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CONDUCTING POLYMER COMPOSITE USING IONIC INTERACTION

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Abstract Conducting polymer composite has been prepared by the polymerization of pyrrole on the poly(amideimide) (PAI) matrix film. In order to enhance the electrostatic interaction between the two phases, sulfonate (SO_3^-) group was introduced into the PAI structure. The presence of electrostatic interaction between conducting polypyrrole and sulfonated PAI has been monitored by the examination of the morphology, mechanical and electrical properties on the varying degrees of conducting polymer composition. As a result, sulfonated-PAI/ polypyrrole composite exhibits superior electrical and morphological properties to PAI/polypyrrole system.

INTRODUCTION

Conducting polymers exhibit the excellent electrical properties, however, common usage of this materials has been restricted due to the poor processability and stability.[1] Various techniques have been introduced to enhance the processability, which include the modification of monomer structure, utilization of soluble precursor, and the preparations of the blend or composite.[2-4] Polymer blend or composite formation is one of the simplest method to provide processability on the conducting polymer. In the process of blend or composite formation using incompatible components, as the composition of one component increases, the phase separation occurs to result in the ultimate mechanical failure. In this regards, it should be stressed that the phase separation should be suppressed in order to provide the desirable properties. The utilization of anion containing polymer as a matrix material is based on the introduction of the coulombic interaction with cation containing conducting polymer. The ionic interaction between the two phases allows the incorporation of more amount of conducting polymers without phase separation as well as regular dispersion of the conducting polymer into the matrix. These advantages would provide the composite with the better properties and long term

stability. In this study, PAI has been used as a matrix material which is an amorphous polymer having excellent mechanical and thermal properties. The PAI structure has been modified to have anionic moieties and sulfonated PAI/polypyrrole (SPAI/PPy) composite has been prepared by polymerization of pyrrole on the matrix film. The effect of the ionic groups in the matrix on the morphological, thermal, and electrical properties has been examined.

EXPERIMENTAL

The sulfonated PAI was synthesized by the method of Lee et al.[5] SPAI/pyrrole composite film was prepared as follows: Thin films of SPAI having 50~200 μm thickness were prepared by solution casting using DMF solvent. The matrix films were immersed in pyrrole/acetonitrile solution (10/90, V/V) for 9 hrs and subsequently immersed in aqueous $FeCl_3$ oxidant solution. Produced SPAI/PPy composite was washed methanol and dried 50°C in vacuuo

RESULTS AND DISCUSSIONS

The incorporation of sulfonate group into the PAI resulted in the inferior thermal stability to that of PAI. A weight loss (ca. 10 %) after the onset of decomposition at 230°C occured due to the loss of the sulfonatopropyl groups. The incorporation of sulfonate group into the PAI structure caused in the solubility change. SPAI with ca. 40 % sulfonation degree is soluble in m-cresol, water/THF, and chlorobenzene.

The formation of SPAI/PPy composite was confirmed by FT-IR and UV/VIS spectroscopy as shown in Figure 1 and 2. In FT-IR spectrum, the appearance of new absorption band at 3490 cm^{-1} is assigned to N-H stretching of polypyrrole. UV/VIS spectra show peak absorptions at 440 nm for π-π^* transition and 800~900 nm due to charge carriers formation.

The morphology of the composite film was monitored by SEM. The PPy domain in the PAI and SPAI matrix are shown in Figure 3. The former system shows large aggregate of PPy, on the other hand, the latter one exhibits evenly dispersed fine particles of PPy. This is conceivably due to the coulombic interaction between the anion containing matrix and cation containing PPy. Thermal stability of composite shows similar trend of degradation compared to that of matrix.

The electrical conductivity of PPy depends on the polymerization conditions,

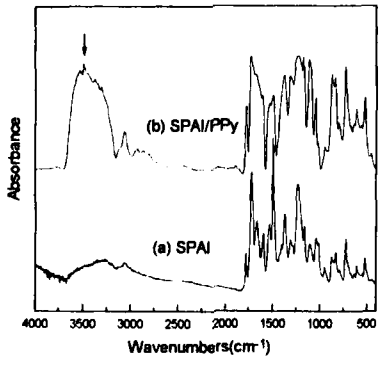


FIGURE 1 FT-IR spectra of the SPAI/PPy composite.

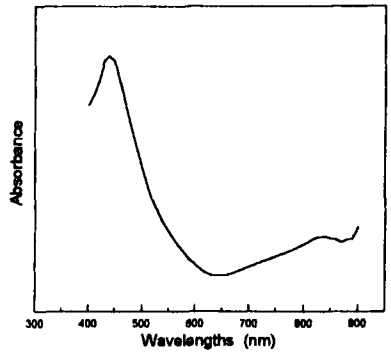
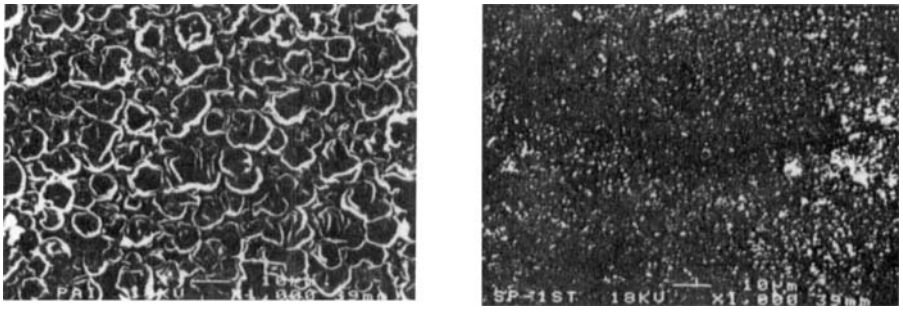


FIGURE 2 UV/VIS spectra of the SPAI/PPy composite.



(a) PAI/PPy (b) SPAI/PPy

FIGURE 3 SEM images of composites: (a) PAI/PPy, (b) SPAI/PPy.

such as oxidant, solvent system, reaction temperature, monomer/oxidant ratio. In this study, pyrrole is polymerized using $FeCl_3$ oxidant, and oxidation potential is controlled using acetonitrile/MeOH cosolvent system. Figure 4 shows the diagram of conductivity variation with reaction time allowed for polymerization. After 30 min. reaction, conductivity reaches up to 7×10^{-2} S/cm without further increase. The conductivity of the PAI/PPy composite film was too low to compare with that of SPAI/PPy composite. In order to get the information of dopant composition, the composite film was analyzed by energy dispersive spectroscopy. In PAI/PPy composite, only $FeCl_4^-$ can act as a

dopant anion, however, dopant composition in SPAI/PPy composite appears $FeCl_{1.5}(SO_3^-)_{2.5}$. This data reveals that sulfonate group in SPAI acts as a major dopant. The polymeric dopant system exhibits better morphological, electrical properties of the composite.

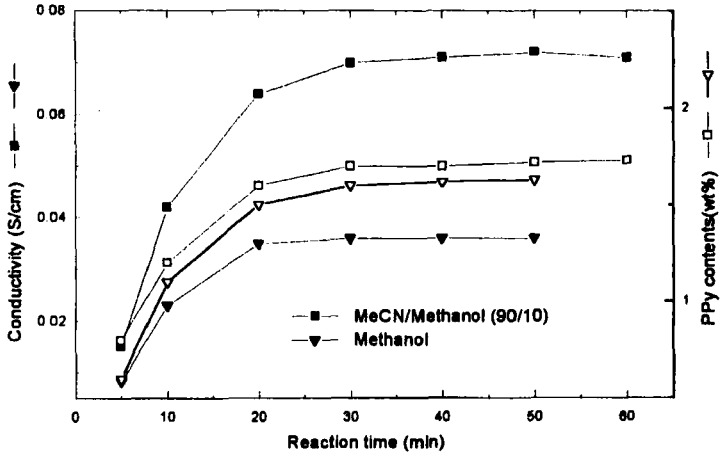


FIGURE 4 Conductivity of the SPAI/PPy composite.

CONCLUSION

Conducting polymer composite of SPAI/PPy was prepared by polymerization of pyrrole on the sulfonated poly(amideimide) matrix film. Incorporation of anionic moieties in the matirx film causes electrostatic interaction between the conducting PPy and anioin containing SPAI matix. The special interaction between the two phases resulted in the better morphological and electrical properties on the composite film.

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