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Perspective

Reimagining Fullerene-Cell Water Dynamics in Living Systems

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Abstract

Fullerene properties suggest that they may mediate the thermodynamics of proton and electron charge transfer, coherent local and long-range quantum electrodynamics, and enhance oxidative stress reduction in complex living systems through interaction with interfacial cell water. The biomolecular interactions of fullerene material in living systems are commonly explained in chemically mediated stochastic terms, strictly governed by Coulomb forces. Emerging biological science has revealed that the complex molecular dynamics found in living systems cannot be described as a collection of independent events defined solely by their classical chemical reactions. These molecular dynamics cannot be random events. Their interaction is characterized by interrelated quantum effects such as electromagnetic potential, coherency, and phase φ fluctuation throughout the biological field. Changes in our understanding of biological science and molecular dynamics and the advances in fullerene material science require a shift in our understanding of fullerene-biomolecular interaction. It is proposed that fullerenes increase interfacial water ordering and act in a bio-capacitor-like manner through protein and membrane binding. Fullerene's diffuse pi clouds can also resonate and enhance the coherent domains in cell water. Through these fullerene-biomolecular dynamics, fullerene materials can be expected to mediate the thermodynamics of proton and electron charge transfer, coherent local and long-range quantum electrodynamics, and enhance oxidative stress reduction.

***Keywords:** Bulk Water; Structured Interfacial Cell Water; Hydration; Fullerene; Phase; System Energy; Coherent Domains; Thermodynamics; Electrodynamic Fields; Coherent; Quantum Electrodynamics; Charge-Transfer*

Abbreviations

CD Coherent Domains; QED Quantum Electrodynamics; φ Phase; $\sum$ System Energy; CNO Carbon Nano-Onions

Introduction

The traditional biological paradigm fails to address the inconsistencies of biological order-based biochemistry governed by molecular diffusion arrays acting independently of the organism's needs [1,2]. Biomolecular interactions within living organisms are not independent events and must occur as components of interrelated events [3]. The quantum criticality required for the complex molecular dynamics necessary for life is intricately coordinated and timely.

Due to the importance of biological water, fullerene-biological interaction must include a discussion of biological water involvement. Water plays both a chemical and physical role in complex biological systems. All water within the crowded environment of the cell can be considered structured interfacial water. The concept that water properties in living systems hydrating surfaces of cellular components differ from ordinary "bulk water" was stressed over a century ago by eminent biologists such as Albert Szent-Györgyi, later Gerald Edelman, and others.

Szent-Györgyi advanced the concepts that 1.) water and electromagnetic fields (EMF) were essential for cellular biochemistry, 2.) the greater 'bulk water' in a cell, the greater the level of cellular dysfunction. He noted the problem of biologists ignoring water and electromagnetic fields (EMF) in their study of biochemistry [3]. It is now recognized that intermolecular interaction cannot occur as individual, independent, or random events in living systems, and structured interfacial water is central to these events.

Structured water provides a semicrystalline semi-conductor environment surrounding cellular components that are conducive to coherence and entanglement necessary for the quantum field in living cells. This state of water results from the dielectric properties of cell structures and constituents and their emersion in strong coherent electromagnetic fields emanating from microtubule-mitochondrial cooperation and DNA [4-7].

The coherency of the electron cloud oscillation in cellular water creates a coherent domain (CD) environment where the Coulomb law of electrostatics may not apply. CDs reduce entropy and contribute to the regulation of quantum electrodynamics (QED) in cellular systems [2]. In this environment, "like" charges can attract resulting in the accumulation of negatively charged tissues observed in cell systems and establishing an environment that facilitates proton and electron transfer thermodynamics [8,3].

Coherent domains (CD) in cell water create and maintain the localized environment for quantum electrodynamic control of the orderly processes in cells and surrounding cellular structures [9-11]. The interaction of the QED field and cellular molecules results in the redistribution of charge and structural change. The resulting charge shifts produce changes in the electromagnetic field envelope of the molecule, which mediates intermolecular dynamics [8].

As proposed by Szent-Györgyi, the loss of structured water in a cell signified cellular dysfunction. This concept was instrumental to Damadian's work leading to the development of Nuclear Magnetic Resonance (NMR) imaging [12]. Changes in cell water are manifested in cancerous states by a decrease in the "ice-like" tetrahedral structuring and an increase in "liquid-like" bulk water.These changes are observed in characteristic Raman spectroscopy and IR absorption [13].

Living systems exist in a low entropy quantum critical state far from thermodynamic equilibrium [14]. In this non-thermodynamic state, dynamic cell activities must act in unison under a unifying and coherent *phase* (φ) of electromagnetic fields that collapses, reassembles, fluctuates, and resonates with intermolecular charge transfer. Bischof points out, "*the spreading of information about each event depends on the same dynamics which produce the event. Biochemical reactions and the spreading of information about them should be two different aspects of the same dynamics and, in particular, do not need additional energy expenses."* [3].

The electrodynamic potential defines the system energy (∑), and its propagation is through the phase (φ) arising from the coupling to coherent quantum fluctuations between of biomolecular interactions. Coherent domains in water collect chaotic energy and store it as coherent excitations that result in phase fluctuations of trapped electromagnetic fields. The collapse of localized coherency fluctuates with phase and produces an observable dynamic molecular meta described by classical physics and biology. An " energy gap " defines the energy necessary to destabilize or destroy coherency in a molecule, cell, or even the system. Intermittent incoherent states participate in quantum intermolecular dynamics during local and long-range coherent dynamics [3].

Discussion

Although pristine fullerenes exhibit nonpolar hydrophobic properties, they are dielectric molecules with large, diffuse pi clouds that acquire an induced dipole moment in electromagnetic fields resulting in excellent polarizability [15-17]. Panich found that hydration of

CNOs reveals a significant deviation in the chemical shift from that of bulk water, which can be attributed to the diamagnetic screening effect of the conducting graphitic layers [18].

Hydrophobic fullerene materials dock with cellular structures at both polar and nonpolar sites. Protein surfaces are highly receptive to fullerenes, where almost twice the nonpolar versus polar binding is observed. Fullerenes bind with cellular membranes and protein secondary structures not typically available for water interaction. Among the nonpolar sites, π-π stacking arrangements with aromatic residues stabilize the fullerene-protein complex and are supported by cation-π and anion-π binding sites. Cation-π binding contributes to the stabilization of the α-helix. Delocalized electrons and double bonds promote anion-π binding and weak hydrogen bond interaction with amino acid residues [18]. Except for defects found in some carbon nano-onions (CNOs), fullerene carbon atoms are bonded to three other carbon atoms resulting in no net charges or permanent partial charges.

Molecular dynamics (MD) simulations using C_{60} have shown dramatic oxygen and hydrogen atom density variation in the first hydration shell. There are distinct peaks with precise imprinting of the 12 pentagons and 20 hexagons of C_{60} on the arrangement of oxygen atoms and high densities above the centers of each pentagon and hexagon. Thirty-two density peaks represent angular or azimuthal ordered oxygen density in the first hydration layer surrounding fullerenes. The result is much greater ordering than expected from a classically empirical model of water ordering around hydrophobic molecules [19].

The acquisition of QED induced coherent resonance and phase φ fluctuation by fullerenes affect electron/proton charge transfer, conformational changes, and bond-forming/breaking steps.Fullerene's ability to acquire induced dipole moment in the electromagnetic fields in the cell and subsequent polarizability is essential to our complete understanding of their intermolecular biological dynamics. However, the development of this aspect of fullerene-biomolecular interaction is beyond the current discussion and will be addressed in a follow-up paper.

The interaction of water with hydrophobic surfaces is responsible for many biologic processes [20,21]. Molecular Dynamic modeling demonstrates that hydrophobic fullerenes bind to nonpolar regions of proteins and membranes. Protein and membrane binding in biological systems often involves π-π and van der Waals binding. This form of binding is likely in biocoronas known to form upon fullerene entry into the biological environment. While the hydration of charged surfaces reduces entropy via restricted molecular rotation of water due to the interaction between their dipole moments and the electric field, loss of entropy due to hydration of hydrophobic surfaces results from asymmetric interaction of the water molecules with the hydrophobic surface and neighboring water molecules [22-24].

The long-range attraction between hydrophobic fullerene materials resonating with CDs in water can change the magnetic signal of the surrounding water. Larger hydrophobic molecules have a greater effect on the clathrate-like ordering of surrounding water with a corresponding greater decrease in system entropy than smaller ones [24,25]. Layers of structured interfacial cell water demonstrate excellent aqueous oxidation/reduction potential [26,27]. The resulting greater increase in layers of structured water may help explain why larger fullerenes, such as C70 and CNOs, are often reported to have greater antioxidant benefits than C60 [16,17,26].

Alternating and collapsing strong fullerene dipoles coherently resonating in phase φ with CDs in cell water would aid the quantum charge transfer in the hydration layers of these cellular components [8,11,22,23]. In-phase ($\varphi\sum$QED) fullerene charge modulation enhances local and long-range ordered water layers, along with the electrostatics thought necessary for the self-assembly of bio-macromolecules (Figure 1). It provides a thermodynamic correlation to the redox potential and energetics of the cell.

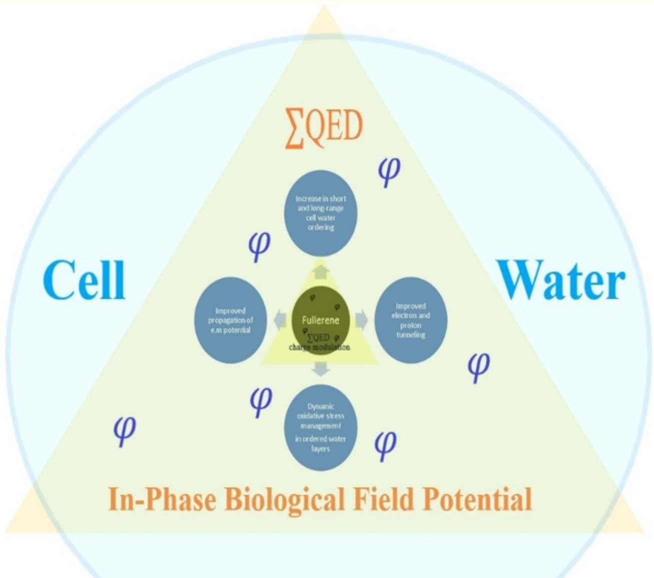

Fig. 1 Fullerenes Improve Cellular Electrodynamics and Oxidative Stress Management Through Enhancement of Cell Water

Figure 1: *Fullerenes improve cellular electrodynamics and oxidative stress management through enhancement of cell water.*

There is much we don't know, but it is conceivable that the reversible electron affinity of pristine fullerenes also aids in native conformational changes, acting similar to ATP by withdrawing electrons when under the influence of the cell's dynamic fluctuating EMF [4,5]. The critical result of the diamagnetic properties of fullerenes is the enhancement of structural order in interfacial cell water. The increase in resulting deviation in chemical and charge shift from bulk water contributes to restoring and enhancing cellular quantum properties of proteins in hydrated mitochondria, DNA/RNA, and cellular membranes. This mechanism could assist damaged or dysfunctional proteins and hypoxic disease states.

Conclusion

Most biomolecules are quantum-critical conductors existing as an ensemble of intermolecular dynamics far from equilibrium.This existence necessitates a cell water medium allowing propagation of the phase of the system. It is proposed that fullerene material increases interfacial water ordering, beneficially altering its electromagnetic properties. Fullerene enhancement of short and long-range structured interfacial water contributes to many of the beneficial effects of fullerenes *in vivo,* including a non-stoichiometric redox mechanism for the well-established antioxidant activity of fullerenes and their impact on cellular energetics**.** Thus, cellular electrodynamics are enhanced when interfacial cell water is influenced by hydrophobic fullerene material. Additional research is needed to confirm and quantify fullerene's effect on cell water. It is a necessary step in developing a fullerene biomedical model and emerging concepts of the quantum cell.The reimagining of fullerene-biomolecular dynamics can facilitate the development of safer and more effective nanocarbon medicines with broad applications.

Conflict of Interest

The author reports he provides biomedical consulting services through Carbone Quantique Biomedical, LLC to the nanocarbon industry.

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