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COMPARATIVE STUDY OF CONTACT ANGLE MEASUREMENTS ON POLYMERMDMO-PPV COMPOSITE NIO AND AG/NIOFILMS

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Abstract

The wettability behavior of MDMO-PPV solution on NiO and Ag/NiO substrates was investigated by contact angle measurement. The present study focuses on the effect of polymer solution concentration (6-10-14 mg/ml) and solvent (dichlorobenzene) on the wettability of substrate surface. The measured contact angles are 12°, 11° and 10°on NiO films and 22°, 17°, 12° on Ag/NiO films, 14°, 11°, 10° on Ag/NiO films, 19°, 16°, 14° on Ag/NiO films at different silver concentrations (2.5, 5, 10 mM) for polymer concentration of 6, 10 and 14 mg/ml. There is no significant changes in contact angle measurements of MDMO-PPV on NiO and Ag/NiO films.

Keywords: wettability, MDMO-PPV polymer, contact angle.

Introduction

Recently, the electron donating p-type and electron accepting n-type polymer solar cells are produced commercially and its cell efficiency is around 10% [Jingbi, You *et al.,* (2013)]. Substrate treatment and wetting behaviors are good tools for increasing cell efficiency in semiconducting polymers.Thin film solar cells technology and nanoparticles exhibit unique physical and chemical properties which have a significant effect on wettability [Rafal, Sliz, (2014), Richard, Magdalena Mandoc M *et al.,* (2007)and Hansson, (2015)]. Wettability provides quantitative data describing the behaviour of liquid droplets on substrate surfaces [Harald, Hoppe *et al.,* (2006)]. Controlling the hydrophobicity or hydrophilicity of a substrate surface is of crucial importance for solar cell device fabrication. In everyday life applications, it is desirable to have highly hydrophilic surfaces in wallpaper painting, biomedical applications such as tissue reconstruction.

In wallpaper painting, the interface between the substrate (wall) and solution (ink) drop is much studied, as it is considered the most critical factor for achieving high printing quality. Polymer solar cell used printing process like printing newspapers and coating technologies [K. Jeroen Van Duren *et al.,* (2004)]. Charge transportation can be improved through the roughness, chemistry of the surface and surface energy, boiling point of liquid.

Surface of a material is a region where phase is transformed one state to another. The energy required to form a surface is called surface energy and it is an important property of every surface. Surface science plays an important role in surface morphology and surface chemical properties [Jan Anton Koster L. *et al.,* (2012)]. Studies of surface roughness, surface energy and contact angle values are important factors for polymer thin films. The study of wetting phenomena at polymer surfaces and interfaces is of interest in the many industrial processes, such as oil recovery, lubrication, liquid coating, printing and spray quenching. The importance of substrate surface energy for polymer thin films is rapidly growing in cell device performance.

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Experiment

Preparation of Solutions

In the polymer synthesis, 6, 10 and 14 mg of MDMO-PPV were dissolved in 1 ml of dichlorobenzene (DCB). The resulting solutions were stirred vigorously for 15 min at RT. In the synthesis of nickel oxide (NiO) sol-gel, the nickel acetate Ni $(CH_3COO)_{2.4H2O}$ was used as a source of nickel (Ni). 4.42 g of nickel acetate was added to 50 ml of ethanol and 0.5 ml of HCl. The resulting solution was stirred vigorously for 90 min at 60°C forming a clear light green solution. In the silver nanoparticle synthesis,$AgNO_3$ (metal salt precursor), PVP (stabilizing agent) and $NaBH_4$ (reducing agent) were used. 5.6mgof $NaBH_4$ were added to 3ml of distilled water to create a 50mMsolution. 2.4mg, 4.8mg, 9.6mg of $AgNO_3$ were added to 6ml of distilled water to create a 2.5mM, 5mM, 10mM solutions. And then $AgNO_3$ solutions were added to the $NaBH_4$(50 mM) solutions using a dropper, at about one drop per second. The color of solution was immediately changed into light yellow. The resulting solution was stirred vigorously for 20 min at RT. Upon the complete addition of the $AgNO_3$, stirring were stopped. Next, polyvinylpyrrolidone (PVP) (dissolving 1mMofPVP in 3 ml distilled water) solutions were added immediately to the resulting solutions in order to prevent nanoparticles aggregation. The synthesis steps are illustrated in Fig. 1.

Formation of Polymer Composite NiO and Ag/NiO Films

NiO sol-gel solution was spun-coat on glass substrate by spin coating with five deposition cycles forming NiO films. Then NiO films were annealed at 700°C on the temperature controlled hot plate. Then silver nanoparticle solutions were deposited on NiO films by spin coating with three deposition cycles and annealed at 100°C for 10 min to get Ag NPs/NiO films. Subsequently, MDMO-PPV solutions were then spun-coat at 1000 rpm for 60 s on the top of NiO and Ag/NiO layers.

Contact Angle Measurement

The wetting properties of polymer MDMO-PPV films on underlying NiO were determined based on measurement of contact angle. The cross-section images of polymer MDMO-PPV liquid drop on glass substrates and on NiO underlying layer were captured by a video camera which is attached with Digital Microscope (U500X). The experimental step up for contact angle measurement is shown in Fig. 2. The video camera performs its digitalization in ranging from 320x230 to 1600x1200 pixels images. The image analysis was performed by using the Axisymmetric Drop Shape Analysis (FTÅ 32) software. Using the profile of the liquid drop recorded by digital camera with a resolution of 640x480 pixels, then the contact angle between the liquid and substrate is measured. At least three measurements are taken for each target drop in order to obtain average contact angle values.

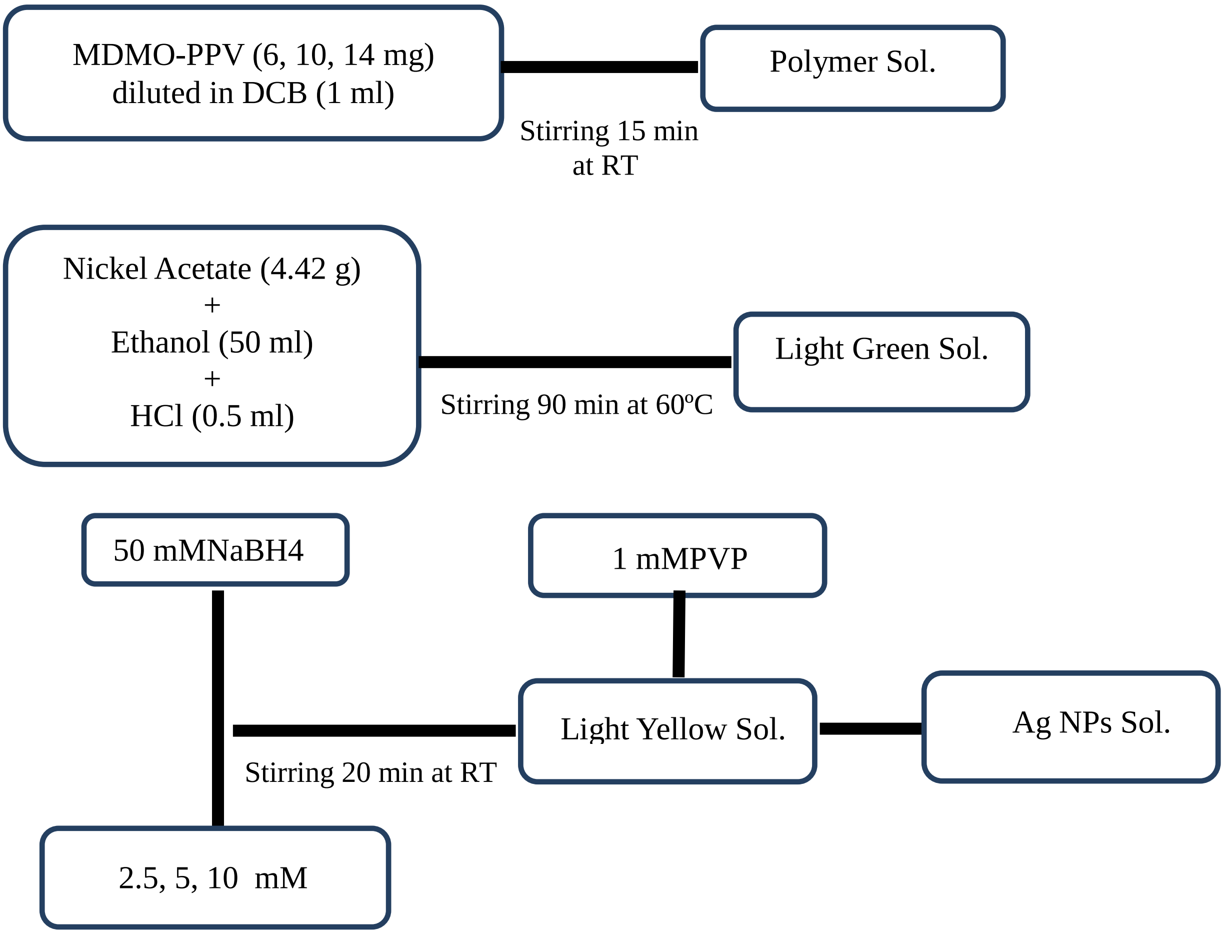


Figure 1 Synthesis steps for polymer, NiO and Ag NPs solutions.

Figure 2 The experimental setup for contact angle measurement.

Results and Discussion

Surface Wettability of MDMO-PPVon NiO Film

Wettability involves the interaction between liquid and solid in contact. The wetting behavior of thin film is characterized by the value of contact angle. The contact angle is an important parameter in surface science and its measurement provides a simple and reliable technique for the interpretation of surface energies. The value of contact angle is directly correlated with the surface structure of the film. The contact angles for MDMO-PPV on NiOfilm annealed at 700 °C were investigated and the photographs of the cross-sectional view of a drop of MDMO-PPV solution (solvent: dichlorobenzene) on NiOfilms areshown in Fig. 3. The contact angle values are listed inTable1.

The contact angles seem to be insensitive to the changes in polymer concentration for the MDMO-PPV on NiO. It is also observed that the contact angles were smaller than on NiO films. It indicates that the higher polymer concentrations on NiO films lead to a better wetting behavior.

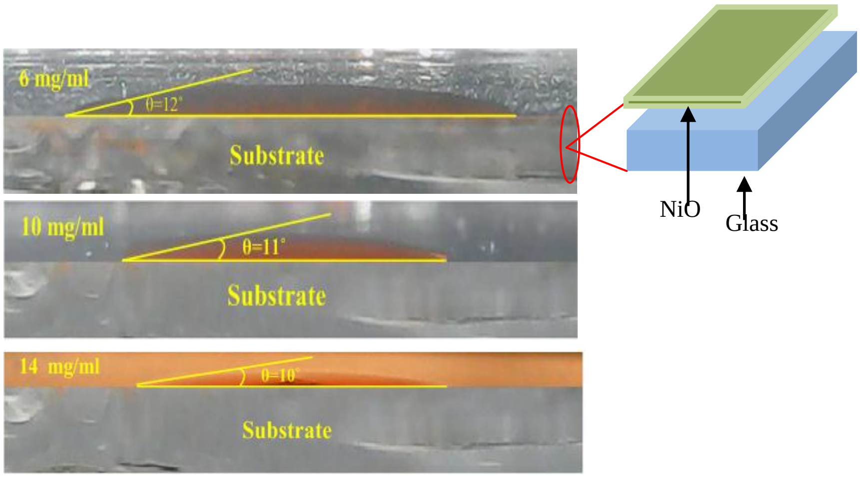
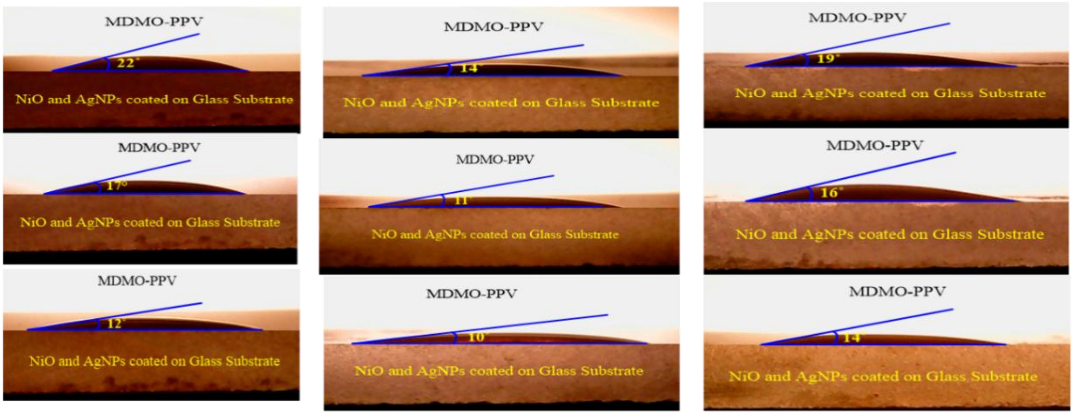


Figure 3 Contact angles of polymer MDMO-PPV solution on NiO film at 700˚C.

Table 1 Contact angle values

MDMO-PPV/NiO			
Temp. (˚C) of NiO	**Polymer Concentration (mg/ml)**	**Solvent**	**Contact Angle (degree)**
700	**6** **10** **14**	**Dichlorobenzene**	**12** **11** **10**

Surface Wettability of MDMO-PPV on Ag/NiO Films



(a) 2.5 mM Ag (b) 5 mM Ag (c) 10 mM Ag

Figure 4 Contact angles of polymer MDMO-PPV solution on Ag/NiO films.

The value of contact angle is directly correlated with the surface structure of the film. The contact angle values are shown in Fig. 4and listed in Table 2. The contact angles seem to be insensitive to the changes in polymer concentration for the MDMO-PPV on Ag/NiO film. Especially, we found that contact angle of MDMO-PPV on 5mM Ag/NiO concentration was less than other two concentrations.

Table 2 Contact angle values

MDMO-PPV/Ag/NiO				
Ag NPs Concentration (mM)	**Polymer Concentration (mg/ml)**	**Temp. (˚C) Of NiO**	**Solvent**	**ContactAngle (degree)**
2.5	**6** **10** **14**	**700**	**Dichlorobenzene**	**22˚** **17˚** **12˚**
5	**6** **10** **14**	**700**	**Dichlorobenzene**	**14˚** **11˚** **10˚**
10	**6** **10** **14**	**700**	**Dichlorobenzene**	**19˚** **16˚** **14˚**

Conclusion

The surface wettability of MDMO-PPV on NiO and Ag/NiO films was examined by contact angle measurement. Contact angles values decreased with increasing polymer concentrations for all films. Thus, the contact values ranging from 10° to 22° confirmed that there is a good wetting at interface of polymer and substrate surface.The wetting behaviours are good tools for increasing cell efficiency in polymer films and solar cell.

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