

Introduction

Conducting polymers are organic polymers able to conduct electricity. An advantage to conducting polymers is that they are very easily processed. Conductive polymers combine properties of metals and organic compounds. Polyaniline is the polymer we will be studying. It is easily synthesized, environmentally stable, and has the ability to become doped and dedoped by simple acid/base chemistry. Polyaniline nanofibers have been recently studied due to their capability of yielding new properties and enhancing the performance of existing applications of the polymer. Polyaniline nanofibers can significantly improve known applications of the polymer in batteries, sensors, actuators, electromagnetic shielding, antistatic coatings, corrosion protection, electro-optic and electrochromic devices, and separation membranes. Conductive polymer films are formed via a multitude of technologies for different applications. Some deposition techniques allow layer thickness to be controlled within the nanometer scale. Deposition techniques fall into two broad categories: physical and chemical processes. Some chemical deposition techniques include: Chemical Solution Deposition (CSD), which involves solutions of materials usually dissolved in an organic solvent or Chemical Vapor Deposition (CVD), which involves gas precursors such as halides and hydrides of the substance to be deposited. Some physical deposition techniques include: Electrospinning, which uses an electrical charge to draw up nanofibers from a liquid or Sputtering, a technique that can use a plasma as a carrier. In this study thin-films are deposited using an immiscible binary system composed of water and oil. Interfacial surface tension between these phases leads to directional fluid flow and film deposition. Once deposited, a film can then be chemically treated in order to produce a freestanding film.

Objectives

To develop a protocol for the production of freestanding films of polyaniline nanofibers, this procedure needs to be applicable to polyanilines derived from various acids. To characterize of films using a scanning electron microscope (SEM) and UV-Vis spectroscopy. To develop a layer-by-layer deposition employing freestanding films as an approach to controlling optical density and nanoscale morphology.

Experimental Design

PANI Synthesis
 PANI was synthesized using a monomer (Aniline) and an oxidant (APS) in different 1M concentrations of acids. Various acids were used such as perchloric acid, para-toluene sulfonic acid, camphor sulfonic acid, sulfuric acid, citric acid, and hydrochloric acid.

Purification
 Polyaniline nanofiber dispersions were kept standing for a period of at least 24 hours. Afterwards they are run through simple dialysis. Ideally we would be able to purify the sample completely, and after a few days dialysis is complete and the samples are ready to be used.

Film Making
 Conductive & continuous thin films of polyaniline nanofibers were grown within seconds via a thermodynamically downhill process. Emulsified nanofibers at the water and oil interface experience an excess pressure at the liquid-liquid interface which leads to directional fluid flow, and film formation due to the extrusion of nanofibers.

Drying
 Films are dried at ambient conditions.

Freestanding Films
 Chemical treatment of dried films leads to freestanding films of polyaniline nanofibers.

Characterization
 Freestanding films were deposited on glass slides for UV-Vis analysis, and on Si/SiO₂ substrates for SEM imaging. Multiple layers were collected for characterization.

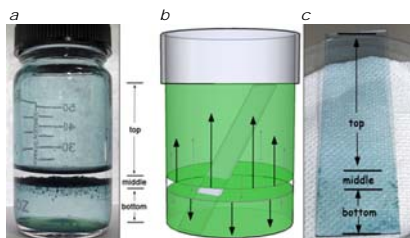


Figure 1. Process for growing films on a substrate. a. Transparent thin film of polyaniline nanofibers deposited on the walls of a glass container. b. Schematic diagram shows spreading directions. c. Continuous thin film of polyaniline nanofibers is collected on a glass slide.

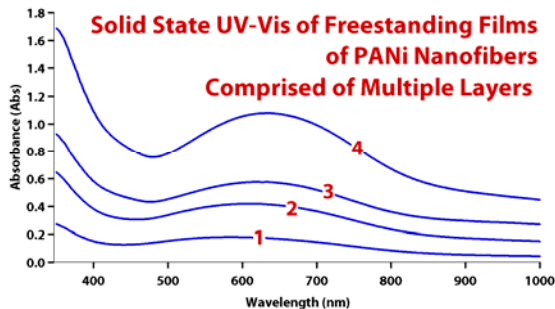


Figure 2. Solid state UV-Vis of transparent freestanding films of polyaniline nanofibers. Freestanding films were deposited on a glass substrate for UV-Vis analysis. Up to 4 freestanding films were deposited on top of each other. The optical density increases as a function of the number of layers.

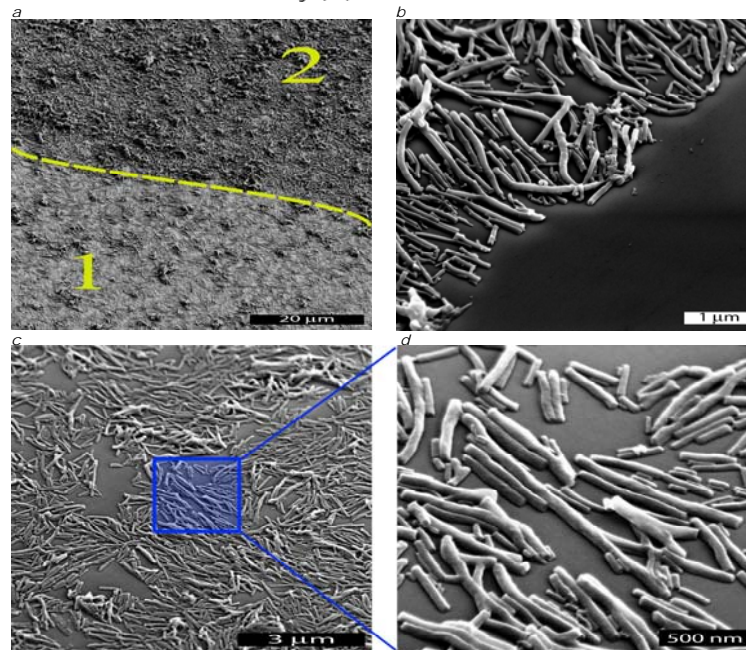


Figure 3. Nanoscale morphology of freestanding films of polyaniline nanofibers collected on Si/SiO₂. a. Difference in morphology is apparent between a 1-layer-film and a 2-layer-film. b. Film edge. c-d. Close-up sequence shows a film morphology characterized primarily by a monolayer of polyaniline nanofibers.

Results

A protocol was developed for making freestanding films of polyaniline nanofibers. Films are grown on a substrate, dried, and then chemically treated in order to produce thin freestanding films of polyaniline nanofibers.

Multilayered polyaniline nanofiber films comprised of layers of freestanding films were developed.

Conclusions

Homogeneous freestanding thin films of polyaniline nanofibers are conductive and continuous, and can be deposited on different substrates for characterization purposes.

Freestanding films can be deposited on top of each other affording a thicker multilayered film for optical density control. Up to 4 layers were deposited.

Future Plans

To develop applications using freestanding films as transparent conductors

To continue studying forces responsible for directional fluid flow and film spreading, for example, the interesting phenomenon of surface tension differentials in Figure 4.

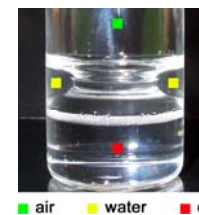


Figure 4. Binary immiscible mixture comprised of water and a heavy oil. Surface minimization leads to the formation of a water catenoid, directional fluid flow, and the spreading of a film of polyaniline nanofibers.