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OZONE AS A LAUNDRY AGENT ON ORBIT AND ON THE GROUND

William N. Agosto, Lunar Industries, Houston, Texas

ABSTRACT

Ozone (O_3), is the strongest commercial oxidizing agent for aqueous systems and may be ideal for space station laundering operations. It can be generated electronically from air in situ. It kills virtually all microorganisms, attacks many organics and inorganics, and breaks down stable ring structures of benzene and related oils when coupled with ultra violet radiation. It cleans and disinfects in cold water without the need for detergent. It leaves no residues. Ozone permits up to 90% wash water recycling and it eliminates wash time, water volume, and recycling problems of a detergent rinse. Ozone is self purging and converts spontaneously to oxygen. It can be rapidly purged by well established catalytic and thermal processes. Scaling of an ozone laundering system for space station may have commercial applications in a consumer model for home use.

INTRODUCTION

Ozone, (O_3) is the triatomic form of oxygen and the strongest commercial oxidizing agent next to fluorine, which is the most chemically active element. Ozone oxidizes many organic and inorganic compounds and kills a broad spectrum of bacteria, algae, and viruses thousands of times faster than chlorine. It converts to oxygen spontaneously without leaving a residue. Accordingly, it cannot be stored practicably but is easily generated just before use by uv irradiation or corona discharge in air. It has a lifetime of several hours in air and about a half hour in water at room temperature which is ample for chemical action and sterilization. It decomposes rapidly over 100°C and by catalytic action at room temperature.

COMMERCIAL USES OF OZONE

Ozone is 12 to 13 times more soluble in water than oxygen, accordingly its most widespread use is in water purification and waste water treatment (1).

Potable Water Treatment

Ozone destroys virtually all forms of bacteria and viruses in potable waters thousands of times faster than chlorine. It increases settling of suspended colloids, removes tastes, odors, and colors. It oxidizes cyanides, phenols, algae, and sulfides like H_2S to sulfates. Since it destroys most dissolved organics, it prevents formation of carcinogenic trihalomethanes that result when chlorinated waters react with residual organics. It also destroys detergents, pesticides, humic, fulvic, and tannic (organic) acids. And it precipitates the hydroxides of iron, manganese, lead, mercury, nickel, cerium, and silver by raising the metals to their highest oxidation state (1). The Los Angeles municipal water system uses 10,000 pounds of ozone per day and has been operating for 8 years. Many European cities ozonate their water supply.

Wastewater Disinfection

One of the largest applications of ozone is the disinfection of secondary or biologically treated wastewater. Ozone is used when a high quality chemical-free effluent is required for flow into reservoirs or fishing areas. Chlorine kills trout and other biota, and unlike chlorine, ozone does not affect the pH (acidity) of the water body (1).

Industrial Applications

Multiton quantities of ozone are used to destroy cyanides in the paint, plating, photographic and mining industries; as well as phenols in paper mills, coke mills, oil refineries, and thermoplastic resin manufacture. Currently, these are the largest industrial waste applications. The use of ozone obviates the need to transport hazardous chemicals or wastes (1).

Ozone is also used to clean water for HVAC chillers and industrial cooling towers where it is reported to reduce scale build up and inhibit corrosion associated with chemical additives that would otherwise be used to prevent scaling. In addition, ozone is used in aqua culture for fish farms hydroponics and in agriculture to remove pesticides from produce.

High Purity Water and Water Polishing

Breweries and bottled water plants ozonate their water to remove residual taste, odor, and for sterilization. Sterility of pharmaceutical deionized and distilled waters is maintained with ozone. Organic contaminants on the surface of electronic components are removed with ozonated deionized water (1).

Odor Control

Probably the largest number of ozone generators in the U.S. is used for sewage odor control. More than 1000 ozone generators are used in wastewater treatment plants and wastewater pumping stations. Other industrial odors controlled by ozone include those from dairy processing plants, fish processing, rubber compounding, commercial kitchens, rendering plants, food processing, and pharmaceutical fermentation (1).

Commercial Laundries

In a new application, ozone has been introduced as the prime cleaning agent some in large institutional laundry systems. It reduces washing time by 20%, chemicals by 45%, and water consumption up to 90% by recycling the wash water with concomitant cost reduction. Ozone laundering is a cold water process and energy consumption is also substantially reduced according to reports from a Westin Hotel in Rancho Mirage, California where a pilot system is now in operation. Similar systems are in operation at nursing homes and prisons in Florida. Since ozone destroys fecal matter as well as body fluids and odors, little or no detergent is required for these applications. Bleach is compatible with ozone and is used for whitening (2).

Aqueous Ozone Dosages

Ozone concentrations vary anywhere from 0.5 mg/liter for mild potable water disinfection to 15 mg/liter for organics destruction in municipal wastewaters. Accordingly, low concentrations are effective for aqueous purification and disinfection (1).

OZONE GENERATION PROCESSES

There are many ways to generate ozone in the laboratory but only two processes are commercial, 1) ultraviolet irradiation of air or oxygen, and 2) silent corona discharge through air or oxygen with high voltage ceramic or glass electrodes (1).

Ultraviolet (uv) Generators

UV models produce only grams/hour (fractions to a few ounces per day) of ozone and are used primarily for odor control in food processing plants, kitchens, air ducts, and dumpsters. The energy efficiency of uv generators are low at about 20 kwh per pound of ozone generated but they are typically lighter, draw less power, and require less air preparation than the corona discharge systems.

Corona Discharge Generators

Energy consumption for corona discharge generators is typically 7-10 kwh per pound of ozone generated from air. In addition, air preparation draws 2-3.5 kwh/lb. Accordingly, power consumption is the main operating cost.

Typically air feed corona discharge systems require several stages of air filtering down to submicron size, a compressor as well as an air cooler and dryer before ozonation. A contact sparger system mixes ozone with influent water and residual ozone is neutralized in a destruct unit. In addition, cooling water or air is normally required for the electrodes of corona discharge systems to prevent degradation in the efficiency of ozone generation.

OZONE AS A LAUNDERING AGENT ON SPACE STATION

Ozone may be the ideal cleaning agent for laundering operations on space station. It is generated in situ out of ambient air, it requires no additives, cleans and disinfects in cold water, destroys body fluids, wastes, and odors, and, unlike soap, it leaves no residue. Soap removal is a major problem in wash water recycling of closed system laundries. The use of ozone as a cleaning agent would obviate the problem since up to 90% of the ozonated water can be recycled. Wash time and water volume are also reduced because detergent rinsing is unnecessary.

Ordinarily, ozone does not attack stable ring structures like oils and benzene. However, it does react with those compounds in the presence of ultra violet radiation. Accordingly, it may be possible to clean up oils and related soils in a space station laundry by irradiating the washload with solar uv during the ozone wash cycle.

One commercial application of an ozone laundry system on space station may be a scaled down washer suitable for the consumer market. Penetration of the home laundry market could be highly profitable. Reduction in detergent effluents and water recycling are attractive features, especially where water is scarce or expensive. New designs for highly efficient and simplified ozonators that are under development enhance the prospects.

Ozone Hazard

Ozone is not a poison in the sense of entering into body chemistry. For example, it does not combine with the blood the way oxygen does. However, as a strong oxidizing agent, it is highly irritating to the respiratory tract even at low concentrations. At least one research group has reported that ozone preferentially attacks cancer cells over normal tissues (3).

Ozone has the advantage that it is self purging. It destructs rapidly between 350 and 400^{o}C and at approximately 38^{o}C in commercially available catalytic reactors. All moderate to large scale commercial ozonation systems include catalytic destruct units to prevent ozone contamination of the ambient. The end product of ozone destruction is oxygen.

CONCLUSIONS

Ozone laundering systems appear ideal for space station applications for the following reasons:

1. Ozone is a cleaning and disinfecting agent that can be generated in situ.

2. It is a cold water wash process.

3. Water volume is reduced because detergent rinsing is eliminated.

4. Ozone and leaves no residue. Accordingly, up to 90% wash water recycling can be achieved.

5. Wash time is reduced 20%.

6. Residual ozone can be readily converted to oxygen in commercial catalytic and/or thermal units.

Due to scaling considerations, the development of an ozone laundry system for space station may lead to consumer applications.

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