LIGHT IONS AND OZONE – GENERATION AND INTERACTIONS WITH LIVING ORGANISMS

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With directly in the living organism born ions exception, LNI coming through three phases: ionisation, attachment by the electronegative molecules and the clusters formation due to local electrostatic interactions. The quantitative analysis of physical parameters leads to conclusion that we cannot find any physical property (till known) explaining the positive affect of LNI on living organisms. Analysis of possible mechanism produces several hypotheses of LNI-organism interaction. A simplified semi-quantitative model of respiratory tract was developed for estimation of ions and ozone interaction with living organisms. A formation of oxygen radicals and products of their chain-reactions in intrinsic conditions is discussed.

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INTRODUCTION

Concentration of light ions, especially negative, belongs to the important parameters, which have to be taken into account at assessment of building interiors. Role of these ions were empirically verified in subjective feeling in environments of different ion micro-clime. In case of higher light negative ions concentration freshness feeling, well-being and comfort were described. In case of higher light positive ions concentration these effects were not such significant, and on the other side, the ion-free conditions were the worst tolerated and they caused lassitude and somnolence. The ozone produced by ionisers is traditionally considered to be undesirable and the ionisers working regime is adjusted to minimize the ozone production. From the other side, the ozone is used in ozonotherapy. This article comes out of traditional evaluation of the light negative ions (LNI) based eighty years ago and practically non-revised until now, tried to find answer to still open questions:

What is the reason of extraordinarily biological efficiency of LNI? How ozone interacts with respiratory tract and what is the reason of its positive influence on organisms?

GENERATION AND INTERACTION WITH ORGANISMS

Ozone is generated by electrical discharges (sparks, coronas, atmospheric pressure discharges), by ultraviolet irradiation, by electrostatic and ultraviolet machines and by photochemical reactions of hydrocarbons , nitrogen oxides and sunlight in smog. Ozone can irritate the eyes, nose, throat, and lungs. airways and cause inflammation much like a sunburn. Other symptoms include wheezing, coughing, pain when taking a deep breath, and breathing difficulties during exercise or outdoor activities. People with respiratory problems are most vulnerable, but even healthy people that are active outdoors can be affected when ozone levels are high. Repeated exposure to ozone pollution for several months may cause permanent lung damage. From the other side ozone accelerates the use of glucose on behalf of the cells, it enters into the metabolism of protein charm into its kinship with thionic roots and it has direct reaction with the insatiable greasy acids that are changed in watersissolver unions, it acts at the microbes against the viruses in general level owed in capable, produces peroxides, improves of metabolism of oxygen in the level of red corpuscles because of increase of consumption of glucose, split of greasy acids and activation of ferments which block the peroxides and free roots, increases of flexibility of red corpuscles and increases 2,3 disphosphoglycerate of red corpuscles.

Sources of positive ions prevalence are computer monitors, static electricity, combustion, electronic microclimates, high humidity and temperature, mobile positive charges, static positive charges , climatic condition (wintertime, the 'Bitter' winds). In nature, ions are formed in a variety of ways, such as UV light, airflow friction, lighting, falling water and by plants. Plant leaves produce negative ions as they emit water vapors. Therefore, plants that have the highest transpiration rates produce the most negative ions. Waterfalls and tropical forests create copious amounts of negative ions. Synthetic building materials, clothing and furniture coverings remove large numbers of negative ions from the indoor environment. The positive static charge of plastics also consumes large quantities of negative ions. Therefore, the negative ion count in modern buildings is often very low. From various physiological effect we focus on three facts:

1. Negative ions accelerate the oxidative degradation of serotonin whereas positive ions have the opposite action and inactivate the enzymes which break down serotonin. (An increase in the serotonin level (5-hydroxytryptamine) produces: tachycardia, a rise in blood pressure, bronchospasmus going as far as asthma attack, increased intestinal peristalsis increased sensitivity to pain, increased aggression; a decrease in the serotonin level is calming and increases defenses against infection.)
2. Our bronchial tubes and trachea are lined with tiny hair filaments called cilia. The cilia normally maintain a whip-like motion of about 900 beats a minute. Together with mucus, they keep our air passages free of dust and pollen. If tracheal tissue is exposed to negative ions the ciliary beat speeds up to 1200 a minute and that mucus flow was increases. Doses of positive ions produces the opposite effect: The ciliary beat slows to 600 a minute or less and the flow of mucus drops.

3. Light ions consumption is observed during long meetings in bad ventilated room due human breathing.

LIGHT IONS ACTIVITY HYPOTHESES

Neuroreflex action of ions – according this theory light ions act directly on free neuron ending. This mechanism can work at least on olfactory fibres. Air with high light negative ions we feel as fresh. Olfactory neurons are part of the limbic system. Activation of the limbic system leads to vegetative changes.

Transport of charge throw alveolar wall into blood using breathing gases – this theory is problematic due to relatively small amount of light ions in air comparing to total particle amount.

Free radicals theory – ions forms free radicals, these radicals are multiplied by chain reaction and act to organism. This mechanism is analogous to ozone action. However, this theory is not very probable, due to two problems: First – amplification of free radicals on biological membranes is realized by lipoperoxidation of unsatured fat acids. This reaction leads to membrane damage. It is in conflict with action of light negative ions and benefit of light negative ions can be explained only as a scavenger of positive ions. Second – forming of free radicals is main mechanism of ozone toxicity in lungs. If we compare acceptable ozone concentration 0.1 ppm i.e. $2.7\ 10^{15}$ O_3 molecules in 1liter of air with light ions concentration, we assumed, that it is $10^8 – 10^{10}$ higher then typical light ions concentration.

The novel *light ions assisted lungs self-cleaning* analyzed in presented paper is based on idea of inner bronchial surface charging. Inner bronchial surface is coated in luminal direction by respiratory epithelium (ciliar cells, sercetory cells and cells of diffuse neuroendocrine system), mucus layer and film of surfactant. Surfactant is based on phospholipides, i.e. linear molecules with hydrophobic and hydrophilic ends. Hydrophilic ends are oriented into mucus layer and hydrophobic lipidic ends are oriented into bronchial lumen. Surfactant presence acts against Laplace's law by decreasing surface tension. It prevents collaption of alveoles and small parts of bronchial tree. Unwanted air impurities (viruses, bacteria, spores, dust) are mostly positively charged. Impurities higher then micrometer in diameter can be eliminated from bronchial tree. This limit size of impurities is, however, in discordance with diameter of anatomic data: Diameter of bronchus coming into alveolus is about 0.3 mm, i.e. 300 times larger.

BRONCHIAL TREE MODEL

- dichotomic bronchial tree (each bronchus divide into two ones of higher level)

- constant diameter rate

$$d_{i+1} = 0.78\ d_i$$
$$i = 1,2,\dots 16$$
$$d_1 = 3\text{ cm}$$

where d_k is diameter of k-th level bronchus

- constant diameter-length rate

$$l_i = 3\ d_i$$
$$i = 1,2,\dots 17$$

where l_i is diameter of i-th level bronchus

- surface of i-th level bronchus

$$b_i = 2\pi\ d_i\ l_i$$
$$i = 1,2,\dots 17$$

- total surface of i-th level

$$B_i = 2^{i-1}\ b_i$$
$$i = 1,2,\dots 17$$

- total volume of i-th level

$$V_i = 2^{i-1}\ \pi\ d_i^2\ l_i$$
$$i = 1,2,\dots 17$$

- effective volume of i-th level

$$G_i = p_f\ B_i$$
$$i = 1,2,\dots 17$$
$$p_f = 1\ 10^{-6}\text{ cm}$$

where p_f is ozone mean free path

- breathing frequency

$$f = 16\text{ min}^{-1}$$

- breathing volume

$$H = 500\text{ cm}^3$$

- ion concentration

$$C = 5000\text{ cm}^{-3}$$

- ozone concentration

$$X = 2{,}7\ 10^{12}\ \text{cm}^{-3}$$

- ion exposition duration

$$t = 30\text{ min}$$

- available ions number

$$Q = H\ f\ C\ t$$

- available ions surface density of i-th level

$$q_i = Q\ /B_i$$

- number of free radicals attacking bronchus on i-th level during one inspiration

$$A_i = \alpha H\ XG_i/V_i$$
$$i = 1,2,\dots 17$$

where $\alpha = 10^6$ is number of free radicals produced by one ozone molecule

- surface density of ozone molecules attacking bronchus

$$a_i = A_i\ /B_i$$
$$i = 1,2,\dots 17$$

- mean surface corresponding to one ion on i-th level

$$Y_i = 1\ /q_i$$
$$i = 1,2,\dots 17$$

- mean surface corresponding to one free radical on i-th level

$$Z_i = 1/A_i$$
$$i = 1,2,\dots 17$$

RESULTS

Table 1. Bronchial tree geometry

Level i	d_i, cm	b_i, cm^2	B_i, cm^2	l_i, cm
1	3,000	169,646	170	9,000
2	2,220	92,898	186	6,660
3	1,643	50,871	203	4,928
4	1,216	27,857	223	3,647
5	0,900	15,254	244	2,699

6	0,666	8,353	267	1,997
7	0,493	4,574	293	1,478
8	0,365	2,505	321	1,094
9	0,270	1,372	351	0,809
10	0,200	0,751	385	0,599
11	0,148	0,411	421	0,443
12	0,109	0,225	461	0,328
13	0,081	0,123	505	0,243
14	0,060	0,068	553	0,180
15	0,044	0,037	606	0,133
16	0,033	0,020	664	0,098
17	0,024	0,011	727	0,073

Table 2. Light ion and ozone exposition

Level i	V_i, cm^3	G_i, mm^3	Y_i, μm^2	Z_i, nm^2
1	63,62	0,17	14,1	4,71
2	51,56	0,19	15,5	3,82
3	41,79	0,20	17,0	3,10
4	33,86	0,22	18,6	2,51
5	27,45	0,24	20,3	2,03
6	22,24	0,27	22,3	1,65
7	18,03	0,29	24,4	1,34
8	14,61	0,32	26,7	1,08
9	11,84	0,35	29,3	0,88
10	9,60	0,38	32,0	0,71
11	7,78	0,42	35,1	0,58
12	6,30	0,46	38,4	0,47
13	5,11	0,51	42,1	0,38
14	4,14	0,55	46,1	0,31
15	3,36	0,61	50,5	0,25
16	2,72	0,66	55,3	0,20
17	2,20	0,73	60,6	0,16

SUMMARY

Biological effect of ozone is given by its extreme oxidative possibility. Numeric results of Z_i show us that lungs antioxidative mechanisms break lipoperoxide chain reaction before destruction of all surfactant layer in lower parts of bronchial tree. One molecule per square nanometer corresponds to surfactant or cellular membrane density. If there were not any antioxidative mechamism, one inspiration of 0.2 ppm ozone will lead to death.

Quantity of light negative ion is very small to changing electric potential in bronchial tree. Even when we suppose, that all ions during 30 minutes breathing will collect on one level of bronchial tree, each cell will be influenced by few tens of elementary charges. Direct influence of light ions on bronchial cell therefore is not probable.

From the other side, local charges on hydrophobic monomolecular layer in tube and possible forming of charged spatial clusters is interesting as experimental model of intraluminal bronchial self-cleaning mechanism for future investigation.

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ГЕНЕРАЦИЯ ЛЁГКИХ ИОНОВ И ОЗОНА И ИХ ВЗАИМОДЕЙСТВИЕ С ЖИВЫМИ ОРГАНИЗМАМИ

В. Кржиха, Л. Аубрехт

Обсуждаются возможные механизмы взаимодействия лёгких ионов с живыми организмами. Лёгкие отрицательные ионы (ЛОИ) при прохождении через живые организмы проходят через 3 фазы: ионизация, захват электроотрицательными молекулами и образование кластеров вследствие локальных электростатических взаимодействий. Количественный анализ физических параметров приводит к выводу, что ни одно из известных физических свойств не может объяснить положительное влияние ЛОИ на живые организмы. Анализ возможных механизмов рождает несколько гипотез взаимодействия ЛОИ – организм. Развита упрощённая полуколичественная модель респираторного тракта для оценки взаимодействия ионов и озона с живыми организмами. Обсуждается образование кислородных радикалов и продуктов их цепных реакций.

ГЕНЕРАЦІЯ ЛЕГКИХ ІОНІВ ТА ОЗОНУ І ЇХНЯ ВЗАЄМОДІЯ З ЖИВИМИ ОРГАНІЗМАМИ

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Обговорюються можливі механізми взаємодії легких іонів з живими організмами. Легкі негативні іони (ЛНІ) при проходженні через живі організми проходять через 3 фази: іонізація, захоплення електронегативними молекулами й утворення кластерів унаслідок локальних електростатичних взаємодій. Кількісний аналіз фізичних параметрів приводить до висновку, що жодне з відомих фізичних властивостей не може пояснити позитивний вплив ЛНІ на живі організми. Аналіз можливих механізмів народжує декілька гіпотез взаємодії ЛНІ – організм. Розвито спрощену напівкількісну модель респіраторного тракту для оцінки взаємодії іонів і озону з живими організмами. Обговорюється утворення кисневих радикалів і продуктів їхніх ланцюгових реакцій.