POLYPYRROLE NANOPARTICLE DISPERSIONS FOR ORGANIC ELECTRONICS APPLICATIONS

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Intrinsically conducting polymer (ICPs), such as polypyrrole (PPy), polyaniline (PAni), and poly(ethylendioxythiophene) (PEDOT), are generally difficult to process because of their insolubility in common solvents. The preparation of aqueous dispersions of ICPs is a common way to overcome this problem since colloidal dispersions may often be used instead of real solutions. Polypyrrole dispersions are commonly prepared by chemical oxidative polymerization of pyrrole in water in the presence of a polymeric steric stabilizer [1]. By using different water soluble polymers during the polymerization such as poly(vinyl alcohol), poly(ethylene oxide), poly(N-vinylpirrolidone) or cellulose derivatives, macroscopic precipitation of the ICP could be prevented and submicrometer dispersions are then obtained [2]. For emerging applications [3] such as Nanoelectronics further improvement in the control of PPy particle size and polydispersity as well as electrical conductivity and deposition methods are certainly required.

This work reports preliminary synthesis results of new polypyrrole nanoparticle dispersions for potential use in Organic Electronics applications. The control of the PPy nanoparticle size is carried out both by means of sonochemical procedures and the use of appropriate steric stabilizers. Hence, synthesis of several PPy dispersion has been performed using ultrasound irradiation (Ultrasonic Processor UP 400S from Dr Hielscher GmbH) in the presence of ammonium peroxydisulfate, as oxidant, and several mixtures of poly(vinyl sulfonate) (PVS) and poly(styrene sulfonate) (PSS) steric stabilizers at 7º C. The stoichiometry of the PPy synthesis reaction in the presence of a mixture of the above steric stabilizers is summarized in Scheme 1.

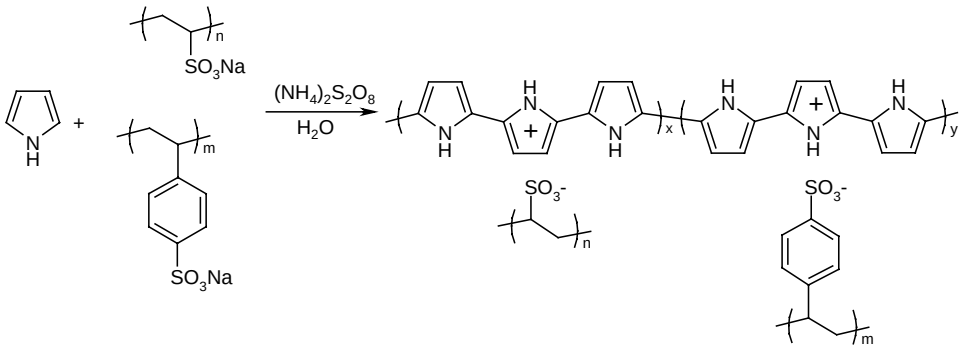
When 100 % PVS is used, macroscopic precipitation of the resulting PPy particles is experimentally found. The conductivity of the PPy-PVS powder was 3.8 S/cm. By using a 50 / 50 wt % PVS / PSS mixture during the synthesis, a bimodal distribution of PPy particle sizes is observed in Dynamic Light Scattering experiments (Beckman Coulter N5 Submicron Particle Size Analyzer) with two peaks centered at 75 and 300 nm, respectively (Figure 1). The conductivity of a PPy film formed from the above mentioned dispersion was 0.016 S/cm. Conversely, when 100 % PSS is employed only a single peak centered at 53 nm is found (see Figure 2). The conductivity of the PPy-PSS film was 0.033 S/cm.

According to these results, the presence of poly(styrene sulfonate) in the media improve the stability of the dispersions. When PVS / PSS mixtures are used different stabilization mechanisms are probably involved. We can speculate that both PPy nanoparticles stabilized by PSS (75 nm) as well as PPy nanoparticles stabilized by a combination of PVS and PSS (300 nm) are then obtained. AFM studies are in progress to investigate the morphology of the new PPy nanoparticle dispersions and their conducting films with potential use in Organic Electronic applications.

References:

[1] S.P. Armes, B. Vincent, Chem. Commun. **4** (1987) 228
[2] J. Stejskal, J. Polym. Mater. **18** (2001) 225
[3] J. A. Pomposo, E. Ochoteco, C. Pozo, P. M. Carrasco, H. J.Grande, F. J. Rodríguez, Polym. Adv. Technol. **17** (2006) 26

Schemes:



Scheme 1. Simplified picture of the PPy synthesis reaction scheme in the presence of a mixture of PVS / PSS steric stabilizers.

Figures:

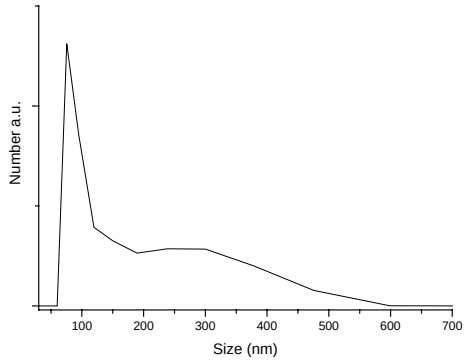


Figure 1. Distribution of particle sizes in PPy dispersions prepared using a 50 / 50 wt % PVS / PSS mixture of steric stabilizers during the synthesis. A bimodal distribution is found with two peaks centered at 75 and 300 nm, respectively.

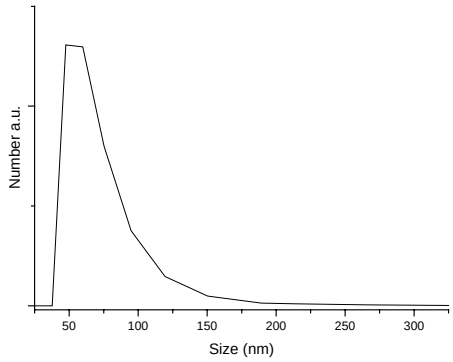


Figure 2. Distribution of particle sizes in PPy dispersions prepared using PSS as steric stabilizer during the synthesis. A unimodal distribution is found with the peak centered at 53 nm.