

## **Ozonated Liquids in Dental Practice – A Review.**

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#### **Part 1: An Introduction to Ozone.**

**Abstract:** This series of cross referenced papers examines the role of ozonated water in health care, in particular, dental care. In Part 1 of Ozonated Liquids in Dental Practice, the historical use of ozone in medicine and dentistry is traced. Ozone gas and ozonoids offer good anti-microbial activity, show no tendency to produce micro-biological resistance, and show no harm to the patient or operator. In an era where stronger and more complex anti-microbials are being produced to combat the ability of micro-organisms to mutate and acquire resistance, ozone offers a pathway that is cheap, simple and 100% effective.

#### **Introduction.**

This series of cross referenced papers examines the role of ozonated water in health care, in particular, Dental Care. The use of ozone in Medicine and Dentistry dates back to the 1920's. There are very few pharmacological products that have been immortalised by poets. One such product is Ozone.

Ozone, chemical formulae  $O_3$  has a long history of usage in public health, and had been used for purification of water due to its efficiency and lack of side effects from the late 1890's. It has been used in the medical profession since the late 19th Century to treat infections and aid wound healing. From 1912, the London Underground tunnel system air conditioning system was ozone treated to freshen the air and reduce cross infection. In the 1920's Dr Edwin Parr, a Swiss dentist started to use  $O_3$  as part of his disinfection system.

The use of  $O_3$  mushroomed in medical care and was used extensively to treat infections, battle wounds and in routine treatment of cancer up to the 1950's. During the inter-war period the advent of cheap chlorine saw the use of  $O_3$  decline for disinfection.

From the 1950's the pharmaceutical industry began to flood the market with the wide variety of anti-microbials and complex anti-viral and cancer drugs we know today. This 'advance' saw the use of ozone decline to such an extent that in some countries, the use of ozone was considered to be unethical and some medical practitioners were threatened with the loss of their licenses unless they stopped its use.

The renaissance of the use of ozone has been a slow, painful and gradual process. Researchers in the 'modern' western cultures still face potential censorship, whereas their counter parts in Cuba, Russia and Germany have unrestricted access to a product that is naturally produced, both in the exterior environment by lightening strikes for example, and within the human body cells as part of the immune response system of white blood cells.

As a former Poet Laureate, Sir John Betjeman, described it in retrospect, the Central Line of the London Underground "was . . . regarded as a sort of health resort, because it was ventilated by the Ozonair™ system, which was meant to smell like the sea, and certainly did smell of something." (Betjeman 1972). The company Ozonair may not exist in the UK any longer (it is now called Waterloo Air Management Ltd), but this company still makes air-conditioning equipment and ozone generators some 90 years on.

### The History of Ozone.

In 1872 ozone was called 'ozonated oxygen' and has been described by Dr Julian Holmes as a 'schizophrenic gas' (*Ozone – The Revolution in Dentistry 2004*). On the one hand, ozone has a long history of beneficial use in the medical and alternative therapy fields. For over 150 years, millions of people have benefited from the effects of ozone to eliminate disease and encourage natural healing. There is a vast amount of research and published data showing the effects of ozone on micro-organisms, fungi and viruses. On the other hand, ozone can be toxic at high concentrations and will attack human lung tissue. This is a similar property to oxygen: it provides mankind with a breathable gas that sustains life. Yet were the atmospheric concentration change by 3-4%, life would cease to exist due to it's toxicity at elevated concentrations.

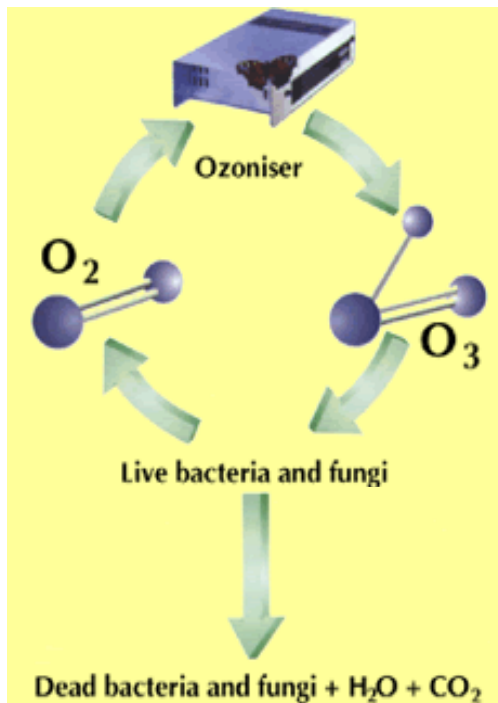


Fig 1.1. Action of Ozone (O<sub>3</sub>)

Immediately after a thunderstorm, the air smells fresh and is refreshing. The same freshness is felt walking along the seashore, it is invigorating and it imparts a feeling of wellness. The sea-air feels fresh and bracing. All this is due to the presence of ozone in the atmosphere.

The electricity produced during a thunderstorm acts on the oxygen in the air converting it to ozone. Similarly the waves pounding on the seashore create electricity, which acts on the air immediately above to generating ozone.

Ozone is a natural element present in the atmosphere. Several organisations and many scientific 'experts' claim ozone to be a toxic gas and that it is harmful to health and life. Every morning, for example, in the USA the radio announcer broadcasts the ozone count. When this count reaches a certain level, the public who have allergies and asthma are advised to stay indoors to prevent aggravation of their condition. These health 'advisors' in trying to help the public, fail to explain or are ignorant of the fact that it is not the actual

concentration of ozone in the air that they are talking about. The ozone count is really the count of the oxides resulting from the oxidation of the pollutants in the atmosphere such as

hydrocarbons and other toxic substances. Ozone is actually destroying these very harmful substances. The oxides are an irritant to the mucous membrane of the respiratory tract. The more dense the pollution, the longer it takes for the resulting oxides to be dissipated. Naturally these asthmatics and the people with allergies find their symptoms aggravated.

In high concentrations, ozone may be harmful. But with over 50 years of using ozone in medicine at correct therapeutic levels, ozone has been shown to be not a killer but a healer. The German ozone society conducted a study in 1980 on the side effects of ozone administered into the body. Over five million ozone treatments in several million patients were studied. They found .007% side effects and only 4 patients died due to inappropriate injection of ozone gas directly into veins. This compares to 42,000 deaths in the hospitals in the USA every year due to drug reactions. The only conclusion that one can reach is that ozone is a much safer therapeutic agent. Yet it fails to explain why the US FDA and Medical authorities has such a problem with ozone therapies, so much so that practitioners have been threatened with legal proceedings and being disbarred from practicing. Could it be that the pharmaceutical companies fear the fact that it cannot be patented, and thus would offer them no income?

Ozone, the tri-atomic state of oxygen, symbol O<sub>3</sub>, has had a chequered history in medical and dental usage. Described in 1785 by Van Marum and named in 1840 by Shonbein 'ozone', from the Greek word "ozein"- to smell, (although some historical authors have suggested another German scientist, Christian Fernandez should be credited with the discovery of ozone) it was not until a reliable and cheap generator was invented by Werner Von Siemens in 1857 did the medical significance of this gas come to the fore. The chemical nature of this new gas was studied in Oxford in 1872. At that time these scientists were working on the chemical properties of oxygen, calling oxygen the "Hero of Chemistry". When they began to study ozone they were not willing to give it a separate identity, so they named it 'Ozonated Oxygen'.

In 1785, Van Marum noticed that air near his electrostatic machine acquired a characteristic odor when electric sparks were passed. In 1801, Cruickshank observed the same odor at the anode during electrolysis of water.

Finally, in 1840, Shonbein named the substance, which gave off this odour, ozone, from the Greek word "ozein"- to smell. The vast majority of historical references to ozone indicate Shonbein was the first scientist to name ozone, although there are some references to another German scientist, Christian Fernandez.

In 1857 Werner Von Siemens designed an ozone generator that has since greatly evolved, but it still designed around the original concept. The cylindrical dielectric type makes up most of the commercially available ozone generators in use, and is often referred to as the "Siemens Type" ozone generator. Following the discovery of the benefits of ozone, many articles were published on ozone, and ozone became useful in water purification, commercial technology and medicine.

In 1902, J.H. Clarke's "A Dictionary of Practical Materia Medica" London, described the successful use of ozonated water in treating anaemia, cancer, diabetes, influenza, morphine poisoning, cancer sores, strychnine poisoning and whooping cough. In 1911, the whole of the London Underground air supply was treated with ozone to reduce infection. As far can be ascertained, this is one of the first instances where large populations were mass-medicated to reduce air-borne micro-organisms and prevent infection.

In the early 20th century, the USA and Germany lead the research into the pharmacological effects of ozone with numerous studies and books being published. Betjeman published poems

about London's railway stations (*Betjeman J, 1972*). He wrote that the Central Line "was . . . regarded as a sort of health resort, because it was ventilated by the Ozonair system, which was meant to smell like the sea, and certainly did smell of something." The underground part of London Underground was air-conditioned with ozonated air. The ozone imparted a 'fresh smell, similar that found on mountain tops and at the sea-side'. The ventilated ozonated air was also regarded as 'healthy to breathe'. Samples analysed from the treated air were found to contain substantially fewer organisms than the street air above. By 1937 the bactericidal properties of treating air supplies with ozone were investigated and well known.

In 1911, "A Working Manual of High Frequency Currents" was published by Dr. Noble Eberhart, MD. Dr. Eberhart, head of the Department of Physiologic Therapeutics at Loyola University, used ozone to treat tuberculosis, anaemia, chlorosis, tinnitus, whooping cough, asthma, bronchitis, hay fever, insomnia, pneumonia, diabetes, gout and syphilis. In 1913, the Eastern Association for Oxygen Therapy was formed by Dr. Blass and associates.

During World War I, ozone was used to treat gunshot and trauma wounds, trench foot, gangrene and the effects of poison gas. Dr. Albert Wolff of Berlin also used ozone for treating colon cancer, cervical cancer and decubitus ulcers in 1915.

In 1920, Dr. Charles Neiswanger MD, the President of the Chicago Hospital College of Medicine, published "Electro Therapeutical Practice." Chapter 32 was entitled "Ozone as a Therapeutic Agent."

In 1926, Dr. Otto Warburg of the Kaiser Institute in Berlin announced that the cause of cancer is a lack of oxygen at the cellular level. Dr. Otto Warburg received the Nobel Prize for Medicine in 1931 and again in 1944. In 1929, a book called "Ozone and Its Therapeutic Action" was published in the USA listing 114 diseases and how to treat them with ozone. Its authors were the heads of all the leading American hospitals.

Dr Edwin Fisch, a Swiss dental surgeon, is credited as being the first dental professional to use ozone in dental practice before 1932 to reduce infection, and introduced it to one of his patients, the German surgeon Dr. Edwin Payr. Dr Payr became interested in its properties and was the first to use it intravenously in 1945 for circulatory problems. Dr Aubourg and Dr Lacoste were French physicians using ozone insufflations from 1934 to 1938. During World War I and II, ozone was used medically to treat wounds and infections.

The use of ozone in the United States can be traced back to the 1940's. In 1948, Dr. William Turska of Oregon began using ozone with a machine he designed himself. In 1951, Dr. Turska wrote the article "Oxidation". He was the first to inject ozone into the portal vein, thereby reaching the liver (a technique that is no longer practiced).

From 1953, a German doctor, Hans Wolff, used ozone in his practice. He wrote the book "Medical Ozone," and trained many doctors in ozone therapy.

In 1957, Dr. J. Hansler patented an ozone generator that has formed the basis of the German expansion of ozone therapy over the last 35 years. In the late 1950s, Dr. Werner Zabel used it to treat cancer and today over 7000 German doctors use ozone therapy daily.

In 1961, Hans Wolff introduced the techniques of major and minor autohaemotherapy. In 1964 spontaneous flocculation in ozone contact chambers led to France constructing an ozone plant to enhance particulate removal. In 1965 in Scotland, United Kingdom, ozone was used to control

surface water colour for the first time. At the same time, Swiss research led to the use of ozone to oxidize micro pollutants such as phenolic compounds and several pesticides.

In 1977, Dr. Renate Viebahn provided a technical overview of ozone action in the body. In 1979, Dr. George Freibott began treating his first AIDS patient with ozone. Test tube studies suggested that ozone could damage viral particles and inhibit HIV's reverse transcriptase enzyme. Two research teams reported that in laboratory studies it inactivates HIV at concentrations which are non-toxic to human cells, but another team found that levels of ozone needed to kill animal viruses also resulted in 30% destruction of blood cells and haemoglobin.

The 1978 FDA report showed that 1.5 million people were hospitalised in the USA due to side effects from medication. On the other hand, medical ozone has been legally used in clinics worldwide on a daily basis since the 1940's. In Germany, ozone side effects are occasionally minor irritations that are caused by incorrect application and quickly disappear. This side effect rate is incredibly far lower than U.S. drug therapy side effect rates.

Ozone, on the other hand, has been found to be an extremely safe medical therapy, free from side effects. A study performed by the German Medical Society for Ozone Therapy in 1980 asked 644 ozone therapists about their 384,775 patients. A total of 5,579,238 ozone treatments had been administered. There were only 40 cases of side effects, which were all operator or administrator caused, noted out of this number which represents the incredibly low rate of .000007%. Only four deaths due to intravenous injection were recorded. Ozone is thus the safest medical therapy ever devised.

In 1980, Dr. Horst Kief reported success in treating AIDS with ozone (*Kief 1980*). In 1987, Dr. Rilling and Dr. Viebahn (*Rilling and Viebahn 1987*) published "The Use of Ozone in Medicine". In 1990, the Cubans reported their success in treating glaucoma, conjunctivitis and retinitis pigmentosa with ozone.

Wells (*Wells et al 1991*) reported that the antiviral effects of ozone include viral particle disruption, reverse transcriptase inactivation and/or a perturbation of the ability of the virus to bind to its receptor on target cells. Carpendale and Freeberg (*Carpendale and Freeberg 1988*) reported that ozone inactivated HIV at non-toxic concentrations, but Wagner (*Wagner et al 1991*) found that at concentrations required to inhibit animal viruses, ozone induced 30 percent haemolysis and destruction of extra-cellular haemoglobin. Bocci (*Bocci 1992*) theorised that ozone induces the production of cytokines such as tumour necrosis factor (TNF) and interferon.

Carpendale and Freeberg (*Carpendale and Freeberg 1993*) reported that 4/5 HIV-positive men with diarrhoea of unknown origin improved when treated with ozone. However, the responders all had relatively high CD4 counts, and diarrhoea can resolve spontaneously, particularly at higher CD4 counts.

Garber *et al* (*Garber et al 1991*) performed a phase I study of ozone blood treatments in 10 HIV-positive individuals. No significant toxicity was observed. Three participants with moderate immunodeficiency showed improvement in surrogate markers. In a phase II controlled and randomized double-blinded study comparing re-injection of ozone-treated blood and re-injection of unprocessed blood for 8 weeks, followed by a 4-week observation period, ozone had no significant effect on haematological, biochemical or clinical toxicity when compared with placebo. CD4 cell count, interleukin-2, interferon gamma, beta<sub>2</sub>-microglobulin, neopterin and p24 antigen were also unaffected by both treatment arms.

Hooker and Gazzard (*Hooker and Gazzard 1992*) conducted an open study of ozone-treated

blood in the treatment of 9 HIV-positive individuals. No significant change in mean absolute (or percentage) CD4 count was seen after 4 or 8 weeks of treatment. The HIV p24 antigen titre did not change significantly during treatment. One participant became weakly p24-antigenaemic during treatment, while another who was weakly antigenaemic at baseline became equivocal during therapy. The treatment was well tolerated: there was no bruising or local pain after the intramuscular injections.

Professor Velio Bocci from the University of Siena Italy has called for and has published excellent research objectively quantifying the therapeutic benefits of using Ozone (*Bocci 1996, Bocci 1996, Bocci 1997, Bocci 1999, Bocci & Aldinucci 2004*). In 1992, the Russians revealed their techniques of using ozone bubbled into brine to treat burn victims with astonishing results.

The renaissance of the use of ozone has been a slow, painful and gradual process. Researchers and teachers in the 'modern' western cultures still face potential censorship and loss of academic status & funding. In the USA, from the 1970's to the present time, many US states went as far as outlawing ozone treatment, and doctors who continued to use it were either forced to abandon it, go 'underground' or face criminal prosecution and loss of their medical registration. This is in stark contrast to their professional colleagues in Cuba, Russia and Germany. In these countries, medical researchers and practitioners have unrestricted access to a product that is naturally produced, both in the exterior environment by lightning strikes for example, and within the human body cells as part of the immune response system of white blood cells.

In the USA, five recent papers have shown that the FDA's assertion that ozone is a dangerous and toxic gas, and has no part to play in modern medical treatments, has received a very large dent. A landmark paper by Wentworth *et al* in 2001 (*Wentworth et al 2001*) showed the biochemistry of white blood cells produced ozone as part of the immune response process.

This was followed by papers from Marx, Babior *et al* and Kettle *et al* (*Marx 2002, Babior et al 2003, Kettle et al 2004*). And in 2002, Young and Setlow (*Young and Setlow 2004*) showed ozone does not cause mutations in bacterial spores.

Some detractors have tried to suggest that ozone could cause mutations. But what if mankind as we understand him/her now *is* that mutation? The energy houses of the human cell, mitochondria, are known remnants from a past symbiotic relationship with bacteria. Should mankind be surprised that we also have mutated in other areas at a cellular level?

Studies examining cellular damage have looked at the reactions with fatty acids, and shown the potential production of toxic aldehydes and hydrogen peroxide as by-products (*Pryor et al 1991, Pryor and Church 1991*). Research examining the effects of tobacco smoke showed that ozone inhalation induced DNA damage in cultured human lung tissue (Kozumbo *et al* 1990). This study does not mean ozone should be branded as dangerous; this study underlies the known damaging effects of tobacco smoke can be enhanced by ozone and smog. Smokers are responsible for their own health, and this study illustrates further education is necessary to show smoking has health issues and may damage or kill the participant or passive smoker.

In 2004, Young and Setlow (*Young & Setlow 2004*) determined that ozone does not kill spores by DNA damage. Rather, ozone seems to render the spores defective in germination, perhaps because of damage to the spore's inner membrane.

Young and Setlow's published research reported that ozone does not cause damage to the spore's DNA, as wild-type spores were not mutagenised by ozone and wild-type and *recA* spores exhibited very similar ozone sensitivity. Spores (termed alpha-beta-) lacking the two major DNA protective alpha/beta-type small, acid-soluble spore proteins exhibited decreased ozone resistance

but were also not mutagenised by ozone, and alpha-beta- and alpha-beta-recA spores exhibited identical ozone sensitivity. Killing of spores by ozone was greatly increased if spores were chemically decoated or carried a mutation in a gene encoding a protein essential for assembly of the spore coat.

Young and Setlow also reported that ozone-killed spores did not germinate with either nutrients or Ca(2+)-DPA and could not be recovered by lysozyme treatment. These workers concluded the major factor in spore resistance to sterilisation agents appears to be the spore coat. Spore killing by ozone seems to render the spores defective in germination, perhaps because of damage to the spore's inner membrane.

The Young and Setlow study would seem to suggest concerns that ozone may cause mutations in cellular DNA may be unfounded, despite the production by ozone of radicals in water and fluids.

The referenced research for the dental use of ozonated fluids date back to the 1950's. Wuhrmann and Meyrath examined the bactericidal effect of aqueous ozone solutions (*Wuhrmann and Meyrath 1955*), effectively repeating the observations of Dr Edwin Fisch in 1932. In the 1960's. Onouchi in 1965 (*Onouchi T 1965*) examined the bactericidal action of aqueous solution of O<sub>3</sub> in dentistry.

The research into ozonated fluids have examined the effects of drinking ozonated water on gut infections (*vanden Bossche et al 1994*), and Khadre and Yousef (*Khadre and Yousef 2001*) examined the sporicidal action of ozone and hydrogen peroxide. This study built on the earlier work of Vestergard (*Vestergard 1994*) who was looking at establishing and maintaining pathogen free conditions in aqueous solutions using ozone. Vestergard's paper examined the use of ozone in space applications for the elimination of pathogens using ozone. Vestergard's area of research was creating pathogen free conditions in aqueous solutions containing organic matter. This research, although concerned with hydroponic agricultural systems, can be carried into general potable water studies. The use of a portable water steriliser using ozone in rural areas, as well as by campers in remote rural locations to create sterile and potable water, is supported by this paper.

The use of aqueous ozone in food cleansing is approved by the FDA in the USA. In 1999, Kim *et al* (*Kim et al 1999*) reviewed the use of ozone in the food industry. Young *et al* demonstrated that mycotoxins could be removed by washing food produce with ozonated water (*Young et al 2006*). Crowe *et al* (*Crowe et al 2006*) evaluated the use of ozone to remove fertilizers on soft fruit and later examined the use of ozone as an alternative to chlorine to disinfect and wash blueberries (*Crowe et al 2007*). In 2007, further studies by Bialka and Demirci (*Bialka and Demirci 2007*, *Bialka and Demirci 2007*) examined the use of ozone to eliminate *Escherichia coli* from harvested soft fruit. In the meat industry, ozone has been used to eradicate *Clostridium perfringens* (*Novak and Yuan 2004*), *Escherichia coli* and *Salmonella* (*Castillo et al 2003*).

There are many benefits to drinking ozonated water, to control oral hygiene and as a source of sterile water. However, patients should also be informed that there is an interaction of aqueous ozone with anti-microbials. This research has been published, illustrating the importance of potential interactions of dissolved ozone and prescribed anti-microbials. Patients who are taking a course of antibiotics may need to be informed that the use of ozonated water inactivates antibacterial agents (*Dodd et al 2006*) and in particular amoxicillin (*Andreozzi et al 2005*), progesterone (*Barron et al 2006*) and tetracycline (*Dalmázio et al 2007*). For concern to dentists is that ozone may inactivate the anti-microbial effects of triclosan (*Suarez et al 2007*).

A current topic of debate in dental material science and long term potential effects, are endocrine disruptors found in resin-based dental restorative materials. Deborde *et al* (Deborde *et al* 2005) showed endocrine disruptors were destroyed by ozonated water. This paper potentially points towards a pathway to remove these chemicals from the body system after placement of 'modern' tooth-coloured or 'white' fillings.

Papers examining the sterilisation of municipal water supplies have show the accelerated chemical reactions of ozone with organic impurities, when compared to chlorine. For example, the chemical kinetics of ozone is extensively discussed by Onstad *et al* 2007 (Onstad *et al* 2007). This and other studies agree that the mode of sterilisation is via the  $\cdot$ OH radical (von Gunten 2003) and organic micropollutants are oxidized with ozone selectively. In a later paper, von Gunten (von Gunten 2003) discussed the 'excellent disinfectant' effects of ozone and this effect 'can even be used to inactivate microorganisms such as protozoa which are very resistant to conventional disinfectants'. von Gunten continues to discuss inactivation rates for six bacterial species, *E. coli*, *Bacillus subtilis* spores, Rotavirus, *Giardia lamblia* cysts, *Giardia muris* cysts, *Cryptosporidium parvum* oocysts. He states that the apparent activation energy for the inactivation of bacteria is in the same order as most chemical reactions (35-50 kJ mol<sup>-1</sup>), whereas it is much higher for the inactivation of protozoa (80 kJ mol<sup>-1</sup>). This requires significantly higher ozone exposures at low temperatures to get a similar inactivation for protozoa.

In a second later paper, von Gunten (von Gunten 2007) further elaborates on the treatment of drinking water. His paper shows the oxidation of organic and inorganic compounds during ozonation can occur via ozone or OH radicals or a combination thereof, as Ozone is an electrophile with a high selectivity. The reactions of ozone with inorganic compounds are typically fast and occur by an oxygen atom transfer reaction. The by-product of main concern is bromate, which is formed in bromide-containing waters. A low drinking water standard of 10 microgL<sup>-1</sup> has been set for bromate. In certain cases (bromide > approximately 50 microgL<sup>-1</sup>), it may be necessary to use control measures to lower bromate formation by lowering the pH, adding ammonia or by a chlorination-ammonia process.

Studies to look at increasing the solubility of ozone in fluids have identified that the use of ultrasonics (Zhang *et al* 2007) increases ozone solubility, and allows the use of less powerful ozone generators. This is of importance to developing countries and rural areas where these units could be run from solar power.

Dental researchers have started to examine the effects of ozonated fluids in periodontal disease. Huth *et al* in two papers in 2006 and 2007 (Huth *et al* 2006, Huth *et al* 2007) examined the effect of ozone on periodontal tissues. The 2007 paper compared traditional periodontal anti-microbial products with the use of ozonated water. Both papers concluded that ozonated water has an excellent anti-microbial effect.

Huth *et al* (Huth *et al* 2007) in their later paper examined the effect of ozone on the influence on the host immune response. These researchers chose the NF-kappaB system, a paradigm for inflammation-associated signaling/transcription. Their results showed that that NF-kappaB activity in oral cells in periodontal ligament tissue from root surfaces of periodontally damaged teeth, was inhibited following incubation with ozonized medium. The Huth 2007 study establishes a condition under which aqueous ozone exerts inhibitory effects on the NF-kappaB system, suggesting that it has an anti-inflammatory capacity (Huth *et al* 2007).

Low *et al* (Low *et al* 2006) evaluated the effects of ozone-treated surface-modified porous silicon, with a view to achieve mammalian cell adhesion onto the modified surface. The success



of these researchers opens alternatives to titanium implant materials. Silicone products are white-coloured, and may offer cosmetic advantages when placed in the aesthetic anterior region.

Water pollutant studies have shown how ozone can be used to treat multiple water sources to manufacture potable water (*Frinak et al 2006, Ku et al 2007, Al Momani et al 2008*), and treat waste effluent (*Ledakowicz et al 2006, Ku et al 2007, Sung et al 2007, Pi et al 2007, Dietrich et al 2007*).

The anti-microbial effect of ozone has also been looked at in terms of treating infectious endophthalmitis, which is usually fatal. *Takahashi et al (Takahashi et al 2004)*. In this study, ozonated water was used to flush the anterior chamber as prophylaxis against infectious endophthalmitis with excellent anti-microbial effects.

Gaseous ozone has long been observed to remove unwanted odours from air and fabrics, without damaging fabrics, for example, in home and hospitality settings. The paper by *Destailats et al in 2006 (Destailats et al 2006)* examined the chemical pathways of how ozone removes nicotine desorption from surfaces.

This collection of papers focuses on the use of ozone in dental care, with a specific emphasis on the use of ozone dissolved in liquids. I will give the reader an introduction to the historical background to the discovery and early research into the effects of ozone. From a very simple application, I will lead the reader to a glimpse of the possible future preventative applications of ozone combined with various fluids in oral care, and the treatment of hospitalised and manually challenged individuals.

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