Synthesis and Characterization of Multilayered and Mixed Conductive Copolymer Nanoparticles

Tanvi Pande, Dr. William Ames
Department of Chemistry, Juniata College, Huntingdon, PA 16652

Introduction

The synthesis of polythiophene and polypyrrole copolymer nanoparticles by chemical oxidation is reported. Thiophene, pyrrole and furan belong to a classification of organic compounds called metalloles in which the carbon atom at position 5 is replaced by a heteroatom. The nature of the heteroatom determines the properties of the metallole, which can be exploited in molecular electronics, UV/ NIR shielding and other chemical, biological and physical applications. In this study thiophene, pyrrole and furan multilayered and mixed copolymers combine and thus enhance the properties of the metallole nanoparticles that are synthesized. This allows for widening the scope for more novel applications. The metallole copolymer nanoparticles are synthesized in the presence of $CuCl_2$ or $FeCl_3$, which acts as a catalyst, at 50°C. Sodium dodecyl sulfate (SDS) is used as a templating agent for the formation of spherical nanoparticles. Mixed, layered, and pure metallole nanoparticles are made using different ratios of thiophene, pyrrole and furan. Characterizations of the obtained copolymers are performed by solubility tests, UV–Vis and IR spectroscopies, scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS).

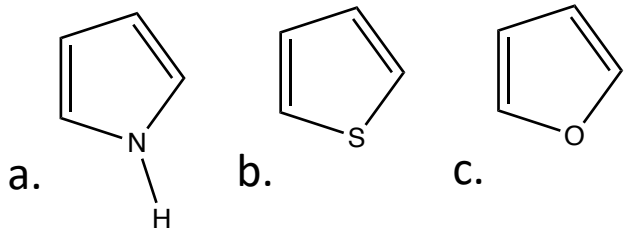

Fig 1. a. pyrrole, b. thiophene and c. furan

Method

60ml of DI H_2O and 0.1g SDS and 2g Metallole (1.9 ml Thiophene, 2.07 ml Pyrrole, 2.1 ml Furan) were mixed in a 250 ml Erlenmeyer flask at 300 rpm and at 50 °C for 20 mins. This allows the metalloles into the SDS micelles.

The catalyst and oxidant are added next. 6.2 ml of 30% H_2O_2, 0.05 g of copper (II) nitrate trihydrate dissolved in 5ml H_2O or 0.05g of iron (III) chloride hexahydrate are added to the mixture. The mixture is left on heat and stirring for 7 hrs.

These steps are repeated till the desired number of layers are formed. Salt is added to the solution to allow it to displace the nanoparticles from the solvent. The solution is centrifuged at 2000rpm (for pyrrole) and faster (for thiophene) for 20 mins and washed with DI water a couple times. Vacuum filtration is performed on the solution with DI water to remove excess solvent and salt. The nanoparticle sludge collected is heated at 150 °C at 25 torr till dry.

The nanoparticles are analyzed using IR-Spectroscopy and coated with a conductive layer of carbene and then sizing analysis is done under the SEM.

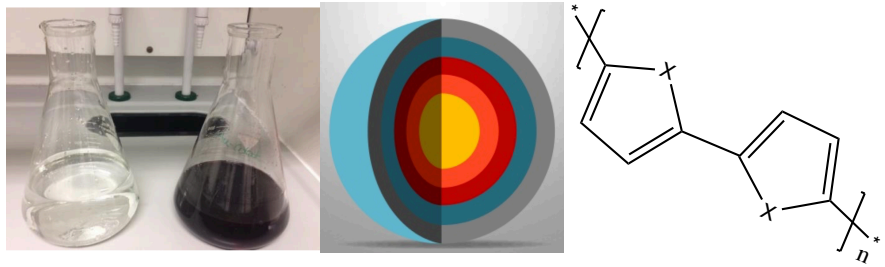

Fig 2. a. before and after images of the nanoparticle solution, b. schematic diagram of the layered nanoparticle, c. polypyrrole

Results

The nanoparticles that were synthesized were dissolved in water and other organic solvents to test-out their solubility in different solvents. Further SEM and IR Spectroscopy analysis was done. The results shown below:

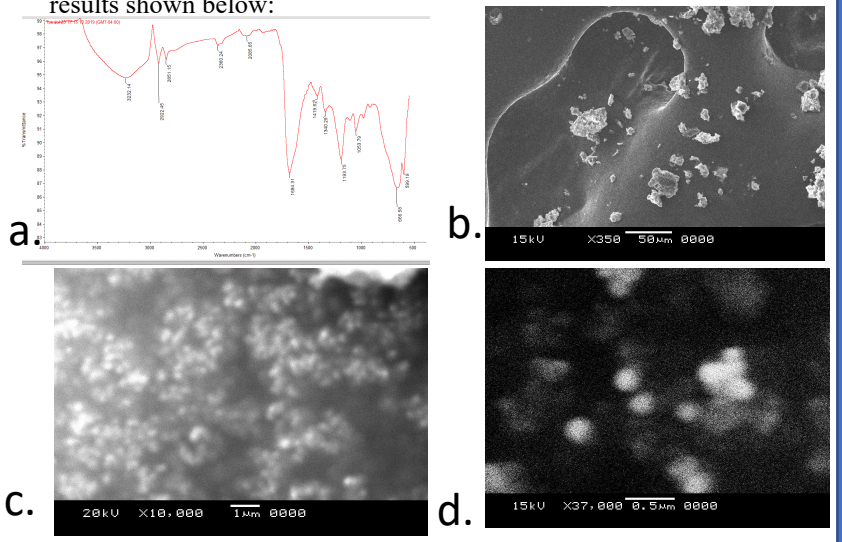

Fig 3. a. IR Spectroscopy, b. SEM of polythiophene np, c. SEM of polypyrrole np, d. SEM of polythio-co-pyrrole np

Acknowledgements

Juniata College, Department of Chemistry and Biochemistry and Juniata College, Department of Biology

Citations

Khademi, S., Pourabbas, B. & Foroutani, K. Polym. Bull. (2018) 75: 4291. https://doi.org/10.1007/s00289-017-2264-z