Understanding the Physics, Chemistry and Biology of Bipolar Ionization (BPI)

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In the high vacuum of space matter is present in an *energized* state and therefore that matter has electric charge. However, on earth most matter is *unionized*. Simply stated ionization is the process whereby an electrically neutral atom or molecule acquires a positive or negative electric charge.

Oxygen is required for most forms of life on Earth. Ordinary oxygen doesn't react well with most molecules but oxygen can be "activated" to become more reactive. Such activation can occur naturally, or artificially derived via electrical, thermal, photochemical, or nuclear means thereby transforming oxygen into reactive oxygen species (ROS). The sources of such high energy include: cosmic radiation, UV light, electrical discharge (lightening), ionizing nuclear radiation, frictional charging by wind or water (i.e., waterfalls, showers), combustion (fire, burning jets, engines) and strong electrical fields (coronas). Changing oxygen into a reactive state occurs by adding an electron by the process called reduction (O2 + e- > O2- superoxide anion); likewise the loss of an electron is called oxidation (O2+ dioxygen cation). The superoxide radical (O2-) is quantitatively *the most important radical* formed in humans.

Human cells constantly produce superoxide as an antibiotic against invading microbes. Superoxide also acts as a signaling molecule, along with NO2, to regulate many cellular processes. Under biological conditions, it reacts with itself to produce H2O2 and O2 (2 O2- + 2H+ > H2O2 + O2) by a process called dismutation which can occur spontaneously or catalyzed by superoxide dismutase enzyme (SOD). Further, the catalase enzyme also produced renders H2O2 into water and O2. To reiterate the superoxide radical anion is quantitatively the most important radical formed in human cells (a 70Kg adult synthesizes at least 10 Kg per year). Ninety-eight % of oxygen consumed by respiring mitochondria is converted into water in human cells but the remaining 2% results in superoxide formation as an antibiotic (antimicrobial)

against invading microbes. SOD is an important antioxidant in nearly all living cells. SOD plays a substantial role in protecting cells from oxidative stress. In fact, organisms without SOD like knockout mice, either die prematurely, or within days of birth. Even mutations in the SOD enzyme in humans can cause familial amyotrophic lateral sclerosis and other mutations to the SOD enzyme can contribute to carcinomas.

Bipolar Ionization (BPI) creates an energy field which produces positive and negative ions. Superoxide can be formed by AtmosAir air ionization. Of the 4 dioxygen states namely O2 dioxygen, O2+ dioxygen cation, O2- superoxide anion, and O2- - peroxide dianion, only superoxide O2- is the most stable and the least reactive oxygen species. When reacting with water it produces hydrated clusters of hydroxyl radicals ([OH-]) which are formed on the surface of microbes, are short lived (half-life 2 seconds) and remove H from microbial cell walls thereby inactivating microbes. This process ultimately produces H2O water as its end product. This fact makes hydroxyl radicals one of the safest processes for *disinfection.* These hydroxyl radicals are the main effector molecules that kill microbes. In fact, the effector hydroxyl radicals [0H-] have a standard oxidation potential of 2.81 considerable greater than H2O2 peroxides (1.78) and even O3 ozone (2.07). It is also important to note that the positive oxygen ions (namely dioxygen cation O2+) are very short lived because they are unstable. The only stable oxygen ion produced is the negatively charged superoxide anion O2- .Both types of negative ions produced – the superoxide anion[O2-] and the [OH-] radical, swing the balance of ions to negative by converting many positive ions to neutral. Remember in the spreadsheet of nature there is most always a balance towards net neutrality of remaining particles.

Recent third-party laboratory and field testing has demonstrated the effectiveness of BPI, exhibiting an 85.8% dust particle decay rate as compared to 12.8% natural decay rate without the system. Lab tests conducted by Syracuse University's Building Energy and Environmental Systems laboratory revealed reductions of over 90% for all common indoor VOCs tested. When testing against three bio aerosolized microbes, the BPI system reduced them by 99.98%.

The second possible reaction of BPI is that the oppositely charged ions cause these highly reactive particles to attract to other particles, or themselves becoming bigger and heavier, by the *process of agglomeration* which then allows them to fall to the ground by gravity thusly taking them out of the air and which never allows them to even get to the filters. Alternatively, the

increase in size of the particles by agglomeration allows the particles to be better trapped by the filters, which now more efficiently can remove these larger particles.

Keep in mind that in normal healthful unpolluted air typically falls between 300-1000 ions/cm3. In "fresh air" there is approximately 2000-3000 total ions/cm3 but air near waterfalls and high mountain tops have their ion concentration in excess of 5000 ions/cm3. In the production of BPI there is a 60% negative ions to 40% positive ratio.

There are four possible processes involving reactions with air ions include: (1) recombination with other air ions, (2) reaction with gaseous molecules, (3) attachment to larger particles and (4) contact with a surface. The former two may be involved with removal of VOCs and the latter two may be involved in the removal of particulate matter including microbes.

It is most important to understand the remarkable difference between microbial and human cells and why the affect of ionization is also different on such cells primarily harming microbes but not humans. The answer lies in the differences between bacterial and human cells:

DIFFERENCES BETWEEN BACTERIA VERSUS HUMAN CELLS

	Bacteria	**Humans**
1.Type of Cell	Procaryotic (primitive)	Eucaryotic (advanced)
2. Mitochondria	ABSENT	PRESENT
3. Cell Walls	PRESENT	ABSENT
4. Ribosomes	70S system	80 S system
5. Nucleus	ABSENT	PRESENT
6. Membrane Bound Nucleus	ABSENT	PRESENT
7. # of Chromosomes	1	MANY
8. Golgi apparatus	ABSENT	PRESENT
9. Plasma Membrane with cholesterol	ABSENT	PRESENT
10. Cell Size	1-10 um	10-100 um
11. Number of cells	single cell	Multicellular
12. Endoplasmic Reticulum	ABSENT	PRESENT

This is only a partial list of differences and there are others. These differences play a significant role in the different effects that air ionization has on these different cell types. This situation is reminiscent and analogous to the reason why antibiotics primarily act on the bacteria cell but not the human cells when applied properly. The reason is that the reaction displays what is called *selective toxicity* to the more primitive cell type (procaryotes) than to the advanced cell type eucaryotes.

An addendum in proof was offered by a human and animal study of the safety of air ionization on humans and animals after the use of ionization equipment for between 4 and 5 years. The study was offered by Dr Hans Hurni of Ciba-Geigy in Basel Switzerland wherein he observed no negative or deleterious effects of ionized air on people or the following animals: mice, rats, guinea pigs, rabbits, cats and dogs (verified by microscopic histologic pathology examination of organs of hundreds of animals).

There have been numerous investigatory reports on biologic effects that ions, both positive and negative, have on animals and humans. It is clear that many such studies were poorly constructed while others show possible relationship between ions and physiological outcomes without any definitive causal link or connection. In other words, there are no definitive associations between charge and moods, diseases, or energy levels. Note: unfortunately there is enormous conflation of information on ozone generators, portable ionic devices (like ionic breeze) and a myriad of others, which either poorly work or do not work at all, with Whole Building Central BPI systems like AtmosAir, which do work.

There is one possible serious aspect of the process of air ionization, or for that matter, any electrical device and that is with possible significant ozone (O3) generation. The accepted standard safety level of (O3) generation from any electrical device is no more than 0.05 ppm. AtmosAir equipment has been tested and has been found to have a better than allowable level of <0.01 ppm. Hence no significant amount of ozone has been found with AtmosAir equipment.

Another aspect of possible concern is with systems that damage DNA. It is most important to note that bipolar ionization kills microbes without damaging DNA (therefore does not cause or contribute to cancer) unlike many other physical and chemical agents such as UV light, radioactivity, or the use of caustic chemicals.

In conclusion, the process of air ionization has been shown to be a relatively safe and effective means for improving indoor air quality which unfortunately has for decades lagged behind outdoor air pollution progress and brings with it the potential for associated health benefits!!