Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 61
ISSUE 2
December
2013

Influence of solvent on the surface morphology and optoelectronic properties of a spin coated polymer thin films

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Received 19.10.2013; published in revised form 01.12.2013

Properties

ABSTRACT

Purpose: The aim of this paper was to investigate changes in surface morphology and optoelectronic properties of MEH-PPV thin films. Thin films were prepared using spin coating method.
Design/methodology/approach: The changes in surface topography was observed by the atomic force microscope AFM. The results of thin films roughness have been prepared in the software XEI. The UV/VIS spectrometer was used to investigate absorbance of the obtained thin films.
Findings: Results and their analysis allow to conclude that the solvent, which is an important factor in spin coating technology has an influence on surface morphology and optoelectronic properties of MEH-PPV thin films.
Practical implications: Known MEH-PPV optoeletronic properties and the possibility of obtaining a uniform thin film show that it can be a good material for optoelectronic and photovoltaic application.
Originality/value: The paper presents some researches of MEH-PPV thin films deposited by spin coating method deposition on glass BK7. A MEH-PPV solution was prepared using three different solvents: chlorobenzene, chloroform and pyridine.
Keywords: MEH-PPV; Spin coating; Spectrometer UV/VIS; Atomic Force Microscope

Reference to this paper should be given in the following way:
J. Weszka, M.M. Szindler, M. Szczęsna, M. Szindler, Influence of solvent on the surface morphology and optoelectronic properties of a spin coated polymer thin films, Journal of Achievements in Materials and Manufacturing Engineering 61/2 (2013) 302-307.

1. Introduction

The rapid development of electronics and materials science, especially relating to semiconductor technology and chemistry of polymeric materials have been the reason for the development of many new materials with very interesting properties. The important achievements in field of polymer materials was to discovered, and develop of electrically conductive polymer technology. The usage of soluble conjugate polymers as active materials in optoelectronic applications has opened up a possibility of fabricating many various devices. In the past few years, poly(2-methoxy-5(2'-ethyl)hexoxy-phenylenevinylene) (MEH-PPV) has been considered as one of the potential and useful conducting polymers for various optoelectronic applications, such as sensors, organic solar cells and organic light emitting diodes (OLED) because of its environmental stability and conductivity properties (Fig. 1) [1-8].

Electrical, optical, chemical, electrochemical and mechanical properties of polymeric materials depend on the action of various physical and chemical factors. The technology of manufacturing and deposition of polymer thin film is a very important. Sol-gel method is often used to obtain thin polymer films because it does not require high temperatures like the PVD or CVD deposition. One of sol-gel method is a spin-coating. Spin coating is a simple method to deposition thin films onto relatively flat substrate. The substrate that is to be covered is held by some rotatable fixture (usually using vacuum holder) and the solution is dispensed onto the surface. The centrifugal force causes the solution to spread out and leave behind a very uniform coating of a chosen material on the surface of a substrate (Fig. 2) [9-18].

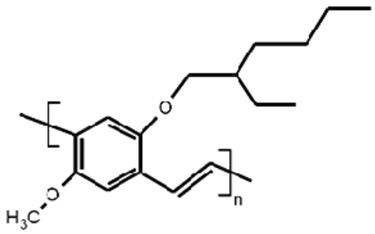

Fig. 1. The structural formula of the polymer conjugated derivative MEH-PPV

The correct preparation of substrates and solution has the greatest impact on the quality and properties of the deposited layers in spin coating method. To prepare a solution successfully a right solvent must be prepared correctly.

2. Materials and methodology

All reagents were purchased from Sigma Aldrich company. MEH-PPV thin films were prepared by the sol–gel spin coating technique. The polymer was dissolved in three different solvents: chlorobenzene, chloroform and pyridine (Fig. 3).

The solutions were prepared with the same ratio between MEH-PPV and solvents. Then the solutions were spin coated with the various spin speed on the glass substrates BK7. Preparation of the substrates was performed in accordance with the procedure:

- rinsing in distilled or deionized water,
- bath in an organic solvent with ultrasonic (successively in acetone and methyl alcohol),
- drying in a centrifuge.

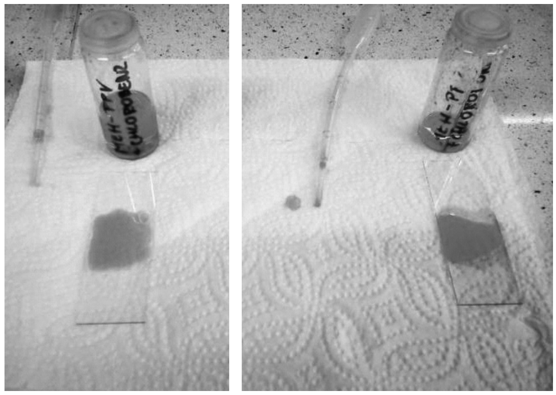

Fig. 3. Solutions prepared with a different solvent

3. Results and discussion

The study of the surface topography was performed by atomic force microscope AFM working in a non-contact mode. It can be observed (Fig. 4-6) that the MEH-PPV thin film has uniformly covered the glass surface without any precipitates. Figs. 4-6 shows an AFM 2D image and 3D representation of the surface topography of MEH-PPV thin film deposited by the spin coating method with the same spin speed.

The surface topography of MEH-PPV dissolved in each solvents have appeared to be similar. Fig. 4 shows the topography of the surface of a thin film of MEH-PPV dissolved in chlorobenzene. The A thin film reveals a uniform granular structure without any precipitates. The 3D representation shows that there are numerous smaller surface undulations which may be indicative of its high roughness. Fig. 5 shows the granular surface of the MEH-PPV dissolved in chloroform. The change of solvent caused the appearance of precipitate. Also in the 3D representation see undulations in the areas around the precipitate. Fig. 6 shows that the change of the solvent on the pyridine caused smoothing of the surface of thin film MEH-PPV. The granules are smaller and similar shapes.

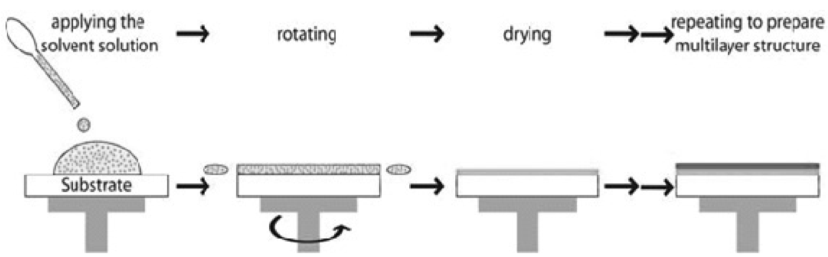

Fig. 2. Spin coating method diagram

Table 1.
Summary of polymer thin films roughness parameters

Parameter	MEH-PPV + chlorobenzene	MEH-PPV + chloroform	MEH-PPV + pyridine
R_q [nm]	0.924	0.986	0.892
Max [nm]	6.223	8.813	4.92

The thin films roughness have been prepared in the software XEI Park Systems (Table. 1). Figs. 7-9 presents an analysis of the roughness each thin film. The thin films roughness was characterized by calculating the R_q roughness parameter and presenting the histograms. Fig. 7 shows the histogram of the MEH-PPV thin film - the distribution of inequalities of its surface. The shape of the histogram and the result obtained R_q, equal to 0.924 nm, are in conformity with the conclusions drawn from the observation of surface topography. In the case of the use of chloroform as a solvent (Fig. 8) precipitate appeared that was delivered to the increase the value of R_q. The lowest value of R_q was obtained for MEH PPV dissolved in pyridine and equals 0.892 nm. The difference in a root mean square (R_q) does not exceed 0.1 nm. In the case of the use of chlorobenzene as the solvent, irregularities does not exceed 6.5 nm (Fig. 7), while in the case of chloroform; 9 nm (Fig. 8). Irregularities on the surface of the MEH-PPV dissolved in pyridine do not exceed 4.92 nm (Fig. 9).

The UV/VIS spectrometer was used to investigate absorbance of obtained thin films. The shape of absorbance curve in each case was very similar and there were two maxima in it that are provided corresponding to the wavelength of 410 nm and 590 nm. A use of pyridine as a solvent resulted in a higher absorbance values. This shift is associated with the transition to the state delocalized exciton (Fig. 10).

a) b)

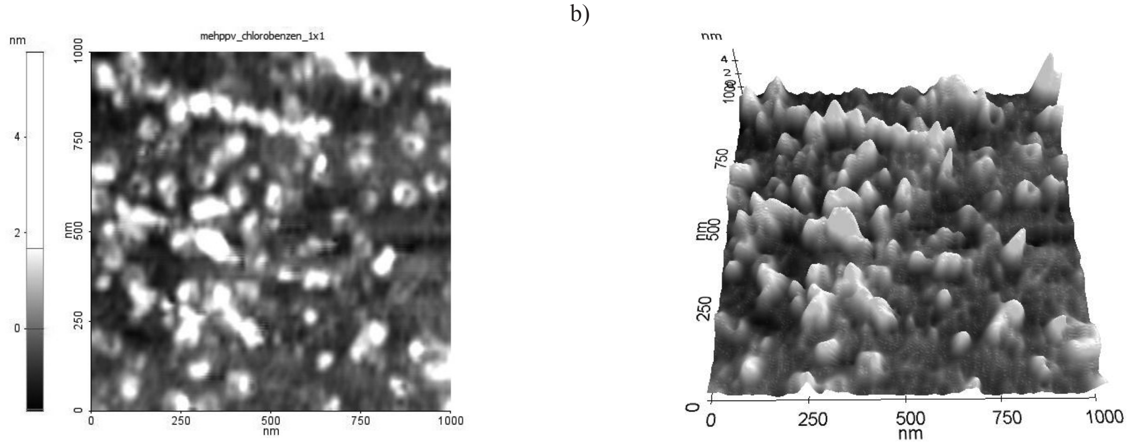

Fig. 4. The AFM topography image of MEH-PPV deposited by the spin coating method obtained from solution with chlorobenzene: a) 2d image, b) 3d representation

a) b)

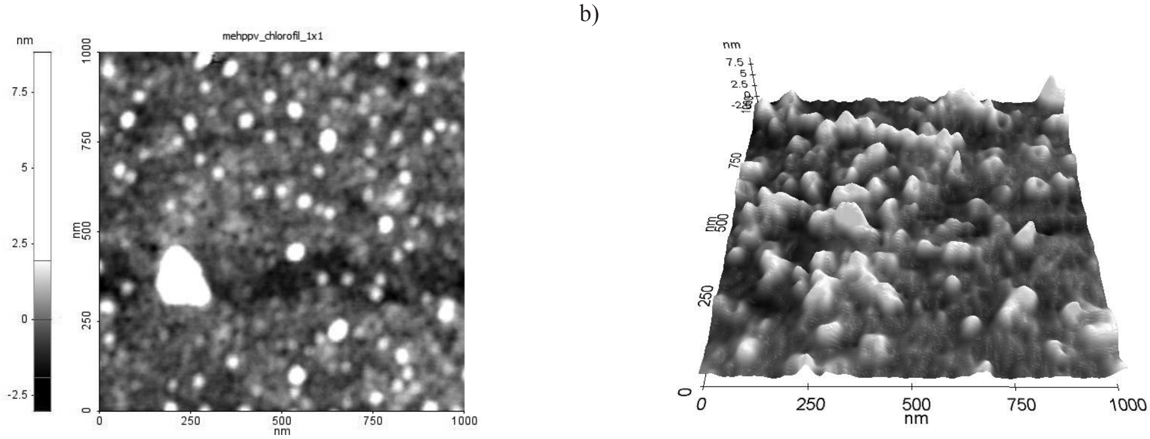

Fig. 5. The AFM topography image of MEH-PPV deposited by the spin coating method obtained from solution with chloroform: a) 2d image, b) 3d representation

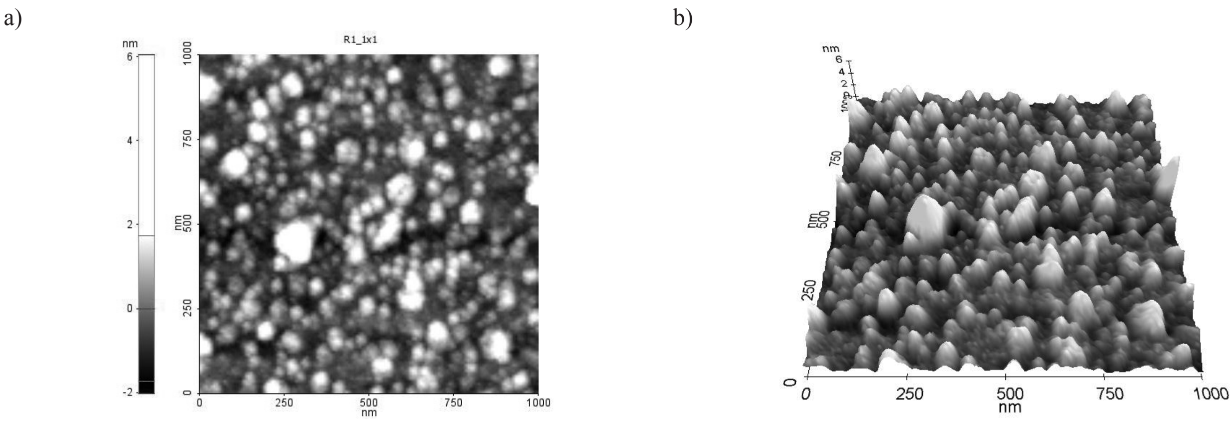

Fig. 6. The AFM topography image of MEH-PPV deposited by the spin coating method obtained from solution with pyridine: a) 2d image, b) 3d representation

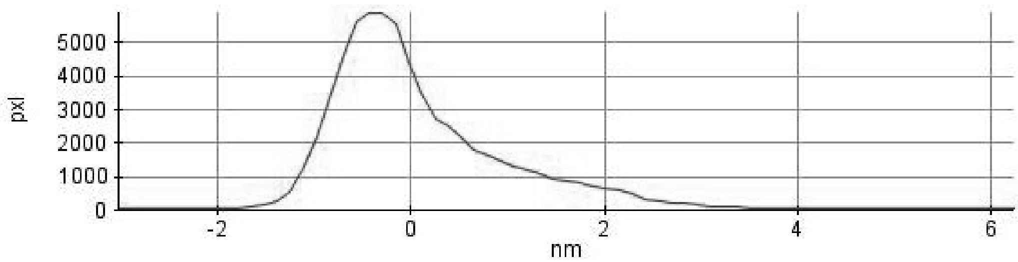

Fig. 7. The histogram of frequency of the occur height for a MEH-PPV thin film deposited by the spin coating method obtained from solution with chlorobenzene

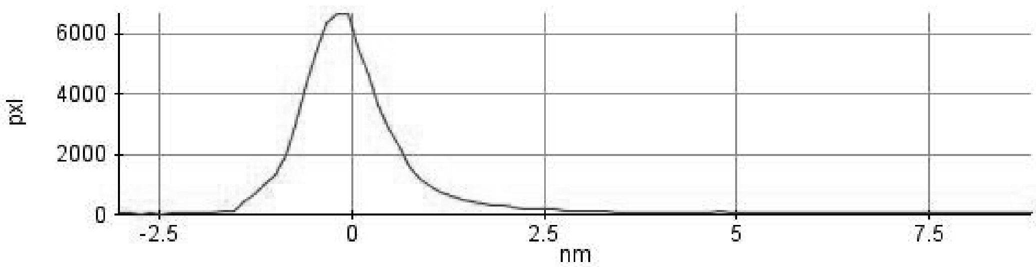

Fig. 8. The histogram of frequency of the occur height for a MEH-PPV thin film deposited by the spin coating method obtained from solution with chloroform

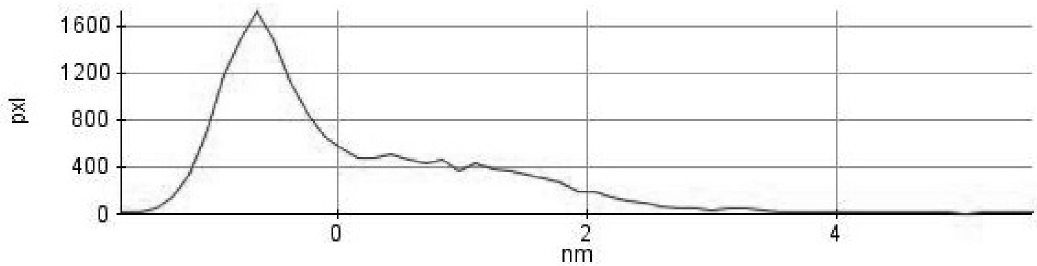

Fig. 9. The histogram of frequency of the occur height for a MEH-PPV thin film deposited by the spin coating method obtained from solution with pyridine

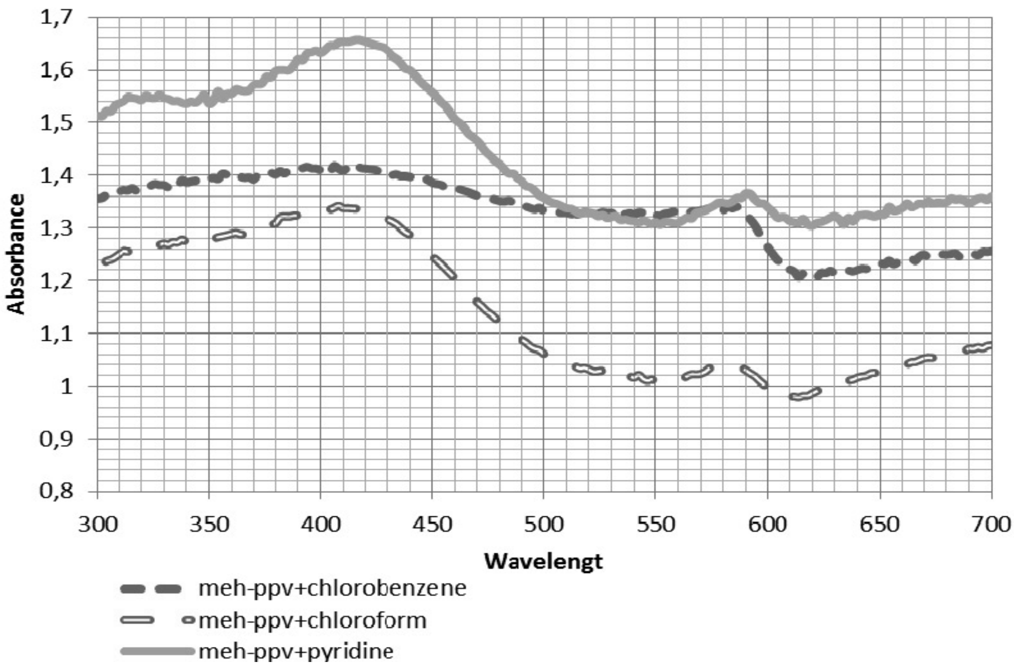

Fig. 10. Spectral absorbance curve for MEH-PPV thin films deposited by the spin coating method

4. Conclusions

Research of surface morphology using the AFM has confirmed a possibility to obtain uniform thin films. Using a spectrometer UV/VIS has confirmed favorable optical properties of MEH-PPV that may be controlled by choosing an appropriate solvent in the sol-gel method. By using three different solvents: chlorobenzene, chloroform and pyridine, shows the maxima in the spectrum of absorbance change their values respectively in the range of 1.05-1.39 and 1.35-1.65. The results may lead to the conclusion that MEH-PPV can be used in photovoltaic and optoelectronic devices.

Acknowledgements

Marek Szindler is a holder of scholarship from project POKL.04.01.01-00-003/09-00 entitled „Opening and development of engineering and PhD studies in the field of nanotechnology and materials science” (INFONANO), co-founded by the European Union from financial resources of European Social Fund and headed by Prof. L.A. Dobrzański.

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