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QED Disinfection of Drinking Water in the Developing World

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Abstract

WHO/UNICEF estimates almost 1 billion people in the developing world do not have access to safe drinking water. Conventional water treatment is unfeasible because of costs and lack of electricity. QED induced UV radiation using hand-held nano-coated drinking bowls is proposed to inexpensively disinfect water without electrical power. QED stands for quantum electrodynamics. QED disinfection is a consequence of QM that forbids the atoms in nano-coatings under TIR confinement to have the heat capacity to increase in temperature. QM stands for quantum mechanics and TIR for total internal reflection. Instead, conservation proceeds by QED inducing the heat to be converted to EM radiation that can be tuned to UV-C radiation to by selecting the proper coating thickness. EPA guidelines for disinfection require the minimum UV-C dose of 16 to 38 mJ / cm^2. With body heat of about 6 mW / cm^2, the drinking bowl disinfects drinking water in 3 to 6 seconds. Extensions of QED radiation in the drinking bowl are made to the disinfection of the Ebola virus.

Keywords: nano-coated bowl, disinfection, drinking water, Ebola virus, quantum mechanics, QED

1. Introduction

Currently, WHO/UNICEF estimates [1] almost 1 billion people in the developing world do not have access to safe drinking water. Moreover, about 2 million childhood deaths have been attributed to water-borne diseases. Conventional water treatment is unfeasible because of costs. Lacking municipal water supplies, the water is collected from rivers or lakes and stored in containers for later use which may also be contaminated. The most direct disinfection is by boiling small quantities of water, but this requires a source of heat which, except for fire, is usually not available. However, focusing sunlight to boil small quantities of drinking water avoids the need to build fires, but would be expensive and only be available during daylight hours. In the developing world, alternative low-cost methods are desirable.

Unfortunately, there are no known low-cost alternatives to purifying water other than by boiling. If, however, portable electrical power is available, the water could be pumped through ceramic or resin filters [2] coated with silver NPs. NP stands for nanoparticle. Silver NPs are widely known to provide antimicrobial action by damaging the DNA of bacteria, but NPs that come off the filter and enter drinking water also [3] damages human DNA that if not repaired, may lead to cancer. Regardless, NP coated filters are unfeasible because electrical pumping power is not available and costly if available.

In contrast, UV disinfection [4] of drinking water occurs outside the body and avoids the danger of cancer posed by NPs in filters. Solar-UV mediated pathogen disinfection for municipal water and wastewater treatment avoids the need for electricity, but is otherwise too costly for the developing world. Currently, LEDs in the UV-C are thought [4] to provide personal disinfection of drinking water. LEDs stand for light emitting diodes. The benefits of UV-C LEDs are mercury free and low voltage sources, but still require a source of electrical power.

2. Proposal

QED induced UV radiation using hand-held nano-coated drinking bowls is proposed by which drinking water is disinfected inexpensively with body heat as depicted in Fig. 1

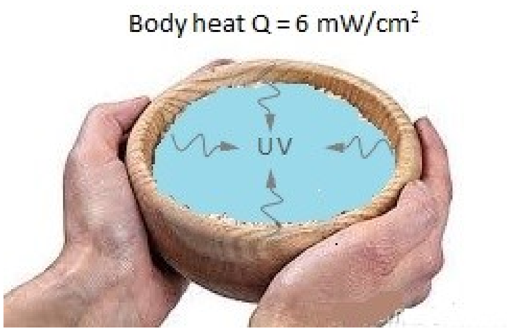

Fig. 1 QED induced UV radiation from body heat in hands disinfecting bowl of water

QED induced disinfection of drinking water is a consequence of QM that precludes the atoms in nano-coatings to have the heat capacity to conserve body heat by an increase in temperature. Instead, the heat is induced by QED to produce UV radiation.

3. Theory

3.1. QM Restrictions

Classically, the atoms in nano-coatings always have the heat capacity to increase in temperature upon the absorption of heat irrespective of their thickness, i.e., there is no size effect in classical physics. QM differs in that the heat capacity of the atom depends on the thickness of the coating. A comparison of the thermal kT energy (or the heat capacity) of the atom by classical physics and QM by the Einstein-Hopf relation [4] for the atom as a harmonic oscillator is shown in Fig. 2.

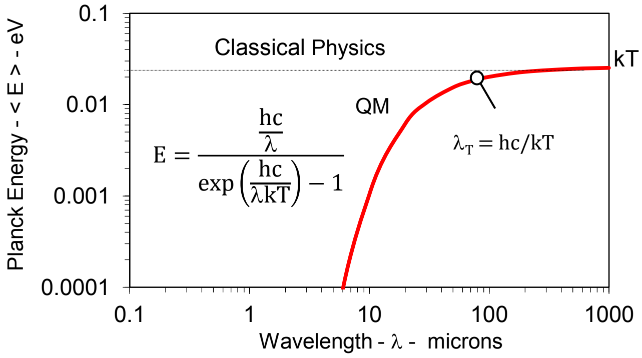

Fig. 2 Heat Capacity of the Atom at 300 K . In the inset, E is Planck energy, h Planck's constant, c speed of light, k Boltzmann's constant, T temperature, and λ wavelength

QM allows the atom in supramicron coatings to have kT energy and increase in temperature for $\lambda > \lambda_T$. However, atoms in micron sized coatings confined to $\lambda < 6$ microns have kT < 0.0001 eV or little heat capacity, while at the nanoscale for $\lambda < 100$ nm virtually no heat capacity is available to conserve absorbed heat by an increase in temperature.

3.2. Confinement and QED Radiation

TIR has a long history. In 1870, Tyndall showed light is trapped by TIR in the surface of a body if its RI is greater than that of the surroundings. RI stands for refractive index. Tyndall used water to show TIR confinement allowed light to be observed moving along the length of transparent curved tubes. TIR may confine any form of EM energy, although in the nano-coating of the drinking bowl the confined EM energy is the body heat from hands holding the bowl.

TIR confinement requires the deposited heat to be concentrated in the coating surface that is a natural consequence of nanoscale coatings having high S / V ratios, i.e., surface to volume ratios. Hence, QED creates standing wave photons within the TIR confinement formed between the coating surfaces, the number of photons conserving the heat absorbed. The wavelength λ of the standing photons is, $\lambda = 2\ d$, where d is the coating thickness.

However, TIR confinement by the coating surfaces is not permanent, sustaining itself only during heat absorption, i.e., absent absorption there is no TIR confinement for QED to conserve the heat by creating standing photons in the coating.

QED relies on complex mathematics as described by Feynman [5] although the underlying physics is simple to understand, i.e., EM radiation of wavelength λ is created by supplying heat to a QM box having sides separated by $\lambda / 2$. In this way, QED conserves absorbed EM energy by frequency up-conversion to the TIR resonance described by the thickness d of the coating. The Planck energy E of the QED radiation,

$$E = h\upsilon, \quad \upsilon = \frac{c/n}{\lambda}, \quad \lambda = 2d \qquad (1)$$

where, n is the RI of the coating.

3.3. UV Disinfection

UV light as a disinfectant penetrates an organism's cell walls and disrupts the genes to preclude reproduction. Research [6] has shown that the optimum UV wavelength range to destroy bacteria is between 250 and 270 nm. At 185 nm, UV light is powerful enough to produce ozone, hydroxyl, and other free radicals that destroy bacteria. The US HEW set guidelines for UV light disinfection require a minimum dose of 16 mJ / cm^2 at all points throughout the water disinfection unit, but recently the National Sanitation Foundation International set the minimum UV light requirement at 38 mJ / cm^2 for treat visually clear water.

4. Analysis

The wavelength of QED radiation emission from the conservation of heat in nanoscale coatings having n = 2 and 4 is shown in Fig. 3.

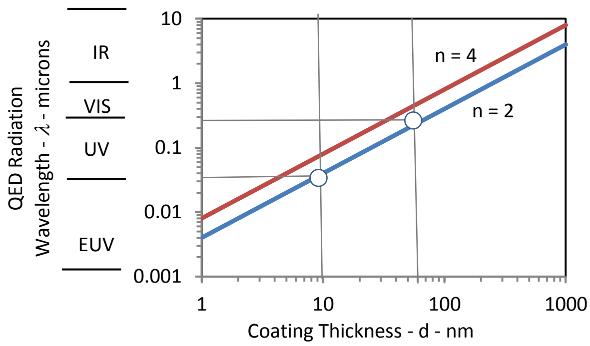

Fig. 3 Wavelength of QED Emission v. Coating Thickness

Insuring TIR confinement requires the RI of the coating to be greater than that of the substrate. Most RI vary from, 1.5 to 3. For the coating having = 2, the QED emission from 10 – 60 nm coating thicknesses produces EM radiation from UV-C to the near EUV. In water, the near UV-C at 254 nm may be transmitted over distances comparable to the size of the drinking bowl without any absorption. For n = 4, smaller coating thicknesses are required to produce UV-C.

Taking λ = 260 nm UV as the optimum UV wavelength for disinfection in a coating of n = 2, the coating thickness is 65 nm and a substrate having n < 2. Materials should be selected that are resistant to corrosion and readily cleanable. Of course, the RIs of the coating and substrate depend on wavelength and require evaluation at λ = 260 nm.

Total human body heat is about 100 W. Since the average surface area [8] for adult men and women is about 1.75 m^2, the heat flow Q = 5.71 mW / cm^2. Hence, the dose to destroy water pathogens of 16 to 38 mJ / cm^2 may be provided by keeping the water in the drinking bowl from 3 to 6 seconds.

5. Conclusions

An inexpensive drinking bowl is proposed for the third world that is simple to use and UV-C disinfects drinking water from body heat in the hands holding the bowl. Unlike other kinds of UV disinfection, no electricity is required.

6. Extensions

Similar to drinking water, the Ebola virus is a worldwide concern. In the U.S., Ebola disinfection includes electric powered hand-held systems that produce a blade-like light beam having an area of 50 mm x 500 mm. However, the protocol for Ebola disinfection in the U.S. is too complex and costly in the developing world requiring unavailable sources of electricity.

In this regard, QED induced EM radiation from body heat in a hand-held nano-coated bowl called an EBOWLA is proposed to provide the UV-C to inexpensively disinfect Ebola without the need for electricity. In operation, the 80 mm diameter EBOWLA provides a cylindrical beam of UV-C light from the body heat transferred to the nano-coating as shown in Fig. 4.

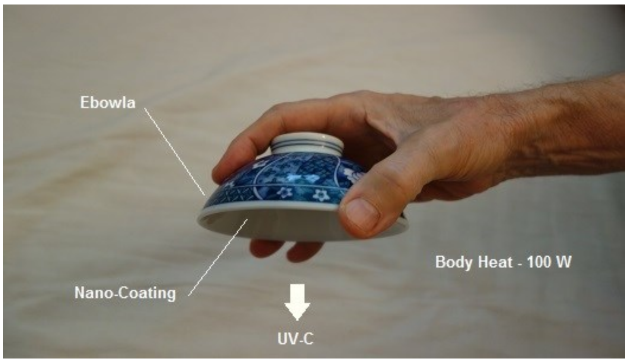

Fig. 4 Hand-held EBOWLA disinfecting Ebola virus using body heat

But like the drinking bowl, the temperature of the nano-coating cannot increase as its heat capacity vanishes by QM. Instead, QED induces the conversion of body heat to EM radiation having wavelength λ = 2 n d, where, n and d are the RI and thickness of the coating. For example, QED induces the creation of UV-C radiation at 254 nm in a coating having n = 2 and d = 63 nm. Since the heat Q supplied by the hand is about 6 mW / cm^2, and since the minimum UV-C dose necessary to destroy [9] the Ebola virus is 0.4 mJ / cm^2, the Ebowla moved in 1 second scans is more than capable of disinfecting patients of the Ebola virus.

The QED induced UV-C radiation from the EBOWLA is especially suited for disinfecting Ebola in the developing world that lacks sources of electricity. Costs are minimal allowing free distribution by governments to individuals.

Moreover, the EBOWLA may be used to disinfect drinking water as suggested in the body of this paper. But even in the developed world, the EBOWLA would allow simple germicidal disinfection for nurses in hospitals or the public in their homes as well as assuring drinking water is free of pathogens.

Where drinking water disinfection is not so important, the EBOWLA need not be a drinking bowl and replaced with a flat nano-coated surface, say carried in the pocket of a nurse or worn as a badge.

Once exposed to the virus, Ebola workers discard protective suits– an expensive procedure in West Africa. By adding an appropriate nano-coating, the suits continually emit UV-C to remove attached Ebola viruses and allow repetitive re-use.

The applications of QED induced UV-C radiation in the disinfection of infectious diseases are numerous and diverse, the development of which is beyond the capability of the author. Collaboration with interested parties is solicited.

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