



## Preparation of Polyaniline Nanocomposites Using Various Surfactants

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In this study, polyaniline nanocomposites were prepared in aqueous and aqueous/non-aqueous media by using ammonium peroxy disulphate as an oxidant in presence of various surfactants such as sodium dodecylbenzenesulfonate and hydroxypropyl cellulose. Morphology, particle size, yield and chemical structure of products were characterized by using scanning electron microscope and fourier transform infrared. The results indicate that the morphology, yield and particle size of products are dependent on the type of surfactant. The results also show that the intensity of peaks is dependent on the type of surfactant.

**Key Words:** Nanocomposites, Surfactant, Chemical structure, Morphology.

### INTRODUCTION

In recent years, intrinsic electrically conductive polymers have been studied extensively because of their potential applications in light-emitting diodes, batteries, electromagnetic shielding, antistatic coatings, gas sensors and activators<sup>1-3</sup>.

The main disadvantage of the conducting polymer, however, is poor processability both in melt and solution processing due to its stiffness of the backbone. To overcome this disadvantage, many works have been done, such as substitution of alkyl chain. On the aromatic ring or nitrogen atom, copolymerization with aliphatic monomers, making blends or composites with other conventional polymers and preparation of dispersed colloidal particles<sup>4-7</sup>.

One of the conducting polymers that has attracted considerable interest in the last few years is polyaniline. Polyaniline seems to be one of the best candidates for the preparation of polymer-based conducting polymer composites. It is stable in a normal atmosphere and recently, significant progress has been achieved in the preparation of processable forms of polyaniline<sup>8,9</sup>. One of the key problems related to the potential applications of polyaniline is its processability. Processability is an important requirement in conducting polymers for their possible commercial use. Since most of the conducting polymers are not processable, much of the efforts made in this field have been directed towards circumventing this problem. To solve this problem, various approaches have been tried, including addition of side groups

to the polymer backbone<sup>10</sup>, grafting of polymers to a non-conducting polymer<sup>11</sup>, direct polymerization of intractable polymers into the final desired shape, making a composite of blend of conducting polymers<sup>12,13</sup> and copolymerization<sup>14,15</sup>. Foremost among the current commercial ventures are applications of conducting polymers in energy storage devices such as rechargeable batteries<sup>16</sup>, electromagnetic interference (EMI) shielding<sup>19</sup>, antistatic coatings<sup>18</sup>, gas sensors<sup>19</sup>, optical devices<sup>20</sup>, etc.

In this study polyaniline nanocomposites were prepared in the aqueous and aqueous/non-aqueous media in presence of sodium dodecylbenzenesulfonate and hydroxypropyl cellulose, by using ammonium peroxy disulphate as an oxidant.

### EXPERIMENTAL

A magnetic mixer model MK20, digital scale model FR 200, scanning electron microscope (SEM) model XL30 and fourier transform infrared (FTIR) spectrometer model Shimadzu 4100 were employed.

Materials used in this work were aniline (extra pure > 99 %,  $d = 1.02 \text{ g/cm}^3$ , Merck), hydroxypropylcellulose (HPC,  $M_w = 10^6$ ) from Aldrich, sodium dodecylbenzenesulfonate (DBSNa) from Loba chemie, sulfuric acid and ammonium peroxy disulphate from Merck. All reagents were used as received without further purification, unless stated otherwise. Distilled deionized water was used throughout this work. Aniline monomer was purified by simple distillation.

**Preparation of polyaniline nanocomposite:** The reaction was carried out in aqueous media at room temperature for 5 h.

TABLE-1  
PREPARATION CONDITIONS AND TYPE OF SOLUTIONS ON THE PARTICLE SIZE AND YIELD OF PRODUCTS

Type of solution	Type of surfactant	Concentration of surfactant (g/L)	Yield of 1 g monomer to polymer (g)	Particle size (nm)
Water	–	–	87	113
Water	Dodecylbenzenesulfonate sodium	2	80	97
Water	Hydroxypropyl cellulose	2	82	84
Water + Toluene (50/50 % v/v)	–	–	78	93
Water + Toluene (50/50 % v/v)	Dodecylbenzenesulfonate sodium	2	75	74
Water + Toluene (50/50 % v/v)	Hydroxypropyl cellulose	2	76	81

The conditions for nanocomposite formation are summarized in Table-1.

In a typical experiment, aniline monomer (1 mL) was added to stirred aqueous solution (100 mL) of sulfuric acid (1 M) containing 1 g of  $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ . 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 temperature *ca.* 60 °C in oven for 24 h.

## RESULTS AND DISCUSSION

As polyaniline is molecular composite containing a cationic polymer backbone, dopant must be incorporated for maintenance of charge neutrality. As a result, it is expected that the chemical and physical properties of the doped polyaniline will be affected by dopant<sup>21</sup>.

The morphology of nanocomposites was studied, using scanning electron microscope. As shown in Figs. 1-6, the size and homogeneity of particles are dependent on the type of surfactant. Polyaniline particles synthesized without surfactant is shown in Fig. 1. As can be seen in micrographs, the composite obtained using surfactants (DBSNa and HPC) 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

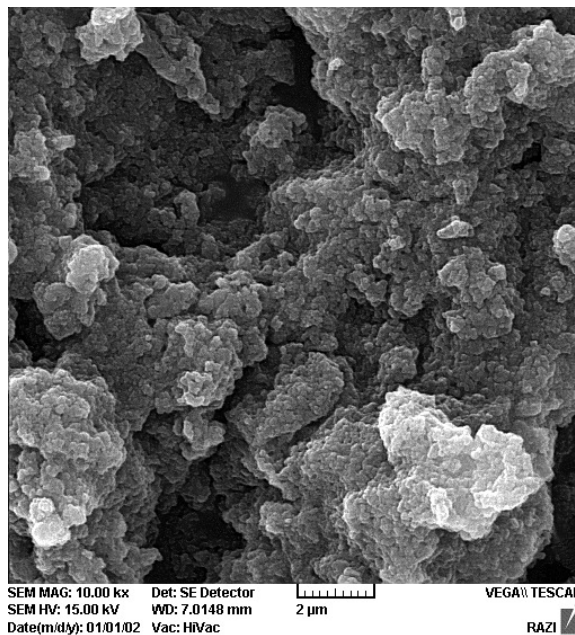


Fig. 2. Scanning electron micrograph of polyaniline in aqueous media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, sodium dodecylbenzenesulfonate = 2 g/L, volume of solution 100 mL, reaction time 5 h at room temperature)

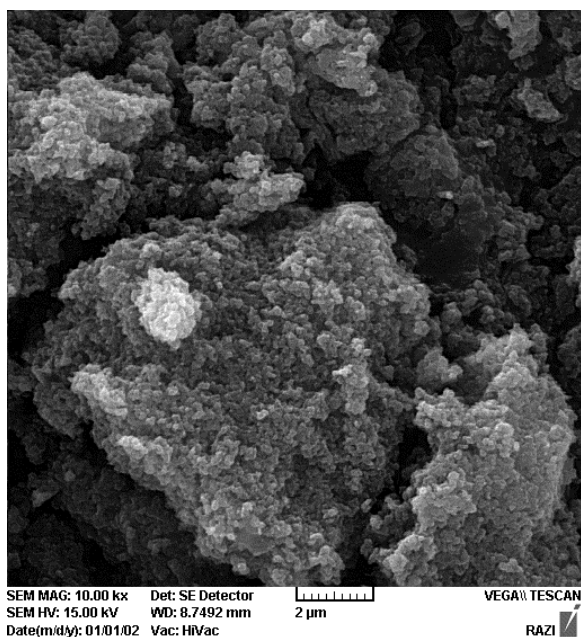


Fig. 1. Scanning electron micrograph of polyaniline in aqueous media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, volume of solution 100 mL, reaction time 5 h at room temperature)

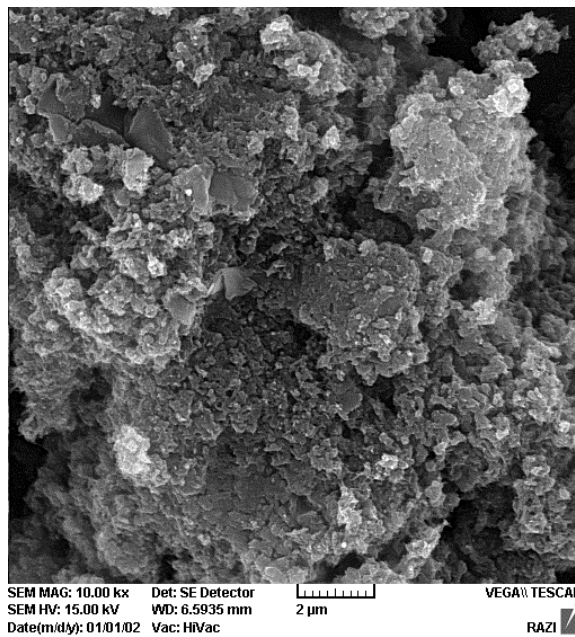


Fig. 3. Scanning electron micrograph of polyaniline in aqueous media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, hydroxypropyl cellulose = 2 g/L, volume of solution 100 mL, reaction time 5 h at room temperature)



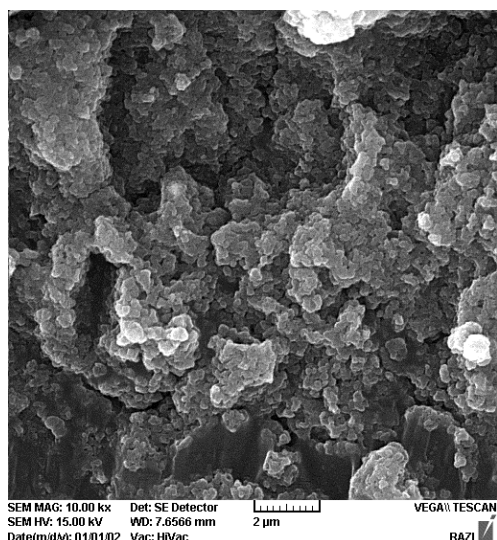


Fig. 4. Scanning electron micrograph of polyaniline in aqueous/non-aqueous (water/toluene) media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, volume of solution 100 mL (50/50 % v/v), reaction time 5 h at room temperature)

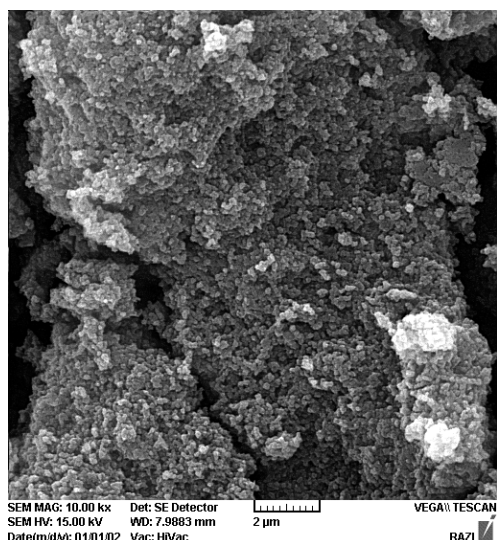


Fig. 5. Scanning electron micrograph of polyaniline in aqueous/non-aqueous (water/toluene) media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, sodium dodecylbenzenesulfonate = 2 g/L, volume of solution 100 mL (50/50 % v/v), reaction time 5 h at room temperature)

aggregation of particles. As can be seen in table, particle size decreases using various surfactants. The size of particles also related to the type of surfactant.

The FTIR spectrum changes appreciably and gradually as the composite is formed using various solutions. For instance, pure polyaniline shows the presence of characteristic absorption bands at  $1559 \text{ cm}^{-1}$  (C=C stretching vibration of the quinoid ring),  $1472 \text{ cm}^{-1}$  (stretching vibration of C=C of the benzenoid ring),  $1303 \text{ cm}^{-1}$  (C-N stretching vibration),  $1129 \text{ cm}^{-1}$  (C-H in-plane deformation),  $809 \text{ cm}^{-1}$  (C-H out-of-plane deformation).

## Conclusion

In this work the characteristics of polyaniline nanocomposites such as morphology, chemical structure and particle

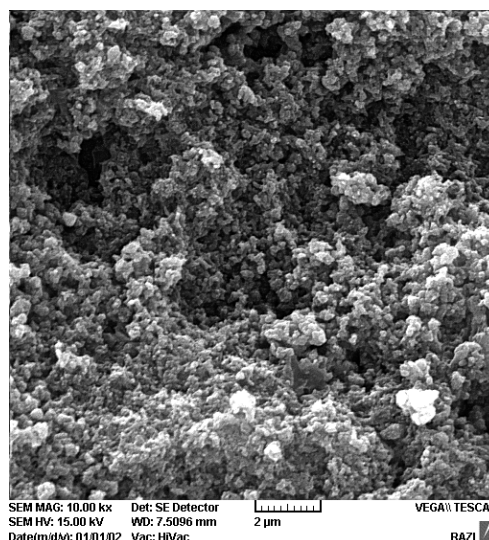


Fig. 6. Scanning electron micrograph of polyaniline in aqueous/non-aqueous (water/toluene) media. Reaction conditions: (ammonium peroxy disulphate = 10 g/L, aniline monomer  $10.75 \times 10^{-2}$  mol/L, hydroxypropylcellulose = 2 g/L, volume of solution 100 mL (50/50 % v/v), reaction time 5 h at room temperature)

size were investigated using various surfactants. It was found that, the type of surfactant has considerable effect on the size, homogeneity, size distribution and morphology of resultant product which is probably due to additive absorption. Spherical nanoparticles were obtained using DBSNa and HPC as surfactant. The structure of products was determined by FTIR spectrum. The results indicate that the intensity of peaks related to the type of surfactant.

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