The power of plants to become sources of electrical energy

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Abstract: The relevance of this study is caused by the further need to develop alternative energy sources. The paper is the first to demonstrate the possibility of accumulating the electric current produced by plants by means of surfaces with high adsorption properties. The use of such currents to power diode lamps and other devices is shown. A literature review in this direction of research is also presented. Conclusions are made about the possibility of using the potential of photosynthesis in low-power energy.

1 Introduction

The need for this study is caused by the fact that traditional sources are becoming obsolete due to many factors. This is a decrease in reserves of coal, gas, oil, timber. Generation of electric energy in hydroelectric power plants, thermal (coal-fired), nuclear power plants is also an expensive technology. Production of electricity at thermal power plants running on coal, fuel oil and other fuels pollutes the atmosphere and causes great harm to the environment. However, modern mankind cannot do without electrical energy. It is quite obvious that there is an urgent need to switch to clean energy. This contributes to new developments in the field of renewable energy sources. The efforts of modern developers are aimed at reducing harmful emissions into the environment and developing economical and environmentally friendly technologies. Developments in renewable energy sources meet such demands. People have been using renewable energy sources, such as solar, wind, and hydroelectric power, for a long time. But recently, new technologies have been rapidly developed in these areas. The cost of the energy produced from these sources is going down, and at the same time gas and coal are getting more expensive. This trend is traced globally. But as long as cheap renewable energy sources are insufficient and inefficient, people continue to use gas, oil, coal, gasoline, wood and recycled waste, and this continues to lead to the threat of climate warming to dangerous limits. In addition, many renewable energy sources are still inefficient and have low efficiencies. Solar photovoltaic cells, on the other hand, have serious limitations - they produce electricity only as long as the sun is shining and require storage systems.

All this makes engineers and researchers turn to energy generating systems such as plants.

Plants are analogous to solar cells. During photosynthesis, pigment molecules (which are natural nano antennas) located in the membranes of photosensitive plant organs absorb the energy of sunlight and convert it into the energy of chemical bonds, in other words,

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accumulate it. In photosystems, the production of the light-sensitive pigment chlorophyll occurs first, followed by the fixation of light energy into chemical energy. Oxidized pigment molecules (chlorophyll, carotene, lutein) are reduced by taking electrons from water, then a series of chemical reactions occur, resulting in the production of oxygen and free electrons and protons (H). The presence of free charged particles in sufficient numbers and their redistribution allows us to talk about the presence of an electric field. The fact that electric currents flow in plants and that there are electrical impulses responsible for certain vital plant cycles is not new. Eric Davis in his book: Electrophysiology of Plants (pp.407-422) also says that according to numerous studies and observations, electric currents are present in all plants.

This has been proven by numerous studies begun some 250 years ago. In 1850 Antoine Becquerel published a paper stating that he discovered electric currents in plants by examining the bark, leaves and wood of plants with platinum probes. This discovery led him to believe that plants were one of the main sources of atmospheric electricity. Ten years later, biologist Nikolai Fedorovich Levakovsky (1833-1898) also observed electric currents in various plants. Another decade later, in 1873, English physiologist John Bourdon-Sanderson (1828-1905) discovered and measured the plant action potential in the leaves of the Venus flycatcher. In addition, it was noticed that plants also need an external electric field. In 1848, the French scientist A. Grandeau experimented with shielding plants from this electric field with a metal mesh ("Faraday cage"). He studied two identical plants under identical conditions. One of them was covered with a mesh and the other was not. It was found that the plant isolated from the electric field developed worse. Various conclusions about the benefits of electric fields and potentials on plant life cycles and yields were drawn from this. This area of research is called the electroculture of plants and is still the subject of research.

It is also known that there is always an electric field near the surface of the earth, which in normal conditions has an average strength of about 100 V/m. With changes in weather conditions (rain, thunderstorms), the field can increase to 10,000 to 20,000 V/m. Thus, plants and other living organisms are adapted to exist in conditions of electric and magnetic fields. According to modern concepts, the effect of electric field on plants at the cellular level is associated with metabolism and it ensures penetration of nutrients inside cells, activates enzymes. Some researchers believe that the electric field affects the absorption of positive aeroions (atmospheric gas ions) by plant leaves, which are just attracted to the ground by its negative charge. Thus, carbon dioxide, necessary for photosynthesis, is absorbed by plants through their channels in an ionized form (in the form of positive ions). Sources of aeroions in the lower atmosphere are mainly cosmic rays, lightning discharges and radioactive radiation. In 1 cm3 of air at the earth's surface there are usually up to 750 positive and 650 negative aeroions.

Energy production by plants under the influence of solar free radiation is quite an attractive topic for many researchers. Many studies and projects have been carried out on this topic. One such project is the research done by French scientists who believe that this approach can transform our ability to generate clean energy from sunlight using plants. During photosynthesis, the photons that are captured by the plant are used to break down water molecules into their constituent parts oxygen and hydrogen. As they do so, they produce electrons (Victoria Flexer, Nicholas Mano, Analytical Chemistry, February 15, 2010.). Another study was carried out by researchers at the University of Georgia. The researchers developed a way to "interrupt" photosynthesis and redirect the electrons before they are used to produce sugars. This is an important discovery because plants operate at a very high quantum efficiency during photosynthesis. Almost every photon of sunlight captured by the plant is converted into an electron. If we compare that to solar cells, we know that today their efficiency is less than 20 percent on average. This is a significant difference and a huge increase in the efficiency of solar energy production. But no such technology has yet been developed (J.O. Calkins, Y. Umasankar and R.P. Ramasamy, 2013). Chemist Maria

Fernanda Cerda uses natural dyes from the native flora of Uruguay to create solar panels. Also known are the projects of the Dutch scientists of the 2015 Plant-e "Starry Sky" venture. This project uses the reserves produced by plants in the root and near-root systems as electrical energy. And there is a sufficient number of such studies.

2 Research methodology

The performed literature review, many studies prove the presence of electric potentials and electric currents in all plants. In our earlier study we experimentally verified the presence of such potentials in various plants (N.R.Abdulkhalikova, K.T.Suyarov, 2022). It is obvious, and as it follows from the literature review, that the electric field contributes to the transport of ions of different varieties to provide plant nutrition from the root system and transport of newly formed substances (starch, sugars) to the root system. We did not set out to recreate or model photosynthesis. For such studies, it is necessary to create nanometer-scale antennae comparable to natural antennae, which are plant pigments. It is known that these pigments contribute to the reception of solar photons in the visible range and the conversion of electrical energy into chemical energy. However, recent developments by American researchers from the University of Texas (Ekaterina Yu Tiguntseva, 2018) give credence to the possibility of such technologies. In addition, materials with high adsorption capacity are needed to capture photon-generated charged particles in a special environment. This is a challenge, although such research is also underway. The aim of this study was to accumulate the currents produced by plants. We used material science methods. For preliminary studies we used cells consisting of the following layers: leaf surface, foil and activated carbon. Activated carbon was chosen because almost all commercial supercapacitors use powdered activated carbon made from coconut shells (Lane, J.; Younes, S.,1992). Excess charges from the sheet surface were collected by the surface of the activated carbon, from which a foil electrode was collected. Such a design is essentially a primitive semblance of a supercapacitor (Dillon, A.C.,2010).

3 Research results

Cells assembled in series-parallel into a battery were capable of powering a diode lamp for some time.

Fig. 1. Diode lamp powered by current collected by a system of double electrodes (activated carbon-foil) from a houseplant.

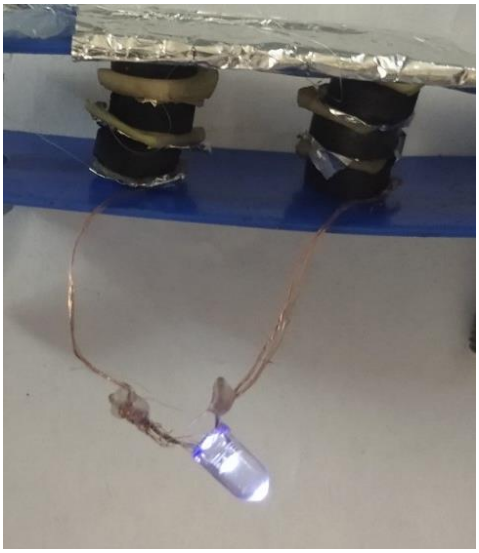

Fig. 2. Diode lamp powered by current collected by a system of double electrodes (activated carbon-foil) from a houseplant. The battery alternates layers of foil, plant leaf, activated carbon (three layers), the batteries are connected in series-parallel.

By increasing the number of elements (cells) in the battery, it was possible to use such a design to recharge a smartphone. The series-parallel connection of such super capacitors in the battery will allow to use it for fast charging of low-power devices.

4 Results discussion

The disadvantage of such a design is the need to choose more efficient absorbing materials (activated carbon is not quite suitable for capturing electrons, rather it is advisable to use it for capturing ions and molecular complexes). In addition, the fact that supercapacitors, unlike accumulators, are devices capable of both fast charging and fast giving up their charge is essential. (Asaithambi, S., Sakthivel, P.; 2021).

Together with our students, we proposed a scheme of a device that allows to discharge a supercapacitor in portions, maintaining voltage on the load for a sufficient period of time for the consumer. The development is under patenting.

5 Conclusions

In the course of conducted research it was revealed that plants not only have electric fields sufficient for their own life resources, but there is also a possibility to collect excessive charges with the help of supercapacitors. Of course, the method is simple and requires serious refinements, both in terms of material science and in terms of circuitry and design. Serious developments are also required to increase the efficiency. But even this simple method makes it possible to get current from any plants. By increasing the number of cells and the design of the device, we can talk about the real possibility of recharging low-power devices with current from plants. Of course, it is too early to talk about industrial-scale electricity generation, but the idea of charging supercapacitors with currents from plants is brought up for discussion to a wide audience for further development.

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