

PHOTOLUMINESCENT AND ELECTROLUMINESCENT EFFECTS IN CONJUGATED POLYMER LAYERS

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The purpose of this work is the investigation of photoluminescent and electroluminescent properties of two novel types of conjugated polymers. For measurements we have used experimental set-up. Conjugated polymer of terephthalaldehyde and cyclooctene and copolymer of benzoquinone and cyclooctene with quinone structure are synthesized for deposition of layers.

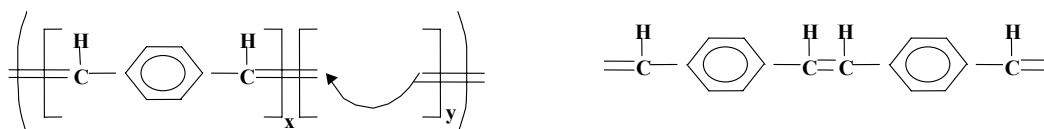
Their photoluminescence at irradiation by Hg spectral lines is locked for and investigated. The polymer is dissolved in organic solvent- chloroforme in proportion 1:1. The obtained solution was deposited by spin-coating method onto preliminary cleaned glass substrates. The photoluminescent spectrums of the layers are detected at two different wavelengths excitation light, selected with spectral filters. The electroluminescent spectrums are detected at 10V DC with special exploitation set- up. The electroluminescent experimental samples have made like as mono-layer structures (with one active electroluminescent layer).

The investigated polymer is possibly can be used in electroluminescent organic structures according to obtained results and its physical properties.

1. INTRODUCTION

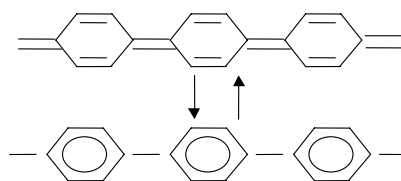
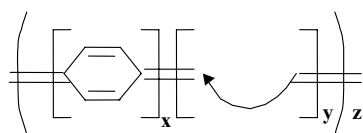
Light-emitting diodes (LED) using luminescent organic conjugated polymers as emissive layers have received attention in both academic research and industrial development [1,2] The ready processability of organic polymers is one of their most attractive features. However, to optimize performance, the effect of polymer structure upon charge transport and emission properties must be better understood and controlled. In this context, synthesis of new luminescent polymers and studies of their photophysical properties are of fundamental interest.

Some of us have developed a very simple method for the synthesis of copolymers consisting of short conjugated blocks interspersed with flexible spacers [3]. This paper report on the study of photoluminescent (PL) properties of films cast from two novel polymers thus synthesized. The conjugated blocks of one of them is with well known poly(p-phenylenevinylene) structure [6]. The other one possesses a novel structure originated from benzoquinone. Figs. 1,2 show the chemical structure of the conjugated blocks of these polymers.



Photoactive chain of poly(p-phenylenevinylene) (PPV)

Fig.1.
Polymer of terephthalaldehyde and cyclooctene



Photoactive chain of polyparaphenylene with quinone structure

Fig.2.

Copolymer of benzoquinone and cyclooctene

2. EXPERIMENTAL

The glass substrates for deposition of polymer layers are preliminarily cleaned by this plan:

1. Boiling 10min in solution by composition $\text{NH}_3:\text{H}_2\text{O}_2:\text{H}_2\text{O}=1:1:3$
2. Washing with deionized water.
3. Solution of polymers in CHCl_3 in proportion polymer to solvent 1:1.

The polymers are deposited with spin coating method on centrifuge T 26 with various revs.

2.1. Conjugated polymer layers

The copolymer of terephthalaldehyde and cyclooctene and of benzoquinone and cyclooctene are synthesized using the method reported previously [7,8].

2.2. Photoluminescent measurements

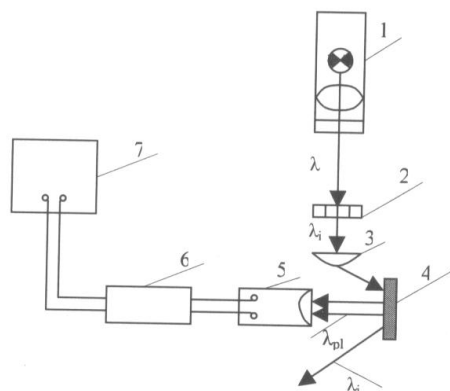


Fig.3.

1-Hg lamp; 2-interference filter given wavelength λ_i from the Hg spectrum λ ;
 3-cylindric lens; 4- irradiated sample;
 λ_{pl} - emission emitted from sample; 5- monochromator DMR-2
 6- photomultiplier- FEU 106; 7-measurement device (Lock-in in nanovoltmeter type 232).

The PL of four samples, i.e. polymer of terephthalaldehyde and cyclooctene and copolymer of benzoquinone and cyclooctene with three different thickness is investigated by using the spectrometric set-up shown in Fig. 3. The emitted light λ of the gas discharge Hg spectral lamp (220 V, 1.3 A) (Zeis) illuminates the sample 4.

The latter generates PL detected by monohromator 5 (type DMR2 (spectral range 360-700 nm)), Photomultiplier Type 106 and Lock-in Nanovoltmeter Type 232 B. The monohromator is protected against the incident beam. Having performed preliminary measurements an entrance slit of 1 mm has been chosen.

Two kinds of PL measurements are performed, i.e. excitation by the integral spectrum λ of Hg lamp and excitation by a selected spectral line λ_i of Hg spectrum.

Four exciting spectral lines λ_i i.e 365,405,436,546 nm are selected by using trademark spectral filters (Zeis), only with 436 nm and 546 nm of selected lines the samples have PL emission.

3. RESULTS AND DISCUSSIONS

All samples were found to convert the light absorbed to PL emission. The latter arises in a spectral region depending on the exciting light λ_i . The intensity of PL depends on the thickness of the layer.

3.1. Photoluminescent effects due to exciting irradiation.

The above integral PL spectrum is analyzed by selective light excitation of PL (Figs.4, 5) illustrate the PL profile of sample of terephthalaldehyde and cyclooctene at three different values of layer thickness. PL is excited by HgI 436 nm and by HgI 546 nm. The profiles are asymmetric due to the essential longer wing to the blue spectral area.

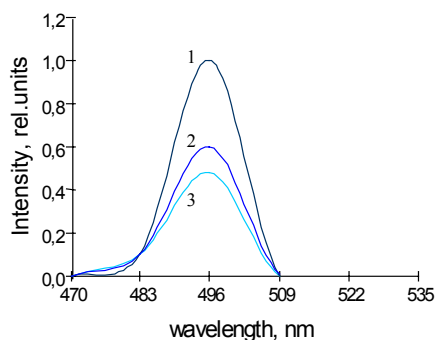


Fig.4.

PL spectra of layers with three different thickness of terephthalaldehyde and cyclooctene with excitation 436nm. 1) 16 μm ; 2) 20 μm ; 3) 12 μm

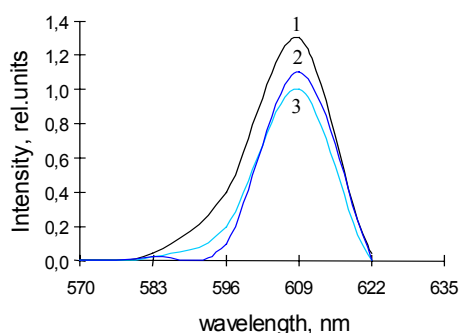


Fig.5.

PL spectra of layers with three different thickness of terephthalaldehyde and cyclooctene with excitation 546nm. 1) 16 μm ; 2) 20 μm ; 3) 12 μm

The maximum of PL is shifted about 60 nm from the exciting lines λ_i 436 nm and 546 nm. The value of PL maximum turns out to depend on the layer thickness. The sample of copolymer of benzoquinone and cyclooctene manifests the same PL with exciting line λ_i 436 nm, but the profile is of lower amplitude. With exciting line λ_i 546 nm the sample have insignificant intensity of emitting PL profile (Fig.6).

All PL profiles lie in the visible spectral region.

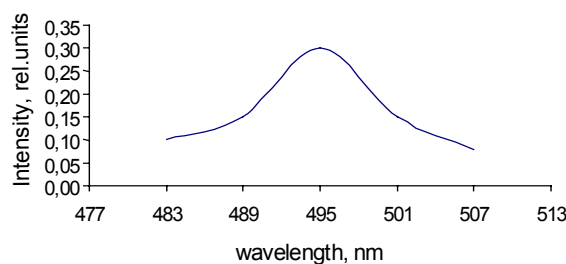


Fig.6.
PL spectra of layer of copolymer of benzoquinone and cyclooctene with excitation 436nm

As seen from the spectral data the polymers studied emit light in various regions of the visible spectrum. Most probably this is due to the fact that the polymer molecules comprise conjugated blocks of different length. The synthetic approach allows controlling the length of these blocks, hence maintaining the wavelength of the emitted light. Further investigations are being carried out.

3.2. Electroluinescent effects in the investigated structures

The electroluminescent spectrums are detected at 10V DC bias with special exploitation set-up (fig8).

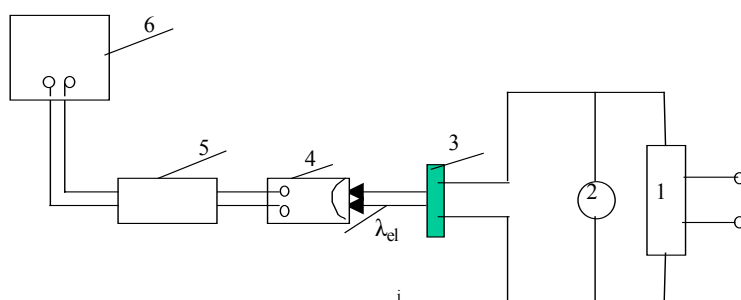


Fig.8.

1-voice voltage generator; 2-voltmeter; 3-sample
 λ_{el} - emission emitted from sample; 4- monochromator DMR-2
 5- photomultiplier- FEU 106; 6-measurement device (Lock-in in nanovoltmeter type 232).

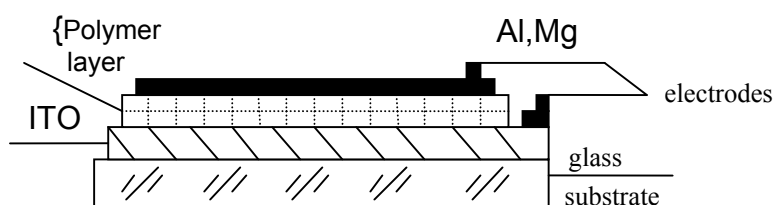


Fig.9.
Mono-layer electroluminescent display structure

For measurements the electroluminescent experimental samples have made like as mono-layer structures (with one active electroluminescent layer) [4,5]. The form of same structure on fig.9 is show. The spectral lines of structures are shifted about 10 nm, then respective photoluminescent spectral lines. Fig (10,11) shows the electroluminescent profiles of two investigated polymers.

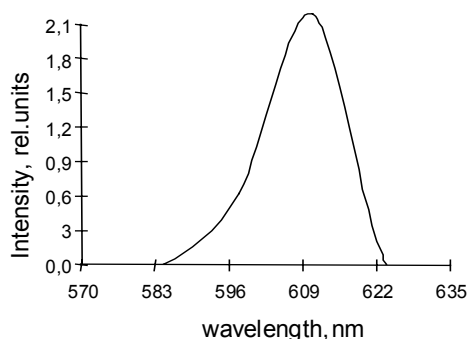


Fig.10.

EL spectra of layers of trephthalaldehyde and cyclooctene with bias 10 V DC.

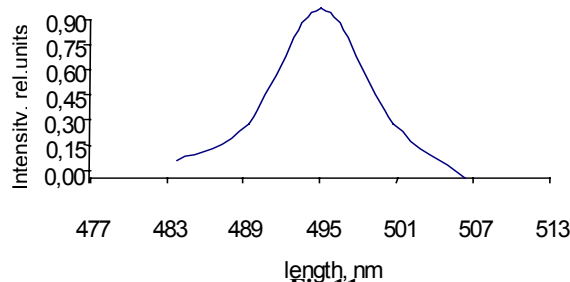


Fig.11.

EL spectra of layers of benzoquinone and cyclooctene with bias 10V DC.

Intensity of investigated samples is heightened but brightness of emitting light is insufficient for construct of mono-layer electroluminescent displays, but the obtained results show that properties of investigated polymers allow they can be used in electroluminescent devices.

5. CONCLUSIONS

The carried out investigations show that the two types of conjugated polymers exhibits a photoluminescence in blue, green and red areas of the visible spectrum. The investigated polymers have electroluminescent properties and p-type conductivity. Therefore, they can be investigated for preparation electroluminescent polymer device samples, which is our further problem.

6. REFERENCES

1. T.M. Brown, R.H. Friend, I.S. Millard, D.J. Lacey, J.E. Burrouges, and Cacialli, *Appl.Phys.Lett.*,77, 3096, 2000.
2. R.H. Friend, W.C. Greenham, Cambridge CB3 OHE, U. K.
3. M.H. Bussac, D. Michoud, L. Zupitoli, *Phis. Rev. Lett.*, 81, 1678, 1998.
4. H. Ishii, K. Sugiyama, E. Ito, K. Seki, *Addv. Mater.*, 11, 605, 1999.
5. R.H. Friend, R.W. Gymer, A.B. Holms, J.H. Burroughes, R.N. Marks, C. Taliani, D.D.C. Bradley, D.A. Dos Santos, J.L. Bredas, M. Logdlund, W.R. Salaneck *Nature*, 397, 121, 1999.
6. C. Jossifov, *Ring Opening Metathesis Polymerization and Related Chemistry*, E. Khosravi and T. Szymanska-Buzar {eds), 425-436, 2002, Kluwer Academic Publishers, Printed in the Netherlands, and the references therein
7. C. Jossifov, *J. Mol. Catal.: Chem.*, 135, 263, 1998.
8. C. Jossifov, *J. Mol. Catal.: Chem.*, 190, 235, 2002.