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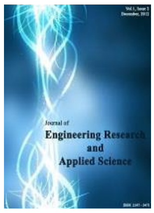

Renewable energy and photovoltaic technology

Y.Sen[1], A. Takmaz[2], A. Kabakcı[2] ,G. Kabakcı[2], G.Deniz[2,a]

[1]Duzce University, Biomedical Engineering, Duzce, Turkey.
[2]Duzce University, Mechanical Engineering, Duzce, Turkey.

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Abstract

Depletion of fossil energy sources has led mankind to search for new energy sources. Consequently the research done on renewable energy sources. In recent years, work on renewable energy resources is increasing rapidly. It is a type of energy that can be needed for a clean environment due to constantly renewed energy. The fact that solar energy is easily accessible and that solar energy is abundant in nature makes solar energy more advantageous. In recent years it has been concerned with the production of photovoltaic batteries, mainly due to their electricity generation work. Production of photovoltaic cells in Turkey is almost none. In this sense, a review of the battery material, production conditions and production efficiency a compilation was made. In this article, electricity production from solar energy, electricity production from photovoltaic battery, PV production techniques are mentioned..

Keywords: Renewable energy; photovoltaic technology; solar batteries.

1. Renewable energy sources

Renewable energy can be described as the source of energy that can exist in in nature's own evolution the next day. New and renewable sources of energy that can take the place of primary energy sources that pollute the environment and are inevitable to be consumed; solar energy, wind energy, geothermal energy, hydraulic energy, hydrogen energy, sea-based energies and biomass energy.[1] Renewable energy sources compete with traditional fuels in four different markets: Power generation, hot water supply and heating, vehicle fuels and rural activities. Renewable energy accounts for about 4% of power generation capacity and accounts for about 3% of global electricity production. Many building's hot water and place heating system,are provided with solar, biomass and geothermal energy. In the world, solar thermal collectors are used by about 40 million households. Biomass and geothermal energy provide heat for industry, domestic use and agriculture. In developing countries, 16 million households use biogas for cooking and lighting, taking the place of kerosene and other cooking fuels. More than two million houses use solar photovoltaics to illuminate their homes and an increasing number of small industries, including tillage, process heat and propulsion, are getting small-scale biogas [2]. Renewable energy sources constitute one in five of the world's total energy resources use. All renewable energy sources can be used to generate electricity. In the world, the use of traditional biomass in heating and cooking is about 9%, the use of hydroelectric energy is about 6% and the use of biofuels is 2% [3].

2. Sunlight

The sun is the most important source of energy, for all living things in the world. The sun transforms its own hydrogen, helium, into a great thermonuclear fusion reaction. The surface of the sun is 5800 Kelvin (K), this energy spreads by radiating everywhere. Over time, this energy travels 150 million kilometers to the world [4].

3. Solar energy

Solar energy is both abundant, continuous and renewable as well as a free energy source. In addition, most of the environmental problems caused by the use of conventional fuels are not found in solar energy production. This type of energy is clean and environmentally friendly. As a result of carbon

[a] Corresponding author;
Phone: +90-380-542-1100, Email: gozdedeniz058@gmail.com

dioxide (CO_2) emissions (emissions), the inevitable product of combustion technology on which fossil fuel use is based, the amount of CO_2 in the atmosphere has increased about 1.3 times over the last century. Over the next 50 years, this amount is likely to increase by 1.4 times. The greenhouse effect caused by in the atmosphere has raised the world average temperature by 0.7 ° C over the past century. This warm, 1 ° C rise causes changes in the world's climate cohorts. Increases of up to 3 ° C may cause erosion of polar glaciers, elevation of the oceans, aridity and agricultural droughts in lakes. So, as energy use can not be abandoned, it is necessary to use natural and alternative resources such as the sun [5,6].

4. Historical development of solar pools

Although photovoltaic cells are accepted as a new technology, their historical development dates back to 1800's. The photovoltaic effect was first discovered in 1839, when the French physicist Alexandre Edmond Becquerel observed that the tension between the electrodes immersed in the electrolyte was light dependent on the electrolyte .Becquerel's research has gained momentum with the discovery of a photo based on the generation of current by dipping two platinum electrodes into a solution containing a metal halide salt. It has been proved by G. W. Adams and R. E. Day in 1876 that solids can also form photovoltaic effects by observing photovoltaic events in selenium (Se) crystals [7]. In 1883, Charles Fritts produced a first serious photovoltaic cell with 1.1% yield by coating a very fine gold layer of selenium (Se). Over the years, photovoltaic effects have also been observed in copper-copper oxide (Cu-CuO) thin film structures. The most comprehensive theoretical work on photovoltaic effect was made by Albert Einstein in 1904, and with this theoretical work, Einstein became Nobel Prize winner in 1921. This theoretical description of Einstein was experimented by Robert Millikan in 1916 and it was announced that in 1932 the photovoltaic effect was observed in the Cd-Se structure. In 1954 the first silicon photovoltaic cell was made by Chapin, Fuller and Pearson. In these cells, a yield of 6%, which is 6 times higher than the previous photovoltaic cells and considered as a turning point for photovoltaic power systems, was obtained [8]. In the years following the "Oil Crisis" in 1973, extensive research and development projects have been launched in the USA, Europe and Japan. Work on the use of solar batteries as an electrical power system in the earth began in 1954. On the one hand, efforts are being made to improve the productivity of silicon-based solar cells that have proven themselves in space studies. And on the other hand, thin film solar cells that can be produced cheaply are being studied because fewer semiconductor materials are needed. Organic photovoltaic cell work done with organic materials has been accelerated solar cells [9]. In the recent past, the divergence of organic materials has changed and the yield of organic solar batteries has increased. Even if they are still inadequate, they are trying to increase power conversion efficiency by using different organic materials. Recently, one of the highest yields recorded in organic photovoltaic cells was measured by By Yongye Liang et al. as 7.4% in the study (laboratory environment) using thienol thiophene and benzodiphiophene materials [10].

5. Electricity generation by photovoltaic battery (PV)

The way to obtain electricity from the sun is to exploit photovoltaic efficiency. The photovoltaic event is a physical phenomenon that is defined as the conversion of sunlight into electrical energy. Solar batteries are semiconductor materials that convert the sunlight coming to their surfaces directly into electricity. This principle of working solar battery generates voltage at its ends, depending on the amount of light falling. The generated voltage shows a right proportional change depending on the amount of incoming sunlight. As the use of photovoltaic solar batteries becomes more important, studies on simulation models are also accelerating. One of the main reasons for difficulty in obtaining the simulation models of photovoltaic solar batteries is that they have different characteristics from classical direct current and alternating current sources, and they are rapidly influenced by their environment and working conditions. The operating temperature, ambient temperature and sunlight intensity characteristics change dynamically. The model to be developed must have the dynamics to respond to these changes. When solar rays fall on the PV cell, some of these rays are absorbed, some are reflected back, and some go directly through the cell. Only the energy in the photons absorbed is converted into electricity. The energy in the absorbed photons is transferred to the electrons in the valence band of the atoms .With extra energy, the electrons break apart from the atoms they are bonded to by covalent bonds. The released electrons are transported to the outside load by means of the electric field formed by contacting "P-type" and "N-type" semiconductors [11].

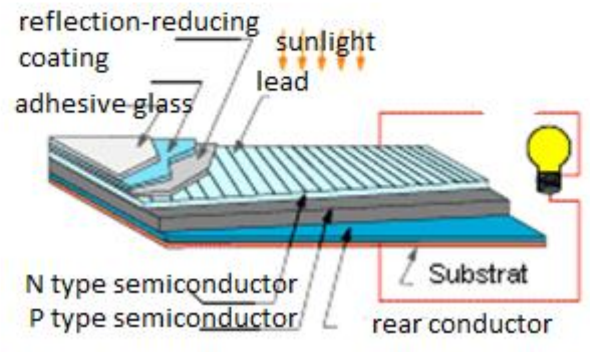

Figure 1. Electricity Generation by Photovoltaic Battery

6. Classification of solar pools

Considering the literature studies, solar batteries; we can classify them under several headings such as application areas, types of materials used, optical characteristics, or technological development stages. We can look under three headings;

•First Generation (crystalline silicon, gallium arsenic solar cells)
•Second Generation (thin films: $CuInSe_2$, CdTe, a-Si solar batteries)
•Third Generation (dye sensitive solar cells, organic solar batteries)

7. First generation solar batteries

The materials most commonly used in making solar batteries are silicon (Si) and gallium arsenic (GaAs).Silicon used in Bell laboratory for the first time in 1954 is the most prominent material in solar cell construction. The fact that the yield of silicon, a raw material with no reserves, has increased considerably since its first production, thanks to its durable crystal structure and its non-toxicity, it has become the most popular material for solar cell use. The crystal structure of silicon is not easily damaged, it ensures the optical and electrical properties are permanent. In addition, crystal silicon technology has advanced considerably due to its intensive use [12].

8. PV Types, production techniques and materials

Crystal-silicon technology is the most popular technology in PV production worldwide. The fact that Thin-Film technology is in thinner layers and that the usage areas are more diverse, increases the research done in this field. In addition, studies on organic solar cell technologies have been accelerated to reduce costs [13].The use of different materials to be used in production techniques is also examined. The use of single and multiple silicon in crystal-silicon technology, or different types of materials (a-Si, CIS, a-Si / c-Si, CdTe etc.) used in thin-film technology, can be seen as materials used in the commercial field.

8.1. Crystal silicon

In 2004, 94% of PV systems (1GW and above) were implemented using this technology. This system can be varied as monocrystalline, polycrystalline, ribbon-Si and sheet-silicon[14].

8.1.1. Single crystalline silicon solar cells

The yield of single crystal silicon solar batteries is around 15-20%. The duration of the cost is between 4-6 years and in a period of 20 years there is a loss of efficiency of about 7%. It is more expensive due to the requirement of pure crystal. The molten silicon mold is poured and allowed to cool, and the yield of polycrystalline silicon solar cells obtained by slicing these silicon blocks is around 12-16%. The cost coverage period is around 2-4 years. However, in the 20 years period, 14% efficiency loss occurs. Production process is cheaper because crystal structure is not completely homogeneous [13] Gallium arsenide (GaAs), composed of gallium and arsenic elements, has a polycrystalline structure and the forbidden bandwidth is about 1.4 eV at room temperature. The distance required to absorb the photons is shorter than that of silicon, which allows GaAs solar cells to be built with a finer structure and fewer materials. Because the gallium element is not as abundant on the earth as silicon, it is less preferred than the silicon in the construction of solar cell. GaAs solar cells are used in optical condensing systems produced for space applications. The reason for the use of solar batteries in GaAs in space applications; it is more resistant to heat and radiation than silicon [14]. The commercial yield of GaAs solar cells is 22% and the lab yield is over 25%. In this case of with other semiconductors, multi-jointed gaAs batteries , a yield of around 30 % was obtained [15].

Cylindrical single-crystalline silicon bullion produced by the "Czochralski", "Float-zone" or "Ribbon" method are cut into thin "wafers". Later, on these wafers, layers of phosphorus and boron atoms (N-type layer and P-type layer) are created. On the top and bottom surface of the solar cell made of silicon nitride or silicon dioxide, there are negative contacts made of nickel, copper and silver that will collect the current generated. These contacts, which are in the buried state, have made it possible to reduce their losses and reduce resistance in transmission. The front surface of the battery can be designed with pyramids and cones in order to better collect the reflected light.

8.1.2. Multi crystalline silicon solar cells

In order to make PV more economical, the demand for using less material led the research to this technology which is produced in thin layers. This technology allows the silicon material obtained from the layer (wafer) to produce discrete solar batteries cells and to electrically connect these cells. These materials, produced by three or more layers at a thickness of 300 μm, provide usability in many applications where flexibility is desired. However, these layers with a thickness of 100 μm have disadvantages such as (excessive mechanical fragility, effect of cutting temperature) their production and transport. Crystalline Si technologies show a steady improvement in conversion efficiency even if it is slow. The efficiency of the systems produced with this technology is currently at least 10%. The highest yield obtained in laboratory environments was 24.5%. The best system yield is around 15-16%.

8.2. Thin-film solar cells

Thin Film technology is PV manufacturing technology using semi-conductive material on layers 1-2 micrometres thick. As a result, the cost of PV production can be reduced. In addition, it is seen as a technology that can reduce production cost according to crystal silicon (c-Si) production technology in the long term due to advantages such as serial production tendency, simpler electrical connections between cells and production tendency in large sizes.

8.2.1. Cadmium tellurium (cdte) solar batteries

Periodic tableware II. cadmium in the group VI. Semi-conductor cadmium wire formed by the combination of tellurium element in the group of forbidden energy gap at room temperature Eg = 1.5 eV dir. This value is very close to the value required to achieve maximum conversion from the solar spectrum. Both high-light-absorbing capability, as well as easy, low-cost production, CdTe semi-conductors provide a single protrusion. As a result of the studies performed, 16.5% yield of CdTe cell was obtained under ideal conditions. For the commercial modules made with this technique, the best efficiency is around 11%. However, due to the toxicity of the cadmium element, it presents problems such as restriction and controlled use.

8.2.2. Amorphous silicon solar batteries (a-si)

The yield from this amorphous silicon pils, which does not exhibit crystal structure, is around 10% and in commercial modules it is around 5-7%. Today, clocks are used as power sources for small electronic devices such as calculators and toys. It is estimated that amorphous silicon solar cells can be used as another important application area, integrated translucent glass surfaces integrated into buildings, building exterior protectors and energy producers [9] Amorphous silicon, which has a very large absorption coefficient, can be uniformly coated on large surfaces at temperatures of around 250 ˚C. Since the absorption coefficients are larger than the crystal silicon, the same amount of light absorption can be obtained using thinner amorphous silicon than crystal silicon. These features make it possible for solar cells, obtained from amorphous silicon, to cost less than those in crystal form. In addition, one of the biggest disadvantages is that the light falling on them significantly reduces their efficiency [33] .Figure 4.1 shows the images of three different Si-based (amorphous Si, single crystal Si, polycrystalline Si) solar cell types.

a) b) c)

Figure 2. a) Amorphous Si solar batteries b) Single crystalline Si solar batteries c) Polycrystalline Si solar batteries

8.2.3. a-Si / c-Si mixed structures

This method consists of a combination of crystal and amorphous silicon structures. c - The Si layer is placed in the middle of the two a-Si layers. High efficiency, having operations below 200 ° C, has considerable advantages such as low energy recycling time and cost reduction. As a result of the work done, the yield in Japan has reached 20.7%.

8.2.4 Copper ındium (cıs) solar batteries

Copper indium solar batteries have high solar absorption coefficient. The forbidden energy ranges can be set to be ideal with the sun's spectrum. The prohibited energy ranges of these batteries are around 1.02-1.68 ev. It is possible to obtain higher efficiency by adding gallium element to CIS material. It is possible to get very high yields from these batteries (19.5%). The use of existing technologies is chosen, especially considering the yield-cost ratio. Figure 3 shows the cell yield, module yield and material costs of PV technologies as of 2004 year. In addition to all these technologies, there are also studies for new technologies.

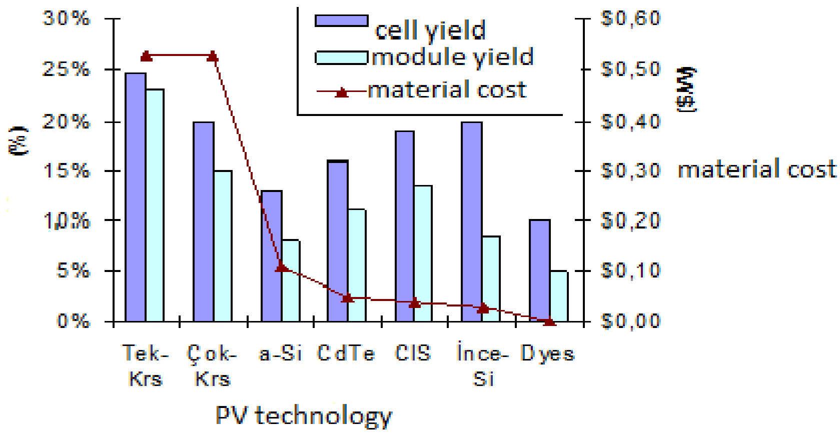

Figure 3: PV technology's cell yield, module yield, cost comparison, 2004.

8.3. Other materials and techniques

8.3.1. Highly efficient and intensified materials (gaas arsenic-gaas)

High-cost semiconductors were begun investigations since more than a third of the solar energy coming from the surface can be converted into electricity. In the results obtained from the experiments conducted in the early 1990s, 30% efficiency was obtained from the "multiple-junction" device. In subsequent studies, cell yield reached 40% and system yield reached 30-35%. Since these systems are very expensive, they are currently being used in space studies.

8.3.2. Dye-sensitized cells

The main difference that distinguishes these cells from other conventional cells is that the element responsible for the absorption of light (dye) is spread through its own charge carrier transport. The most important advantage of this technique is that it is due to the majority carrier transport, as opposed to other conventional inorganic cells. This is not the volume or surface bond in the charge carriers in the TiO2 semiconductor. For this reason, processing is started with impure materials and there is no need for any special room to make transactions. Up to now, 7-11% efficiency has been achieved and it is hopeful for low cost photoelectrochemical materials. However, in this technique problems such as the duration of durability and the fact that the temperature resistance is not suitable for the external environment have arisen.

8.3.3. Organic PV

Organic solar cells, referred to as third generation photovoltaic cell technology, are obtained by placing organic-based materials between two metal electrodes. Which is illustrated in Figure 4, the use of semiconducting polymers as organic-based materials in organic solar cells, has made a significant contribution to the development of these batteries [34] Conductors are promising for the future because they have advantages such as high molecular weight organic molecules which can be easily modified according to desired properties, cheap and easy production techniques.

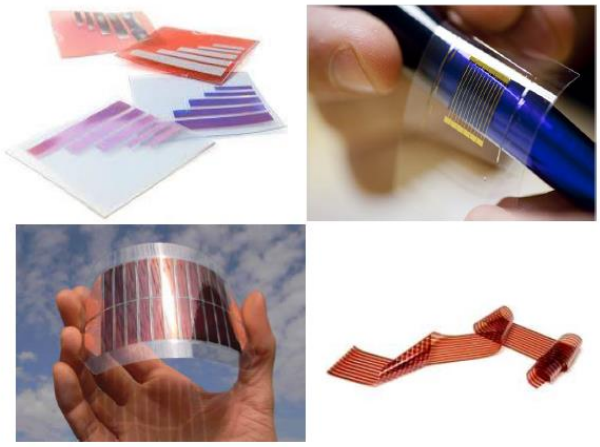

Figure 4. Organic solar batteries with flexibility

While the diversity of inorganic analogues is limited, the fact that the number of organic molecules is on the order of millions also allows to increase the yield and stability of these materials. Due to the lack of reserve stress, organic materials have begun to be investigated in a very detailed way for such studies. The most common type of device is one in which the receiver (donor, p) and the transmitter (acceptor, n) are used together to form a pn-joint. Another advantage of organic materials is that the chemical structures of the materials used can be easily changed. In this way, the absorption range of the materials is made more suitable for the solar spectrum, so that more photon energy can be absorbed. On the other hand, yields are lower than inorganic materials used in solar cells. In addition to improving efficiency in organic solar batteries, there is also a stability problem. Particularly under light and in water vapor / oxygen, the quality drops quickly. Organic materials must be kept away from air and moisture in order to be durable [11] The first organic solar battery was produced by Kodak .The produced batteries have a yield of 1.1%. The reason for the low efficiency is that in the two-layered solar cell, the separation of the electron-emitter pair, which forms the sun's energy, occurs only at the interface of the layers. The reason for the low efficiency is that in the two-layered solar cell, the separation of the electron-emitter pair, which forms the sun's energy, occurs only at the interface of the layers. In other words, the electron-hole pair can not be separated in sufficient quantities. Excitons arising from the absorption of solar energy allow the load carriers to come to the scene. The excitons generated by the absorption of solar energy provide load carriers to occur. The excitons must flow smoothly in order for the photo-current to form. In general, in organic solar batteries, excitons with long life spans contribute to the formation of photo-current. In order to overcome this problem and increase the absorption of light on the active surface, two new methods known as double-layer heteroeklem and volume-heteroeklem were developed in the early 1990s. In these systems, the donor and acceptor are in a mixture with two different materials and a suitable solvent. Thus, the required load separation has been increased to the highest level.In addition to the solvent used, the application of temperature to the solar cell produced is also an important influence. However, this process, variability according to the material. In addition, various materials need to be reinforced in order for the films to form properly. With all these factors in mind, it is desirable to make an organic material more suitable for solar cells. Even if they are still inadequate, it is known that akers with power conversion efficiency of over 7-8%, produced using different organic materials, are produced with increasing acceleration.For this reason, the world's leading research groups are continuing to work on increasing productivity with many different polymers and producing new polymers. For this reason, research and development efforts to improve the efficiency of organic solar batteries have contributed to the development of polymer production technology. Polymers, when first discovered, were known as electrically insulating materials, contrary to what is known today. For this reason, there are areas where electrical insulation is required. In the 1970s, the first conducting polymer, polyacetylene, was discovered. When polyacetylene films are oxidized by iodine (I), fluorine (F) or chlorine (Cl) evaporation, the conductivity increases by 109 times to 105 S / m [12]This value is much higher than the conductivity value of the insulated teflon and is very close to the electrical value (106 S / m) of metals such as silver (Ag), copper (Cu).

It is now known that many polymers such as polypyrrole, polythiophene, polyaniline, polyfuran, poly (N-vinylcarbazole) in the form of powders, films, suspensions or sheets are conductive and commercial productions thereof are being made. Since conductive polymers have important properties such as low cost and can form thin film, the usage areas are getting bigger every day. Examples include organic photovoltaic cells (OPV), field effect transistor (FET), photodiode technology, laser technology, semiconductor chips, integrated circuits, sensors, LCD monitors, computers and various technological devices [13]; The concept of conducting polymers is used for polymers that provide sufficient electrical conductivity with electrons in the structure. In order for the polymers to exhibit electrical conductivity, the polymer structure must have suitable sites for the transport of electrons through the chain. This is provided by the polymers having double bond, the main chain conjugation. Conductive polymers of this type are called conjugated polymers. This provided an important contribution to the formation of organic photovoltaic cells. Conjugated polymers are long chain structures consisting of repeating groups linked to each other by successive single and double carbon-carbon bonds. Single bond sigma (σ) bond, double bond one sigma (σ) bond, and the other is pi (π) bond. Conjugated polymers containing single and double bond sequences on the parent chain exhibit semiconductivity.

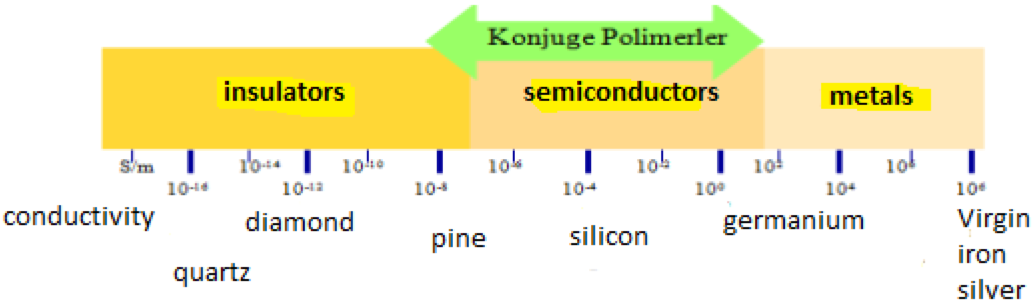

Figure 5. The conductivity values of certain materials and conjugated polymers.

Different methods are applied to improve the conductivity, morphological, mechanical and physical properties of conductive polymers. One of these methods is chemical methods in which properties are improved by preparing conductive polymers, copolymers or composites. Another method is physical methods in which properties are improved by preparing blends of conductive polymers with a suitable reinforcement that plays the role of plasticizer. Organic photovoltaic cells consist of a composition of organic materials, one of which is donor and the other is acceptor. The general structure of organic photovoltaic cells is similar to light-emitting diodes (LEDs). These devices are prepared in sandwich geometry. The transparent indium tin oxide (ITO) coated glass electrode used as the bottom substrate can be configured using chemical etching. The transparent, conductive substrate is coated with a polystyrene sulfonic acid (PSS) doped polyethylene-dioxythiophene aqueous solution. This (3,4-ethylenedioxythiophene): poly (cyclized sulphonate) PEDOT: PSS layer improves the surface quality of the ITO electrode and helps in extraction. At the same time, the work function of this electrode can be changed by chemical / electrochemical redox reactions of the PEDOT layer. The active layers (usually polymer-fullerene), wet treatment or vacuum coating technique are applied [14].

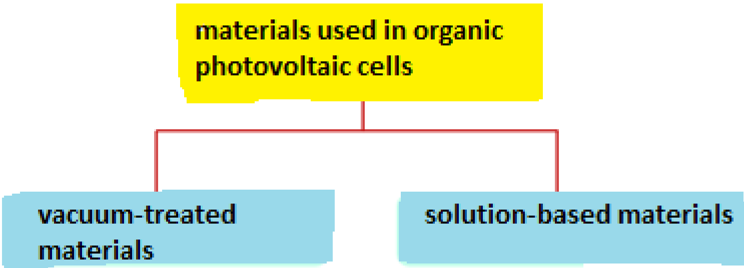

Figure 6. Materials used in organic photovoltaic cells.

As can be seen in Figure 6. organic photovoltaic cell research has concentrated on two types of materials: wet (wet) based processing and vacuum processing. The wet treatment materials must be dissolved in a common organic solvent. The functionality of the side chain given to organic materials allows them to be dissolved in organic solvents. To the wet-processed materials; spin coating, doctor blade, screen printing, ink jet printing can be applied. Semiconductor polymers are also included in this group, since fullerene derivatives can easily be dissolved in organic solvents. Since polymers are long macromolecules, it is difficult to evaporate them. Some small organic molecules which are insoluble in general organic solvents are subjected to vacuum treatment and can be vacuum coated using the sublimation method. In such photovoltaic cells, the pre-elecrode (the side where the light comes from) is ITO. The back electrode (also called the top contact) is usually covered with aluminum (Al). Two of the best performing materials used as active layers in organic solar batteries are poly 3-hexylthiophene (P3HT) and P-Chlorometerabibenzoate (PCBM). Known as the fullerene derivative, PCBM is one of the best n-type materials. This material acts as an acceptor in photovoltaic cell systems and its optical absorption is below the visible region. P3HT is a material that fits well with PCBM and serves as a donor in the structure.

8.3.4. Work Principle of Organic Solar Batteries

The photovoltaic properties of inorganic crystal materials can be explained by the energy band model. Unlike inorganic materials, there are different intermolecular and intermolecular interactions in organic materials that do not have a three-dimensional crystal structure. In order to understand the working principle of organic photovoltaic cell, it is based on inorganic p-n joint. In organic photovoltaic cells, we can explain the conversion of light into electrical current in four steps;

1) Photon absorption for exciton (electron-hole pair) creation,
2) Dispersion of exciton diffusion into the interface between the receiver (acceptor) and the donor (donor)
3) to make load separation in this region
4) Finally In order to obtain the direct current, the electrons are collected in the cathode,and the hole(deşik) colect ın anode [15]

According to the working principle of organic solar batteries, excitons need to be separated within a short distance. Exciton dissociation by electron transfer takes place at the interface of the organic semiconductors with the metal contact or occurs at the interface of the molecule at the different electron acceptor / donor feature. The electron is accepted by the material (acceptor) which is of interest to the high electron. The electron vacancy is accepted by the material (donor) with low ionization potential. The exciton can also be separated by an electric field stronger than the Coulomb attraction force between the electron and the electron gap. In the vast majority of organic solar cells, the electron and electron blanks are transported to different zones. This relocation occurs in the electric field where the electrodes are not symmetrical (different job functions) or due to the potential applied. With the aim of preventing back-flow, the electron and electron blanks, preferably are carried in different materials or phases. For example, in transceiver cells, the acceptor with good electron conductivity and the donor with good space conductivity are more suitable for material use. For a good performance, there should be no energy gap between the organic semiconductor material and the metal electrode. In some cases, the use of an additional material to remove the energy barrier between the two materials increases the efficiency of load collection. The photon has a h * energy.If the energy is greater than the energy of the band gap, is absorbed by the semiconductor material.The electron is shaped as a exciton, from the level called HOMO to the level called LUMO. The processes in energy level and light absorption process are shown in Figure 7. In organic solar batteries this process continues with the separation of excitons. In order to be able to distinguish the load, the electrical field is needed. The electrical field is derived from non-symmetrical ionization energy or work functions. The electrical field is derived from non-symmetrical ionization energy or work functions [16].

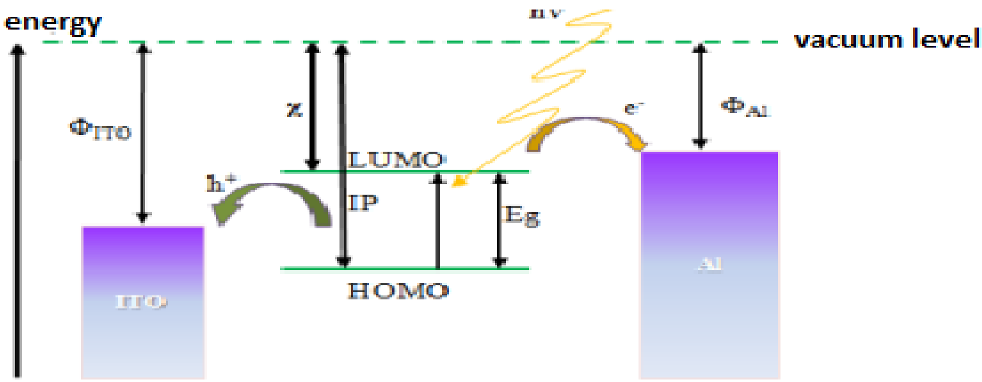

Figure 7. Photon absorption and load carrier transfers.

8.3.5. Organic Solar Batteries According to Structure

According to the structure, organic solar batteries are divided into three. Monolayer photovoltaic cells, two-layer hetero-joint photovoltaic cells and volume hetero-joint photovoltaic cells. Single layer photovoltaic cells, which are the first type photovoltaic cells to be formed, are composed of semiconducting polymers which are compressed between two different metal electrodes with different work function (Figure 8). According to photovoltaic requirements; excitons formed in organic semiconductors must be transformed into free load carriers. The most important way to distinguish excitons is to use electric fields in devices containing polymer alone. In devices containing polymer alone, the most important way to distinguish excitons is to use electric fields. The working principles of such photovoltaic cells can be explained by the formation of the Schottky barrier between the so-called MIM (metal-conductor-metal), or between the low functioning metal and the p-type organic layer. The reason for the low efficiency of such photovoltaic cells is that in these devices, photo-current only occurs in confined regions.

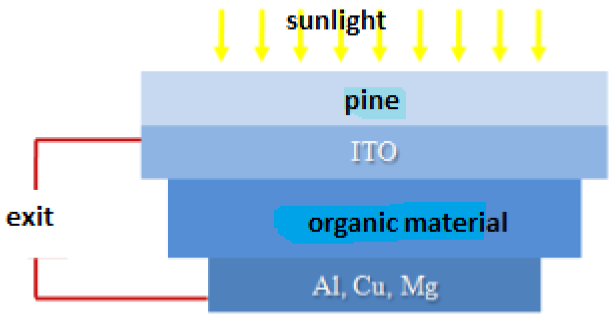

Figure 8. Single layer photovoltaic cell [17].

Another structure, the two-layer heterodyne photovoltaic cells (Figure 9), can be created by compressing over a two-layer device donor and acceptor material. The interaction between the donor and the acceptor is provided at the geometric interface between the two. Photo-physics studies on conjugated polymers and fullerenes show that ultra fast transfer of charge from conjugated polymers to fullerenes. The yield of such devices is limited due to the separation of excitons at interfaces where only strong electric fields are present. The advantage over the monolayer structure has to nano-molecule load transit. The excitons are separated at the interface of the material, and the electrons move into the n-type acceptor and the holes move into the p-type donor material. Hence, each of the holes and electrons are separated from each other, and recombination is greatly reduced [18]

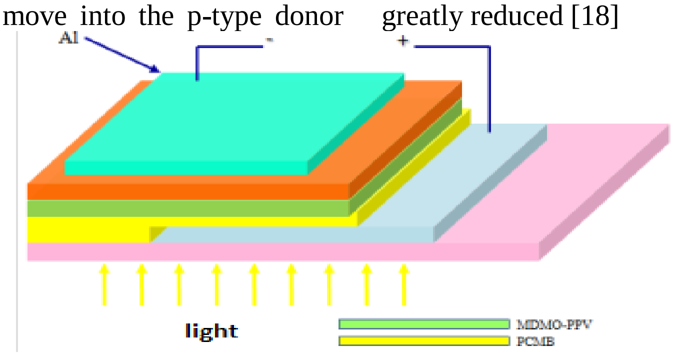

Figure 9. Two layer photovoltaic cell.

According to the structure, the third organic solar cell is the volume heteroe-joint photovoltaic cells. Volume heterojunction cells are basically mixed state in the volume dimension within a length less than the exciton diffusion length of the acceptor and donor moieties. Volume hetero-junction devices, when similar to double-layer devices, the area where the load separation taking place is larger. There is no loss due to the length of the small exciton diffusion, as expected, in the volume heteroejoint, as the interface were distribute. In this context, while all excitons are separated during operation, loads will be separated at different stages. For this reason, the recombination will be greatly reduced and the photo-current will follow the continuous light intensity linearly. Volume heterojoint solar cells are much more sensitive to nano-dimensional morphology than double-layer solar cells. [19]

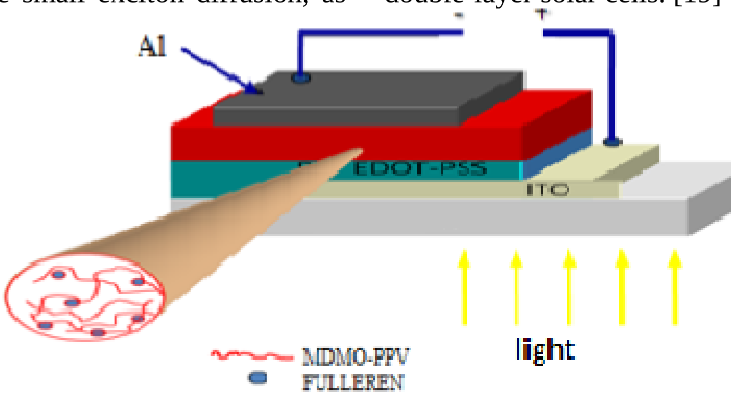

Figure 10. Volume hetero-joint photovoltaic cell.

8.3.6. Theoretical findings in highly efficient semiconducting materials:

Auger (Bract) generation material: This method allows high-energy photons to form two or more electron holes. Theoretical yield of 42% was achieved.

Medium Metal Strip Materials: This method solves the problems of designing PV cells. This method (theoretically); The energy can prevent the photons, which are lower than electron cavities, from moving from one tape to another by placing a thin metal strip on the material. The efficiency obtained from the theoretical studies reached 46%.

The sun's rays spread in different wave lengths. The sequential appearance of the emitted wavelength is called the solar spectrum. If it is to be said literally, the entire spectrum of electromagnetic radiation emitted from the sun and known at different wavelengths is called the Electromagnetic Solar Spectrum. In this spectrum, solar radiation is ordered according to by wavelength and is expressed with in the basic groups given below.

1.Gamma Rays
2. X – Rays
3- Ultraviolet Light
4- Visible Light
5- Infrared Light
6- Radio Waves

As can be seen below, the wavelength boundaries for each ray, may coincide with the next. There is an overlap in the borders. For this reason, the boundaries are not certain with, certain lines. The interactions of different radiations with matter are the same in the overlapping areas.

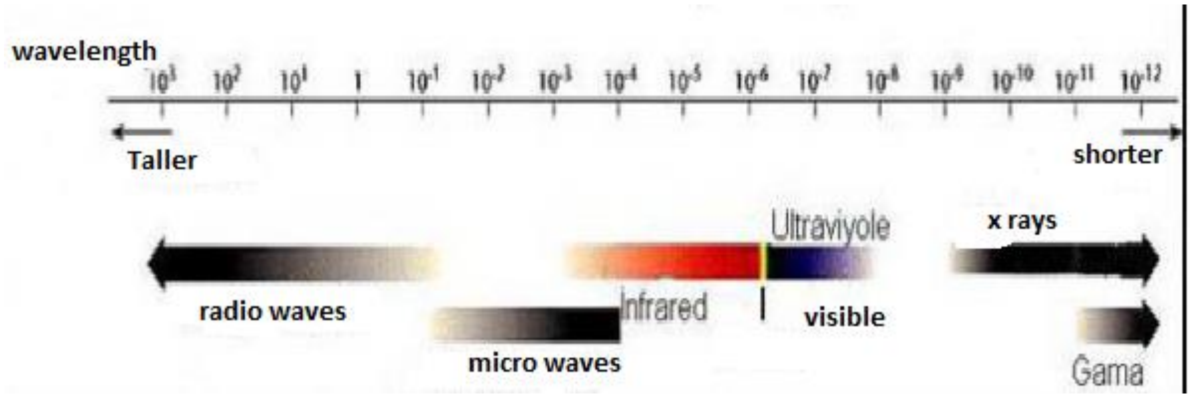

Figure 11/ Electromagnetic Spectrum/

Some of the main groups of the solar spectrum given above are also subdivided. Although all electromagnetic waves are similar, they exhibit different properties in terms of their interaction due to their different forms of existence and different matter relations. Energy of light according to wave length; is very small, very large, or between two different wavelengths of light. Electromagnetic radiation energy; According to their dimensions, the ordered sequence is called the electromagnetic spectrum. Of course, for these energy photons (energy packets), there is a certain frequency and wave length. Thus, depending on our preference, the electromagnetic spectrum; we can think of it as an energy series, a wave series or a frequency series. We mostly use the term 'wavelength'. The amount of wave length of electromagnetic radiation can be infinite. Some of the sun's rays run away to the out. There is a similar relationship with this substance. Generally, wave lengths are very diverse (10 or more main groups) and have different associations with materials. With these wavelength sections we can separate the electromagnetic spectrum into sections

Gamma rays

Gamma rays known as the most energetic waves; have the shortest wave lengths, but also have the highest frequencies and the largest photon energy. Gamma rays can be produced by nuclear reaction. When they pass through the matter, they hit all of the electrons except the atoms and molecules of the material. Gamma rays are sometimes called "ionized radiation" because of the ionization that occurs in this collision event. Ion formation is very reactive with gamma rays. Exposure of living organisms to this ionizing radiation may cause destructive effects. And also, it is possible to kill microbes on food with controlled use.

X-rays

In the electromagnetic spectrum, longer wave length (lower frequency and smaller energy) than Gamma rays is known as a group of X-rays. X-rays can take place by nuclear reactions. But; Very fast moving electrons can be produced by multiplying with metal surfaces. They are found intensely in the storms that occur on the surface of the sun. X-rays are also ionizing radiation, but have less potencial than gamma rays. X-rays can make electrons in the atom going from a low energy to a high energy but it always tries to be an atom. It can also change an atomic core energy. These rays separate electrons and atomic nuclei. It is used for medical purposes and searches for the exact structure of the molecules. X-rays and gamma rays are formed by astrophysical processes in stars and galaxies, and they form part of the "cosmic rays" that keep the world bombarded.

Ultraviolet Light

Ultraviolet radiation is a special part of the solar spectrum. Ultraviolet radiation forms a specific part of the electromagnetic spectrum that is shorter in wavelength (naturally higher energy) than visible light. Ultraviolet radiation forms a specific piece of the electromagnetic spectrum that is shorter in wavelength than visible light.

Visible Light

Ultraviolet-Radiant, visible light with longer wavelength; was in a narrow section of the electromagnetic spectrum. Since it is directly related to the color pigments in the eye retina, it helps us to see. Visible radiation is not ionic. Relation to atoms and molecules; almost all of the energy it has the result of electrons that turn into another energy source. Relation to atoms and molecules; all energy is the result of electrons that convert to another energy. But it remains limited for molecules. The truth is that different materials that have different energies that absorb photons are the result of being perceived from different colors. The human eye is sensitive to electromagnetic radiation between 400 nm and 700 nm. All colors are found in the rainbow that appears in this wavelength range (violet, indigo, blue, green, yellow, orange and red). The shortest wavelength (the largest photon energy) is perceived as purple, and the longest wavelength (the smallest photon energy) is perceived as red. Some living species can detect the light in longer or shorter wave lengths.

Infrared Lights

In the electromagnetic spectrum, the part that appears slightly longer wavelength is the infrared part of the spectrum. The energy of the infrared rays is too small to change the energies of the electrons. Instead of it, infrared radiation; it tends to change the vibrational states of the molecules and this means that molecules in a molecule are swinging forward and back very quickly. When molecules absorb infrared rays, the atoms move faster and thus the temperatures of the molecules increase. The heat lamps work this principle. Heat transport is often known as "radiant heat" in infrared electromagnetic radiation.

Radio Waves

The longest wave in the spectrum is Radio Waves. As the name implies; we use this part of the electromagnetic spectrum in radio communication, on television and on the radar. Radio waves cover a large part of the electromagnetic spectrum. Generally uhf, vhf, television, radar, microwave, millimeter wave etc. We distinguish between subdivisions. These names vary by use. Due to the differences in the propagation routes of these wavelengths throughout the atmosphere, the variants are clearly appear.

In summary; the range of all known wave lengths of electromagnetic radiation related to the electromagnetic spectrum is traditionally divided into a series of intervals. There is basically no difference in any other region compared to a region where it exists. Differences are shaped by looking at what the radiation does to the materials or by their interaction with them. Traditionally, the term light is used only for ultraviolet, visible and infrared radiation. These radiation groups; are the most intense and effective radiations published in the sun and reaching the upper limit of the atmosphere.

9. Conclusions

In this study, solar batteries are described with subspecies; organic material-based solar batteries are compared with other solar cell types in terms of operating principle, cost, efficiency, materials used. As a result, it is known that Si-crystal-based and CdTe-based solar cells, which offer high yields as of today, are quite low in yield, but are available at lower cost than all other solar cell types. Compared to the current cost, it is not wrong to say that organic solar cells are a hoping solar cell type. In this sense, scientists and multinational corporations that manufacture solar panels need to be given speed to work, to increase the efficiency of organic solar batteries, which can be obtained at low cost.

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