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Mimosa Pudica, a Natural Bio-Electrical Polarity Indicator

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Abstract Recognizing the polarity of a DC electric source is an old problem and is important for diverse applications. However, the only known natural indicator of polarity is light-emitting diodes (LED). We have found a bio-natural indicator of the negative pole of a battery. We have shown that Mimosa Pudica (sensitive plant) reacts to an electrical current if the negative pole of a battery is connected to one of its branches (leaf, petiole). Using our experimental results, we proposed an equivalent electronic model that produces the same results as this plant in response to electrical stimulations. As a bio-electric device, some technological usages of this property of such a plant are also discussed.

Keywords Mimosa Pudica, Sensitive Plant, Polarity Detector, Bio-Polarity Detector, Natural Polarity Detector, Leaf Movement

1. Introduction

Electrical polarity (positive and negative) is presented in every electrical circuit and electrons flow from the negative pole to the positive one [1-3]. The methods of recognizing the polarity are very limited. Voltmeters show the polarity of a DC power source (battery) based on a convention [4-6]. Light-emitting diodes (LED) are the only known natural sensitive devices to polarity [7-10].

Electrical signaling in some plants is well known and researches have been done to find the reason of producing electrical signals by plants and measuring their values [11-13].Various stimulations like knocking, touching, cutting, burning, chemicals and electric shocks trigger rapid leaf movements in 'sensitive' plants such as Mimosa Pudica (M. Pudica) and cause the leaf petiole to hang down [14]. Even the reaction of internal cells in this plant has been investigated [15]. In the study reported, we investigated the response of M. Pudica to the electrical stimulation of the leaf petiole. We show that if we connect the negative pole of a battery to the petiole of M. Pudica and inject an electrical current, it will hang down from the junction point, but if we connect the positive pole of the battery to the same petiole it will not react to any electrical stimulation. Based on the results of the experiments an equivalent electronic model was proposed to produce the same responses to the stimulations [16], although the technological usage of this property of such plants is not known well. As the polarity indication of M. Pudica is very reliable, it could be purposed that a few bio-devices use this property in the future.

The rest of this paper is organized as follows. Section 2 introduces the plant Mimosa Pudica. Section 3 describes materials and methods. In section 4, we presented some experiments which led us to our proposed model. Then section 5, an electronic circuit according to our experiments was proposed and finally in section 6conclusions will be presented.

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2. Mimosa Pudica

Mimosa Pudica is a creeping annual plant which grows in the tropical regions of the continent of America, especially Brazil [17]. In Iran it grows in north of Iran, Mazandaran province. In April, this plant could be pullulated by its seeds. The seeds, as shown in Figure 1, are small and dark in color. One of the growing stages of this plant is shown in Figure 2.

In a garden or a pot one can prepare an appropriate environment for this plant to grow, using a mixture of soft soil, sand, some natural fertilizer and a sunny location. Maintenance of this plant is the same as other flowers and doesn't need special care. After about two weeks its buds will start coming out of the soil. First, two little leaves will appear around the planted seed and after a short while, small leaflets with a stem in the middle will grow. The sensitivity of the plant can be examined exactly from this stage. It can close its leaves when touched and bend downward.

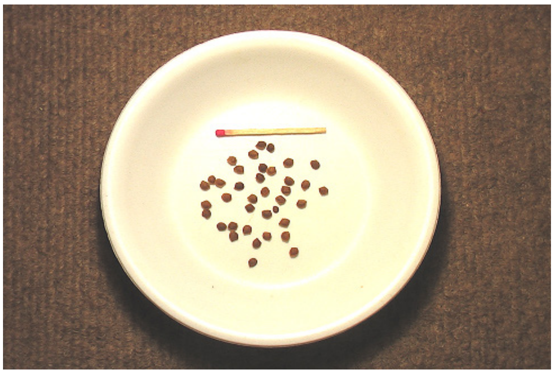

Figure 1. Mimosa Pudica seeds

Figure 2. One stage of Mimosa Pudica growth

Figure 3. Branches, leaves, and flowers of Mimosa Pudica

During the growing of Mimosa Pudica it is better to keep the best growing buds and take the rest out of soil from their roots. At the end, only one or two bushes are enough for each pot. The roots which are taken out of the pot could be used for planting in other places.

Mimosa Pudica gives flowers in July. The flowers are purple and they are as big as a small strawberry (Figure 3). The flowers gradually change into seeds at the end of autumn and by the start of cold winter the plant will die.

3. Materials and Methods

Plants were cultivated from seeds in natural day light at 20-30℃. At the time of the experiments, the plants were about 90 days old. In order to stimulate the petiole of the plants which you can see in figure 4, we used an electrical circuit containing a 9 Volt battery, a regular switch, a 330 kΩ resistor and two electrodes in series. The electrical connection to the petiole was done using a tungsten needle electrode penetrating through the branch. Figure 4 shows the electrical circuit devices used in our experiments to stimulate the plant petiole. We have measured this current with a digital multimeter as I_{dc} = 5.1 μA. The experiments were repeated in 30 different days in summer to check the reliability of the results.

In the model experiment we used an ordinary diode (1N4001) and a LED. The battery was 9 Volt and the resistor was 680 Ω. The current passing through the circuit was about 10 mA.

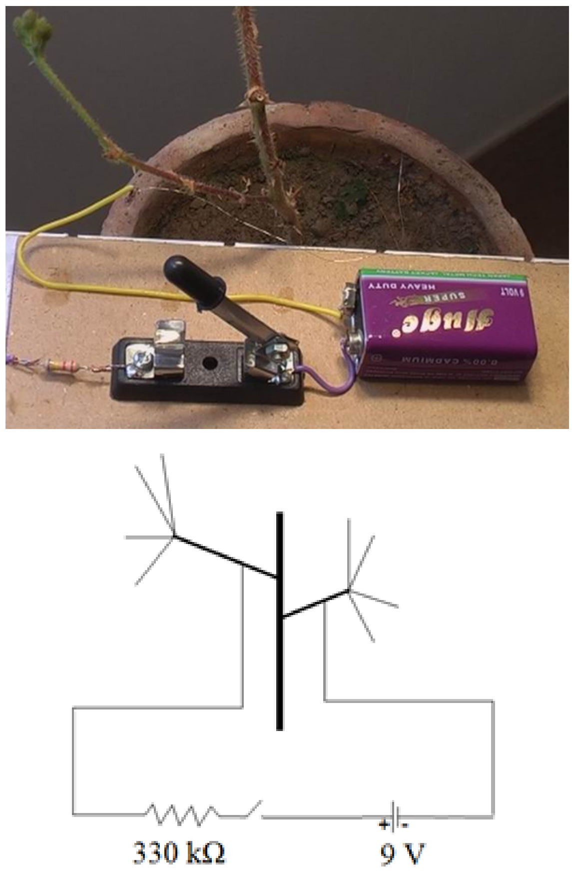

Figure 4. Electrical circuit

4. Experiments

An electrical circuit was prepared with a battery, a switch, a resistor and two electrodes (Figure 4). The negative pole of the battery was connected to a petiole on the right side of the plant and the positive pole was connected to another petiole on the left side of the plant (Figure 5A). A few seconds (about 3 seconds) after closing the switch the negative side petiole hanged down from its junction point to the stem (Figure 5B).

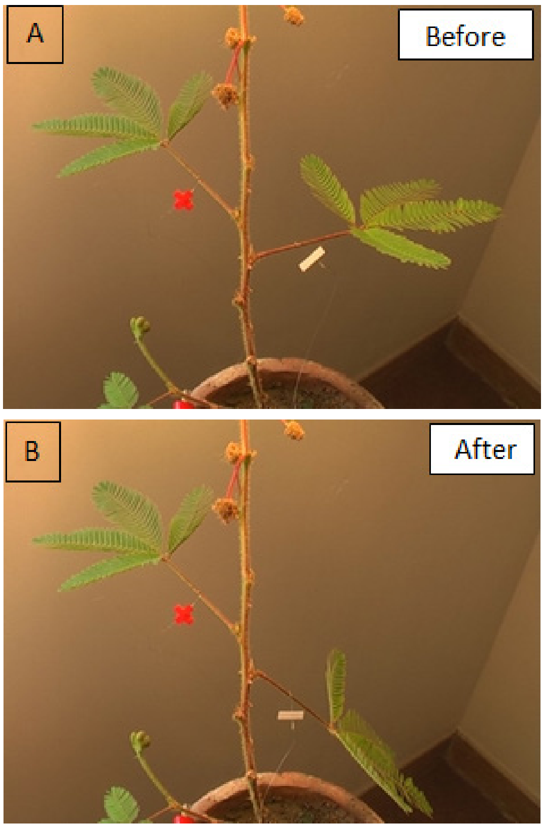

Figure 5. Negative pole connected to the right petiole, **A.** The sensitive plant before electrical stimulation, **B.** The plant after stimulation. The petiole connected to the negative pole of the battery is hanged down

To let the bent branch return completely to its normal position we waited about 30 minutes. Then we changed the polarity of the battery and connected the positive pole to the right hand side petiole and the negative pole to the one on the left (Figure 6A). The petiole connected to the negative pole of the battery (the left side branch) hanged down again after a few seconds (Figure 6B).

These two experiments indicate that the M. Pudica is sensitive to the negative pole of a DC source and can easily recognize the positive and negative pole of a battery. These experiments were repeated carefully in different days and different nights and the results were the same [16]. The precision of the reaction was better in days than nights in which the plant was in the sleeping mode.

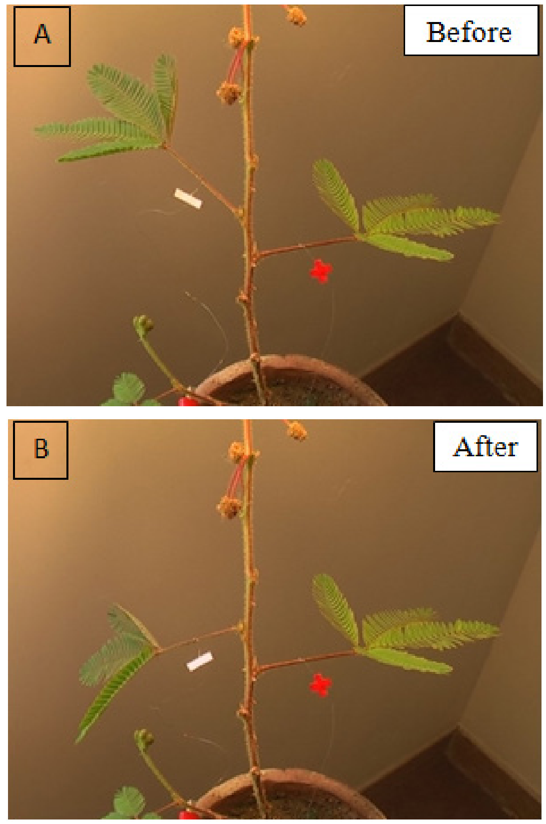

Figure 6. Negative pole connected to the left petiole, **A.** The sensitive plant before electrical stimulation, **B.** The sensitive plant after stimulation. The petiole connected to the negative pole of the battery is hanged down

5. Proposed Model

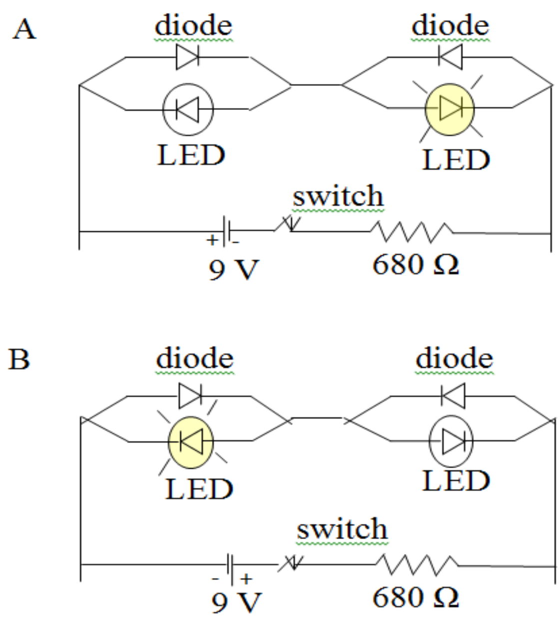

Figure 7. Electronic circuit simulates the bio-circuit, **A.** The negative pole of the battery is connected to the right set of two diodes. **B.** The negative pole of the battery is connected to the left set of two diodes

Based on our experiments and the results, we can compare the bio-circuit of the plant to an electronic circuit like figure 7. In this figure we replaced each junction of the petiole to the stem with a set of two diodes one of which is an ordinary diode and the other one is an LED. If we connect the negative pole of the battery to the right hand side branch of these two sets of diodes only the right LED will light up (Figure 7A) and if we connect the negative pole of the battery to the left branch only the left LED will light up (Figure 7B). This behavior is comparable to the behavior of the bio-circuit of the plant. So we could use it as a negative pole Bio-detector.

6. Conclusions

We have shown that the Mimosa Pudica as a natural device can recognize the polarity of a battery and react clearly when we connect the negative pole of a battery to its petiole. Also this phenomenon can be used as a standard test to recognize and study other sensitive plants. This study can help to develop a method to test the reaction of live animals or plants to the positive and negative pole of a battery or to external electrical signals.

The theory of motion of electrons or ions in an electrical circuit has been taught in classes for many years, but we do not have a simple tool to show the direction of the motion of the electrons. This phenomenon can be used as a simple but reliable tool to show the direction of the motion of the electrons. We can also use this behavior to indicate the motion of ions in electrolytes in chemical reactions and electrolysis.

REFERENCES

[1] Heng Yao, Qiangyi Xu and Ming Yuan, Plant Signaling & Behavior, 3:11, pp. 954-960, November 2008.

[2] Morris S. Alan, Measurement and Instrumentation Principles, Third Edition [Kindle Edition], 2001.

[3] Van Bel A.J.E., Ehlers K. Electrical Signaling via Plasmodesmata. In Plasmodesmata (ed. K.J. Oparka), Blackwell Publishing, Oxford, UK, pp. 263-278, 2004.

[4] Hodgkin A, Huxley A, A Quantitative Description of Membrane Current and Its Application to Conduction and Excitation in Nerve. J. Physiol. 117, pp. 500-544, 1952.

[5] Volkov, A. G., Foster, J. C., Ashby, T. A., Walker, R. K., Johnson, J. A. and Markin, V. S., Mimosa pudica: Electrical and mechanical stimulation of plant movements. Plant, Cell & Environment, 33:163-173.doi:10.1111/j.1365-3040, 2009. 02066.x, 2010.

[6] Fromm, J. and Lautner, S., Electrical signals and their physiological significance in plants. Plant, Cell & Environment, 30: pp. 249-257. doi:10.1111/j.1365-3040.200 6.01614.x, 2007.

[7] Abe T., Chloride Ion Efflux during an Action Potential in the Main Pulvinus of Mimosa Pudica. Botanical Magazine Tokyo, pp. 379-383, 1981.

[8] Heng Yao, Qiangyi Xu and Ming Yuan, Plant Signaling & Behavior 3:11, pp. 954-960, November 2008.

[9] Morris S. Alan, Measurement and Instrumentation Principles, Third Edition [Kindle Edition], 2001.

[10] Van Bel A.J.E., Ehlers K., Electrical signaling via plasmodesmata. In Plasmodesmata (ed. K.J. Oparka), pp. 263-278, Blackwell Publishing, Oxford, UK, 2004.

[11] Hille B., Ionic channels of excitable memberanes. Sinauer Associates, Inc. Publisher Sunderland, MA, USA, 1992.

[12] Hodgkin A, Huxley A., A quantitative description of membrane current and its application to conduction and excitation in nerve. J. Physiol. 117, pp. 500-544, 1952.

[13] Bonnen J. and Gal Ston A. W., Principles of Plant Physiology, Freeman, San Francisco, 1952.

[14] Ismaeel Zahedi, Physiology of Plant Growth and Movements, University of Tehran press, pp.187-195, 1963.

[15] Abdolrahim Araghi, Physical Behaviors of Sensitive Plant to the External Stimulations, Iran Physics Conference, Abstract, pp. 25-33, 1992.

[16] Abdolrahim Araghi, Scientific Observations, Mohamed publications, pp. 11-25, 2005.

[17] Abdolrahim Araghi, Mimosa Pudica: Prevent and Control the Spread of Electrical Signals inside the Mimosa Pudica, Abdolrahim Araghi Publications, pp. 13-16, 2013.