



## Studying of the Photoluminescence and Photo Diodes on the Basis of Cotton Fibres Covered with the Polymeric Composite

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### ABSTRACT

The method of simple immersion of CF is applied in solution of poly - [2-metoksi-5-(2-etilgeksiloks) - 1,4-fenilenvinilen] (MEH-PPV) for a covering on various surface modified cotton fibers. This method provides fast, simple, reliable, a little expense and easily scalable process for a covering of the conducting polymer on textile material, and it mentions the process of layer of assembly, applied earlier.

**Key words:** Photoluminescence, Photo Diodes, Cotton Fibres, Polymeric Composite

### INTRODUCTION

The natural cotton fibers (CF) represent an interesting alternative to inorganic analogs, used as the strengthening agents at preparation of composite materials, because of their good mechanical properties, low cost, universal availability in the most different forms and suitability for reuse [1]. The covering on materials from cotton of the conducting polymers, one of the perspective directions for receiving composite materials, has been widely developed in recent years. These composite materials have good prospect in many practical areas. Series of polymer covered materials are used mainly for creation of light-emitting layers or well absorbing layers for creation of organic photo cells [2,3,4,5,6].

The efficiency of coefficient of transformation of solar elements on the basis of the conducting polymers remains low, because of restrictions in parameters of the used material and not optimality of their properties nowadays. Therefore, studying of the optical and conducting properties, cotton-fiber composite materials, the conducting polymer covered with PPV is of great interest.

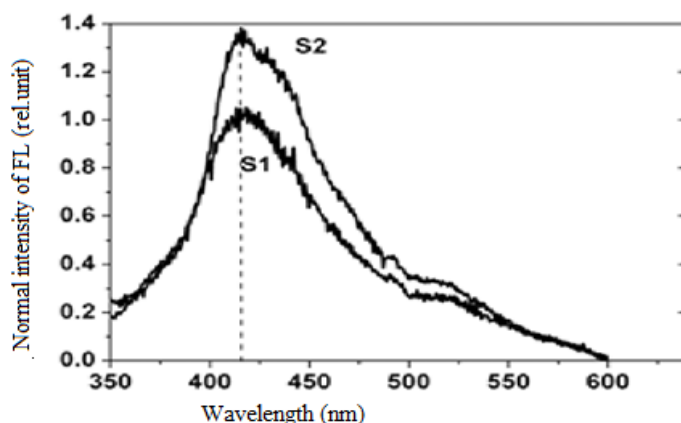
In this work, the method of simple immersion of CF is applied in solution of poly - [2-metoksi-5-(2-etilgeksiloks) - 1,4-fenilenvinilen] (MEH-PPV) for a covering on various surface modified cotton fibers. This method provides fast, simple, reliable, a little expense and easily scalable process for a covering of the conducting polymer on textile material, and it mentions the process of layer of assembly, applied earlier [7]. We displayed that the received MEH-PPV/ composite cotton of fiber showed electric and photoconductivity and also some functional properties, due to physical modification of a surface of cotton fibers.

### EXPERIMENT

To disposal impurity and not cellulose components attached on the surface of cotton fiber and also modifications of a surface, crude cotton fibers were processed previously in water NaOH solution: (i) the cleaning processing (2% of NaOH, pH=11,5 t=90 min., T=95°C, removal of not cellulose connections, structure of cellulose remains invariable - cellulose I) (sample S1), (ii) mercerization (20% of NaOH, pH=13, t=120 min T≤15°C, the structure of cellulose changes - cellulose II) (S2). Thus, originally inert surface of cellulose fiber becomes "activated", and cellulose substances become capable to act as frameworks for further modification as inorganic and also molecular guest materials. Each type of samples of cotton (6 mg) was immersed in MEH-PPV solutions with various concentration in waterless chloroform at the room temperature within 5 minutes and dried up. S1 samples (solution of polymer of 3 mg/ml) and S2 (6 mg/ml) were made on quartz glass from several thousand parallel put CF in 10 mm long. For comparison of the results, samples

of initial MEH-PPV are also made in the same way. Before measurements all samples were annealed within 30 minutes at 80° C for removal of excessive solution and stabilization of the covered material.

The morphology of samples was studied by utilize of the scanning electronic microscope (XL-30 PHILIPS). Ranges of photoluminescence (FL) were measured on a spectrometer of SPEX equipped with the monochromator, diffraction lattice of which is 0.75 m. As the source of excitement He-CD the laser having a power of 50 MW and a length of radiation of 325 nanometers was used. The corresponding neutral light filters were used to obtain various pover of the laser. Volt-ampere characteristics (VACH) were measured on structures of ITO-PEDOT-PSS-XB/MEH-PPV-Ag of sandwich type samples, using of the analyzer of semiconductor parameters of the Keithley 617 electrometer under room conditions and in the dark.

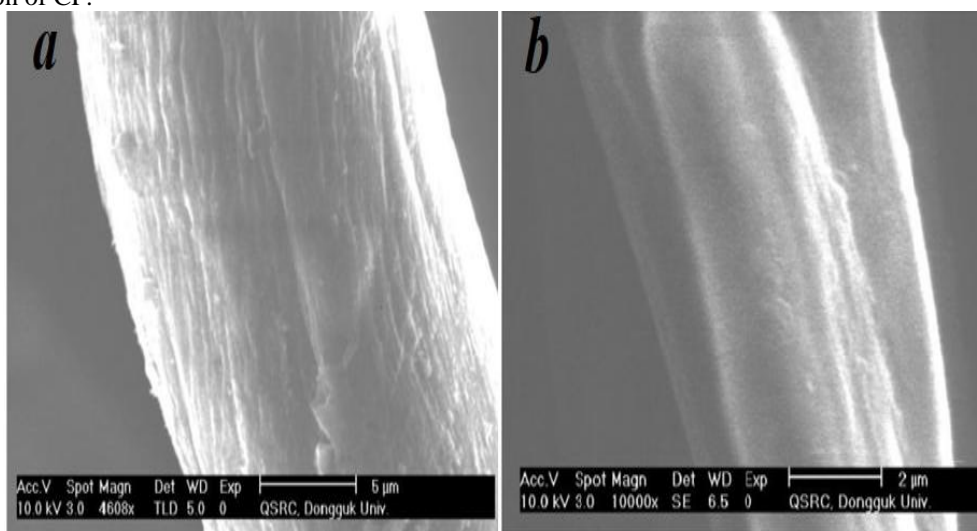


**Fig. 1** Normalized spectral intensity of FL for samples of S1 and S2, rated on spectral intensity for S1 sample

### RESULTS AND DISCUSSION

In the figure 1 the typical stationary spektrum of the FL which are previously processed, not covered with polymer of samples of S1 and S2 is shown. The photoluminescence of a sample of S1 covers spectral range from 340 to 600 nanometers and shows the intensity peak at 411 nanometers. However its intensity is lower than radiation in comparison with S2. For a sample of S2 it is observed relative narrow on width spectrum FL, with the peak of intensity on 411 nanometers. Decomposition of a full range of FL on Gaussian components, were found that spectral parameters for S1 sample not elementary and can be spread out by three Gaussian components with the peaks of intensity at ~ 371, ~ 410 and ~ 481 nanometers. In distinction from S1 samples, for S2 samples, the spread-out peaks of intensity differ and consist of four Gaussian components at ~ 321, ~ 411, ~ 427, and ~ 481 nanometers, respectively.

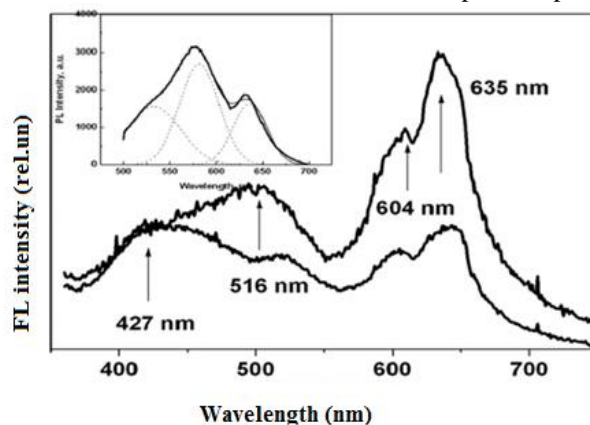
Though values of three peaks of intensity show almost identical values, here it is detected considerable divergences in number of components and the FL form for two studied samples. The appearance of additional peak of intensity at 427 nanometers for samples of S2 shows increase in the size amorphous component structures and it is explained by a gap between or in molecular hydrogen communications in a cellulose chain. Defects and their clusters are the effective centers of a photoluminescence, and the intensity of emission in such conditions defines with density of defective states. From this point of view, observed increase of FL intensity S2 samples can be referred to increase in concentration of such unregulated fragments which arise at transformation of a part of crystal structure with CI to CII which is the reason at mercerization of CF.



**Fig. 2** The SEM-image (a) initial and the cotton fiber covered with MEH-PPV

Surfaces not covered with a cover and with MEH-PPV covering at stages of processing of cotton fibers were characterized by SEM, and the result is shown in the figure 2. The covered fibers have very uniform film dense layer, at the same time the surface of not covered initial CF remains rough that is well visible from fig. 2 (a). As a rule, each separate fiber was covered by a continuous film of polymer with high quality (fig. 2 (b)). The high quality of a covering reflects high affinity between the conducting MEH-PPV and CF polymer. This big affinity can result from specific interactions, such as hydrogen binding between free groups - OH on CF and carbon atoms C = C with double communication in vinyl group on MEH-PPV.

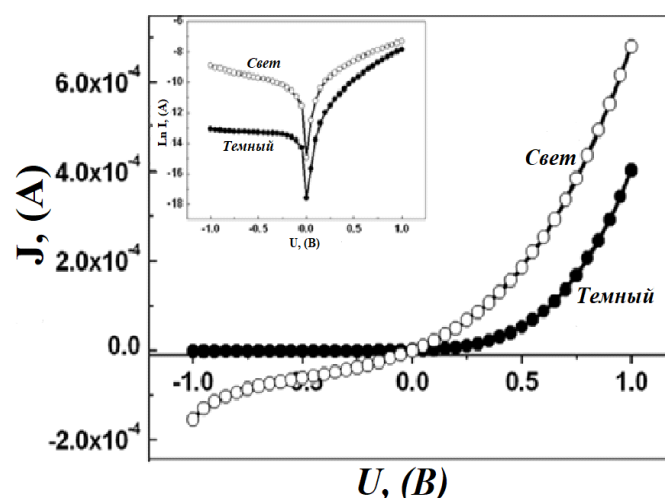
As shown in fig. 3, FL spectr of composite material of cotton fiber of the covered MEH-PPV, was wide, covering all visible range from 350 to 700 nm with four resolved peaks, located near 427, 516, 604 and 635 nm, respectively. The peak on 427 nm was caused by emission of the CF, and peaks of intensity at 516, 604 and 635 nm proceed from the covered MEH-PPV polymer, respectively [8]. For comparison the range of FL of initial MEH-PPV was also investigated and the similar range of FL, except for CF peaks (fig. 3, an insertion) was received. According to this result it is possible to conclude that simple immersion of CF in solution for a covering of the conducting polymer is a safe method and does not lead to essential damage of structure of MEH-PPV. Formation of complexes of oxygen-containing bridges, such as - C-O-, perhaps, also increases adhesion of a surface and creates a new polymeric layer with the shortened length of the conjugation created on limit of the section MEH-PPV/CF. The complexes formed by chemical binding can facilitate charge transfer from CF in a layer polymer emission. The measured dark current of CF / MEH-PPV of a composite almost linearly increased up to 0,3 mA in process of increase bias from 0 to 100 V. Light-emitting diodes with different energy of wavelength of radiation were used to stimulate of the photoresponse.



**Fig. 3** Ranges of FL of light-emitting composite samples of S1 and S2. Insert: a range of FL of a clean film of MEH-PPV polymer on a substrate from quartz glass

Composite samples show the essential strengthening photo excitation in wide area of a range - from the nearinfrared to the ultra-violet region.

Observations clearly showed the superfast reversible metastable photoinduced transfer of electrons from the conducting polymer on CF in hardened films. Using this molecular effect on border between layers, consisting of CF and MEH-PPV, we developed heterojunction photodiodes. Samples consist of CF covered with layers of MEH-PPV 1-2 microns thick clamped between contacts of ITO/PEDOT-PSS and Ag.



**Fig. 4** VACh the structures of ITO-PEDOT-PSS-XB/MEH-PPV-Ag measured in the dark and when lighting. On an insert, there are half-logarithmic dependences of the same VACh, measured in the room conditions

The results of VACH measured in the dark and by lighting show that by lighting the diode current increases at both, the direct and return directions of the applied voltage (Fig. 4) that gives very similar result with earlier published messages [9, 10]. Current increasing by lighting in the opposite direction is more than in direct shift that is characteristic of photo diodes. The created hetero structure can accept reversibly conditions of "switching on" and "switching off" at switching on or switching off of lighting, respectively, with a current ratio on/off equal 55 at  $-1V$  of the enclosed applied voltage. For comparison, the composite of CF/MEH-PPV without creation of hetero-structure, also shows a similar state by lighting and at the same time the ratio on/off is approximately equal 16 at 50 V of the applied voltage. What follows hence that parameters of photosensitivity is better for hetero-structure than for the composite. And photosensitivity of the created diodes is possible to operate by means of the photoinduced changes in electronic properties of hetero structure on border metal semiconductor.

### CONCLUSION

Thus, optical and electric properties of the initial clean CF, the samples which are previously surface modified in the chemical way covered with the conducting MEH-PPV polymer with application of a method of simple immersion were investigated. As described above, the modified CF having photosensitivity MEH-PPV were received incredibly simple, and functional decisions for wearable electronic devices and so-called "smart textile materials" are offered. The results show not only a clear picture about photosensitive properties of the received materials, but also show the potential for development of very cheap photodetectors for registration of photons in UV and visible area of a range on the same heterostructure. Such conducting composites from cotton fibers can find applications in wide areas as wearable and flexible electronics, development of solar electric energy and the biomedical industry.

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