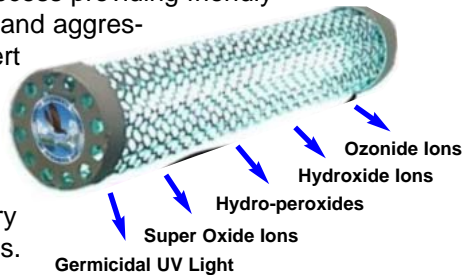


Photohydroionization™ - An Advanced Oxidation Technology

By Ronald G. Fink

Summary

Photohydroionization™, or PHI™, is an Advanced Oxidation technology developed and owned by RGF Environmental Group. Basically, it is a broad spectrum high intensity UV light targeted on a quad metallic catalyst ultraviolet (UV) target in a low-level ozone and moist atmosphere. This creates an advanced oxidation process providing friendly oxidizers, or very safe and aggressive oxidizers that revert back to oxygen and hydrogen. PHI™ Technology has been successfully used in water, air, food, laundry and grease applications.



History

Experiments with food and water irradiation started in the 1960's (RGF employees participated in this work). Results were promising. However, food irradiation remains a problem to date. This is due to inconsistency in results, some taste concerns and mostly public fear of radiation. Irradiated food must be labeled as such, and the radiation symbol carries public concern.

In 1985 RGF formed with the corporate mission to provide the world with the safest water, food and air without the use of chemicals. Experiments with ozone (O₃) and UV light rays proved promising. UV light at 184 NM creates a low concentration of ozone. This low cost, low maintenance method of producing ozone was of commercial interest. However, the low concentration was an efficacy concern. Experiments were conducted by RGF's R&D in the late 1980's, and it was discovered that the use of UV ozone on industrial wastewater was feasible when the low-level UV ozone was activated with UV light, thereby producing a hydroxyl radical, the most powerful friendly oxidizer. This was an important find as the use of ozone was preferred. However, the traditional method of ozone production was the corona discharge or "CD" method, which produced a high concentration of ozone. The CD method was considered not practical due to high cost, high maintenance and high failure rate.

This find led to an 18 year string of discoveries involving: advanced oxidation, utilizing UV irradiation, ozone, fenton reagents, catalytic oxidation, hydro peroxides, titanium-silver-rhodium and copper catalysts, silver ions, oxide ions, super oxide ions, ozonide ions, broad spectrum UV radiation, soft surface irradiation, hydroxide ions, radiated catalytic ionization™, hydroxyl radicals, HE-UV, sintered metal targets, PPC-UV coating, photocatalytic oxidation, photohydrocatalytic™ oxidation and the PHI™ Cell, resulting in numerous patents and over 500 RGF products.

Development

UV light and ozone are not new discoveries. Ozone was first discovered in the late 1800's and used as a water purifier in Europe. UV light was discovered in the 1930's. Actually,

nature discovered it before; it was called the "sun". The disinfection qualities of UV light are also not new. Hospitals have used UV light for decades in operating rooms. Barbers were disinfecting combs in the 1950's with UV light. What is new is the enhancement of both these natural, friendly oxidizers and the validation for use on air, water, food and laundry.

History of Water Systems

The first patents awarded to RGF were for its industrial wastewater treatment systems. RGF pioneered and developed both the discharge and recycling systems for heavy industry. By the mid-1980's, environmental concerns were peaking and RGF's systems were the industry choice. RGF maintains strategic alliances, national accounts and distributorships with many Fortune 500 corporations, including Caterpillar, John Deere, GE, Halliburton, Hertz, NASA, US Department of Defense, US Army, Navy, Marines, Air Force, Baker Oil, Waste Management, Laidlaw, Case, US General Services Administration, Hilton Hotels, FPL, US Nuclear Regulatory Commission, Schlumberger, Steris Corp., Food Safety Systems, ADM, Conagra, Seaboard Farms, Kraft, Coca Cola, Insinkerator, McDonalds, Regal Foods, Shaklee Corp., Sandia National Labs and Nevada Nuclear Test Site. All of the industrial water systems used RGF's advanced oxidation (ozone/UV) systems with great success. RGF water systems have been manufactured since 1985 with over 20,000 water systems installed in 33 countries.

About Ozone

Ozone or O₃ is the result of oxygen (O₂) reacting with an electrical discharge such as lightning, a spark, or an electrical current, or UV light radiation. Ozone is a colorless gas that has an odor similar to the smell of fresh air after a thunderstorm. Ozone is extremely unstable and cannot be stored. It must be generated at the site. Ozone is faster and more powerful than chlorine and is an oxygen-based friendly oxidizer. By friendly we mean oxidizers that revert back to oxygen and hydrogen after they react. High levels of ozone can be a health hazard or even lethal.

History of Air Systems

In the mid-1980's air purifiers started to make their way into the residential market. Ozone air systems were widely used in the commercial restoration business for fire and flood damage to buildings. These applications utilized corona discharge systems (CD) that use a spark or electrically charged plates to simulate lightning. This converted the oxygen (O₂) to ozone (O₃). The CD method creates very high concentrated ozone. Plus by using air as the oxygen source, you are receiving 20% oxygen and 80% nitrogen. The problem with CD systems is with oxygen conversion you also get a nitrogen conversion, which makes nitric acid and nitric oxide. Therefore, most professional CD manufacturers provide oxygen generators (as does RGF) with their systems to prevent the nitric problem.

The problem facing the residential air systems was that the cost of an oxygen generator was so high they went without one. This, of course, created a CD unit that produced high concentrated ozone plus low levels of nitric oxide and nitric

acid. Maintenance was a problem due to the corrosive nature of nitric acid and the high concentration of ozone exceeding the Federal safety limits of .04 ppm. Ozone readings at the exhaust have exceeded 10 ppm, which is potentially lethal. RGF decided to stay out of this dangerous market and stay with our ozone commercial market which only used our equipment in evacuated buildings controlled by professionals.

In the late 1980's we discovered that the lower concentration of ozone could have an effect on odors, mold and bacteria levels as low as .02 ppm (half the Federal safety maximum) were reported as having significant results. Testing this theory, we determined that safe, low levels of ozone could provide a significant reduction in airborne mold, odors and bacteria. The challenge was to create a safe residential air purifier that could produce safe, low concentrations of ozone that would not exceed the .04 ppm Federal limits. This was accomplished in the early 1990's, at about the same time the Federal Government was going after the CD ozone residential units. This battle of the Feds and CD manufacturers gave ozone a very bad name.

With the technology to build a device that produces safe, low concentrations of ozone and the ability to ensure a room would not exceed .04 ppm, RGF set out to validate the use of this device on mold, VOC's, odors and bacteria. Fox TV News was doing a three-part series on indoor air problems and asked us to test one of the CD ozone units. The unit they gave us was producing 18 ppm ozone, a lethal amount that drove the camera crew and news reporter right out of the office. The Fox people then asked if they could independently test our RGF Pure Air unit. They ran tests supervised by an independent air specialist and two medical doctors. The series turned out to be a fantastic infomercial for RGF. The results couldn't have been better. Fox ran this on their national news network and their national health news. Popular Science picked up the story for the magazine and ran it on the Popular Science TV Show. Sales of our Pure Air residential line picked up substantially.

In the mid-1990's, a high-end resort island approached us about water and air problems on the island. The resort was called Little Palm Island. It is a five-acre island located 30 miles from Key West. The island was formerly President Harry Truman's fishing camp. It was also the site of the film "PT-109", the JFK World War II story. The island maintained the original Truman House for the restaurant and had 32 thatched huts for rooms. With the high humidity and the inherent problems associated with an island, environmental problems such as mold and mildew were everywhere.



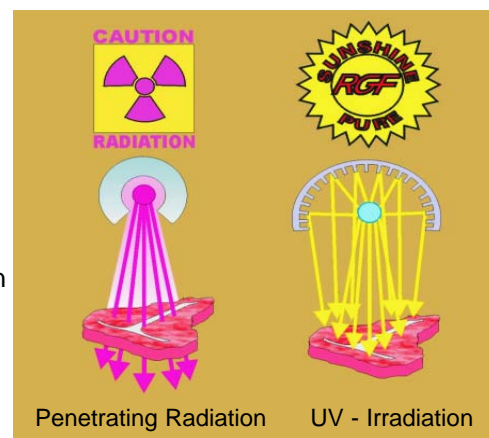
Little Palm receives EnviroVision Plaque

The rooms had sick building syndrome. The food storage rooms and kitchen were mold havens. Sewage was being injected into a sewage injection well. The sewage processing plant was over its capac-

ity. Drinking water was stored in underground tanks. Garbage odors were a problem, as it had to be stored on the island and shipped back by boat. With the use of our newly discovered Advanced Oxidation Technology, RGF was able to provide 19 systems to greatly improve the island environment. We called the project "Envirovision®". With the RGF Advanced Oxidation processes, we were able to provide the island with the purest possible water, air, food and laundry without the use of chemicals. This was the first time RGF was able to utilize numerous systems to cover all four areas: food, air, water and laundry.

The Little Palm Project gave us a few new problems - food, sewage and laundry. Little Palm, being an island, offered a mold, mildew, odor, sewage and bacteria problems like we had not seen before. Food shelf life was short, mold grew on the walls, and airborne mold spores and bacteria were heavy. In the food storage areas, the food needed a chemical-free method of sanitation. Reflecting on food irradiation experiments of 40 years ago and the associated problems with radiation, it was ruled out. The food problem was a surface contamination problem resulting from airborne mold and bacteria in a very growth-friendly atmosphere (warm and humid). Penetrating radiation was overkill. Why penetrate through a food item when the contamination is on the surface? Accordingly, we tried soft radiation, or non-penetrating radiation like sunlight or UV radiation.

Straight 254NM UV, sometimes referred to as germicidal UV, works well on surfaces. Subsequent experiments found that creating an advanced oxidation atmosphere between the UV lamps and the food surfaces or photoionization provided fairly broad kill rates of over 90%.



In addition, we provided ozone/water food wash down stations. Ozone gas dissolved in water is a very aggressive and friendly disinfectant that also removes chlorine and pesticides from fruits and vegetables.

The sewage plant was another unique problem that our PHI technology helped us with. The plant was overloaded and the injection well was under designed (installed by the Trumans in the 1940's). In order to increase the efficacy of the plant, we added fluidized bed technology to the existing plant. Also, we treated the restaurant grease separately. We discovered that the PHI Cell's advanced oxidation gas actually broke the grease down to a food source for the bio plant, which created an interesting scenario. Instead of grease adversely affecting the plant's operation, the PHI treated grease improved the plant's efficiency. To relieve the overflowing injection wells, we installed a sewage reclaim system using the PHI Cell to sanitize the water for irrigation. This system not only helps save the island's natural environment, it provides a highly nutrient rich water source to the island's plant life saving over \$100 per day in irrigation costs.

The laundry also presented a problem. Laundry detergents tend to be unfriendly to sewage plants. Ozone had been used on hospital and hotel laundry since the late 1980's. RGF worked with EPRI (Electric Power Research Institute) to do the first hospital laundries. Results were promising. However, the high concentrations of ozone tended to bleach out colors so it could only be used on whites. Little Palm Island had colored towels, sheets, basically everything. The ozone laundry system had many advantages. Unfortunately, the bleaching problem made it unacceptable. The use of our PHI™ Cell again came to the rescue. The cell produced ozonide ions, hydro peroxides, super oxide ions and hydroxide ions. In safe low levels with small amounts of enzymes, cleaning was as good, even better than harsh detergents. Plus, without all the chemical residue in the towels, they became one-third fuller. Colors were vibrant, allergic reactions stopped, and the island saved energy as the PHI Cell works best with cold water.

Food Systems

With the success of the Little Palm Island Program, the Envirovision Program was then installed in a chicken processing plant. The chicken was being cleaned and soaked with tap water and chlorine. The odor in the plant was high as was the airborne bacterial levels. The chlorine left a residual on the chicken surfaces. When chlorine reacts with an organic (chickens are organic), it forms trihalomethane, a highly suspected carcinogenic.

Chlorine

- Water Treatment .5 ppm
- Swimming Pools 2-5 ppm
- Sewage Odor Control 5 ppm
- Food Grain Washing 400-600ppm
- Food Celery/Carrot Washing 50 ppm
- Food Poultry Carcass Washing 100 ppm

Chlorine has been used to kill germs in drinking water since 1916 in Canada, and since 1908 in the United States.

The potential danger isn't in the chlorine itself. When chlorine is added to water with organic material such as algae or bits of river weeds, it produces by-products known as trihalomethanes and halocetates.

In 1995, the Ontario Cancer Treatment and Research Institute and the University of Toronto found Ontario residents using chlorinated water had higher rates of bladder and colon cancer than people who drink well water. That study said the problems could come both from drinking treated water and from bathing or showering in it and inhaling the water vapor or spray. People who had used chlorinated water for 35 years raised their cancer risk by 1.5 to 1.6 times, the study said. It blamed 10% to 13% of the bladder cancer in Ontario on chlorinated water.

Grain

RGF has replaced traditional anti-microbial chemicals such as chlorine (450-600 ppm) with non-chemical processes and further reduced bacteria by 80% at a grain plant.



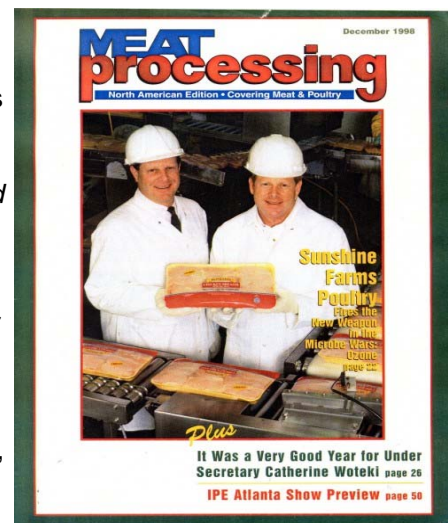
RGF's Photohydroionization™ of Grain

Under a USDA/FDA protocol, we installed EnviroVision Systems to provide the plant with air, water, food surface light and irradiation and sewage grease system. After two years of testing and more testing, the program was granted approval.

Results included:

- Plant Air Over 85% odor and bacteria reduction
- Water Over 80% bacteria reduction
- Food Surface 99% bacteria reduction
- Grease 80% bacteria reduction

The Sunshine / Envirovision project received excellent press with a cover story in *Meat Processing Magazine* and a center spread with *Food Engineering Magazine*. Since the FDA/USDA approval, RGF's PHI technology for water, air and food surfaces has been successfully used on pork, poultry, beef, fish, ready-to-eat meats, grain, beverages and restaurants.



Food Engineering Magazine

On Line

Food Sanitation Processes Receives USDA Approval

Steve Barrie, Senior Editor

Radiation-based food sanitation processes have been approved by the USDA for use in the processing of poultry. The approval is a significant milestone for the industry, as it allows for the use of radiation to kill bacteria on poultry carcasses, reducing the need for chemical sanitizers. The process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.

The first process is a gamma irradiation process. This process uses a source of gamma rays to irradiate the poultry carcasses. The second process is an electron beam irradiation process. This process uses a source of electron beams to irradiate the poultry carcasses.

The USDA approval is a significant milestone for the industry, as it allows for the use of radiation to kill bacteria on poultry carcasses, reducing the need for chemical sanitizers. The process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.

Build It and They Will Irradiate

John Corp (San Diego, CA)

John Corp has received approval from the USDA for the use of radiation to kill bacteria on poultry carcasses. The company's process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.

The approval is a significant milestone for the industry, as it allows for the use of radiation to kill bacteria on poultry carcasses, reducing the need for chemical sanitizers. The process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.

Overseas Plant Construction

John Corp (San Diego, CA)

John Corp has received approval from the USDA for the use of radiation to kill bacteria on poultry carcasses. The company's process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.

The approval is a significant milestone for the industry, as it allows for the use of radiation to kill bacteria on poultry carcasses, reducing the need for chemical sanitizers. The process is safe and effective, and it has been shown to reduce bacterial levels by up to 99.999%.