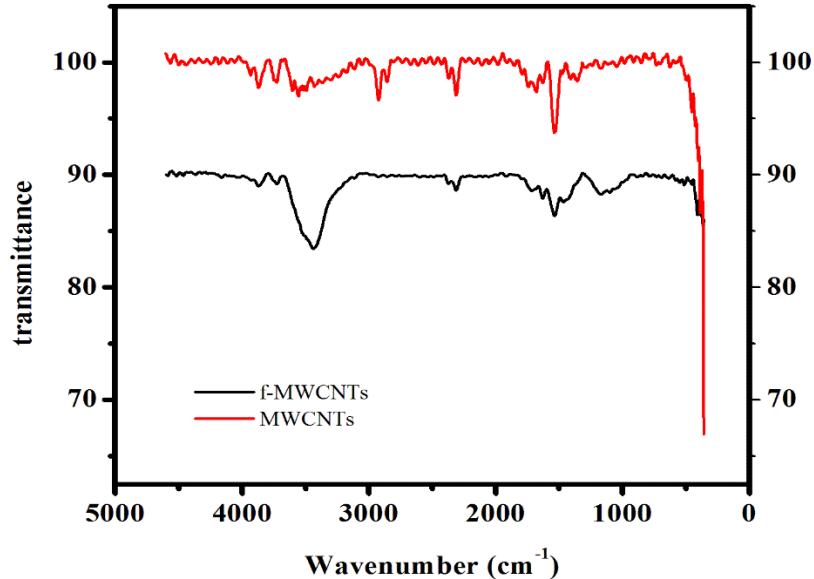


Fig1. FT-IR spectra of MWCNTs and f-MWCNTs

Individualized CNTs are active in the UV-Vis region and exhibit characteristic bands corresponding to additional absorption due to 1D Van Hove singularities, therefore UV-vis spectra can give valuable information about the evaluation of the degree of dispersion of CNTs in aqueous media. Fig.2 shows the UV-vis spectra of [C₁₄mim]Cl -stabilized f-MWCNT dispersion, compared with pristine MWCNTs. The strong peak around 260 nm, approved that CNTs were successfully dispersed in [C₁₄mim]Cl aqueous solution. The increasing in the absorption peak intensity of f-MWCNTs suspension indicates that the dispersion of functionalized nanotubes was enhanced in compared with unfunctionalized nanotubes in the same IL aqueous solutions. This could be due to the presence of polar functional groups on the surface of nanotubes, which can increase the dispersibility of nanotubes .this increasing has a good agreement with other evidences which proved the effect of side wall modification in dispersing of CNTs.

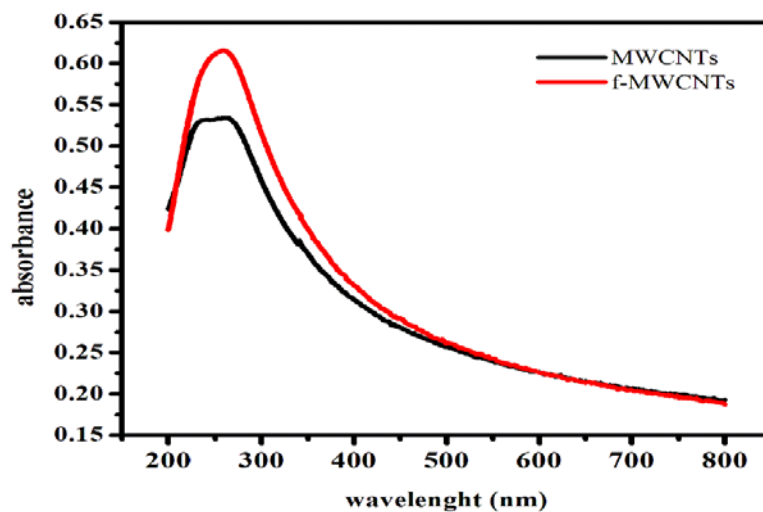


Fig2. UV-vis-NIR spectra of MWCNTs and f-MWCNTs suspensions dispersed in [C₁₄mim]Cl aqueous solution.

4. Conclusion

The ionic liquids can disperse pristine MWCNTs effectively in aqueous solution alone. But the presence of functional groups on nanotubes surface can help them and increase the dispersibility of nanotubes. According to the UV-vis spectra absorption peaks, the greater dispersion of f-MWCNTs in [C₁₄mim]Cl aqueous solution compared with unfunctionalized MWNTs, was attributed to the polar functional groups on nanotubes surface.

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