Ozonated Liquids in Dental Practice – A Review.
Author: Dr Julian Holmes, Lime Technologies Holdings Ltd, Clinical Director.

Date: April 2008.

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Part 4: The Chemistry of Ozone in Plant Oils.

Abstract: In Part 4 of Ozonated Liquids in Dental Practice, the chemistry of ozone with plant oils is examined. There is a new interest in ozone in gaseous form and ozone dissolved in plant and vegetable extracts, where it forms ozonoids. These ozonoids are used in the medical, pharmaceutical industries and in general health care. The use of ozone gas, ozonated plant and vegetable extracts has been researched in various countries. These extracts meet the current trends demanded by consumers towards a more natural and holistic approach to health care. Consumers are keen to avoid the need for animal testing which is regarded as barbaric in the 21st Century despite the understanding that such tests as required for safety issues. This belief by animal welfare groups and the general public has to be balanced with research to show potential toxicity and emergence of microbiological resistance. 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.

Introduction.

There is a great deal of interest in plant and vegetable extracts for use in the medical, pharmaceutical industries. These extracts could potentially provide a number of novel natural products that mimic synthetic additives and antimicrobials, without unwanted side effects. There is a current trend by the consumer towards a more natural and holistic health-care product range. These consumers are also seeking to avoid the need for animal testing. Of prime importance in the pharmaceutical industry is the potential for microbiological resistance and the absence of harm to the end user.

Ozonated plant and vegetable extracts have been researched in various countries, notably Cuba and Russia where original research has been published for the last 40 years on the effects of ozonated sunflower and olive oils. These ozonated oils offer good anti-microbial activity, show no tendency to produce micro-biological resistance, and show no harm to the patient or operator (*Sechi et al 2001*).

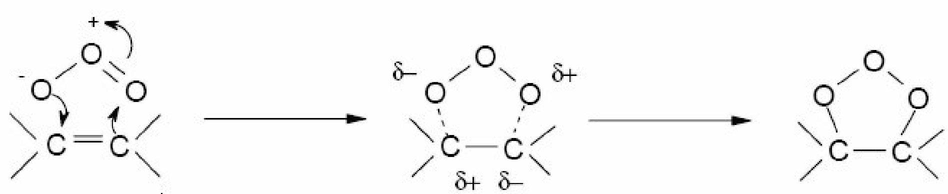
The current resurgence in interest in ozone in medicine has been pioneered mainly in Cuba (*Castañeira et al 1995*), Russia and Europe, with additional research in South Africa. Professor

Bocci from Milan, Italy has published data that shows that ozone should form part of modern medicine and clinical management (*Bocci, 1992,1994,1996,1996,1999,2004*) Professor Bocci has also shown that ozonated extracts have a part to play in the modern medical management of a number of medical conditions (*Bocci et al, 2005*). Professor Bocci has argued that the toxic effects of ozone discussed by Menzel (*Menzel, 1970*) should not prevent it being used in a safe way as an adjunct to modern pharmacology (*Bocci, 2004*).

In Europe, research in dentistry has shown that ozone can eliminate biofilms in water pipes (*Abu-Naba'A et al, 2002*) in dental and medical equipment. Ozone treatment allows a holistic approach to the management of dental infections (*Baysan et al 2000, Holmes 2003*) without the need to amputate large volumes of tooth tissue.

The process of bubbling ozone through plant and vegetable oils was first practiced as part of the protocol for the inhalation of ozone. Ozone was bubbled through olive oil, and the fumes that formed inhaled for lung infections and disorders in the 19th Century. It was observed that over a period of time the ozone reacted with olive oil, leading to the formation of a thick ‘cream’, or petroleum jelly like product. These were called ‘ozonated oils’. With the development of modern chemistry, the structure of these products was determined and named ‘ozonoids’. The chemistry of ozone and how it reacts with plant and vegetable oils is complex.

As a result of its dipolar structure, the ozone molecule may lead to 1-3 dipolar cyclo-addition of unsaturated bonds, with the formation of primary ozonide (I) corresponding to the reaction shown in Fig 4.1. This is called cyclo-addition, also known as the Criegee mechanism, and results in a primary ozonoid.



I

Fig 4.1. Primary ozonide formation

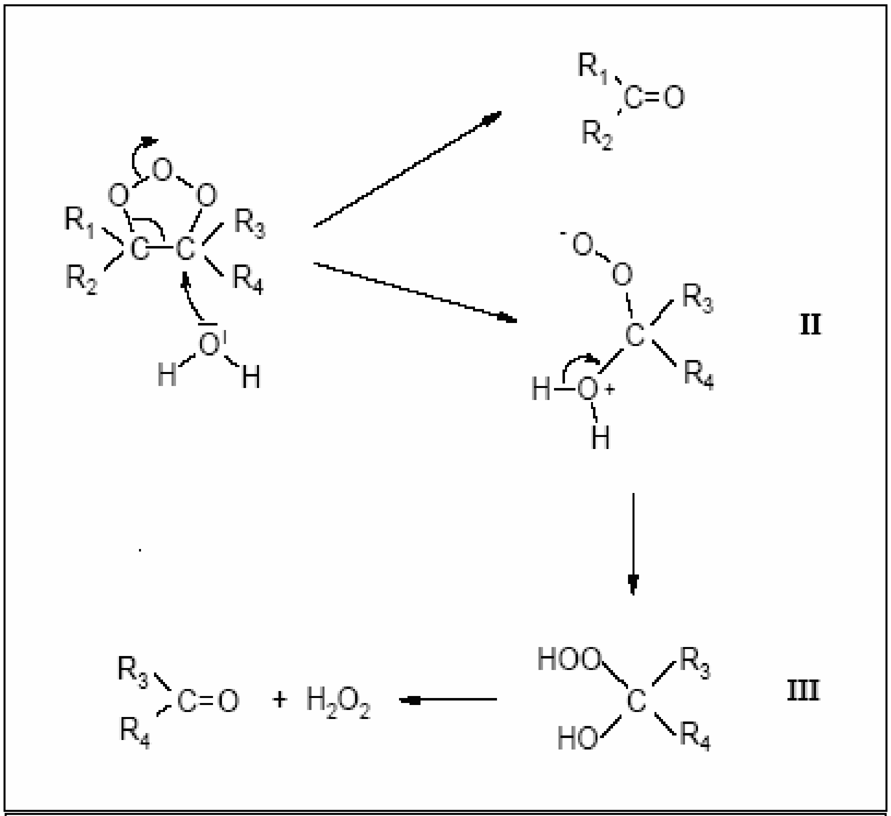


Fig 4.2. Primary ozonide decomposition into a carbonyl compound (aldehyde or ketone) and a zwitterion (II) leading to a hydroxy-hydroperoxide (III) stage that decomposes into a carbonyl group.

In Fig 4.2 the primary ozonide decomposes into a carbonyl compound (aldehyde or ketone) and a zwitterion (II) leading to a hydroxy-hydroperoxide (III) stage that further decomposes into a carbonyl group.

The use of ozone in medicine is based on its oxidative and reactivity properties. Ozonated solutions show a bactericidal effect against a wide range of microorganisms and these solutions have been used externally in many published papers. These properties of ozone are due to its oxidative capacity: in these cases the role of ozone becomes important due to the activation of oxygen dependent reactions of metabolism and the Crebs cycle, with formation of a large amount of protons necessary to restore the buffer capacity of antioxidant defence system against free radical and peroxidates. Ozone is capable of maintaining the dynamic balance of pro-oxidant and ant-oxidant systems responsible for membrane structure and metabolism.

The Use of Ozonoids in the Health Care Industry.

Díaz M (*Díaz 2004*) discussed the ozonation of plant and vegetable oils in a 2004 paper. When vegetable oils, which consist fundamentally of triglycerides, are ozonised, ozonides, aldehydes, and peroxides are formed. Diaz reviewed past research from Cuba and Russia that showed these products are related with the observed biological effect of these oils.

In the pharmaceutical industry, ozonated olive and sunflower oils are recognised. The cosmetic industry lists ozonated olive, sunflower, jojoba and caster oils in the International Cosmetic Ingredient Dictionary and Handbook (Issue 1191).

These oils are classified chemically as ‘esters’ and their function as ‘Skin Conditioning Agents and Miscellaneous’. Esters are a chemical group of substances that are distinguished by a carbonyl group, where R 1-4 are carbon groups at either end of this chain. The primary ozonide shown in Fig 4.1 decomposes into a carbonyl compound (aldehyde or ketone) and a zwitterion (II) that quickly leads to a hydroxy-hydroperoxide (III) stage that, in turn, decomposes into a carbonyl compound and hydrogen peroxide, as shown in Fig 4.2.

There are many areas of health care that ozone technologies can be applied to. This paper highlights a number of areas where current pharmacological treatment has offered little respite to the sufferers, or where the treatment modality has a high economical cost to the general public or the state-funded systems.

The Treatment of Thermal Burns.

Peretyagin *et al,* (*Peretyagin et al 2004.*) published data to show that ozonated oils have a definitive role to play in the treatment of burn subjects. They analyzed the medical behavior of ozonized olive oil. Ozonated olive oils have a wide spectrum of chemical characteristics: the main components are glycerines of oleic and linolenic acid. The research team manufactured 2 different ozonated oils with differing concentrations of ozonoids. Chemically their oils compositions are shown in Table 4.1 below.

Index	Poorly ozonized olive oil	Strongly ozonized olive oil
- O_3 -	2.40 %	4.06 %
superoxide number	240	406
acid number	11.4	15.4
average molecular mass	4.920	3.643

Table 4.1. ozonated oils with differing concentrations of ozonoids

Bactericidal studies examined *Proteus, Staphylococcus aureus, Pseudomonas, Streptococcus,* and *Neisseria* cultures. After 24 hours of incubation, the cultures were inoculated with ozonized oil and no bacteria could be cultured from either inoculated culture. The clinical use of ozonized olive oil was found to be most useful in the first 3 - 4 days following the burn injury, for the local treatment of thermal injury with bacterial infection with *Staphylococcus aureus* and *Pseudomonas,* and showed a decrease in the microbial load by 3 - 4 levels (*Peretyagin et al 2004*).

As observed by many other researchers and workers with ozonated fluids, the use of ozonized oil promotes a more rapid growth of granulation tissue and increase of the healing potential, normalises the blood bactericidal activity, increases the level of lysozyme and phagocytic activity, and the production of antibodies (normalising content of circulatory antibodies components). The healing time for the burn area was observed to be between 7 - 10 days.

It is suggested by the author that a spray-on ozonated oil could be developed from a cosmetic application that is currently being examined. This could be used in burns units, as well as in-home applications. For small burns, a solid wax-like compound can be developed similar to the lip salves found in most pharmacies.

Struchkov *et al* (*Struchkov et al 2004*) found similar bactericidal effects in another study in burn subjects. These workers treated damaged extremities by irrigating them with an ozone-oxygen mixture, using plastic bags, with an ozone concentration of 10 mg/L and a 60 min exposure locally after a surgical treatment. The injured surface was irrigated with ozonized physiologic saline solution at an ozone concentration of 3 mg/L. Peretyagin *et al* (*Peretyagin et al 2004*) in their 2004 paper published similar bactericidal effects, and also described the early establishment of favourable conditions to perform early autodermoplasty and to obtain optimum autograft survival.

The Treatment of Vulvovaginitis.

Rubio *et al* in their 2004 study (*Rubio et al 2004*) showed that ozonated sunflower oil was an effective treatment for vulvovaginitis. Three hundred fifty female subjects, 25 – 34 years of age, were treated with vaginal douches of ozonated sunflower oil, once a day, for 10 days. Microbiological swabs were taken at the beginning and at the end of the treatment. *Candida albicans* was the most frequent micro organism present in this study. Leucorrhoea and pruritus were the common symptoms and these symptoms disappeared after the 3^{rd} day of treatment. The study had a success rate of 95 % for the successful treatment of vulvovaginitis.

The author suggests that pessaries with filled with ozonated oils would offer an easier self-treatment delivery system.

Treatment of women with Human Papilloma Virus (HPV) uteri cervix infection.

Human Papilloma Virus (HPV) is associated with cervical cancer and its preceding lesions. Cervical cancer is the second most common malignant tumour in the world to affect female subjects. In Central and South America and the Caribbean geographical regions, it is the most common female cancer. In spite of several studies made worldwide to establish effective therapeutics against HPV infection, there is no consensus. There are two different treatment modalities for HPV infections.

- The first is based on lesion destruction by mean of chemicals or surgical methods, but this does not eliminate the viral infection, and the disease may recur.
- The second one is based in viral elimination with antiviral agents.

In a study published by Ríos *et al* (*Ríos et al 2004*), ozonated sunflower oil was used to treat HPV. Previous studies had shown antiviral activity in the treatment of viral infections such as the Herpes virus. The main aim of this study was to evaluate the therapeutic efficacy of an ozonated sunflower oil in HPV infected women. To develop this study 12 female subjects with NIC I, associated with HPV and condiloma acuminate lesions were selected. Ozonated sunflower oil was applied daily, in the uteri cervix of each patient, over a 20-day treatment period. Cytological, histological and colposcopic examination for each subject was made before and after the treatment.

Two subjects were lost. Of the remaining 10, eight (80 %) subjects showed total clinical and cytological regression of all lesions. Viral persistence was observed in two (20 %) subjects. There were no side effects reported in this study.

Cosmetic Treatment with Ozonated Fluids.

Díaz *et al* (*Díaz et al 2004*) reported that cosmetic creams with ozonoids as part of their chemical ingredients have a moisturiser and conditioner effect. Skin oxygenation and microcirculation are increased preventing cutaneous aging. These ozonated oils super oxygenate the skin providing enhanced energy leading to increased metabolic rate. This promotes rapid cell renewal and rapid healing. Additional metabolic pathways that protect repairs and rejuvenate skin tissue are positively influenced. The ozonation of these extracts takes place at the double bonds in unsaturated oils. Oils containing omega 3, 6 and 9 fatty acids are better, in that they are the essential fatty acids which have a positive beneficial action on the epidermis in terms of their anti-inflammatory action and that they are superior in slowing down trans-epidermal water loss.

Alternative Plant and Vegetable Extracts.

Plant and vegetable extracts are rich in Omega 3, 6 and 9 oils. These oils have in their chemical structure double bonds that ozone will react with to form an ozonoid, and hence are suitable for ozonation. Omega 3 is linolenic acid with 3 double bonds in its carbon chain. Omega 6 is linoleic acid with 2 double bonds in its carbon chain. Omega 9 is oleic acid with 1 double bond in its carbon chain.

Ozonoids have a ring-type structure (Fig 4.01), and result from the breakdown of the double carbon bonds found in linolenic acid, linoleic acid and oleic acid (Fig 4.02), natural components of plant and vegetable extracts (*Roehm et al 1971, Lynch et al 2003*). Ozone attacks these double carbon bonds, and inserts an ozonoid structure. As olive oil was used in the first protocols, it continued to be used as the oil of choice in the manufacture of ozonoids. It produces a stable product, with a longevity exceeding 15 years.

However, olive oil is one of many commercially available plant and vegetable extracts that contain omega oils. If the concentrations of linolenic, linoleic and oleic acids are known for each plant and vegetable extract, it is possible to calculate a ‘Potential Ozonoid Index’ (POI) (*Holmes 2006, Holmes 2006, Holmes 2007, Holmes 2007*) for each extract, and then select the most appropriate oil for ozonation. By knowing the POI for each oil, ozonation of different oils and oil blends will result in ‘strong’, ‘medium’, and ‘weak’ ozonated products that can be used for different applications.

The molecular mass of omega 3, 6 and 9 oils are within 4g of each other, and hence are not significantly different in weight. Therefore a fixed weight of any ratio of these fatty acids would remain constant. To calculate a factor proportional to the number of double bonds could therefore be computed by multiplying the relative omega fatty acid content by its relative number of double bonds and adding them together. i.e. $\Sigma = (\%\ \text{omega } 3 \times 3) + (\%\ \text{omega } 6 \times 2) + (\%\ \text{omega } 9 \times 1)$.

The POI is calculated by adding the sum of the 3 as the combined factor for that particular oil. The higher the combined factor or POI, the higher the number of double bonds (i.e. reactive sites) as targets for ozonation.

Table 4.2 shows the POI for a number of commercially available plant and vegetable extracts. Average omega 3, 6 and 9 values are shown to account for seasonal variations in their concentrations. The omega oil contents are referenced from the World Wide Web internet site, *www.queenhill.demon.co.uk/seedoils/oilcomp.htm*. The data in Table 4.2 is ranked according to the POI in the extracts selected, and a range from 221 to 92 is shown. Olive oil has a POI of just 92, the lowest in this table. Sunflower oil has a POI of 153, showing the availability of more sites for the formation of ozonoids, and hence a potential higher ozonoid content. This would account for the positive results the Cuban researchers have obtained in their published studies.

Table 4.2 shows that a number of alternative extracts have higher POI's. If nut extracts are excluded on the grounds of potential allergy considerations, flax, hemp (cannabis sativa), evening primrose, safflower, and chia have POI's at 170 or above, perilla has a POI of 165, and grape seed, pumpkin seed and sunflower POI's of 159 to 153.

The most obvious choice of extracts to ozonate are those extracts with the higher POI's – flax (POI=221), hemp (cannabis sativa) (POI=192), evening primrose (POI=173), safflower (POI=172) and chia (POI=170). This has to be balanced with the cost of these extracts, and both flax and hemp (cannabis sativa) are relatively inexpensive, as well as being readily available.

Flax Oil – (POI 221). Flax oil is derived from the flax plant Linum usitatissimum and is known as linseed oil. Flax oil is actually one of the oldest and one of the original "health foods," treasured because of its healing properties throughout the Roman Empire. It was one of the original "medicines" used by Hippocrates and is referenced by Hodrodotus in his History of the Roman Empire.

Besides being the best source of omega 3's, flax oil is a good source of omega 6, or linoleic acid (LA). Sunflower, safflower, and sesame oil are greater sources of omega 6 fatty acids but they don't contain any omega-3 fatty acids. Flax oil is 45 to 60 percent the omega-3 fatty acid alphalinolenic acid (ALA). Flax oil can be used for patients who have dry skin or eczema, or whose skin is particularly sun-sensitive. One problem in the ozonation of this product is the potential for the oil to set solid as ozone is bubbled through it and reacts with the oil. A possibility to be explored is the blending of Flax with Hemp oils to counter this as a 50%-50% mix resulting in a POI of 206.

Hemp (Cannabis sativa) Oil – (POI 192). Hemp oil is derived from the Cannabis sativa plant. Hemp seeds contain 40% fat in the form of an oil. It has a remarkable fatty acid profile, being high in the desirable omega-3s and also some GLA (gamma-linolenic acid). Hemp oil contains 57% linoleic (LA) and 19% linolenic (LNA) acids.

Hemp oil simulates growth of hair and nails, improves the health of the skin, and can reduce inflammation. The intoxicating properties of Cannabis sativa reside in a sticky resin produced most abundantly in the flowering tops of female plants before the seeds mature. The main psychoactive compound in this resin is tetrahydrocannabinol (THC). Strains of hemp grown for oil production have a low resin content to begin with, and by the time the seeds are ready for harvest, resin production has dropped even further. Finally, the seeds must be cleaned and washed before they are pressed. As a result, no THC is found in the final extract product.

PLANT OIL	OMEGA 3%	OMEGA 6%	OMEGA 9%	COMBINED FACTOR (POI)
Flax (Linseed)	**58**	**14**	**19**	**221**
Hemp (C. sativa)	**20**	**60**	**12**	**192**
Evening primrose	0	81	11	173
Safflower	3	75	13	172
Chia	30	40	0	170
Kukui (candle nut)	29	40	0	167
Perilla	55	0	0	165
Grape seed	0	71	17	159
Pumpkin seed	8	50	34	158
Sunflower	**0**	**65**	**23**	**153**
Walnut	6	51	28	148
Soybean	7	50	26	147
Corn	0	59	24	142
Wheat germ	5	50	25	140
Rape (Canola)	**7**	**30**	**54**	**135**
Sesame	0	45	42	132
Cotton seed	0	50	21	121
Rice bran	1	35	48	121
Beechnut	0	32	54	118
Sweet almond	0	17	78	112
Olive	**0**	**8**	**76**	**92**
Avocado	**90**	**0**	**0**	**90**

Table 4.2. Omega 3, 6 and 9 oil content of plant & vegetable extracts. Holmes J 2006

Sunflower Oil (POI 153). Sunflower oil is pressed from the seeds of the common sunflower found growing in most parts of the world. It forms one of the most common cooking oils found in supermarkets after more traditional oils, such as olive oil.

Sunflower oil contains no omega 3 oils, being made up of 65% omega 6 oils. As it is cheap and grows in most soils types and climatic conditions, Cuban and Russian research has focussed on this oil type. Sunflower oil ozonoids are stable for long time periods – for up to 15 or more years. It has a smell of rancid cooking oil when ozone treated that can put off many patients in the western cultures.

Olive Oil (POI 92). Olive oil is pressed from the olives after harvesting. Olive oil is graded as to the number of times oil is reclaimed from the crushed fruit. The first pressing is the most pure and expensive, and is sold as 'Virgin Oil'. Subsequent pressings are used in conjunction with solvents to reclaim residual oils.

The first published literature for the treatment of tuberculosis discussed the merits of inhaling ozone bubbled through olive oil. Physicians found that after a while, a white vaseline-type of oil-gel was left in the bubbler container. It was found that this oil had many pharmacological properties, and was used to combat infections and manage wounds.

Avocado Oil (POI 90). Avocado oil was chosen by researchers in the United Kingdom and South Africa for its innate healing properties, and as it is extensively used as a constituent in health and beauty products.

Rape Oil (Canola) POI 135. Rape oil is more commonly known as Canola oil. It is a light oil used in cooking. Canola was chosen to compliment the range of ozonated oils.

Oil Base		POI
Hemp Oil		**192**
Canola (Rape) Oil		**135**
Sunflower Oil		**153**
Olive Oil		**92**
Avocado Oil		**90**

Table 4.3. POI of selected oils

Table 4.3. By choosing oils with a variation in POI, the concept of a strong, medium and weak ozonated oil range was developed. These are aimed at infection control and wound management for a variety of tissue types.

The development of a range of trans-dermal skin gels and creams was introduced by Holmes in 2006 and 2007 (*Holmes 2006, Holmes 2007, Holmes 2007*). The incorporation of ozonated plant extracts into a skin preparation can be used to enhance the anti-microbial effect, to control wound healing and its management, as well as skin rejuvenation. In some cases, innate sun-blocking properties of the oil and ingredient mix has resulted in products that protect from sun damage as well as promote skin healing and health (*Holmes 2007*). These transdermal skin gels are made from 100% certified organic products and are sold as the HN-Skin Range from Lime Technologies Health & Beauty Limited, part of the Lime Technologies Holding Limited group of companies.

Discussion.

A number of plant and vegetable extracts have been identified as having a higher POI than the traditional olive and sunflower oils used in the manufacturing of ozonated products. These ozonated oils have a role in the cosmetic industry as moisturisers, conditioners, and regeneration products, as well as microbial effects that have been published in the literature. Díaz (*Díaz 2004*) discussed the use of ozonated sunflower, coconut and theobroma oils, and their use in Dermatology, Parasitology and Cosmetology. Lynch e*t al* (*Lynch et al 2003*) showed that the treatment of vegetable oils with ozone gave rise to the consumption of polyunsaturated fatty acids present. Signals present in the 5.10-5.25 ppm regions of ozonated grape and sunflower seed oils were assignable to the ring protons of ozonides. Further ozone-induced modifications to the oils included the production of aldehydes, i.e. -CH2CHO aldehydic group, terminal products arising from the decomposition of ozonides.

Published research has demonstrated that the application of ozone gas to skin tissue has the potential to result in tissue damage (*Thiele et al 1997, Valacchi et al 2005*). Ozone exposure causes damage to cutaneous lipids, an effect which can be attenuated by vitamin E application

(*Thiele et al 1997*). The use of ozone gas has been shown to produce a progressive depletion of antioxidant content in the stratum corneum and this can then lead to a cascade of effects resulting in an active cellular response in the deeper layers of the skin. Using an in vivo model Valacchi *et al* (*Valacchi et al 2005*) have shown an increase of proliferative, adaptive and proinflammatory cutaneous tissue responses.

Díaz *et al* (*Díaz et al 2004*) reported that cosmetic creams with ozonoids as part of their chemical ingredients have a moisturiser and conditioner effect. Therefore, skin oxygenation and microcirculation are increased preventing cutaneous aging. The recently published paper by Valacchi *et al* (*Valacchi et al 2005*) showed that ozonated extracts have been shown to be safe for use on skin tissue. The use of these ozonated extracts and blends are wide: from medical treatment of infections (bacterial, viral and fungal infections eg: gingivitis, athletes foot and herpes), skin conditions (eczema) and wounds (insect bites & stings, cuts, burns, leg ulcers, bed sores).

Ozonated oils can be supplied in a variety of delivery systems, for safe self-administration, to reduce the problems of waste disposal, and potential problems of health hazards with current delivery systems. One such problem area is the delivery of ozonated avocado oil in syringes for the treatment of HIV patients in Africa.

The author suggests that pessaries with filled with ozonated oils would offer an easier self-treatment delivery system. The formulation of ozonated oils in a vaginal, anal or oral pessary offer a simple cost effective treatment modality. This potential has been realised by a South African Company, Copper Eagle Trading with a product named 'Viralon'. Viralon is available as two strengths, Viralon 190 and Viralon 90 capsules.

Ozonated extracts have been combined with other products to form a new range of products in the cosmetic industry for skin tissue protection, repair, maintenance and rejuvenation. These have been launched as the Lime Technologies HN-Transdermal Skin Cream & Gel Range, and are available from Lime Technologies Health And Beauty Limited, a division of Lime Technologies Holdings (Republic of Ireland) Limited.

Ozonated plant and vegetable extracts should be farmed from organically farmed and sustainable crops to avoid contamination by pesticides, fertilizers, and cold pressed to avoid contamination by solvent chemicals used to scavenge the extracts from the plant or vegetable pulp during processing. Once ozonated, these extracts can be blended with other products that have important vitamins and trace minerals, as well as their own innate pharmacological properties.

There is evidence to suggest that ozone therapy has substantial cost advantages when compared to conventional pharmaceutical therapy. Holmes and Lynch, and Mapolón *et al*. (*Holmes and Lynch 2004, Mapolón et al. 2004*) have shown ozone can substantially reduce the cost of health care to the patient and to the state-funded systems. In the Holmes and Lynch study, the reduction in dental costs to the state-funded health service were in the order of 45% (*Holmes and Lynch 2004*).

There is no reason to suppose why these cost benefits could not be carried into the medical health care market. In the Mapolón *et al*. (*Mapolón et al 2004*) study, 168,310 subjects (children and adults) treated with ozone from July 1992 till December 2003 were followed. Ozone administration was via rectal, autohaemotherapy, intramuscular, subconjunctival and local treatment, using gas bag and ozonized oil. Subjects received more than five cycles of ozone treatment. The clinical results were very good, with no side effects. Not a single patient died. Ozone therapy was cheaper than the conventional pharmaceutical treatment with antibiotics, analgesics, anti-inflammatory drugs, etc.

Both the Holmes and Lynch, and Mapolón *et al*. (*Holmes and Lynch 2004, Mapolón et al 2004*) studies underline the potential to develop a new holistic health care model based on cheap and effective materials and delivery systems. These alternatives offer substantial savings to the end users – the general public and the state-funded health care systems.

It has always been assumed that ozone should not be used for pregnant patients or for children. The 2004 study by Grischenko *et al* (*Grischenko et al 2004*) shows ozone has a beneficial effect on the foetal development in the complex treatment of intrauterine foetal hypoxia (IFH).

Pregnant women with IFH were intravenous injected with ozonized physiological solution, 200 mL per day, during 5 days. The concentration of ozone in the solution was 1 - 3 mg/L. An analysis of the clinical histories of the neonates born to these pregnant women with IFH who received intravenous injections of ozonized physiological solution was carried out. This data showed higher average indicators of the physical development of the new-born children than that of the control group: increased body mass of 3300 ± 58 g and increased body length 53 ± 0.5 cm versus 2920 ± 80 g and 48.4 ± 0.4 cm. The clinical results could be explained by improved erythrocyte oxygen-transport function after therapeutic doses of ozone.

Struchkov *et al* (*Struchkov et al 2004*) described an infection control use of ozone gas in a hospital burn unit. Burn trauma victims are susceptible to infection. By treating the whole treatment area, the burn trauma unit was effectively sterilised and no infection was seen with multiple-resistant micro-organisms. In this particular application the whole unit was treated with ozone for 45 minutes.

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