

Century 21 - Pregnant With Ozone

The fascination with Ozone began in the late 1800s with initial commercialization (Nice, France) in 1906. This versatile gas has the capability to both disinfect and to oxidize while returning to harmless oxygen from which it began its career. No wonder the fascination with Ozone.

Yet those three aspects (disinfectant, oxidizing agent, environmentally friendly) of Ozone are both blessing and curses. Their blessings come when all aspects of Ozone are understood by its proponents and users, so that equipment and processes for its applications are well designed and operated properly. But when these design (or operation) aspects are ignored, the Ozone "industry" will be the recipient of the curses of Ozone - under-design, improper application, and poor attention to safety aspects of its use. There may always be people offering inferior ozonation equipment, or offering undersized Ozone generators for a particular application. On the other hand, today there are more Ozone-knowledgeable people and firms than ever before. This has helped the growth of Ozone in its many applications during the past century.

In this paper, the author will focus on the many non-water and wastewater applications for Ozone (see Table I). Since Ozone is a gas, many applications take place by treating solid surfaces with gaseous Ozone. Still other applications involve adding Ozone to a liquid and then applying the solution to a surface.

Table I: Some applications for Ozone, excluding potable and bottled water.
Uses Involving Gas Phase Ozone
Odor Control - in wastewater plants, bars, restaurants, animal facilities, automobiles and homes.
Fumigation - Restoration of fire or flood damaged homes/buildings; bedding and bedclothes
Packaging of pharmaceuticals
Cleansing of semiconductor chips
Pretreatment of plastic films for lamination to metals and for electroless

plating
Bleaching applications - of paper pulps, textiles kaolin clays
Ozone to assist chemical analyses
Regeneration of polymerization catalysts
Oxidation of flue gas constituents
Treatment of air for indoor quality (air conditioning, nursing homes, operating rooms)
Disinfection of used cutting oils
Production of plastic lenses
Making improved quality aluminum oxide films
Uses Involving Liquid Phase Ozone
Chemical oxidations (azelaic acid to Nylon-6; oxidation of crude oils to produce surfactants)
Commercial laundries
Ozone in Agricultural and Food Processing and Storage
Fumigation - of soils and for storage of foods
Sanitization (of wash waters and equipment); retardation of spoilage and over-ripening
Removal of gross surface contaminants
Recycling of wash and waste waters
Treatment of wine barrels and casks
Ice production and storage
Spraying produce
Disinfection of food plant workers shoes

Gas-Phase Ozone Applications

These are several - odor control, fumigation, restoration of homes/buildings that have experienced fires, mildew control, elimination of cat urine odors in home and automobiles, mold/spore control on stored foodstuffs, packaging of

pharmaceuticals, treatment of plastic films prior to lamination (bonding) with aluminum, cleaning surfaces of semiconductors, etc.

Treatment of Air for Indoor Quality

Gaseous Ozone is routinely applied to larger scale air conditioning systems (office buildings, hotels, restaurants, casinos, meeting rooms, airport facilities and other public places, etc.). Ozone is applied at the beginning of the air return line and moves through the ducting system. The dosage of Ozone is determined qualitatively and adjusted downward so that most, if not all, of the applied Ozone decays inside of the air ducting system, thus avoiding the exposure of occupants to Ozone. Treatment of recirculating air with Ozone can reduce the amount of makeup air required, because of the purification provided by the Ozone.

An excellent paper by Kilham and Dodd (1999) describes the use of Ozone in the air conditioning system of the Imperials Bingo Hall (Renton, Washington, USA) to remove offensive odors and to destroy volatile organic chemicals and smoke. The Ozone system designed for this particular system cost the owner \$22,000 replacing the activated carbon system that cost the owner about \$25,000 annually for carbon replacement. This Ozone system has also resulted in energy savings of about \$250.00 per month.

Production of Plastic Lenses

Still another recently issued Japanese patent claims a method for production of plastic lenses using Ozone, although the specific procedure is not revealed in the patent abstract (Arai, 2001).

Disinfection of Used Cutting Oils

Cutting oils used with machine tools are subjected to high heat loads. After use, the oils are collected in drums, filtered, then either sent to waste disposal or reused to whatever extent possible. When stored prior to reuse, biological

growths develop on the surfaces of the oils, which interfere with the desired reuse.

Several European automobile manufacturers are known to be using Ozone to do away with the microbiological growths in drums of stored used cutting oils. In this application, Ozone is applied to the air dead space in the drums containing the used cutting oil, since Ozone does not generally dissolved in the oils themselves.

Fumigation

Ozone in the gaseous phase is also being tested for use in agriculture as a potential replacement for the use of methyl bromide. Methyl bromide is very widely used as a soil fumigant to control soil-borne pathogens including fungi, nematodes, and weeds. Its use is being phased out, however, under the terms of the Montreal Protocol (the international treaty mandating reduction of Ozone layer depleting substances). Because of its Ozone-depletion potential, methyl bromide is scheduled to be completely eliminated by 2005 in developed countries and by 2015 in developing countries. Paradoxically, Ozone use as an alternative soil treatment agent has been tested in numerous field trials (Pryor, 2001; Pryor, 1999). In these tests Ozone was injected 3-5 inches deep directly into soil through buried drip tubing or drip tape 1 - 5 days prior to planting of the intended crop. At dosages of 50-400 lbs Ozone per acre delivered at 1 - 3% w/w concentration in air, yield increases in some trials of up to 50 -75% have been reported for carrots, tomatoes, broccoli, strawberries, cut flowers and orchard replants in soils previously treated with Ozone in this manner.

Ozone gas is also being tested as a weed control agent in crops grown on clear plastic-covered soil. Clear plastic is often laid tightly over soil before planting to increase soil temperatures due to the greenhouse effect it produces. This passive process, called solarization, often increases soil temperatures sufficiently over a 30 - 45 day period before planting to be fatal to a variety of plant pests in the soil. However, preplant weed control during solarization is also

very unpredictable due to the vagaries of climate and weather. Often, increases in temperature are sufficient to induce seed germination and/or tuber sprouting but insufficient to kill young, rapidly growing plants -- thus exacerbating the problem. In laboratory tests, daily or every other day dosages of 1% - 5% Ozone for as little as 5 minutes a day over a 30 day period have been shown to completely control purple nutsedge, a very pernicious weed plaguing warm weather row crop farmers and arguably the most difficult to control in U.S. agriculture. Laboratory data extrapolated to field conditions indicate good control of purple nutsedge possibly could be achieved for as little as 15-20 lbs of Ozone/acre (Pryor et al., 2001). Most other weeds require even lower and less frequent dosages.

Ozone Uses in Agriculture and Foods

It is readily apparent that because of Ozone's ability to oxidize and disinfect, there are many areas of potential applicability for it in the agriculture and foods areas. In the United States, however, in order for Ozone to be allowed to come into contact with foods, such use must be approved by the U.S. Food and Drug Administration. Until recently such approval had not been obtained, and consequently, the exploitation of Ozone in these fields has been discouraged. In 1997, however, an independent panel of experts in food and Ozone sciences convened by the Electric Power Research Institute (EPRI) affirmed that the use of Ozone in direct contact with foods is Generally Recognized As Safe (GRAS) if applied under Good Manufacturing Conditions (add sufficient Ozone to achieve its intended effect) (Graham, 1997).

As important as the GRAS affirmation was in stimulating U.S. activities in food applications, the FDA pointed out that a short statement in the 1982 GRAS approval of Ozone for bottled water disinfection would pose a problem for Ozone. That statement was essentially, "... All other food additive applications for Ozone must be the subject of appropriate Food Additive Petitions."

EPA Requirements for Ozone Under the FIFRA

When the FIFRA was enacted years ago, EPA was required to regulate any chemical for which a pesticidal claim was made. An example of a claim made by purveyors of Ozone equipment that can be considered to be a pesticidal claim is "Ozone kills/inactivates microorganisms, fungi, molds, algae, etc.). Pesticides historically are chemicals of commerce that are supplied in bulk in cylinders or containers that are shipped throughout a geographical region. Ozone does not fall into that category of "chemicals", in that it is generated and used on-site and quickly dissipates or is self-destroyed during use.

Consequently, in interpreting the requirement of the FIFRA, EPA concluded that Ozone is not a "pesticide chemical", and therefore the gas itself is not to be regulated under the FIFRA. However, Ozone generators, while not chemicals, are regulated under the FIFRA as "pesticide devices", as is equipment that produces ultraviolet radiation.

Under the FIFRA, EPA requires that all pesticide devices (which includes Ozone generators) that are made or distributed in the USA, for which a pesticidal claim is made must carry an Establishment Number. This is a number granted by the EPA upon receipt of a properly completed EPA Form 3540-8 (rev. 5/99), "APPLICATION: ESTABLISHMENT REGISTRATION FOR PESTICIDE AND DEVICE PRODUCERS". The application form can be obtained currently by contacting Ms. Carol L. Buckingham (Room 6118), U.S Environmental Protection Agency, Agriculture and Ecosystem Division (2225A), 401 M Street, SW, Washington, DC 20460 USA, tel: 202-564-5008.

Once an Establishment Number has been assigned to a manufacturing facility, that number is required to be placed on devices (Ozone generators) produced at that facility.

An establishment number does not constitute EPA regulatory approval for the use of Ozone on foods (such as that granted by the FDA on June 26, 2001). It merely confirms that the facility that manufactures Ozone-generating devices has complied with the registration requirement of the FIFRA.

The complete regulations applicable to Pesticide Producing Establishments (including those producing pesticide devices == Ozone generators) are available on the Internet at <http://www.access.gpo.gov/nara/cfr/cfr-table-search.html> . Establishment regulations are in the title 40, Part 167 of Code of Federal Regulations.

Now that Ozone is Legal For Use on Foods, What Next

The primary question asked by those in the agricultural and food industries when confronted with Ozone and its approval by the FDA is, "How much Ozone do I need to apply to do what I want it to do?" Unhappily, the best and most truthful answer is, "Aside from some guidance from the published literature, the wise approach is for the want-to-be-Ozone-user to determine the appropriate Ozone dosage and exposure times for the specific agricultural and/or food product(s) to be treated".

In the Food Additive Petition submitted to the FDA, there is a table (reproduced below) which reports Ozone dosage/exposure data obtained during specific studies. These data are the most useful as guidance to the prospective Ozone user, with the caution that the user must determine the minimum Ozone dosage/exposure level necessary to accomplish the intended effect (Good Manufacturing Practice). At the same time, the prospective should determine the maximum Ozone dosage/exposure level that will cause damage to the agricultural or food product being treated. If Ozone is evaluated in this manner for each potential application, the user will have a comfortable operating range of Ozone dosage/exposure. This will allow the user to specify Ozone treatment conditions that will ensure always attaining Ozone's intended effect(s) while also ensuring that excess Ozone sufficient to damage the food product will be avoided.