二零二二年香港學生科學比賽

隊伍號碼： JBBC189　　作品名稱：植物發電 Power Plant in Plant　　參賽類別：研究項目

文獻搜索：

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Castresana, P. A., Martinez, S. M., Freeman, E., Eslava, S., & Di Lorenzo, M. (2019). Electricity generation from moss with light-driven microbial fuel cells. Electrochimica Acta, 298, 934-942.
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Kabutey, F. T., Zhao, Q., Wei, L., Ding, J., Antwi, P., Quashie, F. K., & Wang, W. (2019). An overview of plant microbial fuel cells (PMFCs): Configurations and applications. Renewable and Sustainable Energy Reviews, 110, 402–414. Retrieved form doi:10.1016/j.rser.2019.05.016
Sawin, J. L., Martinot, E., Sonntag-O'Brien, V., McCrone, A., Roussell, J., Barnes, D., & Flavin, C. (2010). Renewables 2010 global status report.

我們的作品就現有產品或研究所作出的改良為：

提出另一種不用耗費其他資源的方法來發電。另外，嘗試使用香港常見植物，探討植物發電在香港推行的可能性。

I.　前言

現今社會對電力需求十分大，使化石燃料被耗盡的警號被敲響。要解決這個問題，唯有靠可再生能源。可是，現時的可再生能源卻因不同限制而不能有效減緩化石燃料的消耗，人們對不可再生能源的依賴仍然極大。因此想到利用植物來發電。知道外國有做過類似研究(Kabutey etc. al., 2019)，嘗試將其套用於香港，以減緩化石燃料被耗盡的速度，同時綠化環境，減輕溫室效應，保護地球。

選用了更容易找到的材料，令技術更生活化。以往研究從未嘗試用光合作用的產品發電，多為用微生物的呼吸作用發電。因此想到既然呼吸作用可以發電，與呼吸作用相似的光合作用或許也能。

II.　目標

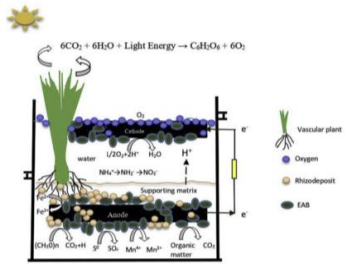
首先，希望找出在香港的植物是不是如外國一些論文所說能夠發電。第二，希望找到預備了的植物種類當中能提供最多電能的種類。第三，希望找到影響植物發電量的因素，以及這些因素之間的關係。

III.　假設

假設植物進行光合作用後的產物可以被微生物使用來產生有能量的電子，從而產生電力。透過找出植物進行光合作用時是否有電壓產出來驗證假設。

IV.　研究方法

在實驗一，檢測不同植物在花盆中的發電效能。



植物發電的原理 (Kabutey et al, 2019)

植物發電裝置圖

完成裝置後，以萬用電錶來收集植物進行光合作用時所產生的電壓指標，並重複了 9 次試驗以確保研究的可信性。

對照裝置：

對照裝置 1：沒有陽光照射，電壓為 0mV	對照裝置 2：沒有植物，電壓為 0mV

因此在實驗過程中產生的電壓，可以合理推論為是在光合作用下產生。

在實驗二，要找出影響植物發電量的因素。
雖然光照度增加會令光合作用速率增加，但從實驗一結果發現光照度與發電量似乎沒有太大關係，所以認為有其他因素影響植物發電量，希望找出對植物發電量影響最大的因素。
估計，植物發電量是與所吸收水量有關，因為水分影響植物的光合作用，光合作用速率影響植物發電量，水量有機會影響泥土中微生物的活躍程度，影響植物發電量。
因此設計了實驗二來驗證這項假設。實驗二分為兩部分：一，找出植物澆水前後發電量的分別；二，找出長時間不澆水對植物發電量的影響。

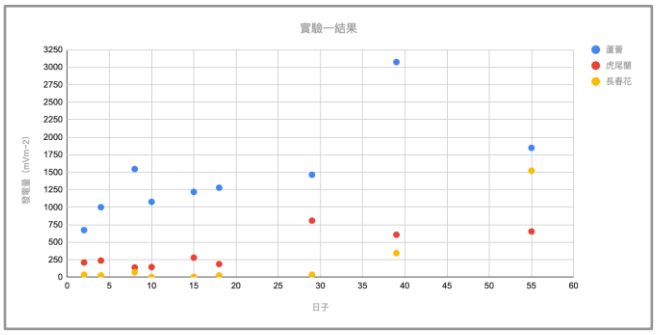
在實驗三，探討植物發電實際應用的可能性。
預備了六種植物，分別是蘆薈、發財樹、常春藤、黃金葛、薄荷、富貴竹，放置在同一個設有植物發電裝置的盆子裡。用萬用電錶來收集植物進行光合作用時所產生的電壓指標，藉以探討多種植物同時進行光合作用能產生的電壓。

V. 研究結果

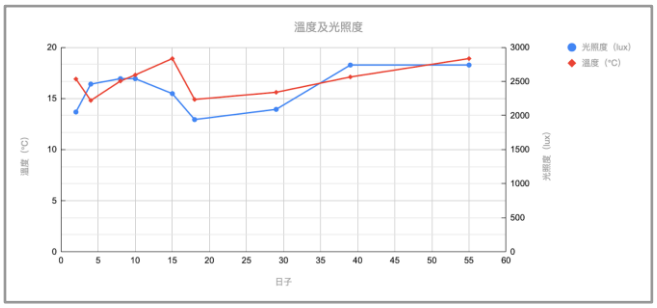
實驗一結果：

發現植物在光合作用期間的確有電子的釋出，而且這些電子可以被收集及量度。相信這是由於植物進行光合作用時，沒有被植物消耗的有機物會從根部排到泥土，當中的微生物把這些有機物分解時會釋出電子，因此只要安置電極於植物根部及在泥土中加入導電物料，就能夠收集植物在光合作用時所產生的電能。

不同日子下各每平方米植物所產生的電壓



不同日子的溫度及光照度



實驗二結果：

第一部分：
實驗中的兩棵植物澆水後的發電量比澆水前高得多。推論這是因為植物在澆水後，光合作用的速率增加，微生物更活躍，產生高能量電子的速率加快，因此能夠產生更多電力。

第二部分：
植物不澆水數天後發電量與每天澆水相比，明顯地下降了。推論這是因為長時間不澆水，會令植物進行光合作用的速率下降，令微生物產生高能量電子的速率下降，因此令植物的發電量下降。而不澆水越久，光合作用的速率越低，植物的發電量也越低。

實驗二結論：
一，吸收水量對植物發電量的影響最大。二，植物在澆水後的發電量比澆水前的高。三，植物越久不澆水，發電量就越低。

實驗三結果：

可見，大規模的植物發電仍然有其效能，有電壓產出。因此，植物發電仍有潛力。

期望這項技術可以應用在不同的綠化帶中，例如在公園的植物下鋪設這項電路，並在休息長椅上加設 USB 插頭，讓人們可以在長椅休息時為手機、充電器等充電。亦期望這項技術可普及化，使人們愛上種植，在家種植不同植物，作環保充電器。另外，若此措施可應用於大型耕作農業上，相信能帶來大量電能供農民自用或出售，解決能源問題。

VI. 結論

植物進行光合作用後的產物可以被微生物使用來產生有能量的電子，從而產生電力。不過，現時植物的發電效率不高，如何提升植物的發電率仍有待科學家研究。

☑ **我們的作品是以我們學校之前的比賽作品為題進行了持續研習，有關改良如下：**

用了更多時間驗證植物發電數據的準確性，嘗試用更多植物進行大規模植物發電的研究，探究其普及化的可行性。

Hong Kong Student Science Project Competition 2022

Team Number: JBBC189 **Project Title: Power Plant in Plant** **Project Type: Investigation**

Literature review:

BP Statistical Review of World Energy 2016. Retrieved from:
https://www.ls-energy.hk/chi/world-energy-consumption.html
Castresana, P. A., Martinez, S. M., Freeman, E., Eslava, S., & Di Lorenzo, M. (2019). Electricity generation from moss with light-driven microbial fuel cells. Electrochimica Acta, 298, 934-942.
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The enhancement our project has made for the existing related products or research is summarized as below:

Came up with another way to generate electricity without consuming other resources. Also, common plants in Hong Kong were used to explore the possibility of promoting Power Plant in Plant in Hong Kong.

I. Background

Nowadays, the demand for electricity has been increasing and alarms that fossil fuels are being exhausted. To solve the situation, we can only rely on renewable energies. However, the current renewable energies can't slow down the consumption of fossil fuels effectively due to various limits. We still rely on non-renewable energies. So using plants to generate electricity to slow down the rate of exhaustion of fossil fuels is considered. It may also help the greening of the environment, reduce greenhouse effect and protect the Earth.
Easier-to-find materials have been chosen to bring the technology to life. Previous studies have never been tried to generate electricity with the products of photosynthesis, and mostly used the respiration of microorganisms to generate electricity. So we thought that since respiration can generate electricity. Photosynthesis, which is similar to respiration, may also be able to do it.

II. Objectives

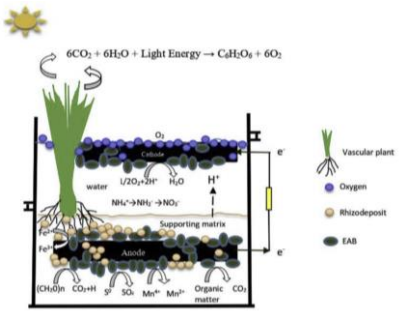
First, find out if plants in Hong Kong can generate electricity as some foreign papers say. Second, find out which kind in the prepared plants can generate the most electricity. Third, find out the factors that affect the power generation of plants, and the relationship between them.

III. Hypothesis

Assume products of photosynthesis in plants can be used to generate electrons by microorganisms, and so on to generate electricity. The hypothesis is tested by finding whether there is voltage generated during photosynthesis of plants.

IV. Methodology

Experiment 1: testing the power generation efficiency of different plants in flower pots



Theory of Power Plant in Plant (Kabutey et al, 2019)

Diagram of Power Plant in Plant

Use a multimeter to collect the index of voltage of the plants during photosynthesis after finishing the device. The experiment is repeated 9 times to ensure the credibility of the study.

Controlled device:

Controlled device 1: the voltage is 0mV when there is no sunlight

Controlled device 2:voltage is 0mV when there is no plant

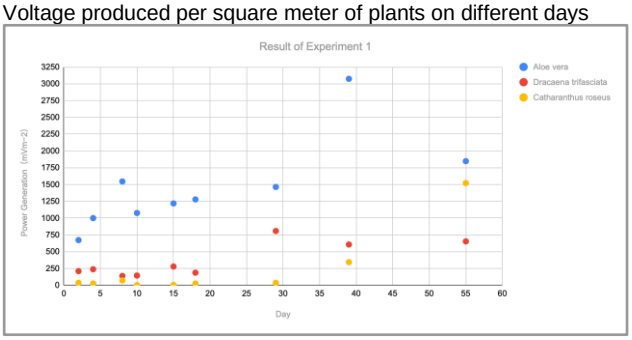
Therefore, the voltage generated during the experiment can be inferred to be generated by photosynthesis reasonably.

Experiment 2: testing the factors affecting the power generation of plants
Although the increase of illuminance will increase the rate of photosynthesis, it can be seen from the first experiment that the illuminance does not seem to have much relationship with the power generation. So, it is believed that there are other factors that affect the power generation of plants.
It is estimated that the power generation of plants is related to the amount of water absorbed, since the amount of water affects photosynthesis of plants. It might affect the activity of microorganisms in the soil, and thus affect the power generation of plants. Experiment 2 is designed to prove this hypothesis. There are two parts in experiment 2: finding the power generation of plants before and after watering; finding the effect of going without water for a long time on the power generation of plants.
Experiment 3: discussing the feasibility of practical application of Power Plant in Plant
6 kinds of plants, aloe vera, guiana chestnut, hedera helix, epipremnum aureum, mentha, dracaena sanderiana, were prepared and placed in a flower pot with a Power Plant in Plant device. A multimeter is used to collect the index of voltage of the plants during photosynthesis. So as to find out the voltage generated during the photosynthesis of plants.

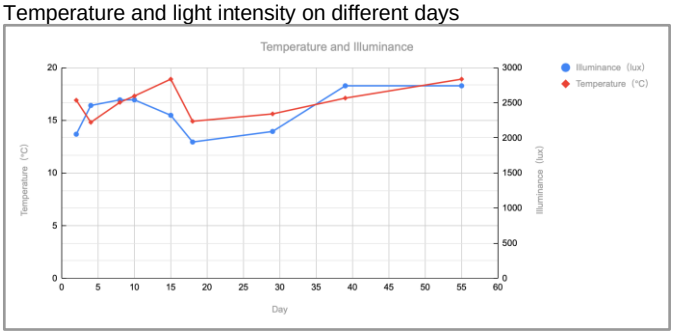
V. Results

Experiment 1 result：

Voltage produced per square meter of plants on different days



Temperature and light intensity on different days



It is found that plants do release electrons during photosynthesis, and these electrons can be collected and measured. It is believed that this is because some organic matter that is not consumed by plants will be discharged from the roots into the soil when plants perform photosynthesis during the day, and the microorganisms in the soil will decompose these organic matter, so as long as the electrodes are placed on the roots of the plants and added to the soil the electricity generated by plants during photosynthesis can be collected.

Experiment 2 result：

Part 1： The generations of electricity of the two plants are much higher after watering than before watering. It is inferred from this that when the plants are watered, the rate of photosynthesis increases, so the microorganisms are more active, the rate of production of high-energy electrons increases. Therefore more electricity is produced.

Part 2： Compared with watering everyday, the generation of energy of the plants decreased significantly. It is inferred that this is because long-term non-watering will reduce the rate of photosynthesis of plants, the rate of microorganisms producing high-energy electrons, and thus the power generation of plants. The longer the plant is not watered, the lower the rate of photosynthesis and the lower the power generation of the plant.

Conclution：First, the amount of water absorbed has the greatest impact on the power generation of plants. Second, the power generation of plants after watering is higher than that before watering. Third, the longer the plant is not watered, the lower the power generation.

Experiment 3 result:
It is proved that large-scale plant power generation still has its efficiency and voltage output. So, the potential of plant power generation still remains. It is hoped that this technology can be used in different greenbelts, such as laying the circuit under the plants in parks and adding USB plugs on the benches, so that people can charge their mobile phones, chargers, etc. while resting. It is also hoped that this technology can be widespread and make people interested in planting, and plant at home as environmentally friendly chargers. Also, if it can be applied in large-scale farming, it is believed that the technology will bring a huge amount of electricity for farmers to use or sell out, and thus solve the energy problem.

VI. Conclusion

The products of photosynthesis in plants can be used to generate electrons by microorganisms, and so on to generate electricity. However, the efficiency of Power Plant in Plant is not high. How to improve its efficiency is still a study for scientists.

☑ **Our project is developed based on our school's previous project and the enhancement is as below:**

To explore the feasibility of the popularization of Power Plant in Plant, we used more time to verify the accuracy of the datas and tried more kinds of plants to research large-scale power generation of plants.