A vegetative voltaic cell

A large and cheap source of energy is an essential requirement for the development of a growing nation. With the advancement of civilization, the demand for energy sources has grown and the need for new sources of energy becomes essential. At present, besides conventional energy sources, a constant quest for non-conventional energy and researches in this area are in progress.

Common voltaic cells use commercially available inorganic salts as electrolytes for power generation[1]. Since all plant materials contain various types of inorganic and organic electrolytes[2] absorbed through their root systems or synthesized through metabolic processes, I have examined the possibility of constructing a cheap vegetative voltaic cell using commonly available plant materials. The results are summarized here.

An insulated, waterproof box is covered with a lid where the electrodes are properly arranged (Figure 1 *a* and *b*). The lid carries electrodes for each of the chambers in the box with series and parallel connections, and the final output terminal passes through the outer surface of the lid (Figure 2).

The vegetative voltaic cell consists of two types of electrodes of different elements, and the two electrodes with their chambers form a unit (Figure 3). One of the electrodes acts as the anode and the other as the cathode. Several types of electrodes can be used for the study. By combining a number of units in series and parallel combination, a battery of cells of moderate power can be formed at any desired value (Table 1).

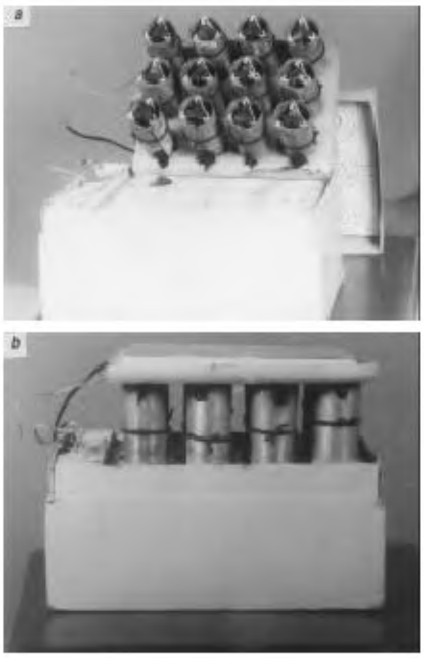

Figure 1. Arrangement of electrodes in the vegetative voltaic cell. ***a***, Top view and ***b***, Side view.

In the device shown in Figure 2, there are 12 chambers and the volume of each chamber is 50 cm^3. Carbon as the cathode (7.5×5.0 cm) and zinc as the anode (10.0×5.0 cm) gave good results. Carbon electrodes are placed at the centre of each of the chambers on the lid and zinc electrodes are fixed around the carbon electrodes, leaving some space (0.5 cm) between them.

The power generated depends on the nature and condition of the leaves, size and nature of the electrodes and the type of combination of the units. A comparative account is given in Table 1.

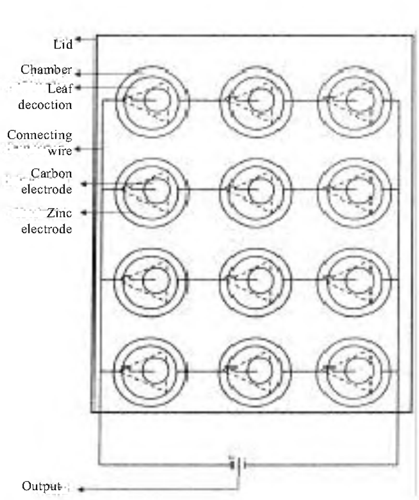

Figure 2. Top view showing arrangement of electrodes on the lid of the device.

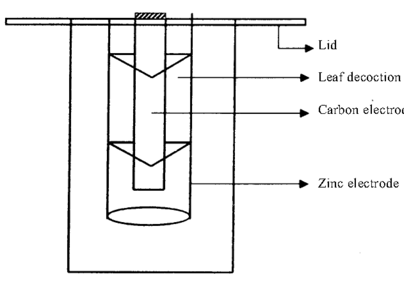

Figure 3. A single unit of the device (side view).

Leaves of any plant (Table 2) can be used for the study, where 250 g of mature fresh leaves is ground with distilled water to make a decoction of 500 ml. Juicy, fresh plant leaves or leaves of succulent plants with proper preservatives such as borax, Na-benzoate, etc. give better results. The slurry is then poured into the chamber. Table 2 gives the pH of the decoction as also the voltage, conductivity and current. The four plants shown in Table 2 belong to different plant families, some of which differ in their metabolic patterns. Thus, *Bryophyllum* is a Crasulacean plant and its cell sap is acidic in nature due to dark fixation of CO_2 at night, whereas the other three plants do not have this type of metabolism. Consequently, it is expected that many other plants can be used conveniently depending on their electrolyte content. The observed current may be considered as a short-circuit current which is practically proportional to the corresponding emf, which in turn fluctuates depending on electrolyte concentration. There is apparently a buffering system in the plant cells leading to the small differences observed. With the help of this device, any low power-consuming circuit such as those in a transistor radio, a calculator, an electronic wall clock, a light-emitting diode, etc. can be operated.

There is no direct impact of light for such power generation, since the same power is obtained in darkness. Electrolytes, oxidants and reductants present in plant organs, which participate in the complex biochemical reactions, are apparently involved in the generation of power. The advantages of this vegetative voltaic cell are as follows:

(i) Unlike costly and complicated conventional cells using salt, acid or alkali, this device generates power from substances present in biological materials,

Table 1. Current output from different arrangements

Series connection (units)	Parallel connection	Output
12	X	12 V at 70 mA
3	Four groups ($4 \times 3 = 12$)	3 V at 300 mA
1	X	1.0–1.2 V at 50 mA

Table 2. Vegetative voltaic cells using different plants*

Plant material	pH of decoction	Potential difference (V)	Conductivity (mmhos)	Current (mA)
Bryophyllum calycinum	4.63	3.4–3.2	2.8	302.0–300.0
Basella rubra	5.19	3.1–3.0	4.5	297.5–280.0
Barleria cristata	6.82	3.0–2.9	4.6	295.0–285.0
Adhatoda vasica	7.52	2.8–3.1	4.2	267.0–260.0
Mixture of above (1 : 1 : 1 : 1)	5.43	3.0–3.3	3.8	286.0–278.0

*Plant decoction contains 1% borax to prevent microbial contamination.

especially from plant leaves. Plant leaves are abundantly available in the vegetative world.

(ii) The mechanism has the simplicity of a voltaic cell. It has no harmful effects, is free from environmental pollution hazards and can be operated by anyone.

(iii) The device can generate power from leaves of any plant, including weeds. Any part of a plant such as the soft stem, root, fruit juice, leaf and algal material can be used for this purpose.

(iv) The vegetative voltaic cell can be re-used by changing the leaf decoction. Again, by replacing any part of the device, it may further be repeatedly used. Here, the corrosive effect of the energy source is nominal, so the electrodes remain in good condition for a long duration. As the electrolytes are mostly weak organic ions, corrosion would be much less than in the case of strong electrolytes. One of the electrodes is carbon, which is not affected by corrosive action. The other one is zinc, which however is susceptible to a certain extent.

(v) The plant decoction was treated with Na-benzoate or borax to prevent microbial contamination, as mentioned in the text. At room temperature, no change is observed for 5–6 days. If stored in a refrigerator along with the preservative, no marked change is observed for eight months.

(vi) In a voltaic cell, polarization effect is one of the problems to produce power, because a very thin layer of hydrogen gas is wrapped over the cathode. As a result, the potential difference becomes gradually reduced. In this case the balance of natural oxidants and reductants present in plant leaves presumably nullifies such effects, leading to better results.

(vii) Here, power is generated from plant sources on the principle of voltaic or electrical cell, and there is no impact of sunlight. So power can be obtained during the day or night (in light and darkness) on a regular, continuous basis.

1. Grob, B., *Basic Electronics*, Tata McGraw-Hill, New Delhi, 2000, 8th edn, pp. 322–324.
2. Salisbury, F. B. and Ross, C. W., *Plant Physiology*, Wadsworth Publishing Company, California, 1992, 4th edn, p. 120.

ACKNOWLEDGEMENTS. I dedicate this article to the memory of late Prof. S. S. Baral, and express my gratitude to Prof. S. P. Sen who motivated me to work in the field of electrophysiology. I also thank my teachers Dr Pratip Palit and Dr G. G. Maiti for their kind encouragement.

Received 5 July 2002; revised accepted 25 April 2003

PRAJJAL DATTA

Department of Botany,
Kalyani University,
Kalyani 741 235, India
e-mail: prajjalmail@yahoo.com

Ethanolic extract of *Bacopa monniera* (Brahmi) induces shortening of cell-cycle durations in naturally synchronous *Physarum polycephalum*

Plants have been used as sources of medicinal and pharmaceutical agents in the form of isolates, extractives or as lead compounds for synthetic optimization. Vinca alkaloids, Epipodophyllotoxins, Taxanes and Camptothecin represent different classes of plant-derived anticancer agents that continue to be an important component of modern pharmaceuticals[1].

Bacopa monniera L. (Scrophulariaceae), commonly known as Brahmi, is a creeping herb with a bitter taste found throughout India in damp and marshy areas. It has been used in folklore medicine and the ancient traditional system of Ayurveda as a nerve tonic for improvement of intelligence, memory and revitalization of sense organs, to treat epilepsy, insomnia, asthma, rheumatism and also as a diuretic and cardiotonic[2–4]. Several phytochemical studies have been carried out on the plant in Indian laboratories, and it is known to contain nicotine, brahmine, herpestine, hersaponine, bacosides A, B, C, D and other chemicals like stigmastanol, b-sitosterol and stigmasterol[2,5–8]. In pharmacological studies, alcoholic extract of *Bacopa* has been shown to possess anticancer activity against Walker carcinosarcoma 256 in rats[9], growth-inhibitory effects on Sarcoma 180 cultures[10], activity affecting avoidance response in rats[11–13], and a potent antioxidant activity[14].

Here, we report the phase-specific effects of Brahmi on cell-cycle durations in the lower eukaryotic myxomycete fungus, *Physarum polycephalum*. In surface cultures of this syncytial organism, over a million nuclei divide in perfect natural synchrony, making it an ideal model system for such studies.

B. monniera plants were collected from the botanical garden at the University of Calicut during February and March 2002. Authenticated fresh plants were ground in a mortar, defatted with petroleum ether (1 : 10 w/v; 60–80°C) and filtered. The residue was then Soxhlet extracted with 80% ethanol (1 : 10 w/v) for 12 h. The extract was evaporated to dryness (yield: