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Research Article

# Another Method for Producing Hybrid Plasma: the Hidden Science of the Enclosed Plant Terrarium

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## Abstract

**Introduction:** Enclosed plant terraria have been in use for more than a hundred years but no scientific explanation for their long-term ability to sustain the plants with no water, low light and no air have been proposed. For the present study, we constructed an enclosed and sealed terrarium with a variety of broadleaf plants and measured daily ionization and absolute humidity levels for 1 month compared to a similar container without plants.

**Methods:** Twelve healthy, watered broadleaf plants were placed in a large 19-quart plastic container and sealed with snap closers. A similar but empty container was used as a control.

**Protocol 1:** The time to reach maximum negative ion counts determined by introducing an ion counter into the canister and a hygrometer to measure humidity were monitored daily for 30 days.

**Protocol 2:** After the 30-day study, the plants were removed from the canister. For the next 10 days, the same procedure was followed daily.

**Results:** The time (in seconds) to reach maximum negative ion counts ($2999x10^3$ ion counts/sec, for this instrument) and absolute humidity (90+%) in the first 10 days and the last 10 days of the month-long monitoring period were maintained at exceedingly high levels. Even when the plants had been removed from the container. All p values were >0.05.

**Conclusions:** In an enclosed and sealed terrarium with a variety of broadleaf plants, and measured daily ionization and absolute humidity levels for 1 month negative ion counts and humidity were maintained at significantly high levels for another 10 days, even when the plants were removed from the container.

## Introduction

In our previous reports we have documented a newly described form of non-thermal plasma consisting of water and gas [1,2]. Briefly, these methods were based on the separation of free water molecules from bulk water due to a concentration gradient [3]. In one method, the 12-19% of free water molecules in bulk water, have a molecular size (2.7 A) which can pass through the pores of sealed glass jar (8-12 A, [4]) placed at the bottom of large cylinder containing 2000 mL of distilled water. The hydrostatic pressure, in addition to the concentration gradient between the outside and inside the jar allows the accumulation of free water molecules inside the sealed jar. Once separated from bulk water the inherent kinetic interaction of the free water molecules initiate stripping of electrons from the water molecule resulting in an ionization reaction consisting of positive and negation ions, free electrons and neutral atoms. By definition, this constitutes a non-thermal plasma which were called hybrid-plasma, (HP) part water and part gas. When the jars are removed from the water and instrumented with an ion counter and hygrometer, they measured ionization levels greater than $2999x10^3$ ions/cm3 and humidity levels greater than 99%, respectively.

Another passive, water-based method for forming HP was by adding 800mL distilled water to a 4000mL acrylic cylinder. Inside the cylinder an uncovered 500mL jar equipped with an Ion counter and hygrometer was placed on a platform above the water line. The acrylic cylinder was sealed with a cover. After 24 hours the same: high or maximum readings were registered on the ion counter and hygrometer.

The present report describes another passive process, no external energy input for the formation of hybrid-plasma by confining broadleaf plants in a container without water for 2 weeks. The container was instrumented with an Ion counter to measure ionization levels and a hygrometer for determination of absolute humidity.

## Methods

Twelve healthy, watered broadleaf plants were placed in a large 19 quart plastic container and sealed with snap closers. A similar but empty container was used as a control. Each container was instrumented with a hygrometer to measure absolute humidity. Starting at 24 hours, we determined the negative and positive air ion counts in both containers as well as registering the humidity values, respectively. After 24 hours, we noted that the experimental container showed maximum negative ion levels within seconds of introducing the ion counter into the container and humidity level of 90+%. Therefore, the following protocol was followed daily for the next 30 days.

### Protocol 1

The humidity levels were determined from the hygrometer readings without opening the canisters. The ion counter was introduced into the canister while opening the lid momentarily. A timer was quickly started to determine and register when the negative ion count reached maximum ($2999x10^3$ion counts/sec). Humidity levels were also recorded. The time, in

seconds, to reach maximum negative ion counts was recorded daily for one month as well as daily humidity levels.

### Protocol 2

After the 30-day study, the plants were quickly removed from the canister. For the next 10 days, the same procedure was followed daily, measuring the negative ion counts and the humidity levels.

### Statistical analysis

The mean time required for negative ion counts to reach the maximum value and the mean humidity levels in both experimental and control containers throughout recording periods were registered and compared by a student's T-test. A p-value of <0.05 was considered significant.

## Results

Table 1 shows a comparison of the times in the first 10 days of the 1 month period with plants in the container compared to the last 10 days Also we measured the last 10 days of the monthly period with the plants removed from the container. These data indicate that there is a statistically significant fall off in the level of ionization in the last ten days of the month in both cases. Based on time to maximum remained high. In all cases the humidity values were 90%+. As a control set, data collected from a separate container without plants, during this same time period showed ion counts that varied from 2-300 x$10^3$ ion counts /sec, and humidity levels averaging 40%. These findings clearly suggest that ionizations and humidity levels were exceeding higher due to the presence of the plants and were sustained even when the plants were removed.

**Table 1:** shows the comparison of the time (in seconds) to reach maximum negative ion counts (2999x$10^3$ ion counts/sec, for this instrument) in the first 10 days and the last 10 days of the month-long monitoring period.

| Time to Maximum Ion count in the Terrarium | | | |
|---|---|---|---|
| Number | Start of the month | End of the month | Plants removed |
| 1 | 20 | 120 | 151 |
| 2 | 40 | 126 | 202 |
| 3 | 21 | 112 | 268 |
| 4 | 30 | 36 | 190 |
| 5 | 48 | 30 | 144 |
| 6 | 31 | 45 | 268 |
| 7 | 25 | 33 | 103 |
| 8 | 44 | 67 | 80 |
| 9 | 33 | 85 | 55 |
| 10 | 32 | 62 | 80 |
| Average | 32.4 | 72 | 154 |
| SD | 9.32 | 37.2 | 76.7 |
| p-value | | 0.01 | 0.000001 |
| | | | 0.009 |

The last column indicates the after a 10 day time period time in seconds for the ion count to reach maximum when the plants had been removed from the container. All p values were >0.05.

## Discussion

### Major findings

We constructed an enclosed plant terrarium with a variety of broadleaf plants and monitored the time to reach maximum ion counts and absolute humidity levels on a daily basis for 10 days at the start and end of the month after the plants were removed from the container. The ion counts and humidity levels were significantly higher than measured in a container without plants. These values matched those obtained in our previous studies in which we characterized the properties of newly formed non-thermal plasma called hybrid-plasma (HP).

### Background

Nathaniel Bagshaw Ward (1791-1868) was an English doctor who popularized [1] a case for growing and transporting plants which was called the Wardian case [4]. Ward first noticed the effects of a hermetically sealed glass container in 1829. He had placed a chrysalis of a sphinx moth in damp soil at the bottom of a bottle and covered it with a lid. A week later he noticed that a fern and grass seedling had sprouted from the soil. His interest piqued, he saw that evaporated moisture condensed on the walls of the bottle during the day, and ran back down into the soil towards evening, maintaining a constant humidity. Ward went on to develop the "Wardian Glass case" which was an enclosed plant terrarium that was self-sustaining with minimal requirements for air, light or water. In the present report, we reconfigured the Wardian Case using a variety of broad leaf plants specifically for producing copious transpiration. We hypothesized that the HP that was manifested by the sustained high levels of ionization for 1 month was due to the free water molecules liberated by the transpired water from the broad leaf plants. Based on the kinetic interaction of the unencumbered free water molecules, the same HP resulted as, described in our previous and recent publications [1-3]. Standard methods for non-thermal plasma production had relied on the application of external energy, usually in the form of electrical discharges applied to a gas [5]. An important difference between the standard methods and our passive form of is that the latter plasma can be accumulated and stored, whereas the previous method produces a short-lived plasma (seconds). We defined this new form of NTP as a plasma consisting of a mixture of water and gas, Hybrid-Plasma (HP). Evidence that water was present was indicated by humidity level at or near 99%, well above ambient humidity. Evidence of the presence of a gas was indicated by the ionization levels throughout the enclosed container, which correspond with ion counts well above 3 million ion counts.

### Future Studies

It is interesting to note that the hybrid-plasma induced using the method of confining a body of water [2] maintained high levels of negative ion concentration for only 6 days before rapidly dissipating. This was in sharp contrast to the month long maintained high levels for the month long monitoring period with the inducer being the broad leaf plants. This difference provides the ability to accumulate and apply the maintained hybrid-plasma for multiple scientific, medical and commerial purpose. Indeed, our preliminary studies have shown anti-dehydration, anti-aging [6] and food preservation without refrigeration.

## Conclusions

We constructed an enclosed and sealed terrarium with a variety of broadleaf plants and measured daily ionization and absolute humidity levels for 1 month compared to a similar container without plants. The experimental set showed exceedingly high levels of ionization > 2999x$10^3$ ion counts /second and humidity of 90+% which was sustained over the monthly period even when the plants were removed. Only background levels of negative ion counts and relative humidity (2-300 and average relative humidity of 40%) were measure in the control container over the same time. Based on our previous studies, also using no external source of external energy input we hypothesized that these broadleaf plants were emitting hybrid-plasma, i.e., a mixture of water and gas into the ambient environment.

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