UDK: 21474

THE RISE OF ORGANIC SEMICONDUCTOR CONDUCTORS: A REVOLUTION IN ELECTRONICS

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Abstract: Currently, the electronics and Nano electronics industry is developing rapidly, which leads to an increase in demand for environmentally friendly materials, namely semiconductors and organic semiconductors. One of the important achievements of science in recent years is the development of organic semiconductor conductors, which are widely used to develop electronic devices and allow the creation of various devices in industry based on their composition. Organic semiconductors are carbon-based compounds that exhibit semiconductor properties, which allow them to conduct electric current like traditional inorganic materials, such as silicon, but devices based on organic semiconductors stand out from others with their reliability and low cost. Also, the technology for obtaining organic semiconductors and their reliability are much better than other technologies available today. OLED devices, organic solar cells, and OLED lighting panels based on organic conductors are very different from semiconductor devices in terms of their reliability, and their flexibility and ease of manufacture make them very important for various electronic applications. This article discusses the unique advantages of organic semiconductors and the technologies developed based on them, namely OLED devices, OLED screens, solar panels, and their operating principles, as

ISSN 3030-3907

well as sensors used in medicine and their types, and provides brief information on the work being done on organic semiconductors in our country.

Keywords: Organic conductors, OLED device, Organic solar cells, OLED lighting panels, and Mode-2 biosensors.

Annotatsiya: Hozirgi payitda elektronika va nonoelektronika sanoati jadalik bilan rivojlanib bormoqda bu esa ekologik toza materiallar ya'ni yarimo'tkazgich va organik yarimo'tkazgich materialarigan bo'lgan talabni ortishiga olib kelmog'da. Sungi yillardagi fanning muhim yutuqlardan biri bu organik yarimo'tkazgichli o'tkazgichlarning rivojlanishi bo'lib, ular elektron qurilmalarni ishlab chiqish uchun keng qullanilmog'da va bu turdagi materiallarni ularni tarkibdian kelib chiqib sa'notda turli qurilmalar yaratish imkonini beradi. Organik yarimo'tkazgichlar yarimo'tkazgich xususiyatlarini ko'rsatadigan uglerod asosidagi birikmalar bo'lib, ular an'anaviy noorganik materiallar, masalan, kremniy kabi elektr tokini o'tkazishga imkon beradi lekin organik yarimo'tkazgichlar asosida ishlab chiqilgan qurilmalar boshqalarida ishonchliligi va tan narhini arzonligi bilan ajralaib turadi. Shuningdek, organik yarimo'tkazgichlarni olinish texnologiyasivasi va ularni ishonchliligi hozirgi kundagi boshqa texnologiyadan ancha afzalroqdir. Organik o'tkazgichlar asosida ishlab chiqarilgan OLED qurilmasi, Organik quyosh batareyalari, OLED yoritish panellari o'zlarini ishonchliligi bilan yarimo'tkazgichli qurilmalardan ancha farq qiladi va ularning moslashuvchanligi va qulayliklardan foydalangan holda ishlab chiqarish qobiliyati ularni turli xil elektron ilovalar uchun juda muhumdir. Ushbu maqola organik yarimo'tkazgichlarning noyob afzalliklari va ular asosida ishlab chiqilgan texnologiyalar yani OLED qurilmalari , OLED ekranlari quyosh panellari va ularni ishlash prinsifi, shuningdek, tibbiyotda qullaniladigan datchiklar va ularni turlari o'z ichiga oladi va mamlakatimizda organik yarimo'tkazgichlar bo'yicha qilinayotgan ishlar haqidagi qisqacha ma'lumotlarni o'z ichiga oldi.

Kalit so'zlar: Organik o'tkazgichlar, OLED qurilmasi, Organik quyosh batareyalari, OLED yoritish panellari va Mode-2 biosensorlari.

Аннотация: В настоящее время электронная и нано электронная промышленность развивается быстрыми темпами, что приводит к росту спроса на экологически чистые материалы, а именно полупроводники и органические полупроводниковые материалы. Одним из важнейших научных достижений последних лет стала разработка органических полупроводниковых проводников, которые широко используются при создании электронных приборов и позволяют использовать эти типы материалов в промышленности для создания различных устройств на их основе. Органические полупроводники — это соединения на основе углерода, которые проявляют полупроводниковые свойства, что позволяет им проводить электричество подобно традиционным неорганическим

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материалам, таким как кремний, однако устройства на основе органических полупроводников выделяются на фоне остальных своей надежностью и низкой стоимостью. Кроме того, технология производства органических полупроводников и их надежность значительно превосходят другие доступные сегодня технологии. OLED-устройства, органические солнечные элементы и осветительные панели OLED на основе органических проводников существенно отличаются от полупроводниковых приборов по своей надежности, а их гибкость и простота изготовления делают их очень важными для различных электронных приложений. В статье рассматриваются уникальные преимущества органических полупроводников и технологии, разработанные на их основе, а именно OLED-устройства, OLED-экраны, солнечные панели и принципы их работы, а также датчики, используемые в медицине, и их типы, а также приводится краткая информация о работах, проводимых в области органических полупроводников в нашей стране.

Ключевые слова: Органические проводники, OLED-устройство, органические солнечные элементы, панели освещения OLED и биосенсоры Mode-2.

Introduction:

Organic conductors and semi-conductors are a special class of polymers which may possess interesting optoelectronic properties. They are conjugated polymers with their structures containing at least one backbone chain of alternating double and single bonds (conjugated double bonds). Organic semiconductors are solids whose building blocks are pi-bonded molecules or polymers made up by carbon and hydrogen atoms and – at times – heteroatoms such as nitrogen, sulfur and oxygen. They exist in the form of molecular crystals or amorphous thin films. In general, they are electrical insulators, but become semiconducting when charges are injected from appropriate electrodes or are introduced by doping or photoexcitation. Organic semiconductors have ffectiveness which to be used in electronics sphere. There are some useful sides below that we will provide in detail. [5]

1. **Sustainability**: Traditional semiconductor manufacturing processes often rely on toxic materials and generate significant waste. In contrast, organic semiconductors can be synthesized from renewable resources, making them a more environmentally friendly option.

2. **Flexibility**: One of the standout features of organic semiconductors is their flexibility. This characteristic opens up a realm of possibilities for creating bendable and adaptable electronics, paving the way for innovative designs that could revolutionize wearables and portable devices.

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3. **Cost-Effectiveness**: The production of organic semiconductors often requires less energy and can be done using solution-based processes. This can significantly reduce manufacturing costs, making electronic gadgets more affordable to consumers. [13].

4. **Lightweight:** Organic semiconductors are typically lighter than their inorganic counterparts, making them ideal for applications in lightweight consumer gadgets, drones, and other portable devices. As the demand for innovative electronic gadgets grows, organic semiconductors are making their mark in various domains: André Berna nose and co-workers at the Nancy-University in France made the first observations of electroluminescence in organic materials in the early 1950s. They applied high alternating voltages in air to materials such as acridine orange dye, either deposited on or dissolved in cellulose or cellophane thin films. The proposed mechanism was either direct excitation of the dye molecules or excitation of electrons. Then, Chemists Ching Wan Tang and Steven Van Slyke at Eastman Kodak built the first practical OLED device in 1987. This device used a two-layer structure with separate hole transporting and electron transporting layers such that recombination and light emission occurred in the middle of the organic layer; this resulted in a reduction in operating voltage and improvements in efficiency. [14]

- **Organic Light Emitting Diodes** (OLEDs): OLED technology is perhaps the most well-known application of organic semiconductors. Used in televisions, smartphones, and tablets, OLEDs provide vibrant colors and deeper blacks while consuming less power than traditional LED screens. Another application for OLEDs are in displays. They are particularly popular with TV manufacturers because they generate light directly and so don't need the white backlight and filters that are found in other technologies, meaning the overall display can be thinner. They also open the possibility of making flexible displays and several electronics manufacturers are expected to launch bendable products in the next few years, although this is not without its challenges. [14]

- **Flexible Displays**: With the integration of organic semiconductors, flexible and foldable displays are becoming a reality. This technology has the potential to transform smartphones and tablets into dynamic devices that can easily adapt to different shapes and sizes.

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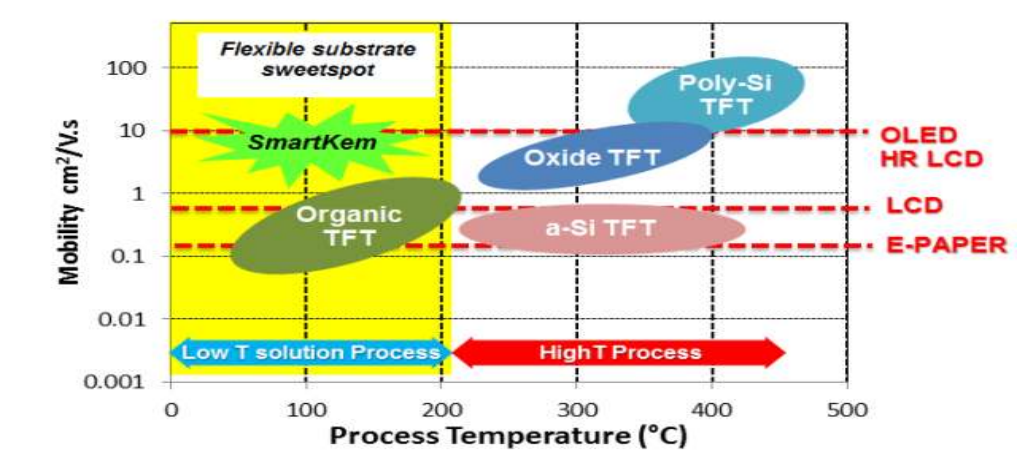


Fig. 1. The structure of organic materials

In addition to this, organic semiconductors are can be used to make organic photovoltaic cells which are gaining traction as a sustainable alternative to traditional solar technologies. These cells can be printed onto various surfaces, offering lightweight and flexible solar solutions for powering gadgets and even larger installations.

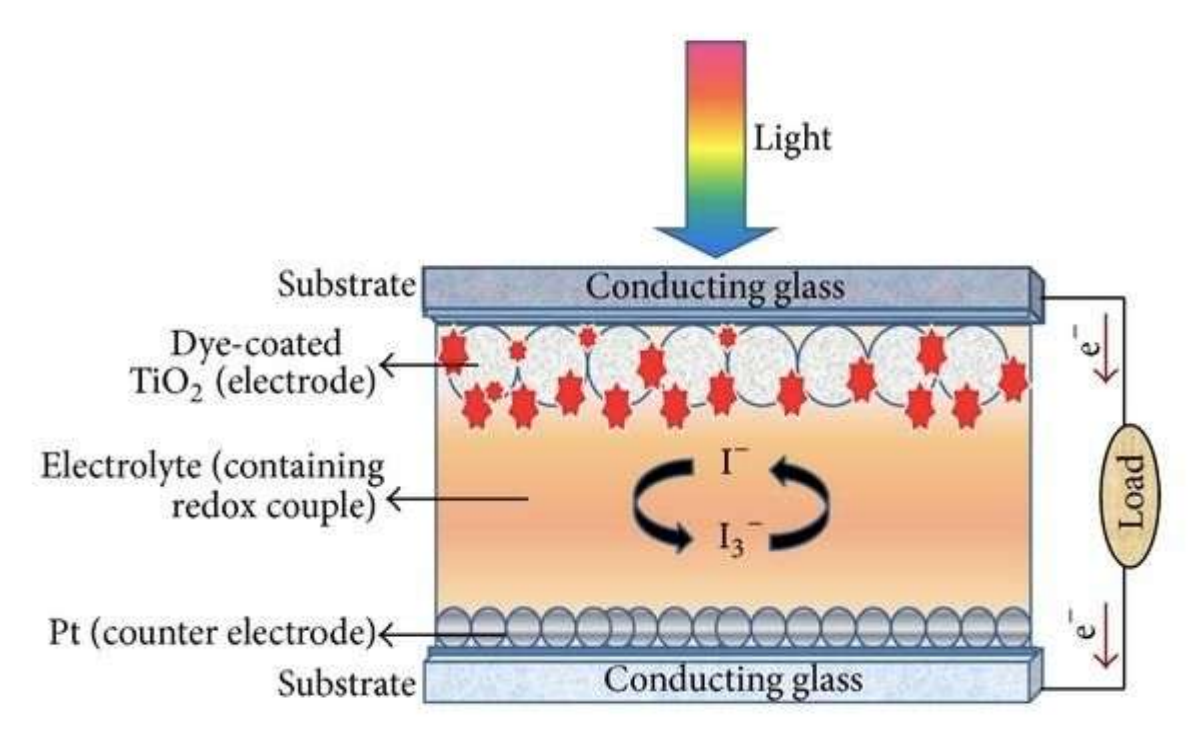


Fig. 2. The structure of organic solar cells

Organic solar cells are gaining importance. Furthermore, as used in other solar cell technologies, organic solar cells (polymer and dye sensitized solar cells) do not require materials and/or toxic materials of very high purity. However, their lower efficiencies (0.01-15%) arising due to the different recombination losses are the key limitation of organic solar cells as of now. Organic solar cells have certain drawbacks, including their low efficiency and short lifetime (only 5% efficiency compared to 15% of silicon cells).

ISSN 3030-3907

Nevertheless, their numerous advantages can be justified by current international investment and research in the development of new polymer materials, new combinations and structures to improve efficiency and, in the coming years, achieve low-cost and large-scale production. The objective of the next decade is to produce commercially viable organic solar cells and so much is still going on in this aspect. [12]

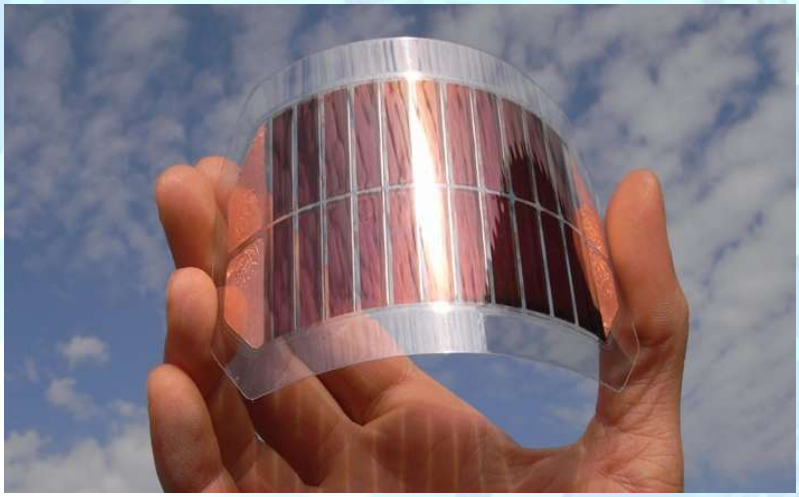


Fig. 3. Prototype OLED lighting panels

Sensors: Organic semiconductors can be utilized in sensors that detect environmental changes, making them suitable for smart home devices and wearable technology. The potential for low-cost, printable sensors could lead to significant advancements in health monitoring and environmental tracking organic semiconducting polymers are a highly versatile, promising class of materials for biosensors since their organic synthesis can be tailored to achieve various functionalities for different applications. This versatility is evidenced by the numerous, innovative techniques in recent literature to synthesize organic biosensor materials. [11].

Electrochemical biosensors have especially great potential for widespread, in-vivo application, since recent biosensor materials exhibit high sensitivity, LODs as low as 0.0986 μM, and broad linear ranges spanning five orders of magnitude Novel electrochemical transistor configurations including OECTs enhance sensitivity through signal amplification and represent a popular new direction in biosensor design. Mode-2 biosensors utilizing complex moieties are most common and historically well-established; here the organic semiconductor only transduces the electrochemical signal, while additional moieties including enzymes and bacteria are primarily responsible for detection. Consequently, numerous semiconductor functionalities have been developed to bind to these moieties, including amine groups for enzymes, and fused-ring backbones which also improve charge transfer. Developing chemical functionalities with improved enzyme binding may also reduce the current overdependence on GA crosslinking for enzyme adhesion. [1]

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In addition, recently, our countries' scientists learned and analyzed of organic semiconductor substances is their spectroscopic study. In this work, using the XRD-6100 X-ray phase analysis method, X-ray diffraction patterns were obtained of complex compounds synthesized in the laboratory of the Institute of Bioorganic Chemistry named after Academician A.S. Sadykova of the Academy of Sciences of the Republic of Uzbekistan of organic semiconductor. Absorption spectra of this material were recorded in the spectral range from 180 to 1100 nm. Based on the obtained UV spectrum, the band gap of this sample was determined. The numerical value of the Eg-band gap for this sample is approximately equal to Eg = 1.29 eV. This indicates that the substance we synthesized is a very good semiconductor material. In addition, the analysis of organic semiconductor substances includes the study of their electronic structure and energy levels. This allows us to determine how the electrons of a substance move and interact with each other, which is important when developing electronic devices based on these materials. After this, the current-voltage characteristics of this organic semiconductor were measured, the results of which are shown in Fig. 4. As is known from the literature [1], the direct branch of the real current-voltage characteristic of a p-n junction is initially described by an exponential function, and then completely determined by the ohmic resistance of the semiconductor.

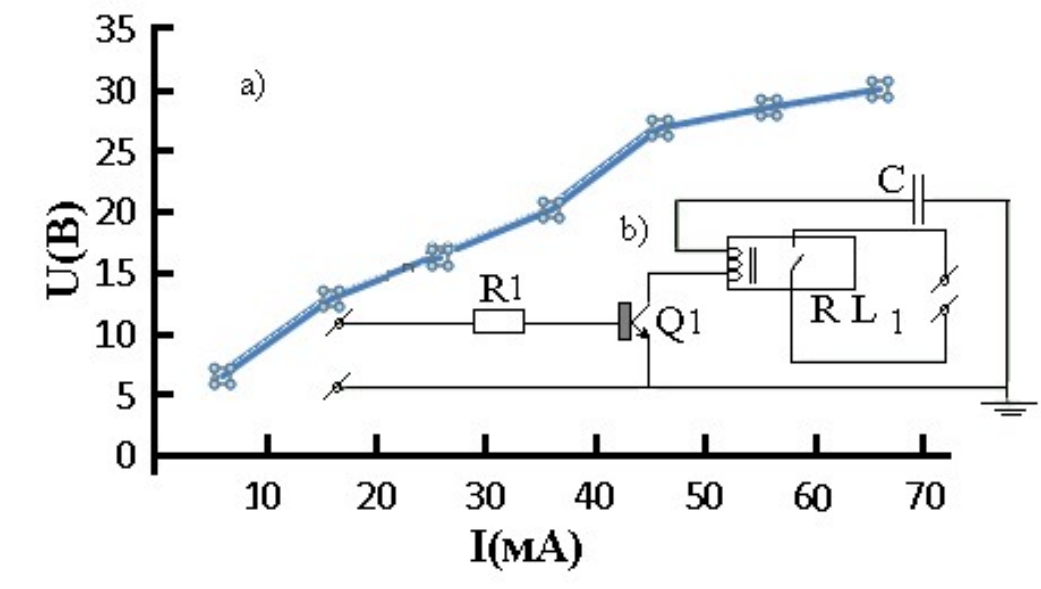


Fig. 4. a) Current-voltage characteristic of an organic semiconductor, b) electrical diagram of the current-voltage characteristic process.

Figure 4 b) above shows the circuit diagram of the main board. Here we use an organic semiconductor in the liquid state, obtained from a Cu2+ chelate complex; it has an n-p-n junction. A resistor with a resistance of 200 Ohms is connected to its base, which, in turn, is connected through its contacts to the power source. The relay has 4 contacts and is designed to operate at a current of 5 amperes and 12 volts. Its main function is to

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connect and disconnect a sample for testing. And the capacitor was used as a filter. And Figure 3a) below shows the current-voltage characteristic of the result obtained on the basis of the device assembly developed above. As you can see, the results showed a linear relationship. A linear increase in voltage results in a corresponding increase in current. The relative error is about 5%, which indicates the correctness of the experiment and the reliability of the results.

Conclusion: The advent of organic semiconductor conductors marks a significant step toward a more sustainable and innovative future in electronics. Their unique properties offer a wealth of opportunities for developing the next generation of gadgets that are not only efficient but also environmentally friendly. As research and technology continue to evolve, organic semiconductors will likely play a crucial role in shaping the electronics landscape for years to come, providing consumers with enhanced, eco-conscious options for their daily technology needs.

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ISSN 3030-3907