



Effect of Surfactant Concentration on the Characteristics of Polyaniline Nanocomposite

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Polyaniline nanocomposite was prepared by chemical oxidative polymerization of aniline using $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ as an oxidant in the presence of sodium dodecylbenzenesulfonate (DBSNa) as surfactant. The product was characterized in terms of morphology with scanning electron microscopy and chemical structure by fourier transform infrared spectroscopy.

Key Words: Polyaniline, Nanocomposite, Surfactant, Morphology, Particle size.

INTRODUCTION

Polyaniline (PAn) has attracted considerable attention because of its unique electrical, optical and electrooptical properties and its numerous potential applications¹. Specific applications of conductive polymers are used in optical devices, antistatic materials, corrosion protection, *etc.* For many of them, a necessary condition is that the properties of polyaniline are sufficiently constant as a function of time and under different conditions. In such cases polyaniline is used as a passive electroactive material whose properties are not externally controlled². Extensive research has been directed toward the improvement of the processability of polyaniline by copolymerization with substituted aniline^{3,4} or doping polyaniline with stable functionalized protonic acid^{5,6}. Conducting polymers have various applications such as rechargeable batteries⁷, electromagnetic interfluence (EMI) shielding⁸, antistatic coatings⁹, gas sensors¹⁰, optical devices¹¹, removal of heavy metal from water and wastewater¹², *etc.* Another approach to enhance the processability of polyaniline is a composite method using various polymeric materials¹³. Two types of polyaniline composites are available according to the polymerization of polyaniline such as post-polymerization and *in situ* polymerization. The post-polymerization method implies that chemically synthesized polyaniline is dispersed in a polymer matrix under either a solution state or a molten state of matrix. Nonetheless, since the doped polyaniline salt is hydrophilic with a high surface energy, it is hard to disperse directly the polyaniline in polymer matrices such as polystyrene and poly(methyl methacrylate). Considering the dispersion of polyaniline, the *in situ* polymerization is superior to the post-polymerization method.

Generally, aniline is polymerized within an aqueous acidic solution containing a suitable polymeric stabilizer in the *in situ* polymerization method. Water soluble polymers such as PVA¹⁴, poly(vinyl pyrrolidone)¹⁴ and PSSA¹⁴ have been used as stabilizers for the *in situ* polymerization method. After the polymerization, stable polyaniline dispersions are generally obtained, in which the polyaniline particles in the order of 100 nm are finely dispersed in an aqueous medium. Shape of the polyaniline particles depends on the stabilizer used and polymerization conditions. The polyaniline dispersion can be directly casted to form a composite film, in which uniform distribution of polyaniline nanoparticles is maintained in the composite film. It is also noted that the composite films containing polyaniline nanoparticles often show low percolation threshold of particle¹⁵.

EXPERIMENTAL

The monomer aniline (reagent grade) was distilled into colourless under reduced pressure prior to use. Other chemicals were reagent grade and used as received without further treatment. All of the aqueous solutions were prepared with double distilled water.

Synthesis: The reaction was carried out at room temperature for 5 h. Optimal conditions for composite formation are summarized in Table-1. In a typical experiment 1 mL aniline monomer was added to stirred aqueous solution (100 mL) containing 1 g of $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ and various concentration (0.1-0.4 g) of sodium dodecylbenzenesulfonate. After 5 h, the polymer was filtered and in order to separate the oligomers and impurities, the product was washed several times with deionized water. It was then dried at room temperature.

TABLE-2
YIELD AND PARTICLE SIZE AND CONCENTRATION OF SURFACTANTS

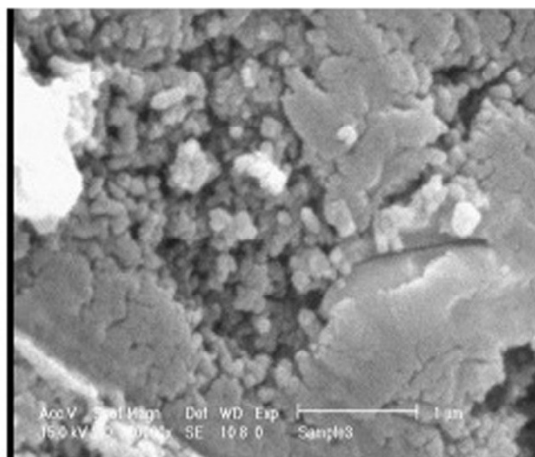
Type of surfactant	Type and concentration of oxidant (g/L)	concentration of surfactant (g/L)	Yield of monomer to polymer (% w/w)	Particle size (nm)
–	$((\text{NH}_4)_2\text{S}_2\text{O}_8) = 10$	–	85	95
DBSNa	$((\text{NH}_4)_2\text{S}_2\text{O}_8) = 10$	1	74	85
DBSNa	$((\text{NH}_4)_2\text{S}_2\text{O}_8) = 10$	2	69	80
DBSNa	$((\text{NH}_4)_2\text{S}_2\text{O}_8) = 10$	4	55	80

RESULTS AND DISCUSSION

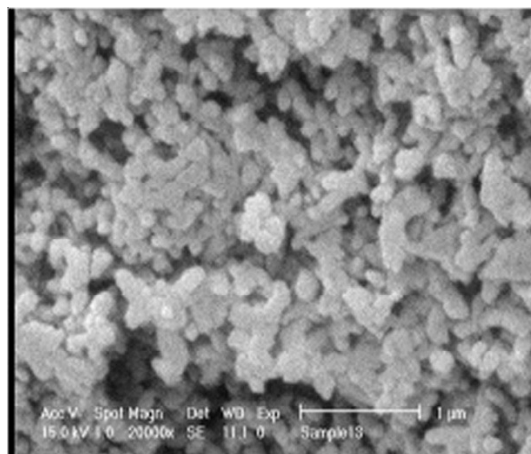
As can be seen in Table-1, the yield and particle size are *in situ* dependent on the concentration of surfactant that by increasing the concentration of surfactant yield and particle size will decrease.

The morphology of the nanocomposite was characterized by using scanning electron microscope. As shown in Fig. 1a-d, the homogeneity of particles is dependent on the concentration of surfactant. As can be seen in micrographs, the nanocomposites obtained using surfactants (sodium dodecylbenzenesulfonate, 0.1-0.4) exhibits spherical particles. It is apparent that using surfactant decreases the tendency to form agglomerates which leads to more homogeneous distribution, because surfactant prevent from gross aggregation of particles. As can be seen in table, particle size decreases by increasing surfactant concentration. The structure of obtained product was determined by FTIR spectrum. The FTIR spectroscopy has provided valuable information regarding the formation of polyaniline composites. FTIR analysis has been done to identify the characteristic peaks of product.

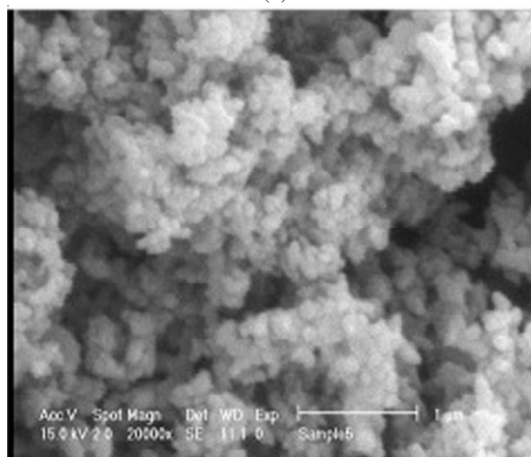
FTIR spectra in the $2500\text{-}400\text{ cm}^{-1}$ region, for polyaniline nanocomposite is shown in Fig. 2a-d. As can be seen, the FTIR spectrum changes greatly and gradually as the composite is formed using various concentrations surfactant. For instance, pure polyaniline (Fig. 2a) shows the presence of characteristic absorption bands at 1566 cm^{-1} (C=C stretching vibration of the quinoid ring), 1486 cm^{-1} (stretching vibration of C=C of the benzenoid ring), 1304 cm^{-1} (C-N stretching vibration), 1130 cm^{-1} (C-H in-plane deformation), 811 cm^{-1} (C-H out-of-plane deformation).



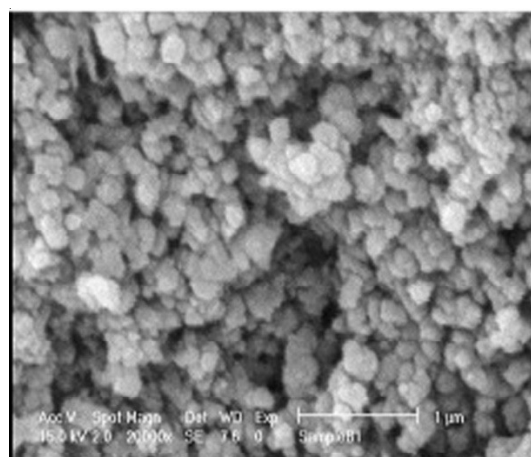
(a)



(b)



(c)



(d)

Fig. 1. (a) SEM micrographs of polyaniline; (b) composites polyaniline/DBSNa (1 g/L); (c) polyaniline/DBSNa (2 g/L) and (d) polyaniline/DBSNa (4 g/L)

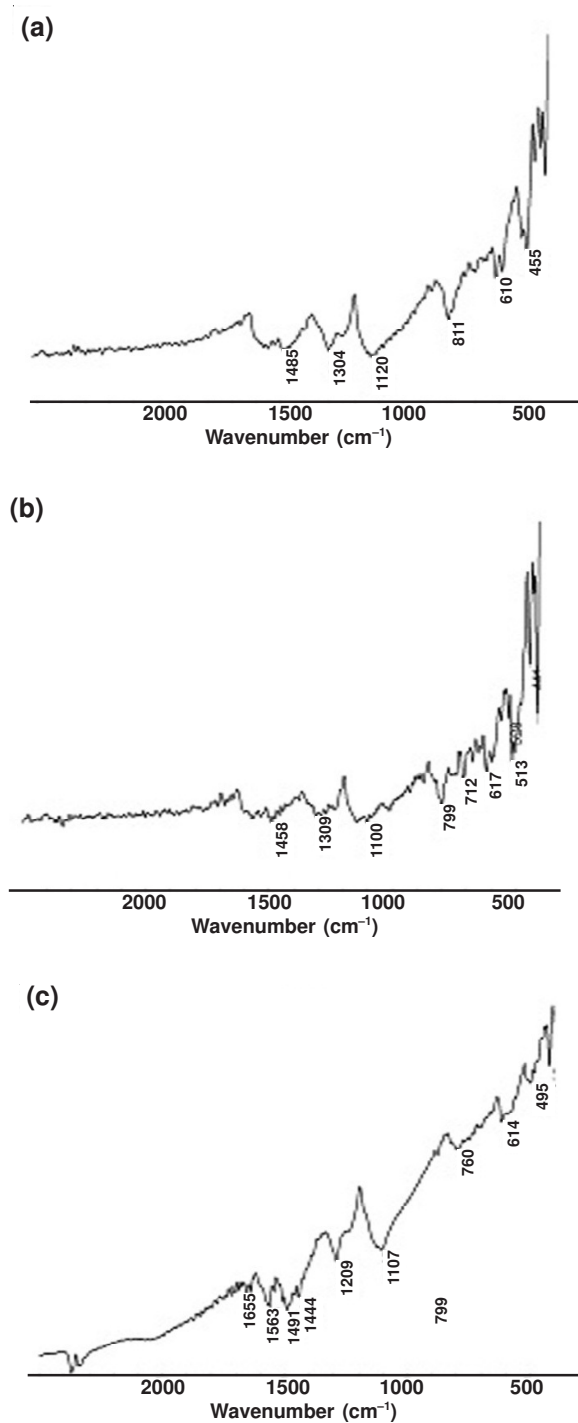


Fig. 2. (a) FTIR spectra of polyaniline; (b) composites polyaniline/DBSNa (1 g/L); (c) polyaniline/DBSNa (2 g/L) and (d) polyaniline/DBSNa (4 g/L)

Conclusion

In this study, polyaniline nanocomposite was prepared by chemical oxidative polymerization of aniline using $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ as an oxidant in the presence of sodium dodecylbenzene-sulfonate (DBSNa) as surfactant. It was found that the concentration of surfactant has a considerable effect on the particle size and morphology of the resulting product which is probably due to the adsorption of the surfactant to polymer physically and due to the influence of surfactant on the chemical and physical properties of the solution. The chemical structures of the products were determined by FTIR spectroscopy. The results indicate that the intensity of the peaks is dependent on the concentration of surfactant.

REFERENCES

1. W.R. Salaneck, I. Lundstrom, W.S. Huang and A.G. MacDiarmid, *Synth. Met.*, **13**, 291 (1986).
2. T. Vikki, J. Ruokolainen, T. Ikkala, P. Passiniemi, H. Isotalo, M. Torkkeli and R. Serimaa, *Macromolecules*, **30**, 4064 (1997).
3. S. Wang, F. Wang and X. Ge, *Synth. Met.*, **16**, 99 (1986).
4. M.T. Nguyen, P. Kasal, J.L. Miller and A.F. Diaz, *Macromolecules*, **27**, 3625 (1994).
5. Y. Cao, P. Smith and A.J. Heeger, *Synth. Met.*, **48**, 91 (1992).
6. A. Andreatta and P. Smith, *Synth. Met.*, **55**, 1017 (1993).
7. N. Li, J.Y. Lee and L.H. Ong, *J. Appl. Electrochem.*, **22**, 512 (1992).
8. A.J. Epstein and A.G. Macdiarmid, *Synth. Met.*, **69**, 179 (1995).
9. A. Ohtani, M. Abe, M. Ezoe, T. Dio, T. Miyata and A. Miyke, *Synth. Met.*, **57**, 3696 (1993).
10. M. Matsuguchi, J. Io, G. Sugiyama and Y. Sakai, *Synth. Met.*, **128**, 15 (2002).
11. E.H. Falcao and W.M. De Azevedo, *Synth. Met.*, **128**, 149 (2002).
12. H. Eisazadeh, *J. Chin. Polym. Sci.*, **25**, 393 (2007).
13. J. Anand, S. Palaniappan and D.N. Sathyanarayana, *Polym. Sci.*, **23**, 993 (1998).
14. S. Adhikari and P. Banerji, *Synth. Met.*, **159**, 2519 (2009).
15. L. Sun, H. Liu, R. Clark and S.C. Yang, *Synth. Met.*, **84**, 67 (1997).