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Study of Opto-electronic and Physical Properties of Novel Flexible Substrate Material

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1. Introduction

Flexible displays are more flexible, more rugged, more lightweight, more compact, and easier carried than than conventional displays with glass structures. The flexible displays can further be fabricated by roll-to-roll processes to substantially increase and decrease productive costs. But the flexible displays have a important key point that is how to prepare flexible substrate with high thermal stabilities, good dimensional stabilities, strong mechanical property, high optical transparency, and good hydrophobicity. These requests of the flexible substrate are serious test for commercial plastic materials in present. So the flexible substrate materials must overcome that whether they can adapt to productive conditions of conventional displays in future developments of flexible displays, and we especially care about thermal stabilities and whether they can accept breaks of high thermal processes. Besides, a little water vapor will seriously affect life of organic opto-electronic devices, because the organic opto-electronic devices are sensitive to water vapor. Therefore, the hydrophobicity of flexible substrate surface is also an important material property for the flexible substrate materials, especially for organic opto-electronic devices.

2. Experimental

We have successfully synthesized the novel poly(arylene ether)s shown in Fig.1, and we call it P-44. Then we fabricated P-44 to be film shown in Fig.2.

We used thermogravimetric analyzer (TGA) to measure decomposition temperature (Td^{onset}) of the polymer and differential scanning calorimetry (DSC) to measure its glass transition temperature (Tg), melting temperature (Tm), and crystalline temperature (Tc). And we used thermomechanical analysis (TMA) to measure its heat deflection temperature (HDT) and thermal expansion coefficient (CTE). We understand thermal stabilities of the polymer by above measurement.

We measured transmittance of the polymeric film (thickness: 0.3mm) by UV-Vis spectrometer. And for the reason to observer whether this polymeric film has the phenomenon of birefringence or not, we used ellipsometer to measure their refractive indexes (n) and extinction coefficient (k) in the range of visible light.

In hydrophobicity of the polymeric thin films, we measured its contact angles with system of drop shape analysis. The polymeric thin film is separately dropped by four kinds of solvents: deionize water (DI-water), ethylene golycol, and diiodomethane.

In the aspect of electric properties, we used Precision Impedance Analyzer to measure dielectric constant and dielectric loss of the P-44 film.

All measurements were carried out at room temperature under ambient condition.

3. Results and Discussion

Thermal Properties

From Fig.3, we can find when we heat the P-44 to 900℃, the char residue still exist over 70%. It reveals P-44 has giant molecular weight. By the data of DSC, we can observer P-44 has high Tg and no Tc shown in Table.1. By finding Tc hardly, we could know P-44 doesn't crystallize easily. From the measurement of TMA, we can obtain HDT and CTE of P-44 film is 315℃ and 21ppm/℃ shown in Table.1. And by the record, we can prove P-44 to be amorphous when HDT is lower than Tg by 20℃.

Water absorption

We assume A to be weight P-44 film dried by oven for 24hr, B to be the weight P-44 film soak in DI-water for 24hr, C to be weight A subtract B, and D is water absorption. From this measurement, we can get the water absorption of P-44 film shown in Table.2.

Hydrophobicity

Table 3 presents contact angles of the P-44 thin film with diiodomethane, ethylene golycol, glycerol, and DI-water. It indicates the contact angle of the P-44 thin film measured by DI-water is 114.5°. P-44 film has good hydrophobicity results from this polymer possesses the fluorine.

Dielectric properties

Table.4 shows that P-44 film has low dielectric constant and dielectric loss. That because fluorine has the strong ability of attracting electron, and it cause the electron resonance hardly by the electric field. This lead to the molecule polarizes not easily.

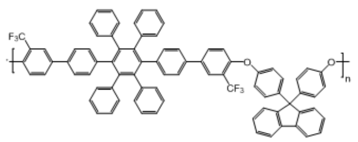

Fig.1 Structure of the novel poly(arylene ether)s

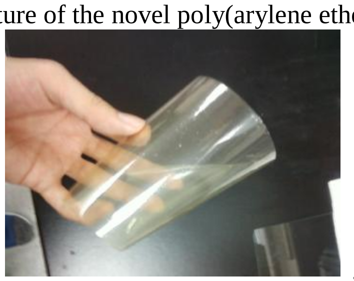

Fig.2 Photo of the P-44 film (Size: $12x11cm^2$, Thickness: 0.3mm)

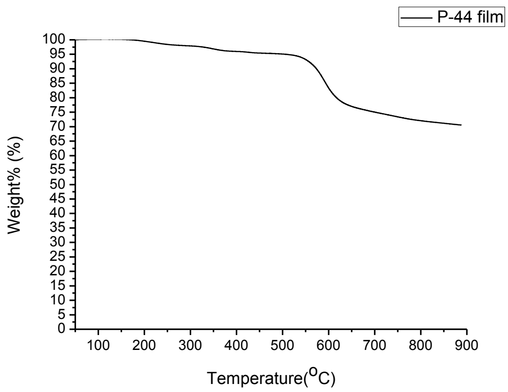

Fig.3 TGA thermograms of the novel poly (arylene ether)s

	Td	Tg	HDT	CTE	Tm	Tc
P-44	543℃	335℃	315℃	21ppm/℃		

Table.1 Thermal stabilities of P-44

Material	Water absorption (%)
P-44	0.22%
Polycarbonate(PC)	0.4%
Polyethersulfone(PES)	1.4%
Polyimide(PI)	3%
Polyethylene terephthalate(PET)	0.6%

Table.2 Compare water absorption with commercial plastic material

	Diiodo-Methane	Ethylene glycol	Glycerol	Water
Glass	44.4°	41.3°	54.6°	53.2°
P-44	36.83°	62.1°	81.1°	114.5°

Table.3 Contact angles of the P-44 thin film and glass

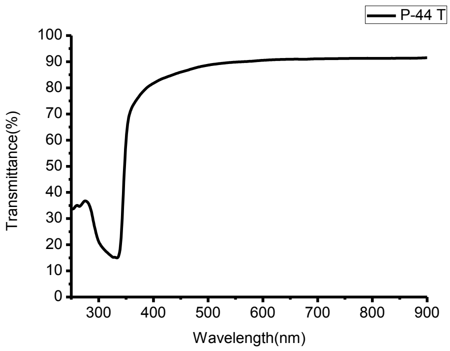

Fig.3 Transmittance of P-44 film (Thickness:0.3mm)

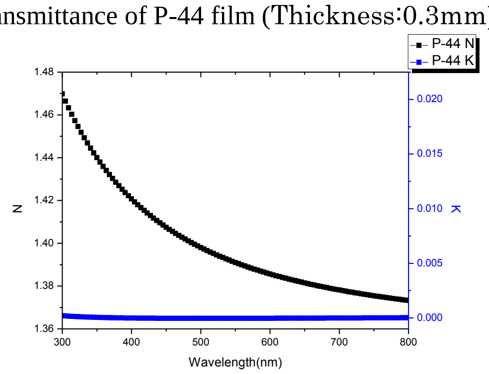

Fig.4 Refractive index and extinction coeffecient of P-44 film (Thickness:0.3mm)

	Dielectric constant @ 1m Hz	tanδ	Q factor
P-44	2.52	0.0027	365
Polyethylene terephthalate(PET)	3	0.007	143
Polycarbonate(PC)	2.9	0.01	100
Polyimide(PI)	3.5	0.025	40
Polyethersulfone(PES)	3.5	0.016	62.5
Polyethylene Naphthalate(PEN)	2.9	0.004	250

Table.4 P-44 compares dielectric properties with commercial plastic materials@1m Hz

4. Conclusions

In this research, we have realized the novel PAEs polymers P-44 that have well thermal stability, and its decomposition temperature (Td) is 543℃ ; and the glass transition temperature (Tg) is 335℃. Comparing with the commercial polymers, this polymer can be manufactured in higher temperature.

According to the data of transmittance, we can find that P-44 film has high transparency in the region of visible light. Furthermore, the refractive index of P-44 film is 1.37 ~ 1.47 and we can know P-44 doesn't have the phenomenon of birefringence.

In the measurement of hydrophobicity, we find contact angles of the P-44 film measured with DI-water is 114.5°. It shows that the P-44 film has low polarity and good hydrophobicity. By the measurement of water absorption, we can realize P-44 film has very low ability of water absorption.

In the aspect of electrical measurement, we can find P-44 has low dielectric constant and low dielectric loss.

According to the analysis of the material, we can know P-44 polymeric film has good thermal stability, high transparency in the region of visible light, good hydrophobicity, bad water absorption, not birefringence, and well dielectric properties. Having these well material characters, we can apply it to the flexible displays in the future.

Acknowledgements

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