Chapter

The Influence of a Diamagnetic Copper Induced Field on Ion Flow and the Bernoulli Effect in Biological Systems

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Abstract

The Bernoulli Effect describes the principle of conservation of energy that optimizes pressure and motion in fluid flow and may be applied to fluid dynamics in vascular arterial and cellular membrane flow. One mechanism that is known to influence fluid flow that has *not* been included in the Bernoulli Effect equations is viscosity or resistance to flow. To date the liquid phase of matter with regards to the relationship between viscosity, pressure and flow is the least well understood of all phases. Recent cellular studies suggest that a diamagnetic copper influenced dielectrophoretic electromagnetic field may induce a Bernoulli Effect within biological systems. The data presented here suggests that an increased viscosity via this copper influenced dielectrophoretic electromagnetic field may significantly contribute to this Bernoulli Effect or conservation of energy while positively impacting cellular health and function via both kinetic and potential bio-energy influences in biological systems.

Keywords: Bernoulli effect, copper, diamagnetism, kinetic bio-energy, potential bio-energy, viscosity

1. Introduction

The Bernoulli Effect was formulated by a Swiss mathematician, Johann Bernoulli in 1738 to describe the principle of conservation of energy in fluid flow and can be applied to fluid dynamics in vascular arterial and cellular membrane flow [1–3]. The study of the Bernoulli Effect can enhance an understanding of how pressure relates to motion and energy to drive physiology in these areas of the body. One known mechanism for inducing flow that has *not* been included in the Bernoulli Effect equation is viscosity or resistance to flow [3]. To date, the liquid phase with regards to viscosity, pressure and flow is the least well understood of all the phases of matter [4, 5]. Viscosity can be defined as quantifying the internal frictional force that arises between adjacent layers of fluid that are in motion as can be found in plasma and cellular membrane flow [6].

Since water constitutes ~75 percent of the fluids that flow in the adult human body, water can be seen as not only critical to the sustenance of the physiological functions of life but also to the understanding of the conservation of energy in fluid flow of the body [7]. Studies of water have shown the potential of water-dielectric interfaces (as seen with chloride and water in plasma flow and cellular membranes) in electrostatic/potential energy harnessing and harvesting [8]. Recent cellular studies have also suggested that water and molecular attractions may play significant roles in the harnessing of energy components such as kinetic and potential bio-energy at the interface of cell membranes and in plasma flow [9–13]. Water that resides adjacent to hydrophilic surfaces/membranes appears to have defining characteristics that differ from bulk/free water (outside membranes and in the environment) and these unique features may correlate to the capacity to use magnetic attraction to harness energy and facilitate flow and movement of ionic solutions within plasma and across cell membranes [9, 14, 15]. Also, the use of a dielectrophoretic electromagnetic field (DEP EMF) that is generated with the influence of the noble diamagnetic metal, copper appears to have a significant impact on cellular function in biological systems [9, 14, 15]. Decades ago, research on diamagnetic copper and the role it plays in living systems began after the discovery that it was necessary for hemoglobin formation in rats, yet copper and its defining attributes of its contributary role in biological systems remain elusive to date [16]. Could viscosity that is not included in the Bernoulli equation by Johann Bernoulli be a significant component of the actual harnessing of magnetic energy in fluid flow in biological systems? It is known that a magnetorheological fluid becomes thicker and more viscous when subjected to a magnetic field [10]. The influence of diamagnetic copper on the generation of a.

DEP EMF appears to increase viscosity and change water structure in these kinematic viscosity and bubble coalescence studies presented below. This data suggests that this increase in viscosity may be related to a magnetic structural shift of the diamagnetic chloride's attraction to water and other materials in living systems [9]. This data, along with other recently published studies suggest that the influence of this diamagnetic metal (copper) induced DEP EMF on the dielectric anion, chloride may increase viscosity and decrease pressure in the flow in living systems thereby offering alternative kinetic and potential bio-energy sources (conservation of energy/Bernoulli effect) for plasma and membrane flow in cellular functions within biological systems [9, 12, 13, 17]. Historically, increased viscosity in fluid flow in living systems (i.e., plasma flow) has not been desirable due to its association with stagnation and dysfunction of fluid flow. With the use of the data from the kinematic viscosity and bubble coalescence studies along with theory and computational equations, we will discuss some possible unknown characteristics of magnetism and viscosity and how it may impact conservation of energy in fluid flow in biological systems.

2. The role of diamagnetic copper in the generation of dielectrophoretic electromagnetic fields

Copper is an essential trace element that is vital to the health of all living things. While the importance of copper in health maintenance is widely accepted, exactly how this trace element functions within biological systems has been poorly defined to date. It is known that diamagnetic materials such as copper and chloride are repelled by and flow in *opposition* to a magnetic field. In contrast, paramagnetic materials such as sodium and ferromagnetic materials such as iron are attracted to and flow *with* the magnetic field [9]. Diamagnetic materials possess complete shells which behave as electric current loops that orient themselves in specific ways in magnetic fields. Copper is diamagnetic because unpaired electrons in the 4 s orbitals are localized to form metallic bonds. Historically, it has been thought that diamagnetism offers a weak or negligible contribution to a magnetic field. However, recent data suggest that diamagnetic metals such as copper may indeed play a significant role in the energy of life or the internal energy components of kinetic and potential bio-energy by the facilitation of a separation of charge. Charge separation between the position and negative ions is essential to facilitate movement in and around membranes and plasma cells. The zone within or near membranes is usually fixed and negative while the positive charges by contrast are free to diffuse in the regions around and beyond [14]. The persistence of positive and negative attraction that occurs in lower magnetic states (weaker field flow) appears to require a phosphorylation of ATP to provide the energy to facilitate charge separation required to induce flow and maintenance of ion differentials in and around cells. Due to the nature of the need for charge separation (via an energy source) within an electromagnetic field to facilitate movement of positive charges (cations such as potassium, sodium, magnesium, hydrogen and calcium) across membranes and in the plasma, the addition of a diamagnetic metal to the generation of this electromagnetic field in order to create a DEP EMF is essential (**Figure 1**). A DEP EMF induces dielectrophoresis or a phenomenon in which a force is exerted on dielectric particles such as chloride and changes the magnetic attraction from positive and negative attract to *like attracts like* or *like likes like* (**Figures 1** and **2**) [9, 14, 15]. Data suggest that this magnetic shift may actually represent a change in viscosity and a harnessing of kinetic and potential bio-energy in living systems.

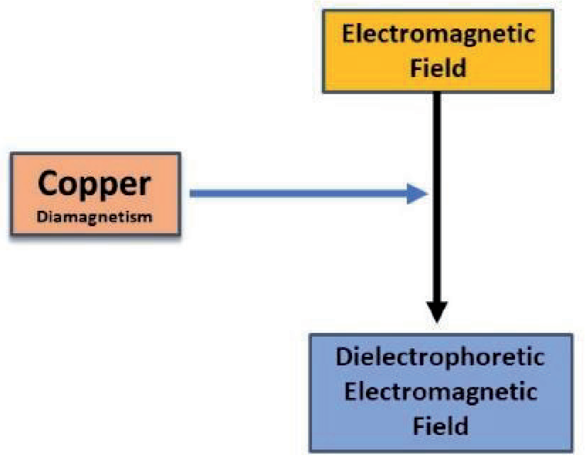

Figure 1.
The addition of the noble diamagnetic metal, copper to essential to generate a dielectrophoretic electromagnetic field. Copper can be said to perform as a field separator between cations and anions that generates a magnetic shift in attraction from positive and negative attract to "like attracts like" [9, 14].

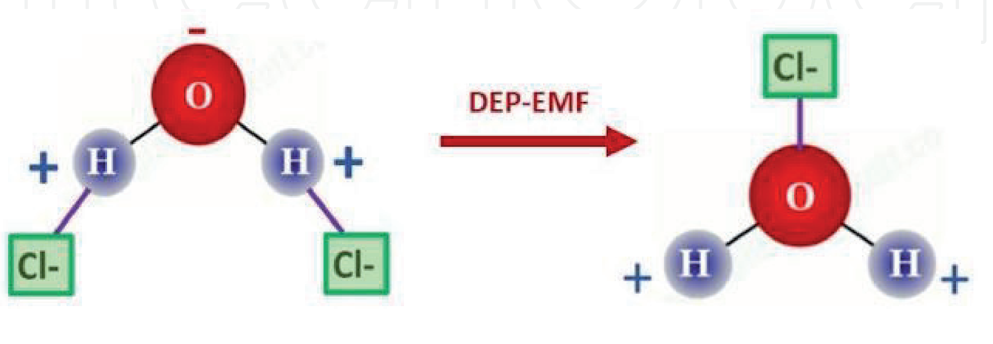

Figure 2.
A polar water molecule in low and high magnetic states: With decreased magnetic energy that may occur outside a living organism or in free waters in the environment, where positive and negative charges are known to attract [9, 14], the negatively charged chloride anion may be attracted to the positively charged hydrogen side of the polar water molecule. This water form may be seen in "unstructured/free water." with increased magnetism and internal potential energy that may reside at the membranes of and within living organisms [9, 14], the negatively charged chloride anion is attracted to the negatively charged oxygen side of the polar water molecule (structural change). Positive and negative charges are no longer attracted since there is a magnetic shift to "like attracts like" [9] or "like likes like" [14].

3. Dielectrophoretic electromagnetic field induced effects on kinematic viscosity

Dielectrophoresis (DEP) has been known to influence the flow and movement of microparticles, nanoparticles and cells [18, 19]. DEP can be explained as the net force encountered by a dielectric (polarized) particle in an electric field [20]. This force is impactful on all charged and uncharged particles and all particles exhibit dielectrophoretic activity in the presence of non-uniform electric fields. The strength of the force is dependent on the medium, electrical properties of the particles, the size and shape of the particles and the designed frequency of the field. This DEP force (F_{DEP}) can be written where E is the electric field and m(ω) is the induced dipole moment on the particle (Eq. (1)) [9]:

$$F_{DEP} = \left[m(\omega) \bullet \nabla \right] E \tag{1}$$

DEP can influence a polarizable particle (ion) that is suspended in a medium that is driven by alternating current (ac) or direct current (dc). When a particle that is more polarizable (positively charged) than the surrounding medium the net movement of the particle is oriented towards the region of the highest field flow/strength or positive dielectrophoresis (pDEP). Conversely, particles with polarizability less than that of the medium move towards the region of the lowest field gradient (in opposition to the field) or negative dielectrophoresis (nDEP). The chloride anion is a diamagnetic ion with possible dielectric properties and is therefore repelled by a magnetic field and orients in opposition to the field causing a repulsive force. The positively charged cations of sodium, potassium, magnesium, calcium etc., appear to follow the flow of the field.

In lower magnetic states, positive and negative charges are known to attract thereby allowing chloride anions to form hydrogen-bonded bridges with water molecules while the cations (sodium, potassium, calcium, magnesium etc.) bond to the oxygen side of the water (**Figure 2**) [9, 21]. In a higher magnetic state that may occur in the presence of a DEP EMF, there appears to be a shift in magnetic attraction that has been termed as "*like attracts like*" or "*like likes like*" (**Figure 2**) [9, 14, 15]. This magnetic attraction shift may cause the chloride anion to maintain a different orientation to the water molecule allowing for covalent (stronger) bonding between the chloride and oxygen (i.e., biochloride) as well as between the hydrogen molecules [9, 14, 15] (**Figures 2 and 3**). This magnetic restructuring may coincide with and manifest in micrographs as changes in the bubble coalescence (**Figure 4**). Dr. Gerald Pollack is a pioneer in the science of water structure and he refers to the bubble or droplets noted in the water coalescence studies as vesicles. He hypothesizes that these vesicles change characteristics depending on the phase of water inside (that exists as water vapor) that is generated from the energy they absorb [22]. Dr. Pollack has also identified the phenomenon of EZ water where he discusses how water at the membranes and inside a cell is structured differently than in free/bulk water in nature. He refers to this structured or EZ water as the fourth phase of water [22]. The magnetic shift or change in attraction to "*like likes like*" appears to create an exclusion zone (EZ water) adjacent to the membrane that is a negatively charged crystalline structure or what we have termed biochloride (BCl−) while the cations continue to reside in the free/bulk water zone (**Figure 5**) [22]. While ion differential flows across the membranes in most cells, the red blood cell is a torus and carries the differential on the surface of this torus thereby facilitating plasma flow [12, 23]. The diamagnetic chloride is known to play a significant role in the flow of Band3/AE1 anion exchange while the cations reside outside the negative membrane surface in the Stern layer [12, 23].

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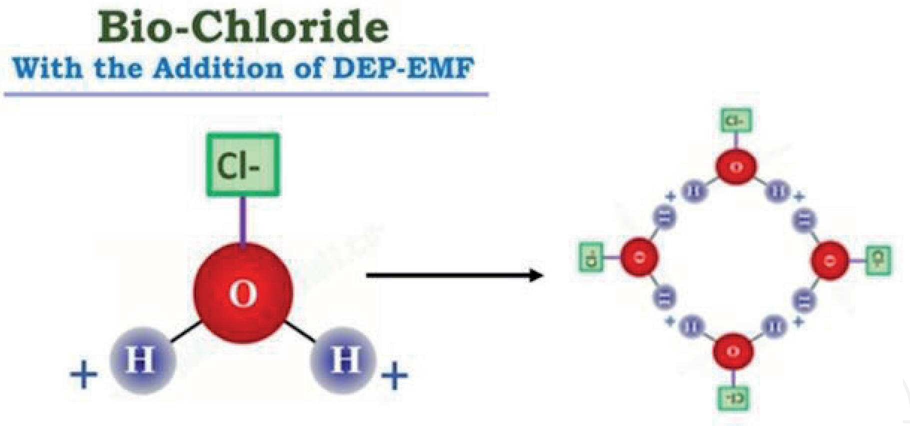


Figure 3.
Like attracts like - covalent bonding. In the presence of a non-uniform DEP EMF, there is a "like attracts like" or "like likes like" shift in magnetism. The chloride anion forms more stable covalent bonding (versus less stable hydrogen bonding) with the oxygen side of the polar water molecule and the hydrogen atoms do not form hydrogen bonding between other molecules, but instead form more stable covalent bonds between each other.

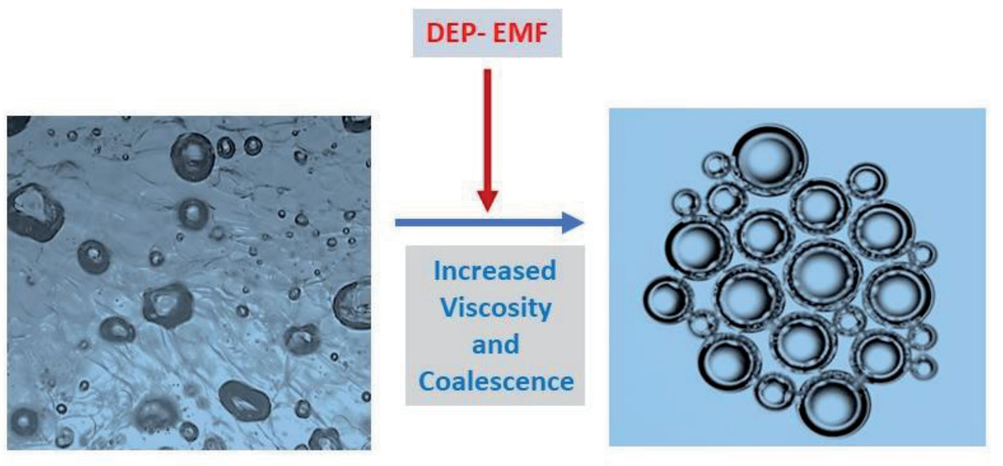


Figure 4.
*Water structure studies in the presence of a dielectrophoretic electromagnetic field (for 30 minutes). A 20°F hypotonic saline solution (left) was examined under a microscope 40X (left) with no exposure to dielectrophoretic electromagnetic field and after a 30-minute exposure (right) to the DEP EMF, notice the change in the coalescence of the bubbles (vesicles) that occurs along with the increased viscosity (**Table 1**). The bubbles/vesicles change form as they absorb energy as well as the phase of water (water vapor) inside the vesicles [22].*

In addition to these magnetically driven structural changes, this data suggests that the application of a non-uniform 2.5 ampere DEP EMF may significantly increase kinematic viscosity (resistance to flow) (**Table 1**). Kinetic viscosity (ν or "nu") is the ratio of the viscosity of a fluid to its density (η/ϱ) or a measure of the resistive flow of a fluid under the influence of gravity (Eq. (2)) [24].

$$\nu = \eta / n \tag{2}$$

A common unit that is used for kinematic viscosity is the square centimeter per second (cm^2/s) or Stokes (St) named after the Irish mathematician and physicist George Stokes. In our kinematic viscosity studies, using transparent plastic tubes with containing a chrome steel ball and a slower teflon ball, we found a significant increase in the hypotonic saline solution's kinematic viscosity that had been exposed to the non-uniform 2.5 ampere DEP EMF and the control saline solution that had not been exposed to the DEP EMF (Control Mean 8.29 cm^2/s; Treated Mean 7.08 cm^2/s; $p = 0.001$) (**Table 1**).

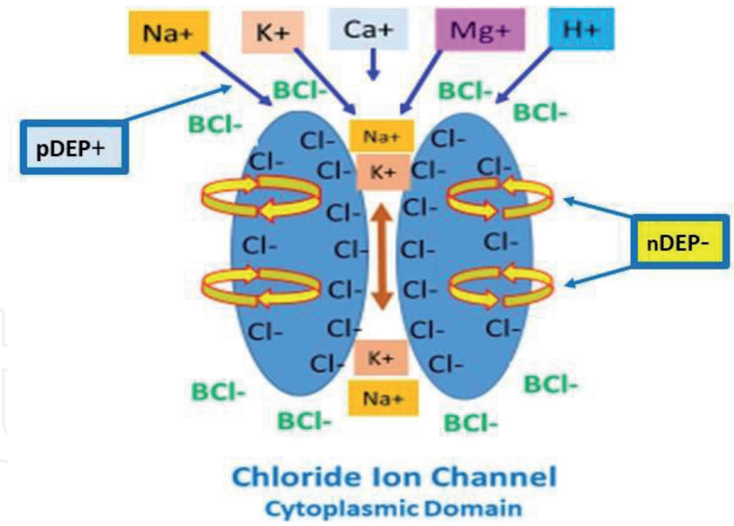
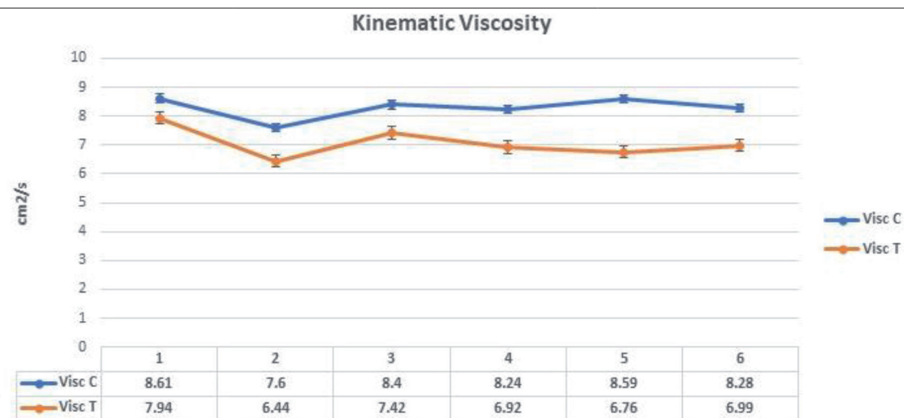


Figure 5.
*Diamagnetic anisotropy is seen here where the diamagnetic chloride anions (Cl-) spin is in opposition to the flow of the field (***nDEP-***) but are driven/fueled by the potential (molecular ionic attraction potential) energy. The positively charged cations (Na^+) (K^+) (Mg^+) (Ca^+) (H^+) flow with the field (***pDEP+***). Also, the biochloride (***BCl-***) and EZ (4th phase) water reside at both the plasma and cytoplasmic domains at the membrane and allow for the cations to enter the membrane through this magnetic shift in attraction. The magnetic shift to "like attracts like" allows for free flow of cations through the membranes (kinetic energy) possibly without a need for phosphorylation of ATP, thereby utilizing magnetic energy harnessed within the EZ-structured water/bio-chloride. This may offer a conservation of energy (Bernoulli effect) mechanism by using magnetism instead of ATP phosphorylation to drive ion differential maintenance. Note: The ionic differential of a red blood cell in the plasma is on the surface of the torus versus across the membrane [12, 23].*



t-test	df	ts	p	Mean Control	Mean Treated
Kinematic Viscosity	10	4.5846	0.001	8.29 cm^2/s	7.08 cm^2/s

Table 1.
Kinematic viscosity study- t-tests of viscosity (cm^2/s) between DEP EMF control versus treated hypotonic saline solution.

4. Kinematic viscosity induced effect on pressure, kinetic bio-energy and potential bio-energy

One known effect of an increase in viscous forces is the ability to conduct negative work (drop in fluid pressure along the flow path) on the fluid, reducing its macroscopic mechanical energy while increasing the internal energy (microscopic kinetic/molecular ionic potential energy) and resulting in a slight increase in temperature [4]. Since pressure is a measure of fluid mechanical energy per unit volume, the correlation of a decrease in macroscopic mechanical pressure along the flow path (i.e., through vessels or across membranes) along with the increased internal energy (kinetic and potential bio-energy) of the fluid is noted in the Bernoulli Equation below (Eq. (3)) [25]:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2 \tag{3}$$

The variables $\mathbf{P_1}$, $\mathbf{v_1}$ and $\mathbf{h_1}$ refer to the pressure, speed and height of the fluid at the initiation point and the variables $\mathbf{P_2}$, $\mathbf{v_2}^2$ and $\mathbf{h_2}$ refer to the pressure, speed and height of the fluid as it flows to another point. Also, $\frac{1}{2}\boldsymbol{\rho}\mathbf{v}^2$ = kinetic energy per unit volume (Eq. (4)) and $\boldsymbol{\rho}\mathbf{gh}$ = potential energy per unit volume [25]. It is known that $P_2 < P_1$ for as the fluid transitions along the flow path, the pressure energy decreases while the kinetic energy and potential energy increase. In other words, increased fluid speed creates decreased internal pressure. This Bernoulli Equation as well as viscosity induced by a DEP EMF may indeed correlate to a conservation of energy principle where the increase in viscosity may trigger the lowering of pressure in the regions where the flow/velocity is increased along with increased kinetic bio-energy and potential bio-energy.

The average kinetic energy ($\mathbf{KE}_{\mathbf{avg}}$) per unit volume (**V**) of flowing fluid can be expressed in terms of the fluid density (**ρ**) and maximum flow velocity ($\mathbf{v_m}$) (Eq. (4)) [25]:

$$KE_{avg} / V = \left(\frac{1}{2}\rho\right)\left(v^2{}_m / 3\right) \tag{4}$$

When the kinetic energy of fluid is examined with regards to laminar flow (as occurs in the plasma and across the cellular membranes) one must take the average of the velocity (shear stress and velocity gradient = viscosity) squared into account. The relationship between velocity and viscosity again speaks to the strong correlation viscosity has to kinetic energy. Increased viscosity and increased velocity may indeed be a significant factor in the internal kinetic energy (and pressure changes as well) and temperature regulation in biological systems. Might this non-uniform 2.5 ampere DEP EMF driven increase in kinematic viscosity offer a Bernoulli effect/conservation of energy (via increased kinematic viscosity➔ increased averaged velocity ➔ decreased pressure) in biological systems? Could this also have implications for membrane flow, plasma flow, blood pressure regulation and temperature control in the living organisms [9, 12, 23]?

One area where potential energy of a moving fluid in biological systems may reside would be in or near the membranes of cells. According to Dr. Pollack and EZ water (fourth phase) can be seen to function as a battery [22]. There have also been additional studies that suggest this structured or EZ water may increase the magnetic property or diamagnetism of the chloride ion and significantly modulate chloride ion channels both across the membranes and on the surface of red blood cells [9, 11–13, 23]. As stated earlier, chloride is a diamagnetic ion (that displays dielectric properties) that is both repelled and driven by the magnetic field. This dielectric behavior may offer a diamagnetic anisotropy mechanism in the membrane (**Figure 6**). *In vitro* and human studies using a copper influenced DEP EMF have shown a significant increase in chloride channel modulation [9, 11–13, 23]. The paramagnetic cations (Na^+, Mg^+, Ca+, K^+, H^+) move in the direction of the field or with the flow of the field, while the diamagnetic chloride anion will move in opposition to the field, acting as a field separator and facilitator of movement (through repulsion) for the cations (**Figure 6**). Chloride ion channel inhibition has been

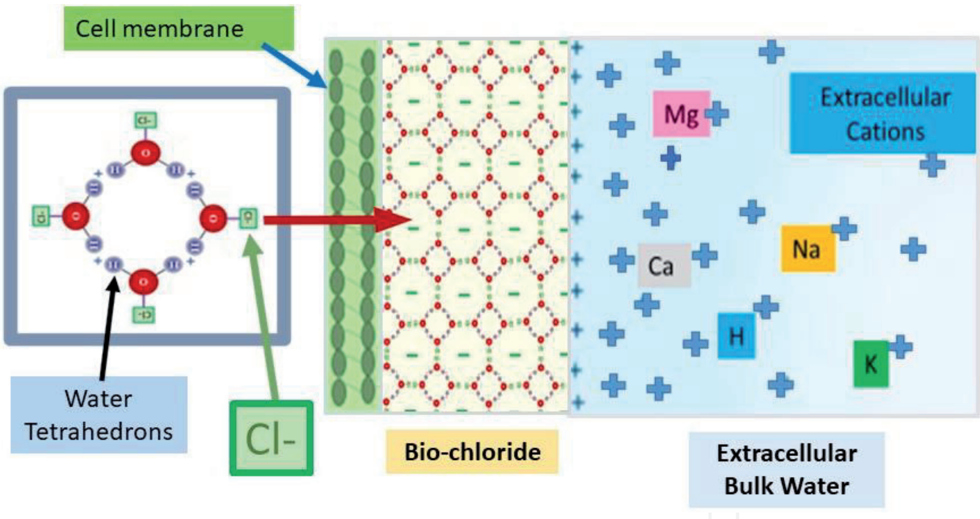


Figure 6.
*The internal potential molecular ionic attraction energy forms an exclusion zone or the fourth phase of water. The internal potential energy driven molecular ionic attraction facilitates a "like attracts like" or "like likes like" (EZ water) where chloride and water create crystalline structure with water tetrahedrons as they absorb magnetic energy [9, 14, 22] (***Figures 2–4***). The hydrogen ions bond or coalesce (molecular ionic attraction potential energy) and the negatively charged diamagnetic chloride anion (with an oxygen operating as a charge separator- bio-chloride/EZ water) spins in opposition to the field facilitating the passage (kinetic energy) of the charged cations through the field/membranes. This constitutes diamagnetic anisotropy and basically catapults the cations through the membrane with electromagnetically driven kinetic energy and potential energy in biological systems (***Figure 5***) [9, 14, 22].*

noted with increased levels of extracellular ATP [26]. Volume sensitive chloride channels have also been found to be regulated by intracellular ATP concentrations [27]. Since the application of this DEP EMF has shown significant upregulation of chloride ion channels in *in vitro* studies, might this external DEP EMF application offer an external energy source that is not dependent or regulated by ATP levels in the organism? Could this offer an energy conservation source for cellular function within biological systems?

5. Dielectrophoretic electromagnetic field induced effects on vesicle coalescence

Five millimeters of a 3 mM hypotonic saline solution prepared with laboratory-grade deionized water and molecular biology grade NaCl (Promega, Madison, WI) were placed on a glass slide in a 20°F freezer for 30 minutes. This same hypotonic saline solution was then exposed to a non-uniform 2.5 ampere DEP EMF field using a compilation of 6 stainless steel rings around a center copper ring for 30 minutes and five millimeters of this DEP EMF treated solution was also placed on a slide in a 20°F freezer for 30 minutes. The control and treated slides were then examined under 40x light microscopy and micrographs were immediately taken. Upon analysis of the micrographs, there were noticeable differences in the bubble/vesicle coalescence between the frozen hypotonic saline solution that was not exposed to the DEP EMF and the frozen hypotonic solution that was exposed to the DEP EMF (**Figure 4**). The effects of viscosity on bubble/vesicle coalescence have been studied both experimentally and numerically and a higher viscosity in liquids showed an increase in coalescence time and characteristics and when compared to lower viscosity liquids [22, 28, 29]. Upon analysis of the micrographs, there were noticeable differences in the bubble/vesicle coalescence between the frozen hypotonic saline solution that was not exposed to the DEP EMF and the frozen hypotonic solution that was exposed to the DEP EMF (**Figure 4**). This characteristic change in vesicle organization in the presence of the DEP EMF may correspond to a change in how water and ions orient to each other (**Figures 2** and **3**).

6. Conclusions

Life sustenance is an energy consuming process where biological systems must transform energy from one form to another through complex chains of biochemical and physiochemical events. Historically, increased viscosity of plasma and fluid flow in the body has been associated with increased coagulation, dehydration and other potentially unwanted pathophysiology. This data suggest that an *externally* applied copper influenced non-uniform DEP EMF may increase viscosity due to a magnetic restructuring of water and ions (via dielectrophoresis) thereby harnessing kinetic bio-energy (plasma and membrane flow) and potential bio-energy (EZ water-biochloride, diamagnetic anisotropy) in biological systems. This harnessing of energy may add an additional energy source that is available to cells, thereby conserving the need for higher levels of *internally* generated energy such as ATP for phosphorylation. Since cell stress/inflammation, the basis of all disease, is due to lack of adequate energy sources to carry out cellular physiological function, the ability to decrease cell stress by providing an externally applied (i.e., battery charge) energy resource for the cell to use and relieve energy deficits may open the door for new areas of research with multiple morbidities. The application of a copper influenced dielectrophoretic electromagnetic field appears to increase viscosity (harnessing of magnetic energy), decrease pressure (via decreased macroscopic mechanical energy) while conserving energy and facilitating motion/fluid flow in biological systems, i.e., the Bernoulli Effect (**Figure 7**) [9, 11–14, 22, 23, 30–34]. Therefore, this field application and the effect on ion flow has the potential to address multiple co-morbidities such as: hypertension, cancer, wound care, organ dysfunction, infectious disease and cardiovascular disease [9, 12, 13, 17, 23, 33, 34].

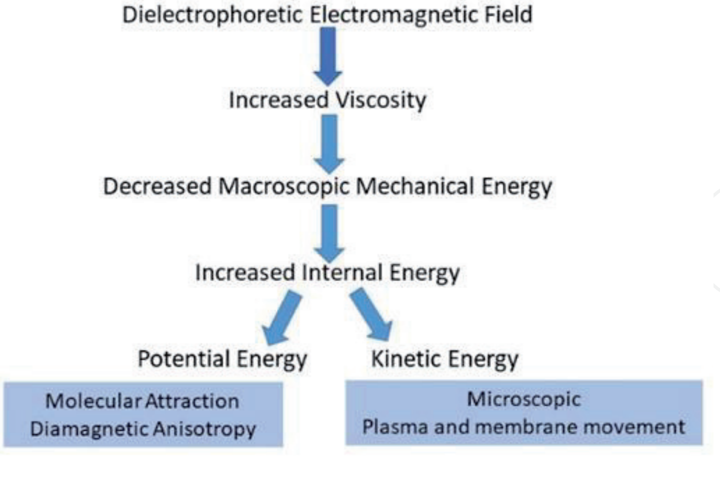


Figure 7.
Dielectrophoretic electromagnetic Fields's generation of potential and kinetic bio-energy and possible conservation of energy (a Bernoulli effect in biological systems) where internal, kinetic and potential energy remain constant or increase in exchange for a decrease in system pressure and an increase in temperature (homeostasis of ion differentials, blood pressure and temperature).

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