

A New Form of Non-Thermal Plasma: Production, Properties and Applications

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Background

What is plasma?

- Matter can be a solid, liquid, gas or plasma
- Plasma is the 4th state of matter which also applies to water
- Plasma is an ionized gas produced by electrically exciting gas molecules to collide thereby stripping electrons and becoming ionized.
- Plasma can be partially ionized and exist at room temperatures. These plasmas are referred to as non equilibrium plasmas, cold plasmas or non-thermal plasmas (NTP's) and are the subject of this discovery.

Methods

Non-Thermal Plasma Produced Without External Energy

- A water tight covered 500mL jar equipped with an Ion counter and hygrometer was held to the bottom of a 4500 mL acrylic cylinder with Velcro (n=6).
- The cylinder was filled with 4000 mL distilled water.
- After 24 hours, 90 - 99% humidity was registered on the hygrometers and maximum readings of >2 million ion counts /cm³ on the ion counters. The ionization readings indicated a reaction had taken place.
- The sealed jars were removed and placed on a shelf for daily measurements. The ion counts and humidity values exhibited declining values over 14 days.

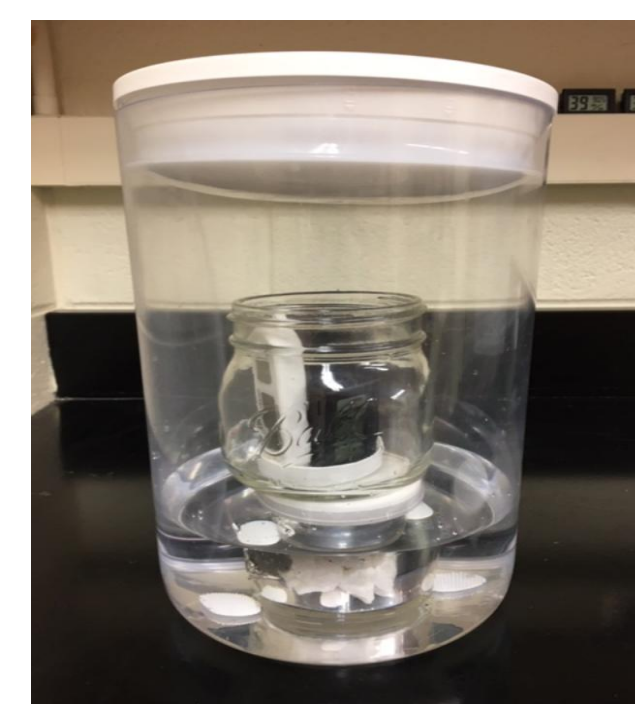


Hypothesis

The size difference in water molecules allowed for molecular separation and confinement of only the smallest molecules. These experiments showed that free water molecules (2.7Å), were able to pass through the glass pores of a jar (8-12Å) by way of osmosis and diffusion. When liberated from bulk water and confined, free water molecules exhibit high kinetic energy. These kinetic molecules interacted and resulted in a new form of NTP in the collection jar; an ionized mix of gas and water we call Hybrid-plasma or HP (Patent Pending).

Breeder Reactor for HP

We have developed the a breeder reactor for HP production. We added 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 covered.

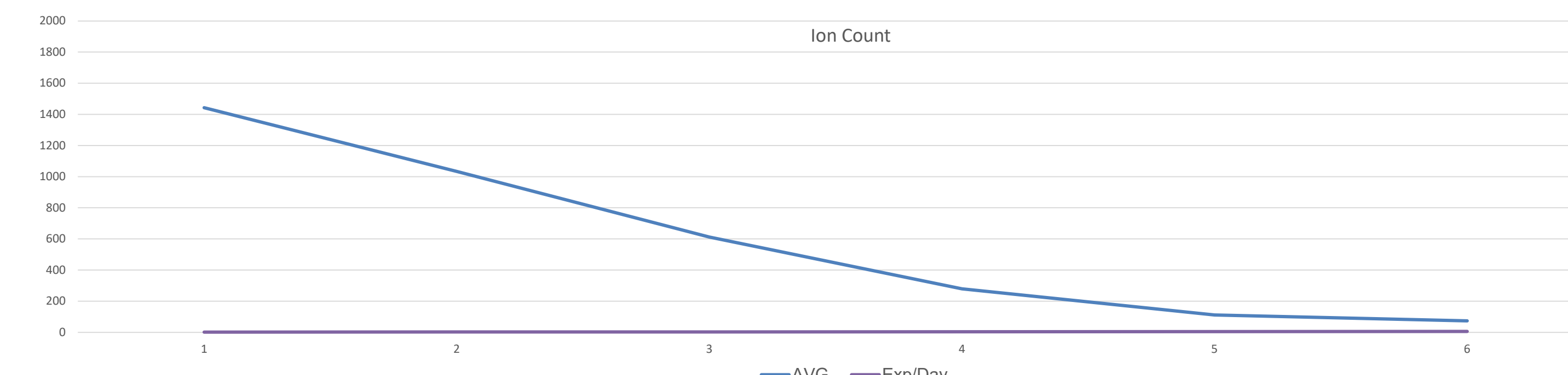


After 24 hours, high or maximum readings were registered on the ion counter and hygrometer. The uncovered jars were sealed with a plastic cover and placed on a shelf for daily observation (n=10).



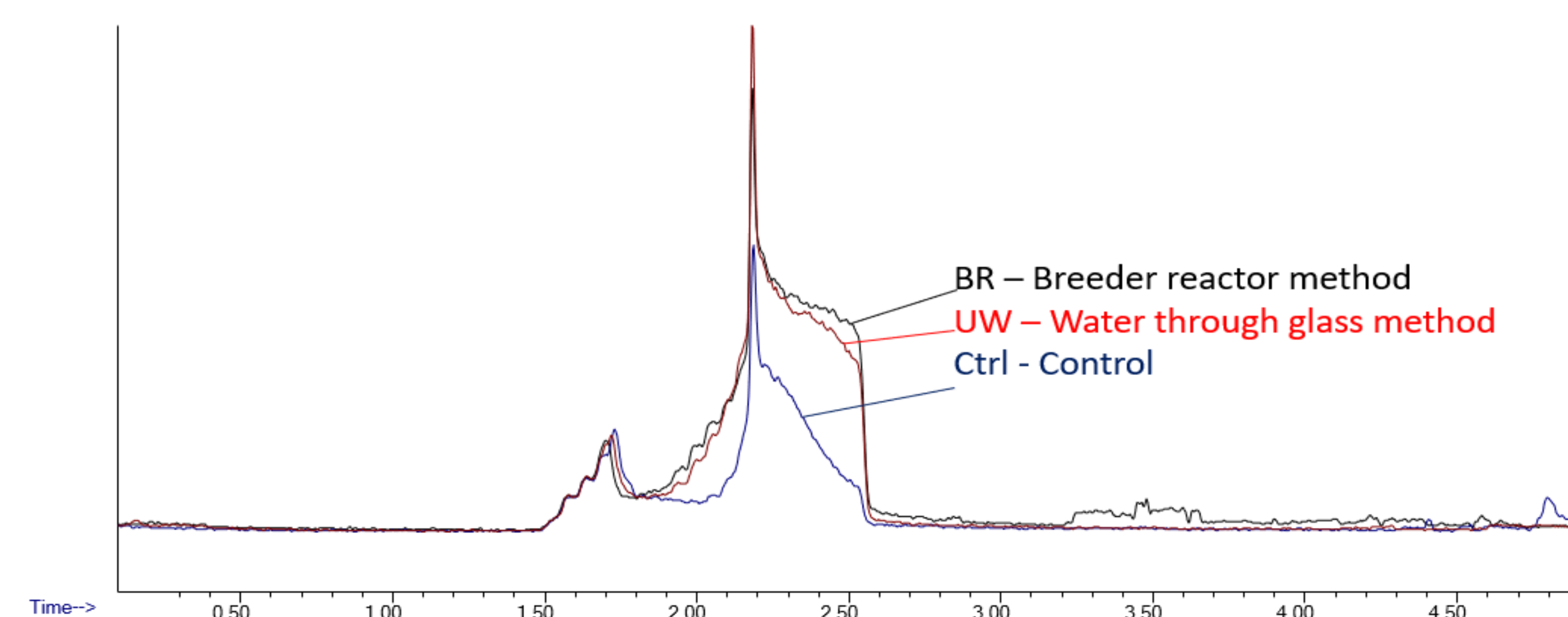
Hybrid Plasma Longevity

After HP accumulated in breeder reactor collection jars (n=10), the ion counters registered a mean ion count of 1443 and a mean hygrometer reading of 93%. Both readings gradually declined as ionization energy diminished each day.



Spectral Analysis of Hybrid Plasma

Spectral analysis indicated hydroxide (OH⁻) as a major component of HP confined in the jar. Both production methods produced hydroxide levels 2 times greater than the control.



Hybrid Plasma Applications

- Preservation of Produce Without Refrigeration
- Anti-Dehydration
- Anti-Oxidant Properties
- Anti-Aging Effects
- New Prospecting Methods for Antibiotics

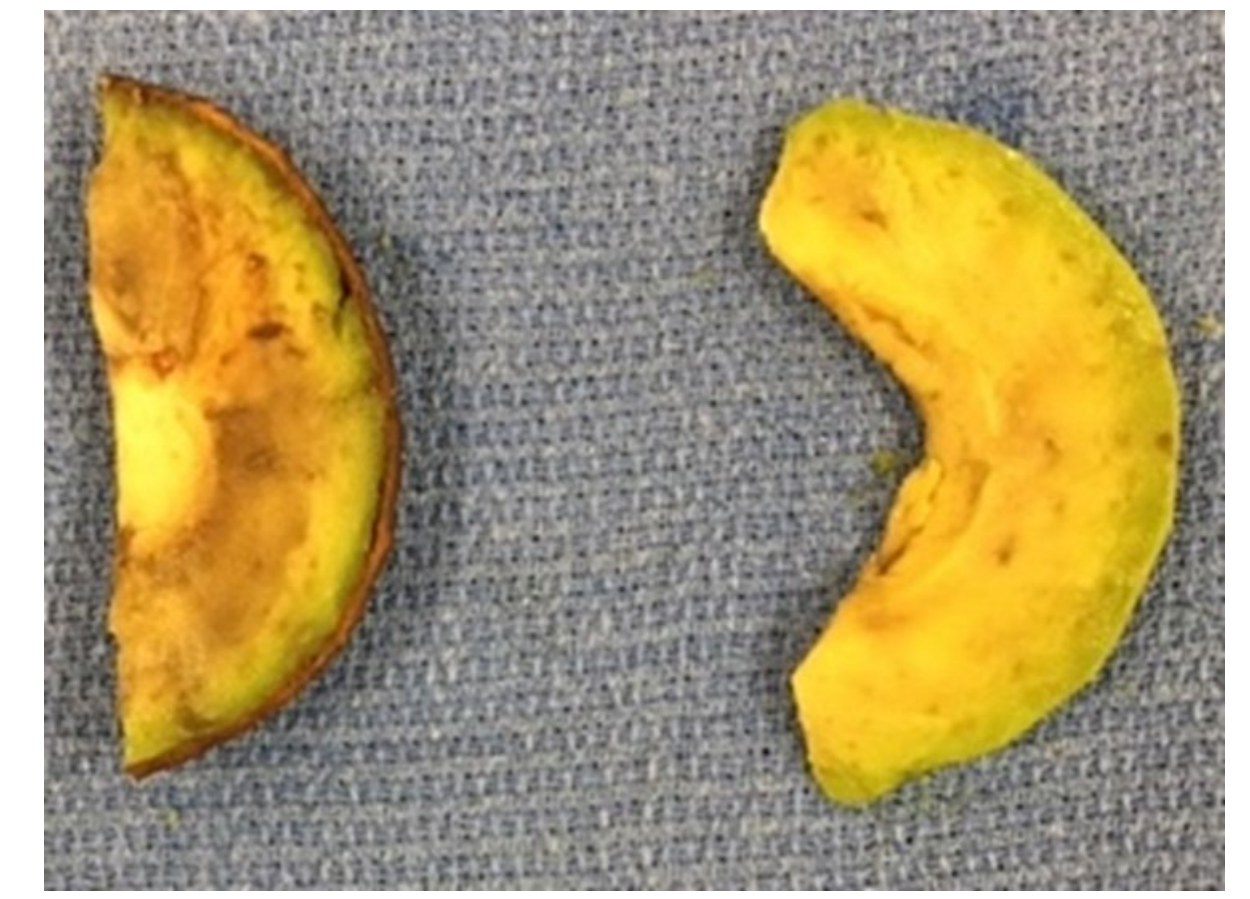
Preservation of Food Without Refrigeration

Pictured are tomatoes kept for 28 days in our breeder reactor at room temperature. For comparison a tomato kept at room temperature and humidity (~10% - 50%) for the same period of time are shown. Note the crinkling of the tomato's skin indicative of severe water loss. We hypothesized that the presence of HP is responsible for the anti-dehydration properties.



Anti-Oxidant Properties of HP

To demonstrate the anti oxidant properties of HP, two small samples were taken from a fresh avocado. One was subjected to an HP environment (right), and the other to the ambient environment (left). After 24 hours we see that the HP had an anti-oxidizing effect and prevented browning of the avocado slice.



Anti Aging Effects of HP

Seedlings grown in water (left) in room ambient environment compared to a plant in HP for 10 days (right). The HP plant showed diminished growth with under-developed leaves compared to normal growth with well developed leaves of plant grown in water.



Anti-Aging Effects of HP

- After 10 days, both the hydroponically grown plant and the HP grown plant showed growth but the HP plant was substantially smaller with under developed leaves.
- When water was restored to the plant grown in HP, the plant growth continued normally but was reduced in size compared to the plant grown continuously in water suggesting that the plasma had an anti-aging effect on plant growth.



Antibiotic Prospecting by Production of Fungal Pellets

In our previous publication we have reported that Mung beans grown in Pakistan were shown to be contaminated with as many as 54 different fungal varieties. By allowing the Mung bean seeds (right) to remain in an atmosphere of HP for several days a green coating of fungus developed around each of the seeds (left). Scientists can order seeds from global sources for potential antibiotic development thereby eliminating costly travel and complex inefficient soil sampling methods. This can be particularly important to find new antibiotics against resistant bacterial variants.



Summary

- At present non-thermal plasma is formed by injection of external energy into a gas. However, this NTP is short lived (seconds).
- Two methods were used to separate free water molecules. Once unencumbered by the bulk water, the kinetic energy of these molecules resulted in HP induced without external energy input and can be accumulated and stored.
- We have demonstrated that HP has food preservation, anti oxidant, anti-aging and potential for new antibiotics development.
- Our ongoing studies have provided new methods for producing HP without external energy input as well as new applications.