International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(Research Article)

Check for updates

Analysis of water disinfection by chlorine and UV radiation using resonant recognition model

Irena Cosic [1,*], Drasko Cosic [1] and Ivan Loncarevic [2]

[1] *AMALNA Consulting, Department of R and I, Black Rock, 3193, Australia.*
[2] *QuantBioRes - QBR A/S, Department of R and D, Copenhagen, 2860, Denmark.*

International Journal of Science and Research Archive, 2025, 15(03), 1165-1169

Publication history: Received on 07 May 2025; revised on 14 June 2025; accepted on 16 June 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.15.3.1858

Abstract

Water disinfection is important in wide range of applications, like in laboratory, swimming pools and drinking water supplies. There are two major ways to disinfect water: UV radiation for laboratories and smaller drinking water supplies, and Chlorine treatment for swimming pools and larger water supplies. Here, we are trying to find out if there is any common mechanism between UV radiation and Chlorine water disinfection processes. By applying the Resonant Recognition Model (RRM), we have found out, here, that there is a possibility for Chlorine chemical reaction to be based on resonant energy transfer and that this resonant energy transfer is at the specific wavelength range same as UV radiation wavelength range used for water disinfection. These results are giving new perspective to possibility that molecular interactions/chemical reactions are based on resonant energy transfer at specific wavelength, which determines the specificity of their activity and not on their aggregate state. We postulate that interaction of particular chemical with surrounding structures is based on electromagnetic energy transfer between interacting entities.

Keywords: Water Disinfection; Chlorine; UV Radiation; Small Molecules; Resonant Energy; Resonant Recognition Model

1. Introduction

Disinfection of water from small laboratory amounts all the way up to larger amounts, like in swimming pools and drinking water supplies is huge problem. For small laboratory amounts of water usually the ultraviolet (UV) radiation is used, while for the larger volume of water usually the Chlorine treatment is used.

In laboratory settings, UV water purification process disinfects water by exposing it to UV radiation, with the aim to inactivate microorganisms like bacteria and viruses. UV systems are also commonly used in various industries, for water purification and sanitation. This process is a chemical-free and environmentally friendly method of water treatment [1].

UV water disinfection primarily occurs because UV radiation in the range of 200–280nm is destroying microorganisms [1]. UV irradiation directly destroys the DNA of microorganisms and acts on pyrimidines in DNA, destroying the double helix structure of DNA where pyrimidine is located, consequently killing bacteria [2,3]. Therefore, UV irradiation causes microbial DNA to lose its chemical and physical structural properties, inhibits the production of molecules necessary for microbial growth, and thus prevents DNA replication, leading to bacterial and other microorganism death [4,5].

On the other hand, Chlorine is widely used in disinfection of large volumes of water, like in swimming pools and water supplies, as a very effective and cheap process. Chlorine (Cl) is a chemical element, a yellow-green gas at room

* Corresponding author: Irena Cosic.

temperature with a strong irritating smell. It is a highly reactive chemical, which is essential for sanitation and public health, and is widely used in the treatment of water and wastewater [6-8].

Water chlorination is the process of adding Chlorine or chlorine compounds to water. This method is used to kill bacteria, viruses and other microorganisms that can cause waterborne diseases such as cholera, dysentery, and typhoid [6-8]. Chlorine is commonly used disinfectant in drinking water treatment to provide continuous disinfection from the treatment plant to the consumer's tap, ensuring water remains safe for drinking. Chlorine is also commonly used to disinfect water in swimming pools to kill bacteria, viruses, and algae, to ensure safe and clean swimming environment. In addition, Chlorine works by reacting with organic impurities in the water like sweat, urine, and body oils, oxidizing them and breaking them down into harmless byproducts [6-8].

Interestingly both UV radiation and Chlorine have similar effects in disinfecting water by killing bacteria, viruses, other microorganisms and chemically reacting with organic impurities. Thus, it is puzzling to find out if there is any common mechanism for UV radiation and Chlorine activity on water disinfection. For that purpose, we have used here the Resonant Recognition Model (RRM), which proposes that molecular interactions are based on resonant energy transfer. We have used the RRM model to calculate the resonant energy of Chlorine and compare it with the energy of UV radiation.

2. Methods: Extended Resonant Recognition Model for Small Molecules

The Resonant Recognition Model (RRM) is biophysical, quantum physics, model that proposes molecular interactions to be based on resonant energy transfer between interacting molecules. It was initially established for analysis of protein interactions with other proteins and DNA/RNA. The RRM model is based on findings that certain periodicities/frequencies within the distribution of energies of free electrons along the protein are strongly correlated with the protein biological function/interaction [9-16]. However, the initially established RRM approach has been only applied to large linear macromolecules like proteins and/or DNA/RNA [9-15]. We have recently extended the RRM model for small molecules [16,17], where we proposed that small molecules also recognize their targets on the distance and interact through electromagnetic resonant energy transfer enabling specific activity. To expand the idea of electromagnetic resonant recognition to small molecules and their interaction with proteins, RRM model has been extended by calculating electromagnetic frequencies of free electron energies within the small molecules [16,17].

For that purpose, we have proposed that energies of free electrons in small molecules are the most relevant for such resonant energy transfer and can be calculated as the electron-ion interaction pseudo-potential (EIIP) of small molecule using the following semi-empirical formula as developed by Veljkovic [18-20]:

$$< k + q |w| k > = 0.25 \times Z \times \sin(\pi \times 1.04 \times Z) / (2 \times \pi)$$

where q is change of momentum of delocalized electron in the interaction with potential w (EIIP) in Rydberg (Ry = 2.18 x 10^{-18} [J]), while Z is average valence number over the whole small molecule.

The corresponding electromagnetic wavelength for this energy can be calculated using de Broglie formula as follows:

$\lambda = (h \times c) / E$ in vacuum, where c is speed of light (c = 2.998 x 10^{8} [m/s]) and

$\lambda = (h \times v) / E$ in other materials, where v is speed of light in materials other than vacuum

where λ is wavelength of light [nm], h is Planck constant (h = 6.626 x 10^{-34} [Js]), E is energy [J] of free electrons within small molecules.

All biological processes and interactions are taking place within water and/or biological materials and thus speed of light will depend on refraction index within these materials

$$v = c / n$$

where v is speed of light in materials other than vacuum, c is speed of light in vacuum and n is refraction index of materials other than vacuum.

For water refraction index is 1.33, while for biological materials refraction indexes are: for cell membranes 1.46-1.60, for cytoplasm 1.35-1.39, for proteins 1.36-1.55 [21] and for double-stranded DNA (dsDNA) is a higher refractive index of 1.53-1.58 [22].

Bearing in mind all the above, we have hypothesized that wavelengths produced by energies of free electrons within small molecules are critical for small molecule functions and their recognition and interaction with their targets including macromolecules like proteins and DNA. The hypothesis, that wavelengths produced by energies of free electrons within small molecules are critical for small molecules biological functions and their recognition and interaction with proteins, has been already tested in couple of examples [16,17].

Here, we have applied extended RRM model for small molecules to Chlorine with the aim to find out the potential electromagnetic wavelength range of its activity. As Chlorine is potent disinfectant in water and acts similarly as UV radiation, we have compared the calculated Chlorine wavelength range with UV radiation wavelength range used for water disinfection.

3. Results and Discussion

This research has been focused on water disinfection from microorganisms. It is known that water disinfection from microorganisms occurs with UV radiation within the range of 200-280nm, mostly destroying the DNA double helix structure of microorganisms. On the other hand, Chlorine as disinfectant has the same effect on microorganisms. The question is if Chlorine disinfection ability is somehow related to UV radiation. For that purpose, we have applied to Chlorine the extended RRM model, which proposes that small molecules interact through electromagnetic resonant energy transfer with their target enabling specific activity (molecular interaction) at specific wavelength. Chlorine (Cl_2), as small molecule, performs disinfection from microorganisms, similarly to UV disinfection, involving destruction of cell membrane and DNA double helix. Thus, RRM calculations have been done for refraction indexes for cell membrane and DNA double helix, as presented in Table 1. The RRM calculated Chlorine wavelength ranges for cell membrane and double helix have been presented in Table 1 together with the wavelength range for UV disinfection of microorganisms.

Table 1 Chlorine RRM proposed wavelength range compared to UV radiation wavelength range for water disinfection through microorganism cell membrane and DNA double helix destruction

Impurities in water	**Refraction index**	**Chlorine Wavelength [nm]**	**UV Wavelength [nm]**
Cell membrane (microorganisms)	1.46-1.60	266-291	200-280
DNA double helix	1.53-1.58	269-278	200-280
Disinfection		**266-291**	**200-280**

As can be observed from Table 1, the RRM proposed wavelength range for Chlorine water disinfection through microorganism cell membrane and DNA double helix destruction is almost completely overlapping UV radiation wavelength range for the very same function. It is interesting that there might be common mechanism for UV radiation and Chlorine activity on water disinfection. We propose that this common mechanism is based on resonant energy transfer from disinfectant (UV or Chlorine) to its targets: microorganism's cell membrane and DNA double helix. Such resonance could produce destruction of microorganisms' cell membrane and DNA double helix. These results give a new perspective to the possibility that chemical reactions are based on resonant energy transfer at specific wavelength (frequency), which determines the specificity of their activity.

4. Conclusion

Using the RRM biophysical, quantum physics model, we have presented here that Chlorine exhibits the same electromagnetic characteristic frequency range as UV radiation frequency range used for water disinfection. Such results can explain how both Chlorine and UV radiation have the same effect for water disinfection process through microorganisms' self-membrane and double helix distraction. More generally, our results are providing another proof that specificity of chemical reactions are based on resonant energy transfer at specific wavelength (frequency).

Compliance with ethical standards

Disclosure of conflict of interest

Authors declare they have no competing interests.

Contributions

Conceptualization, I.C., D.C. and I.L.; Methodology, I.C. and D.C.; Software, D.C.; Resources, I.L.; Writing—Original Draft Preparation—Review and Editing, I.C., D.C. and I.L

Funding

This research received no external funding.

References

[1] EPA, author: Ultraviolet disinfection guidance manual. Office of Water, Washington D.C., 2003; 35–59.

[2] Goto N, Bazar G, Kovacs Z, Kunisada M, Morita H, Kizaki S, et al.: Detection of UV-induced cyclobutane pyrimidine dimers by near-infrared spectroscopy and aquaphotomics. Sci. Rep., 2015; 5, 11808, doi: 10.1038/srep11808.

[3] Yokoyama H, Mizutani R: Structural biology of DNA (6-4) photoproducts formed by ultraviolet radiation and interactions with their binding proteins. Int. J. Mol. Sci., 2014; 15, 20321–20338, doi: 10.3390/ijms151120321.

[4] López MA, Palou E: Ultraviolet light and food preservation. Novel Food Processing Technologies. CRC Press; Washington D.C., 2005; 405–421.

[5] Kim HJ, Yoon HW, Lee MA, Kim YH, Lee CJ: Impact of UV-C Irradiation on Bacterial Disinfection in a Drinking Water Purification System. J Microbiol Biotechnol., 2023; 33(1), 106-113, doi: 10.4014/jmb.2211.11027.

[6] Matthews D (13 November 2021): How a simple solution slashed child mortality in rural Kenyan villages. Vox. Retrieved 15 November 2021.

[7] Guidelines for drinking-water quality. WHO Guidelines Approved by the Guidelines Review Committee (4th ed.). World Health Organization., 2022; 6.

[8] Disinfection with Chlorine | Public Water Systems | Drinking Water | Healthy Water | CDC. www.cdc.gov. 10 October 2018. Retrieved 30 April 2020.

[9] Cosic I: Macromolecular Bioactivity: Is it Resonant Interaction between Macromolecules? -Theory and Applications. IEEE Trans on Biomedical Engineering, 1994; 41, 1101-1114.

[10] Cosic I: The Resonant Recognition Model of Macromolecular Bioactivity: Theory and Applications. Basel: Birkhauser Verlag, 1997.

[11] Cosic I: Resonant Recognition Model of Protein-Protein and Protein-DNA Recognition, in Bioinstrumentation and Biosensors. Marcel Dekker Inc New York, 1990; 475-510.

[12] Cosic I, Lazar K, Cosic D: Prediction of Tubulin Resonant Frequencies Using the Resonant Recognition Model (RRM). IEEE Trans. on NanoBioscience, 2015; 12, 491-496, doi: 10.1109/TNB.2014.2365851.

[13] Cosic I, Cosic D, Lazar K: Is It Possible to Predict Electromagnetic Resonances in Proteins, DNA and RNA? Nonlinear Biomedical Physics, 2015; 3, doi: 10.1140/s40366-015-0020-6.

[14] Cosic I, Cosic D, Lazar K: Environmental Light and Its Relationship with Electromagnetic Resonances of Biomolecular Interactions, as Predicted by the Resonant Recognition Model. International Journal of Environmental Research and Public Health, 2016; 13(7), 647, doi: 10.3390/ijeprh13070647.

[15] Cosic I, Cosic D: DNA-Protein Interactions at Distance Explained by the Resonant Recognition Model. International Journal of Sciences, 2024; 13(11), 1-5, doi: 10.18483/ijSci.2805.

[16] Cosic I, Cosic D, Loncarevic I: New Concept of Small Molecules Interaction with Proteins – An Application to Potential COVID-19 Drugs. International Journal of Sciences, 2020; 9(9), 16-25, doi: 10.18483/ijSci.2390.

[17] Cosic I, Cosic D, Loncarevic I: Analysis of Ivermectin as Potential Inhibitor of SARS-CoV-2 Using Resonant Recognition Model. International Journal of Sciences, 2021; 10(1), 1-6, doi: 10.18483/ijSci.2433.

[18] Veljkovic V, Slavic I: General Model od Pseudopotentials. Physical Review Letters, 1972; 29, 105-108.

[19] Veljkovic V: A Theoretical Approach to Preselection of Cancerogens and Chemical Carcinogenesis. Gordon & Breach New York, 1980.

[20] Veljkovic V: The Dependence of the Fermi Energy on the Atomic Number. Physics Letters, 1973; 45A(1), 41-42.

[21] Mohsin ASM, Salim MB: Probing the Intracellular Refractive Index and Molecular Interaction of Gold Nanoparticles in HeLa Cells Using Single Particle Spectroscopy. International Journal of Nanomedicine, 2018; 13, 6019-6028, doi: 10.2147/IJN.S175523.

[22] Inagaki T, Hamm RN, Arakawa ET: Optical and dielectric properties of DNA in the extreme ultraviolet. J. Chem. Phys., 1974; 61, 4246-4250.