HSPI The Open Access Publisher

IJCV INTERNATIONAL JOURNAL OF CLINICAL VIROLOGY
ISSN 2692-4994

Review Article

On the effect of millimeter waves on DNA and RNA of viruses

Ikhlov BL*

Perm State National Research University, Perm, 614998 Bukireva str, 15/1, Russia

More Information

*Address for Correspondence: Ikhlov BL, Perm State National Research University, Perm, 614998 Bukireva str, 15/1, Russia,
Email: boris.ichlov@gmail.com

Submitted: June 18, 2022
Approved: July 15, 2022
Published: July 18, 2022

How to cite this article: Ikhlov BL. On the effect of millimeter waves on DNA and RNA of viruses. Int J Clin Virol. 2022; 6: 029-033.

DOI: 10.29328/journal.ijcv.1001046

Keywords: Resonance; Replication; Breaks; Power; RNA

Check for updates

OPEN ACCESS

Annotation

Based on the differences between RNA and DNA, formulas for the natural frequency of torsional vibrations of single and double RNAs are obtained.

It is shown that, despite the fact that millimeter waves are delayed by the skin of the human body, there are conditions under which they can freely penetrate through the human body.

It is shown that centimeter waves, whose frequencies are multiples of the natural frequencies of torsional vibrations of the spirals of short DNA or RNA viruses, can cause subharmonic resonance in the spirals of RNA and DNA, which leads to the destruction of these molecules. Centimeter waves of non-thermal power flux density freely pass through the human body, which makes it possible to use them in vivo.

A table has been compiled with the physical characteristics of DNA and RNA of the most dangerous viruses, indicating the frequencies of the external electromagnetic field that cause resonance in the DNA and RNA helices, which leads to the denaturation of molecules.

In a series of experiments, it was shown that irradiation with microwaves with a resonant frequency of 180,402 GHz on samples with COVID-19 for 20 seconds. It has a disinfecting effect.

Introduction

The therapeutic effect of millimeter-wave waves (extremely high frequency, EHF) at a non-thermal level is widely used in clinical oncology. EHF therapy is used to treat gastric polyps and uterine fibroids, benign ovarian tumors, localized fibroadenomatosis and fibroadenoma of the breast, cancer of the stomach, breast, ovaries, body, and cervix, esophagus, lung, colon, ENT organs, etc. In oncology, EHF therapy can be used only for the treatment of benign tumors or as a palliative effect in order to reduce the severity of pain and toxic syndromes, combined with surgical treatment or with chemotherapy and radiation therapy [1-5].

At the same time, the mechanisms of EHF exposure during treatment have not been identified, the very effect of EHF on any organs has not been proven. In view of the impossibility of penetration of EHF through the skin of the human body, an effect on acupuncture points is assumed, but EHF does not have a point character. Probably, there is a thermal effect in combination with the placebo effect.

At the cellular level, millimeter waves can be absorbed by NH_4^+ cations or $H_2P0_4^-$, $HP0_4^{2-}$, HCO_3^-, NO_3^{2-}, SO_4^{2-} anions, whose spectra also lie in the terahertz and IR regions, see [6,7]. An extensive study of the effect of millimeter waves on living cells is presented in a number of articles by Zalyubovskaya, Smolyanskaya, Chernavsky, et al. in a special issue of the journal "Successes of Physical Sciences" [8]. The effect of millimeter and shorter waves on DNA was also studied in [9-14].

In experiments on the effect of centimeter waves on bacteria, a sharp decrease in the survival rate of E. coli ATCC 25922 (up to 20%), complete destruction of *M. Avium* 104, and a thousandfold decrease in the survival rate of *Mycobacterium tuberculosis* H37RV (*Pasteur*) ATCC 25618 were obtained [15,16]. A decrease in survival occurred when the frequency of the electromagnetic field (EMF) coincided with the natural frequency of torsional vibrations of the helices of bacterial DNA molecules.

In [17] it was proved that in vitro DNA molecules of bacteria *E. coli* M17, *M. Avium* and *Mycobacterium Tuberculosis* are able to absorb centimeter waves of EMF. This happens when the frequency of the microwave EMF is in resonance with the natural frequency of torsional vibrations of the helix of the DNA molecule. In the elastic rod model, using Lagrange formalism and experimental data, general formula for these oscillations was obtained:

$$f = 21,75BP^{-1/2}THz \quad (1)$$

Where BP is the number of base pairs. The numerical coefficient 21.75 integrally takes into account the heterogeneity of the DNA chain, its compactification, and its environment.

As a result of excitation by an external field of torsional vibrations in DNA molecules, the number of single-strand breaks in DNA increases dramatically, and the bacterium dies.

It was shown in [18] that the effect of centimeter and millimeter waves on the short DNA of lymphocytes leads to a sharp increase in the number of single-strand breaks (OR) in the DNA helix. The samples were irradiated for 10 minutes. The number of OR DNA molecules in lymphocytes increases compared to control samples: when exposed to radiation at a frequency of 3.5 GHz by (32.3 ± 0.9)%, at a frequency of 50 GHz by (40.1 ± 1.1)%, at a frequency of 70 GHz by (49.8 ± 0.7)%. These points belong not to one, but to three curves, whose extremes can be obtained by extrapolation, approximately counting the curves of the dependence of the number of OP on the frequency as parabolas, which is quite correct [15]. The molecular weight of the DNA of lymphocytes is. At the maximum mass of DNA lymphocytes (5330 bp), the frequency of torsional vibrations of its spiral is 298 GHz according to the formula (1). This frequency is very close to the extrapolation of 310 GHz using a parabola for the 70 GHz point, the difference can be explained by the fact that the DNA of lymphocytes was taken outside the cell. This proves that the OR in the DNA isolated from lymphocytes arises as a result of the excitation of torsional vibrations of the helices of molecules by microwaves in DNA molecules. In turn, the data [18], confirm the results [15-17].

The question arises: is it possible to apply a similar approach to short RNA viruses?

Single RNAs

In most single RNA, there are short complementary sequences that pair and form loops, so short intramolecular double-stranded sections are constantly formed in single chains. Base pairing leads to the formation of nucleotide sections in the form of loops, spiral sections form U-shaped fragments in which antiparallel sequences of nucleotides connected by hydrogen bonds are connected by at least three nucleotides forming a bend. Due to the interaction of RNA nucleotides and their combination into pairs according to the principle of complementarity, in addition to loops, hairpins, hairpins with an inner loop, duplexes with two protrusions, pseudo-nodes (two hairpins combined in a special way), and molotoid ribozymes appear in the molecule.

Thus, a single RNA molecule has the form of a randomly folded chain. Local conformations of nucleotides are close to the optimal canonical for 85% of nucleotides, and 15% are in one of the more intense canonical conformations [19,20].

The moment of inertia of the single helix turn of RNA J is half that of DNA, therefore, half that of BP. Accordingly, the natural frequency for RNA is $2^{1/2}$ times greater than the frequency for DNA. But the rigidity of a single chain is half as much, it would seem that the formula should not change.

However, in DNA, two connected helices rotate relative to each other. I.e., two DNA helices react to microwaves separately, the rigidity in (1) during the transition from DNA to RNA relative to torsional vibrations can be considered unchanged, therefore, the multiplier $2^{1/2}$ in the formula for RNA is preserved.

The nitrogenous base in RNA, complementary to adenine, is not thymine with a molar mass of 126.11334 g/mol, as in DNA, but uracil with a molar mass of 112.08676 g/mol (an unmethylated form of thymine). That is, the mass and, accordingly, the moment of inertia of the spiral coil is less.

The effect of an external electromagnetic field on disordered RNA twists non-spiral sections of the chain into a spiral, therefore formula (1) is also valid for single RNAs. As a result, we have:

$$f_{RNA\_SINGLE} = 31,196N^{-1/2} \quad (2)$$

Where N is the number of bases (not pairs). For double helix RNA or two RNAs in a capsid

$$f_{RNA\_DUBLE} = 22,0589N^{-1/2} \quad (3)$$

Where N is the number of base pairs.

Virus genome

The monkey virus SV40 has a double-stranded ring DNA. The genome of herpesviruses is represented by linear DNA, which closes into a ring in an infected cell. The double-stranded ring genomes of papovaviruses are replicated with the preservation of the ring structure. The genome of retroviruses is formed by RNA. The M13 and fiH174 phages parasitizing in *E. coli* bacterial cells have ring-shaped single-stranded DNA. The genome of the hepatitis B virus is a double-stranded ring of DNA, the length of the genome is different in different isolates. One of the chains ("plus-chain") DNA is shorter than the other (its length is 1700-2800 nucleotides), i.e. the spiral is only partially double-stranded. The second chain is also not closed, a polymerase molecule (P) is covalently attached to its 5' end.

Let's estimate the characteristic lengths of DNA or RNA helices of viruses using formulas (1), (2), and (3).

For example, bacteriophage T4 has one double-stranded linear DNA molecule consisting of only 160-103 pairs of nucleotides, frequencies – 1.72 – 2.14 THz.

The influenza virus has an absolute value of the total molecular weight of the vRNA. Depending on the method of its determination, it varies from 4,86 × 10^5 to 5,9 × 10^6

Da for different authors. Since the mass of one nucleotide is approximately 345 Da, the lengths of the vRNA are from 7000 to 8500 nucleotides.

HIV genetic material is represented by two copies of positive-sense (+) RNA.

The number of nucleotide pairs of short DNA and RNA viruses lies in the range of 100 – 240,000 bp.

The calculation shows that the lengths of RNA or DNA of most dangerous viruses correspond to frequencies lying in the sub-terahertz (at the limit of the millimeter range), terahertz, and IR ranges, and this, it would seem, does not allow radiation to be delivered directly to the infected cell due to the skin effect. The shorter the wavelength, the greater the skin effect.

Even in the absence of heating, the EMF of the millimeter range attenuates in the upper layers of the skin at a thickness of 0.2 mm - 0.8 mm, especially strongly weakened by the conductive germ layer (hydrated proteins, collagen molecules, connective tissue cells).

However, firstly, the skin effect strongly depends on the magnitude of the EMF intensity. For example, the EMF power flux density of 10 mW/cm^2 allows overcoming the skin. Accordingly, with a wavelength of 3.7 – 8.7 times smaller, power flux densities of 1.15 - 2.7 mW/cm^2 are required to eliminate the skin effect. For example, the energy density of relic radiation in the millimeter range is extremely small, about 400-500 photons per 1 cm^3, the radiation reveals itself in decimeter antennas as noise with an effective temperature of 2.7 K. Therefore, the relic radiation passes freely through the human body, about 105 relic photons are constantly present in the human oral cavity.

Curiously, there are no viruses with an RNA length in the region of 37,826 nucleotides, which corresponds to the frequency of torsional vibrations of the RNA helix of 160.4 GHz. Perhaps the fact is that this is the peak frequency of background radiation. Although its energy density is small, because its effects are constant, it can affect the evolution of RNA viruses.

If we take into account that the skin layer is not an ideal surface, but a layer with many folds and pores, then the possibility of field penetration beyond this layer increases, and the density of the EMF power flow can be doubled.

Secondly, it is possible to use subharmonic resonance. In addition to the natural frequency, resonance also occurs on subharmonics, at frequencies of the driving force that are multiples of the natural frequency, for example, etc. With increasing multiplicity, the resonance intensity decreases rapidly, the greater the multiplicity, the slower the amplitude increase [21,22]. Therefore, the exposure time should be increased. Under the action of a driving force with a frequency n time less than its own, the oscillation amplitude increases to a maximum exceeding the amplitude of the free oscillator oscillations. Thus, to influence short macromolecules, centimeter waves with frequencies of the order of 10 GHz can be used, the frequencies of which are multiples of the natural frequencies of the millimeter range. EMF of such frequencies freely passes through the human body. Resonance occurs at all frequencies of the driving force that satisfy the relation, where m and n are integers.

Thus, it is advisable to calculate the natural frequencies of torsional vibrations of DNA and RNA spirals of the most dangerous viruses and the frequency of EMF in the centimeter range, which lead to their destruction. The data are summarized in Table 1.

Experimental confirmation

In [23], a method for inactivating the influenza A (H3N2) virus was found. It is noted that the inactivation coefficient above 50% can be observed in the entire studied frequency range of 8-8.4 GHz.

Table 1: Physical characteristics of virus genomes.

Name	Length	Genome	f_1, GHz	f_2, GHz	Multiplicity
Monkeypox virus	196 858 bp	DNA	49,0	9,804	5
Variola major virus	240 000 bp	DNA	44,4	11,100	4
Adenoviridae	34-36 тыс. bp	DNA	118 - 114	-	-
Human respiratory syncytial virus, HRSV	15 277 bp	DNA	176	10,351	17
Rhinovirus	10 000 n	RNA	217,5	10,357	21
Hepatitis B virus, HBV	3200 n	DNA	f_3	-	-
HIV-1	9180	2 RNA	230,23	10,010	23
Coxsackievirus	7396 bp	DNA	252,9	10,116	25
Ebola virus Zaire	18 959	RNA	226,56	10,298	22
E.v. Sudan	18 875	RNA	227,07	10,321	22
E.v.Bundibugyo	18 940	RNA	226,68	10,3035	22
Influenza viruses	7000-8500 n	vRNA	372,86-338,37	-	-
A (H3N2)	13 628 n	RNA	267,228	8,35	32
Coronaviruses	26-30 тыс. n	RNA	193,47-180,11	-	-
SARS-CoV-2	29 903	RNA	180,402	10,022	18

Here bp is a base pair, n is a nucleotide, f_1 is the natural frequency of torsional vibrations of the DNA or RNA helix, f_2 is the frequency of the generator in the centimeter range necessary for the destruction of DNA or RNA, f_3 is the frequency, the value of which must be established experimentally.

At a frequency of 8.35 GHz, a 100% inactivation coefficient has been achieved, that is, this frequency is resonant. However, there are a number of significant shortcomings in the article.

1) The authors used a spherical model of the virus [24], that is, together with a capsid, which can have the shape of an icosahedron. However, the virus RNA is an irregular spiral, it has a different topology, and different properties, hence a different frequency spectrum. Although the authors established the resonant frequency not from the selected model, but by experimental selection.

2) The article claims that the influenza virus dies at temperatures above 55 degrees. At a temperature of 37.5 degrees. The influenza virus stops multiplying, at 38.5 C the virus dies. In clinical practice, when the thermometer readings are no more than 38.5 C, antipyretics are not indicated.

3) In the experiments conducted by the authors, the temperature increased by 7 degrees, to 34.5 degrees. This is not a critical temperature, but the thermal effect is of a statistical nature, so an increase in temperature had an effect on reducing the activity of viruses.

4) That is why, far from resonance, the results of 50% inactivation of viruses were obtained (although it is unclear how 50% can be obtained with a PCR test, except in real-time).

5) The article specifies several values of the power flow density: 765 - 882 W/m^2, 810 W/m^2, 486 W/m^2, 320 W/m^2. The used power flow density is 20 - 40 times higher than sanitary standards. However, the exposure time is only 15 minutes, which corresponds to the exposure time for dm- and cm-therapy used in pulmonology. At the same time, the question remains about the achievability of the organ affected by the coronavirus by the electromagnetic field, since at thermal capacities, the depth of penetration of microwave EMF into the body is about 12-15 cm.

The length of the A (H3N2) virus RNA is 13628 nucleotides. The calculation by formula (1) gives the natural frequency of torsional vibrations of the virus spiral as 267.228546 GHz, which is a multiple of the frequency of 8.35 GHz with a high degree of accuracy. Thus, the data [23] confirm formula (2).

Indirect confirmation of formula (2) is the data of DNA irradiation of arthropod hemolymph amoebocytes [25].

A direct confirmation is the data of experiments on the irradiation of COVID-19 [26]: positive samples of COVID-19 were used. In 14 experiments, it was shown that microwaves at an estimated frequency of 10.022 GHz completely destruct COVID-19 RNA molecules. The control and experimental positive samples were selected, and the exposure time for the experimental sample was 2 hours. The RT-LAMP test was used for verification. The radiation source was an Agilent Technologies E82570 1 microwave generator, an Agilent Technologies E82570 power amplifier was used to amplify the signal to 1 W. The density of the microwave power flux was 2.5 mW/cm^2.

The corresponding experiments to test formula (1) in terms of disinfection of COVID-19 outside the human body using millimeter waves were carried out using an EHF-ND type generator. 15 samples containing COVID-19 were examined on dry gauze, in insulating capsules. The density of the radiation power flux on the capsule surface is 3 MW/cm^2. The irradiated samples were analyzed using RT-LAMP PCR tests. At a resonant frequency of 180,402 GHz, 3 samples were irradiated for 10 seconds, the result was negative. 4 samples were irradiated for 15 seconds, and 1 sample showed the presence of COVID-19. 8 samples were trained for 20 seconds, all samples showed the absence of COVID-19. At a non-resonant frequency of 180.0 GHz, 4 experiments were conducted, samples were irradiated for 25 seconds, and all samples showed the presence of COVID-19.

Conclusion

Thus, the assumption is confirmed that microwaves, whose frequency coincides with the natural frequency of torsional vibrations of the spirals of RNA viruses, as well as their subharmonics, lead to the destruction of these RNAs.

Millimeter waves can be used for disinfection [27]. Centimeter microwaves of a non-thermal level of power flux density freely pass through the human body, the action of microwaves with frequencies that are multiples of the natural frequencies of torsional vibrations of RNA and DNA spirals of viruses leads to their destruction [28]. That is, the results obtained can be used in medicine.

The author expresses gratitude to the associate professor of the Perm branch of the Centralized Clinical and Diagnostic Laboratory P. V. Popov, professor of the PSNIU I. L. Volkhin, and Doctor of Technical Sciences of the Perm Polytechnic University N. A. Kharlamova for their help in the work.

References

1. Devyatkov ND, Betsky OV. Features of the interaction of low-intensity millimeter radiation with biological objects. In the collection: The use of low–intensity millimeter radiation in biology and medicine. M.: IRE of the USSR Academy of Sciences. 1985; 6-20.
2. Mkrtchyan LN, Sitko SP, Shukaryan SG. On the effect of millimeter electromagnetic radiation on tumor growth in an experiment. // In the collection: Fundamental and applied aspects of the use of millimeter electromagnetic radiation in medicine. - I All-Union Symposium with international participation. Kiev, May 10-13, 1989 (collection of reports.). 1989; C. 315-317.
3. Sevastyanova LA. Features of biological effects of radio waves of the mm band and the possibility of their use in medicine. Bulletin of the USSR Academy of Medical Sciences. 1979; C. 65-68.
4. Sitko SP, Mkrtchyan LN. Introduction to quantum medicine. Kiev, Pattern. 1994; 147.
5. Devyatkov ND, Betsky OV, Kabisov RK. The effect of low-energy pulsed EHF and microwave radiation of nanosecond duration with high peak power on biological structures (malignant formations). Biomedical radio electronics. 1998; 56-62.

6. Pentin Yu A, Vilkov LV. Physical methods of research in chemistry. M.: Mir. 2003; 683.
7. Pentin Yu A, Vilkov LV. Physical methods of research in chemistry. M.: The World. 2003; 683.
8. Scientific session of the Department of General Physics and Astronomy of the USSR Academy of Sciences on January 17-18, UFN, 1973; 110.
9. Gapeev AB, Chemeris NK. The effect of continuous and modulated EHF EMR on animal cells. Bulletin of New Medical Technologies. 2000; 7:20-25.
10. Globus T, Khromova T, Gelmont B, Voolard D, Tamm LK. Terahertz characterization of dilute solution of DNA. Proc of SPIE. 2006; 6093: 609308.1-608309.12.
11. Semenov M, Bolbukh T, Maleev V. Infrared study of influence of water on DNA stability in dependence of AT/GC composition. Journal of Mol Structure. 1997; 408/409: 213-217.
12. Fischer BM, Walther M, Uhd Jepsen P. Far-infrared vibrational modes of DNA components studied by terahertz time-domain spectroscopy. Phys Med Biol. 2002 Nov 7;47(21):3807-14. doi: 10.1088/0031-9155/47/21/319. PMID: 12452571.
13. Tsurkai MA, Sobakinskaya EA, Smolyanskaya OA. Investigation of the spectrum of a DNA molecule in the terahertz frequency domain. Scientific and Technical Bulletin of St. Petersburg State University of Information Technologies, Mechanics and Optics. 2012; 1(77): 15-18.
14. Tsurkay MA, Sobakinskaya EA, Smolianskaya OA. Study of the spectrum of the DNA molecule in the terahertz frequency region. Scientific and Technical Herald of St. Petersburg State University of Information Technologies. Mechanics and Optics. 2012; 1(77):15-18.
15. Ikhlov BL, Melnichenko AV, Oshchepkov AY. The effect of a high-frequency electromagnetic field on microorganisms. Bulletin of New Medical Technologies. 2017; 24(2): 141-146.
16. Ikhlov BL, Shurygin AA, Drobkova VA. Possibility of bactericidal action of microwaves on Mycobacterium avium and Mycobacterium tuberculosis strains. Tuberculosis and lung diseases. 2019; 97(1): 25-27. https://doi.org/10.21292/2075-1230-2019-97-1-25-27 ;
17. Ikhlov BL. Resonant Absorption of Microwaves by Macromolecules. Open Access Library Journal. 2022; 9.
18. Tekutskaya EE, Vasiliadi RV. Structural damage to the DNA of human peripheral blood lymphocytes under the influence of physical factors. Human Ecology. 2017; 12: 9-14.
19. Wan Y, Kertesz M, Spitale RC, Segal E, Chang HY. Understanding the transcriptome through RNA structure. Nat Rev Genet. 2011 Aug 18;12(9):641-55. doi: 10.1038/nrg3049. PMID: 21850044; PMCID: PMC3858389.
20. van Batenburg FH, Gultyaev AP, Pleij CW. PseudoBase: structural information on RNA pseudoknots. Nucleic Acids Res. 2001 Jan 1;29(1):194-5. doi: 10.1093/nar/29.1.194. PMID: 11125088; PMCID: PMC29770.
21. Doev VS, Doronin FA. Resonant modes in linear oscillatory systems with multiple frequencies. News of the St. Petersburg University of Railway Transport. 2006; 1:17-22.
22. Butikov EI. Pendulum with oscillating suspension (subharmonic resonances). Computer tools in education. 2011; 1: 31-49
23. Yang SC, Lin HC, Liu TM, Lu JT, Hung WT, Huang YR, Tsai YC, Kao CL, Chen SY, Sun CK. Efficient Structure Resonance Energy Transfer from Microwaves to Confined Acoustic Vibrations in Viruses. Sci Rep. 2015 Dec 9;5:18030. doi: 10.1038/srep18030. PMID: 26647655; PMCID: PMC4673452.
24. Lamb H. On the Vibrations of an Elastic Sphere. Proc London Math Soc. 1881;13:189.
25. Ikhlov BL, Volkhin IL, Yu OA. On the mechanism of action of microwaves on arthropods. Biophysics. 2022; 67: 327-332. https://elibrary.ru/item.asp?id=47997849
26. Ikhlov BL. Short Spiral Macromolecules in an External Electromagnetic Field. Open Access Library Journal. 2022; 9: 1108684 DOI: 10.4236/oalib.1108684 https://www.scirp.org/journal/paperinformation.aspx?paperid=117490
27. Ikhlov BL. Distribution and disinfection of covid-19. International Conference “Process Management and Scientific Developments”, Birmingham, United Kingdom (Novotel Birmingham Centre). 2020; 104-110. DOI 10.34660/INF.2020.87.64.016
28. Ikhlov BL, Volkhin IL, Yu OA. A method for suppressing the development of COVID-19 and HIV by non-thermal resonant microwave therapy.