SCIENTIFIC AIR SOLUTIONS

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RE: BioTurbo System Trial Results

Summary

The effects of ozone (O_3) concentration (0.25 and 0.58 ppm), relative humidity (50 to 60%) and treatment time (0 to 140 seconds) on the inactivation of ethylene gas at 5, 10 and 20 ppb were studied. These trials show the destructive effects delivered by the BioTurbo treatment. The statistical analysis of developed predictive model suggested that O_3 concentration, relative humidity and treatment time significantly ($P<0.01$) increased the rate of ethylene reduction. Among the three factors, the effect of O_3 concentration on ethylene was the greatest, while effect of RH was the least. The interaction between O_3 concentration and RH exhibited a significant and synergistic effect ($P<0.05$).

Ethylene gas, 5, 10, 20 ppb, supplied by Special Gas Services, Inc., http://www.specialgas.com was used to confirm efficacy of generated ozone from the BioTurbo system.

Results

The MiaTech, BioTurbo system eliminated all ethylene levels, 5, 10 and 20 ppb within 60 seconds.

Trials

For these trials, the BioClean cube was removed and a plate reducing the 10 inch to three inch opening was fitted with flexible tubing to connect the BioTurbo system to the SAS test chamber.

The Scientific Air Solutions (SAS) test chamber, 4ft/8ft/4ft (height/length/width) is separated into a treatment (left side) and a control (right side). The treatment side of the SAS test chamber was fitted with a 3 inch inlet valve which was connected to the BioTurbo discharge. Fresh ambient air, provided by a 3 inch line was connected to the control side of the test chamber.

A split manifold from a single ethylene gas supply was fitted into the treatment and control sides of the test chamber. Gas flow controllers were also installed on each line to assure the same flow (amount) of ethylene was delivered to each side of the test chamber.

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Trials started with 5 ppb and proceeded to 10 ppb and 20 ppb ethylene gas.

The BioTurbo unit was turned on and immediately ethylene gas in both chambers was monitored via an Interscan 4000 Series Compact Portable Analyzers (ppb).

Ozone levels were monitored inside the BioTurbo system and in the treatment side of the test chamber via a Programmable Logic Controller (PLC, Unitronics) and an Aeroqual sensor monitoring O_3 production.

Temperature and relative humidity of the chambers (treatment and control) were also monitored during these trials.

From three separate trials, readings were taken from each chamber's ethylene detectors on 10 second increments for approximately 2 minutes with the averaged results given in Tables 1 - 6.

In an effort to confirm the ethylene detection limits, 250 ml samples were drawn from the outlet valve and analyzed via a Perken Elmer GC MS.

Background BioTurbo

BioTurbo was designed to remove ethylene from fruit and vegetable storage areas. The BioTurbo will also kill 99.9% of bacteria, fungi, mold, mildew and yeast. The Bio Turbo is composed of two aluminum cubes connected by a flexible/expandable 10 inch (25.4cm) aluminum tube. One of the cubes is named BioTurbo and the second cube is BioClean. In the BioTurbo cube, the air is first pulled through a dust filter to remove any larger particles of dust and dirt followed by a cell destruct filter which destroys 99.9% of the airborne pathogens. The air then enters the ozone chamber where the ethylene is eliminated. The ozone and air is then transported through the tube to BioClean cube which contains a catalyst that converts the ozone back to oxygen.

Background Ethylene

Ethylene gas (C_2H_4) is an odorless, colorless gas that exists in nature and is also created by man-made sources. Not easily detectable, it exists where produce is stored. In nature, the largest producers are plant and plant products (i.e., fruits, vegetables and floral products) which produce ethylene within their tissues and release it into the surrounding atmosphere. It is also a by-product of man-made processes, such as combustion.

As is often the case, the role of ethylene and its effects on produce was discovered by accident. Lemon growers would store newly harvested green lemons in sheds kept warm by kerosene heaters until they turned yellow and ripened enough to market.

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When new modern heating systems were tried, the lemons no longer turned yellow at the same rate. Research soon found that the important factor in the ripening process was small amounts of ethylene gas given off by the burning kerosene in the heaters.

Ethylene, also known as the 'death' or 'ripening hormone' plays a regulatory role in many processes of plant growth, development and eventually death. Fruits, vegetables and flowers contain receptors which serve as bonding sites to absorb free atmospheric ethylene molecules. The common practice of placing a tomato, avocado or banana in a paper bag to hasten ripening is an example of the action of ethylene on produce.

Increased levels of ethylene contained within the bag, released by the produce itself, serves as a stimulant after reabsorption to initiate the production of more ethylene. The overall effect is to hasten ripening, aging and eventually spoilage.

A refrigerator acts in much the same way. Kept closed to retain the desired temperature, it also enables an increased concentration of ethylene to accumulate. Any closed environment, such as a truck trailer, shipping container or warehouse, will have a similar effect.

Storage of produce items is of economic importance to the food and floral industry. Storage allows producers, handlers and sellers to spread availability over periods of strong and weak demand, maintaining supply and stabilizing cost. Within the industry, it is estimated that losses directly related to ethylene run into the billions of dollars annually. Removal of ethylene from the storage and shipping environment retards spoilage reduces loss and increases profit.

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Table 1
Averaged results from three trials of BioTurbo Treatment
5 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.25	0	5	5
	10	5	5
	20	3	5
	30	0	5
	40	0	5
	50	0	5
	60	0	5
	70	0	5
	80	0	5
	90	0	5
	100	0	5
	110	0	5
	120	0	5
	130	0	5
	140	0	5

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Table 2
Averaged results from three trials of BioTurbo Treatment
10 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.25	0	10	10
	10	10	10
	20	7	10
	30	6	10
	40	4	10
	50	0	10
	60	0	10
	70	0	10
	80	0	10
	90	0	10
	100	0	10
	110	0	10
	120	0	10
	130	0	10
	140	0	10

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Table 3
Averaged results from three trials of BioTurbo Treatment
20 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.25	0	20	20
	10	20	20
	20	14	20
	30	10	20
	40	6	20
	50	3	20
	60	0	20
	70	0	20
	80	0	20
	90	0	20
	100	0	20
	110	0	20
	120	0	20
	130	0	20
	140	0	20

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Table 4
Averaged results from three trials of BioTurbo Treatment
5 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.58	0	5	5
	10	2	5
	20	0	5
	30	0	5
	40	0	5
	50	0	5
	60	0	5
	70	0	5
	80	0	5
	90	0	5
	100	0	5
	110	0	5
	120	0	5
	130	0	5
	140	0	5

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Table 5
Averaged results from three trials of BioTurbo Treatment
10 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.58	0	10	10
	10	8	10
	20	2	10
	30	0	10
	40	0	10
	50	0	10
	60	0	10
	70	0	10
	80	0	10
	90	0	10
	100	0	10
	110	0	10
	120	0	10
	130	0	10
	140	0	10

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Table 6
Averaged results from three trials of BioTurbo Treatment
20 ppb Ethylene

Ozone Concentration (ppm)	Time (sec)	BioTurbo Treatment (ppb)	Control No Treatment (ppb)
0.58	0	20	20
	10	16	20
	20	5	20
	30	0	20
	40	0	20
	50	0	20
	60	0	20
	70	0	20
	80	0	20
	90	0	20
	100	0	20
	110	0	20
	120	0	20
	130	0	20
	140	0	20

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