A Study toward Disintegration of Coronavirus using Near-infrared Light Therapy

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Abstract

A coronavirus is a protein molecule covered by a thin layer of fat. It binds to the human cells and replicates within the cells. The near-infrared light produces intense heat, and also penetrates tissue in order to deliver energy to cells. In the present study, an ideal model of a cell full of viruses is considered. The propagation of near-infrared electromagnetic waves in such a dielectric medium is examined to check whether the near-infrared wavelengths may deliver energy to the medium. With the known observations of refractive indices of cell and virus, below the near-infrared wavelengths, it is computed that the near-infrared wavelengths deliver “excessive” energy to the dielectric medium. Thus, light at near-infrared wavelengths may penetrate and heat tissue affected by coronavirus. It may result in the melting of layer of fat of coronavirus in cells. Near-infrared light therapy at discrete wavelengths in the band (700 – 900 nm) may reduce severity of conditions in the gravely affected coronavirus patients.

Introduction

The model calculations presented in this report are in view of a pdf file mailed by Johns Hopkins University, which has quoted reference [1]. Accordingly, the corona virus is a protein molecule covered by a thin layer of fat, the lipid membrane. The virus binds to the host cells and then penetrates to release the viral DNA, which controls the cell’s metabolism. It then replicates itself within the cells of its host and forms new viruses. It is the thin layer of fat that protects the virus from being destroyed. However, this thin layer of fat may be dissolved by heat. Now, it is known that near-infrared light at wavelengths between 700 – 1400 nm generates the “most intense” heat in the infrared spectrum 700 – 2500 nm. The wavelengths between 700 – 1400 nm form the near-infrared wavelength band. These wavelengths penetrate into human tissue. These are absorbed, delivering energy to cells. The near-infrared wavelengths heat tissue for the consequent health-related benefits [2]. The corresponding therapy is called near-infrared light therapy. The longer wavelengths in the band are also known to penetrate “deep” into tissue, compared to the shorter wavelengths, in the near-infrared band [2].

In the present study, an ideal model of a cell-plus-viruses has been envisaged, where a large number of viruses are ideally placed in a cell so as to form an ideal spherical microcavity at near-infrared wavelengths. The dielectric medium of such an ideal microcavity has been

examined to determine whether such a dielectric medium may have “excessive” (photon) energy transfer, compared to “normal” energy transfer, by near-infrared wavelengths.

Observations

Basic Data on Virus

Size of virus: 20 - 400 nm (nanometer, 1 nanometer = 10^{-9} meters) [3]

Diameter of virus, assumed spherical, in the present model:

- (i) 100 nm, lower portion of near-infrared band
- (ii) 200 nm, near-infrared band

Radius of virus in the present model:

- (i) 50 nm, lower portion of near-infrared band
- (ii) 100 nm, near-infrared band

Refractive index of virus at 532 nm: 1.45 [4]

Refractive index of virus in the near infrared band 700 – 1400 nm, in the present model:
1.45

Basic Data on Human Cell

Size of cell (nucleus + cytoplasm): 8000 nm

Thickness of cell membrane: 10 nm

Thickness of membrane, assumed spherical, in the present model:
10 nm

Thickness of cell, assumed spherical, in the present model:
8000 nm

Refractive index of cell: 1.36 - 1.38 [5]

Refractive index of cell at 510 – 750 nm: 1.33 – 1.38 [6]

Refractive index of cell in the near infrared band 700 – 1400 nm, assumed in the present model:

- (i) 1.37, lower portion of near-infrared band
- (ii) 1.30, near-infrared band
- (iii) 1.31, near-infrared band
- (iv) 1.32, near-infrared band
- (v) 1.37, near-infrared band

Methodology

(i) Radius of virus $r = 50$ nm, cell refractive index $n = 1.37$, lower portion of near-infrared band

The design of an ideal spherical microcavity at 650 nm of viruses of radius $r = 50$ nm (diameter 100 nm) and refractive index $n = 1.45$ in a cell of refractive index $n = 1.37$ is presented in Figure 1.

Figure 1. A spherical microcavity consisting of virus-core of radius $r=50$ nm ($n=1.45$), and eight pairs of layers of cell ($n=1.37$) and virus ($n=1.45$). Two pairs of layers of virus and cell are depicted. There are 17 viruses in a cell, overall.

Such a microcavity is termed as Bragg Onion Resonator without the stem [7]. (The stem is an opening, which is used to excite TE/TM modes of monochromatic electromagnetic waves.) It is also termed as Bragg Reflector [8]. The formulation of a Bragg Onion Resonator for TE_{10} (and TM_{10} mode) of electromagnetic wave propagation has been coded in the C programming language [9]. This C programming code has been used to compute the wavelength of resonance in the spherical microcavity in Figure 1. (A similar set of computations can be made for TM_{10} mode.)

The thickness of virus-layer is $d = 650/4 \cdot 1.45 \approx 112$ nm, which approximately equals the size of virus-core (diameter) of 100 nm. The thickness of cell-layer is $d = 650/4 \cdot 1.37 \approx 119$ nm. There are 17 viruses in a cell. The total thickness of the spherical microcavity, including the thickness of the membrane, is roughly 4000 nm; the cell size (diameter) is 8000 nm.

The spherical microcavity in Figure 1 implies resonance at wavelength 694.1 nm. The quality of occurrence of resonance in the microcavity is “good”. A resonance in a cavity implies “excessive” transfer of (photon) energy at the computed wavelength. (In the present study, it suffices to qualify the meeting of the condition of occurrence of resonance in a microcavity as “high” or “good” or “fair”.)

It may be noted that one cannot design an ideal spherical microcavity at 650 nm for the virus-core of radius $r = 100$ nm (diameter 200 nm), since the virus-core size (200 nm) is not roughly equal to the designed virus-layer thickness $d \approx 112$ nm at 650 nm.

(ii) Radius of virus $r = 100$ nm, cell refractive index $n = 1.30$, in near-infrared band

The design of an ideal spherical microcavity of viruses of radius $r = 100$ nm (diameter 200 nm) and refractive index $n = 1.45$ in a cell of refractive index $n = 1.30$ at 1050 nm is considered.

The thickness of virus-layer is $d = 1050/4 \cdot 1.45 \approx 181$ nm, which approximately equals the size of virus-core (diameter) of 200 nm. The thickness of cell-layer is $d = 1050/4 \cdot 1.30 \approx 202$ nm. There are 10 viruses in a cell. The total thickness of the spherical microcavity, including the thickness of the membrane, is roughly 4000 nm; the cell size (diameter) is 8000 nm.

The spherical microcavity implies “good” resonance at wavelength 904.8 nm. A resonance in a cavity implies “excessive” transfer of (photon) energy at the computed wavelength. (In the present study, it suffices to qualify the meeting of the condition of the occurrence of resonance in a microcavity as “high” or “good” or “fair”.)

It may be noted that one cannot design an ideal spherical microcavity at 1050 nm for the virus-core of radius $r = 50$ nm (diameter 100 nm), since the virus-core size (100 nm) is not roughly equal to the designed virus-layer thickness $d \approx 181$ nm at 1050 nm.

(iii) Radius of virus $r = 100$ nm, cell refractive index $n = 1.31$, in near-infrared band

The design of an ideal spherical microcavity of viruses of radius $r = 100$ nm (diameter 200 nm) and refractive index $n = 1.45$ in a cell of refractive index $n = 1.31$ at 1050 nm is considered.

The thickness of virus-layer is $d = 1050/4 \cdot 1.45 \approx 181$ nm, which approximately equals the size of virus-core (diameter) of 200 nm. The thickness of cell-layer is $d = 1050/4 \cdot 1.31 \approx 200$ nm. There are 10 viruses in a cell. The total thickness of the spherical microcavity, including the thickness of the membrane, is roughly 4000 nm; the cell size (diameter) is 8000 nm.

The spherical microcavity implies “good” resonance at wavelength 902.8 nm. A resonance in a cavity implies “excessive” transfer of (photon) energy at the computed wavelength. (In the present study, it suffices to qualify the meeting of the condition of the occurrence of resonance in a microcavity as “high” or “good” or “fair”.)

(iv) Radius of virus $r = 100$ nm, cell refractive index $n = 1.32$, in near-infrared band

The design of an ideal spherical microcavity of viruses of radius $r = 100$ nm (diameter 200 nm) and refractive index $n = 1.45$ in a cell of refractive index $n = 1.32$ at 1050 nm is considered.

The thickness of virus-layer is $d = 1050/4 \cdot 1.45 \approx 181$ nm, which approximately equals the size of virus-core (diameter) of 200 nm. The thickness of cell-layer is $d = 1050/4 \cdot 1.32 \approx 200$ nm. There are 10 viruses in a cell. The total thickness of the spherical microcavity, including the thickness of the membrane, is roughly 4000 nm; the cell size (diameter) is 8000 nm.

The spherical microcavity implies “fair” resonance around wavelength 1188 nm. A resonance in a cavity implies “excessive” transfer of (photon) energy at the computed

wavelength. (In the present study, it suffices to qualify the meeting of the condition of the occurrence of resonance in a microcavity as “high” or “good” or “fair”.)

(v) Radius of virus $r = 100$ nm, cell refractive index $n = 1.37$, in near-infrared band

The design of an ideal spherical microcavity of viruses of radius $r = 100$ nm (diameter 200 nm) and refractive index $n = 1.45$ in a cell of refractive index $n = 1.37$ at 1050 nm is considered.

The thickness of virus-layer is $d = 1050/4 \times 1.45 \approx 181$ nm, which approximately equals the size of virus-core (diameter) of 200 nm. The thickness of cell-layer is $d = 1050/4 \times 1.37 \approx 192$ nm. There are 10 viruses in a cell. The total thickness of the spherical microcavity, including the thickness of the membrane, is roughly 4000 nm; the cell size (diameter) is 8000 nm.

The spherical microcavity implies “fair” resonance around wavelength 1175 nm. A resonance in a cavity implies “excessive” transfer of (photon) energy at the computed wavelength. (In the present study, it suffices to qualify the meeting of the condition of the occurrence of resonance in a microcavity as “high” or “good” or “fair”.)

Data Analysis

In a real-world scenario, the formation of viruses in a cell is a random process. One has to consider propagation of near-infrared electromagnetic waves in a random dielectric medium. The data on the dielectric medium comprising virus and cell need also to be appropriate to near-infrared wavelengths. The present study is desired in the prevailing dire coronavirus situation. The aim of the study is to adopt the existing dielectric data in an ideal-world scenario, to compute “excessive” transfer of (photon) energy to the dielectric medium of cells-plus-viruses, if it exists, compared to “normal” delivery of energy by near-infrared waves to tissue of cells alone. Such a study may imply “reasonable excessive” delivery of energy by near-infrared waves to tissue of cells-plus-viruses in a real world scenario, which is the need of the hour.

The virus sizes of 100 nm and 200 are reasonable estimates of small- and large-size virus. The refractive index of 1.45 of virus is also a reasonable value. The refractive of cell of 1.37 is appropriate to lower limit of near-infrared band of 700 – 1400 nm. In the present study, the refractive index of cell is taken 1.30, 1.31 and 1.32 in the near-infrared band. (The dielectric medium is not an intrinsically absorbing medium of light. Therefore, refractive index decreases with wavelength of light. In an intrinsically absorbing medium, the refractive index increases with wavelength.)

The propagation of near-infrared light in an ideal dielectric medium of cell-plus-viruses implies “excessive” absorption of (photon) energy at the computed wavelength, compared to “normal” absorption by tissue.

The (photon) quantum of energy ($h\nu$, J) at 1000 nm wavelength, with the usual notation of symbols, is two-orders of magnitude higher than kinetic unit of energy (kT, J) at 300 K.

Conclusion

The observations on the refractive index of virus and human cell are known at below the near-infrared wavelength band. The refractive index of cell may be “logically” decreased in the

near-infrared band. The model calculations in the present study adopt values of refractive index of cell of 1.30, 1.31 and 1.32. The virus of size ~ 100 nm and ~ 200 nm have been used in the model calculations. The fat layer of virus in cells may melt by absorption, and heating of tissue, of near-infrared light at discrete wavelengths in the band (700 – 900 nm).

The near-infrared light therapy may provide relief to patients moderately and severely affected by coronavirus. However, it may not be useful to minor-affected coronavirus patients. The near-infrared device, such as, LED/laser may be suitably utilized. The level (optical power output, in milliwatts/watts), duration (seconds/minutes) and any side effects of near-infrared light therapy can only be provided by experts.

The temperature of melting of lipid membrane (fat layer of virus) for a variety of lipids commences around 24°C to 46°C [10]. The solar radiation in the visible and infrared spectrum, (250 – 2500 nm), heats both earth and atmosphere through a variety of physical processes. At night, the earth reradiates solar radiation in the longer wavelength spectrum around (750 – 30000 nm) to maintain earth's and atmosphere's temperature, again through a variety of physical processes. There is likely to be melting of coronavirus lipid membrane (fat layer), of viruses in the environment, by heating in summer months. It is expected that the rising of temperature in summer months shall lead to “natural sanitization” of the environment by the solar radiation. It may lead to decrease in coronavirus cases in summer months.

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