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Research article

Bubble mediated polymerization of RNA and DNA

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Abstract: Research dedicated to trace rotational motion of bubbles in saline water revealed that these may generate either single cationic or cationic/anionic motions, including spliced double helix flow. In all cases, the aggregated ionic flows propagate in spiraling as well as rotational manner. However, if bi-ionic or double helix motion is generated, the flow is oppositely directed and has opposite electric charges. Next, the assembled flow is forced to pirouette within the bubble vortex. During that processing the narrowing of spiraling flow takes place and result in increase of revolutions to even millions per second. As a result, a significant friction is induced between revolving ionic hydrates allowing continuous detachment of electrons from covalent atomic shells of electropositive elements. Then, free electrons may be attracted by electronegative elements that are dissolved in seawater. Afterwards, that negatively charged elements may undergo electrical condensation around cationic centers of revolutions. That explain a unique mechanism which operates when negatively charged phosphate compounds and pentagonal blocks found in RNA and DNA as ribose as well as pentagonal rings in nitrogenous bases A and G are being winded. The compensative anionic flow and revolutions may conduct winding of hexagonal blocks found in nitrogenous bases A, G and C, T or U. These assume to gather more positive charge needed to bridge negatively charged sugar molecules in nucleic acids. Thus, the continuity in generation of electronegative compounds and spiral manner of arranging them within the sub-bubble vortices should be regarded as a mechanism responsible for precise, rotational-electric polymerization of elongated macromolecules of RNA/DNA architecture. Reported research refers mainly to physical processes activated by rising bubbles thus should be confronted with other experimental methods used in genetics, microbiology and chemistry.

Keywords: bubbles in seawater; aggregation of ions; friction between revolving ions; generation of electronegative compounds; synthesis of ringed molecules; assemblage of RNA/DNA

1. Introduction

Bubbles in seawater are produced by breaking wind waves [1,2] or rain droplets impaction [3,4]. Diameter of bubbles range from 2 μm to a few mm, with maximum occurrence about 50 μm [3,5]. After formation, each bubble rises towards the water surface with a speed that depends on bubble volume, water temperature and related water viscosity [5]. However, more recent research indicated that, the velocity of bubbles rise also depends on rotational system that develops at bubble walls [6].

Measurements at sea have shown that plumes of bubbles can be dispersed downward to the depth of c. 4 times greater than the height of the significant waves at the sea water surface. However, if subsurface circulation of Langmuir type is developed, bubbles may be transported even to the depths of 6 times greater than the height of the surface waves [7]. Moreover, research dedicated to wind wave energy indicated that bubbles may dissipate about 50% of wave kinetic energy by converting friction into heat [8]. Considering the bubble rotational features [6], the dissipation of sea wave's energy can be explained as a result of friction between spiraling and revolving cationic and anionic hydrates conducted within the bubble vortices [9].

Laboratory investigations revealed that rising bubbles may develop a clockwise rotational motion at bubble upper half sphere and opposite directed in the bottom half sphere and inside bubble vortex, in the Northern Hemisphere [6]. Then, either motions or only a single i.e. bubble bottom half sphere motion undergo pirouette narrowing that enhances rotations in the bubble vortex [9]. In addition, the complementary research dedicated to reveal rotational kinetics of water molecules displayed that these during evaporation develop significant rotational kinetics, which reflects the "latent heat of evaporation" as well as the related "latent heat of condensation" [10].

Herein, a concept of bubble mediated rotational-electric processing is presented as responsible for continuous polarization of electronegative compounds that are dissolved in seawater. That concept is adopted to explain efficient electric-rotational condensation of negatively charged elements around cationic centers of revolutions and continuous formation of elongated electronegative polymers along the spiraling cationic flow. That concept finally elucidates the mechanism of precise (rotational) formation of RNA and DNA in marine environment.

2. Methods

Traces of bubbles in motion were studied in artificial or real seawater with salinity of 8 g/kg (brackish water) or 35 g/kg (values typical for oceanic water). Streams of bubbles were produced by adding either a few crystals of sea salt or a piece of a Sal Ems factitium effervescent salt (*SEf*). Investigation based on photographic records of bubbles in free buoyancy motion and inspection of rotational features formed at bubble boundaries. Experiments were carried out in transparent glass cylinders of 50–100 mL or in 0.1–1 L volume glass aquariums illuminated from below or from above by incandescent or LED light sources [6]. During experiments water temperature was measured in order to adjust a proper camera shutter speed (t). Values of t ranged from 1/5 to 1/30 sec., according to speed of bubble vertical rise and type of camera lens. All experiments were conducted in the Northern Hemisphere within latitudes 53–55° N.

In addition, an experimental setup allowing the observance of the rotational behavior of airborne, free evaporating water molecules as well as rotational motion of vortex-jet droplets was developed [10,11]. Observations were carried out using ultra-light rotary detection discs which

intercepted either steam of evaporating water molecules or stream of vortex-jet droplets produced by bursting bubbles. The applied method allowed observing counterclockwise rotational motions carried by steaming water molecules [10] as well as that carried by upward projected vortex-jet droplets produced by bursting bubbles [6]. Additional experiments allowed confirming that vortex-jet droplets contain a dominating net positive electric charge, while film droplets originated from bubbles upper caps contain a net negative electric charge [11].

3. Results

3.1. Bubbles rotational motions

It was documented that bubbles rising in saline water may separate ions and performs spiraling motion posing either single stranded or double stranded manner [6,9]. Examples of typical rotational motions assembled by stream of rising bubbles are shown in Figure 1. The captured traces refer to free bubble upward directed buoyant motion and show: 1) a single stranded rotational motion that is generated at the bubble bottom half-sphere; 2) two stranded rotational motion assembling dense anionic circuits generated on the upper bubble half-sphere and cationic assembled at bottom half sphere (these circuits are located inside the traces thus are not visible); 3) a double helix motion, forming "hollow cylinders" with a narrowed diameters showing relatively higher speed of rise.

The two traces forming double helix rotations directly indicate a possible link between bubbles and architecture of polymeric DNA. In addition, the results of experiments devised to define electric charge of droplets ejected by bursting bubbles indicated that bubbles may generate two oppositely directed and oppositely charged motions that are simultaneously assembled at upper and bottom half spheres [11]. These are: cationic-counterclockwise (left directed–L) motion assembled at bubble bottom half sphere and anionic-clockwise directed (dextrorotary–D) motion formed at bubble upper half sphere. The continuity in ions acceleration and aggregation occurring at bubble curvatures causes' steady separation of ionic hydrates according to their mass. As a result, heavier anionic hydrates are steadily gathered within bubbles upper half spheres, while relatively lighter cationic hydrates as well as electronegative elements with low atomic mass, are drawn into bubble vortices. The electronegative compounds as: nitrogen (N), oxygen (O), carbon (C) and phosphorus (P) are dissolved in sea surface waters as atmospheric gases or as compounds derived from lithosphere.

In addition, rising bubbles may scavenge and accumulate other components that are dispersed in seawater, [10] including hydrophobic compounds [12]. That specific behavior of bubbles results in continuous aggregation of hydrophobic materials that are transferred to bottom part of bubbles [13]. Afterwards, the collected materials are incorporated into bubble vortex forming a whirling reactor (Figure 2). If the composition of vortex contains electroneutral compounds, these may provide a vortex core that may isolate spiraling ionic strands and stabilize electrically polar molecules. Thus, chains of molecules may be continuously synthetized and laminated within the spiraling sub-bubble reactor.

To underline the possibility of bubble mediated assemblage of elongated macromolecules one bubble of diameter Do = 0.2 mm, forming double helix motion was selected for calculations [9]. That particular bubble trace was captured in artificial seawater under water temperature of 30 ℃ and salinity of 30 g/kg [9]. That bubble rose with velocity of 7.5 mm/s; accelerating ionic hydrates at bubble circumference to c. 358 mm/s^2. Assuming that pirouette reduction of spiraling motion was conducted

to 2 nm (e.g. typical diameter of RNA/DNA) the estimated number of turns yields value of $10 \cdot 10^6$ s^{-1}. However, that value refers to so call non-viscous conditions thus is overestimated.

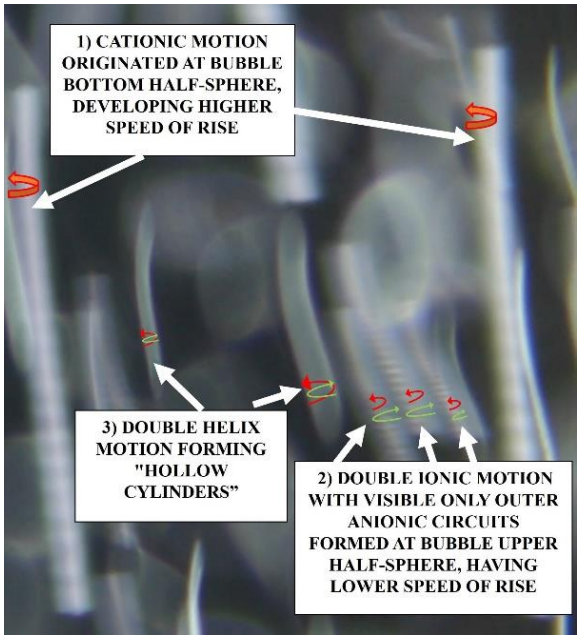

Figure 1. Traces showing three types of bubble rotational motions: 1) cationic flows (red arrows) generated at the bubble bottom half sphere, 2) double-ionic rotational system (red and green arrows) simultaneously aggregated at upper and bottom half spheres, 3) double helix motion forming "hollow cylinders". Bubbles were generated by *SEf* salt in seawater of Tw = 25 °C and S = 8 g/kg. Image was taken using Canon 350D with EFS 18–55 mm lens enhanced by 8 dioptric lens, t = 1/15 sec.

Moreover, it is assumed that electric polarization of ionic circuits steadily gathered at bubble wall should also induce electrical attraction between polar circuits. However, observations indicated that cationic centripetal strand dominate by means of gathered mass, electric charge and rotational energy, as compared with anionic strand. Therefore, in Figure 2 cationic strand (marked by red spiral) is longer than anionic (green spiral) indicating that cationic rotations are expected to last longer during the cease of motion at molecular scale. A photographic example showing a curled shape of rotational reactor formed below bubble in motion is presented in Figure 3. That particular sequence shows two upper anionic strands (marked by green/red curves) that are aggregated at bubble upper half-sphere and elongated cationic strand (marked by red vertical spiral) that is forming spiraling axis. The photographed trace also visualizes narrowing of cationic motion conducted in the sub-bubble vortex. Such processing is likely continued into molecular scale, until all rotational energy is converted to heat and/or used for assemblage of RNA or DNA. However, a final dissipation of energy is likely conducted by spiraling and revolving cations (as indicated by end of red spiral in Figures 2 and 3).

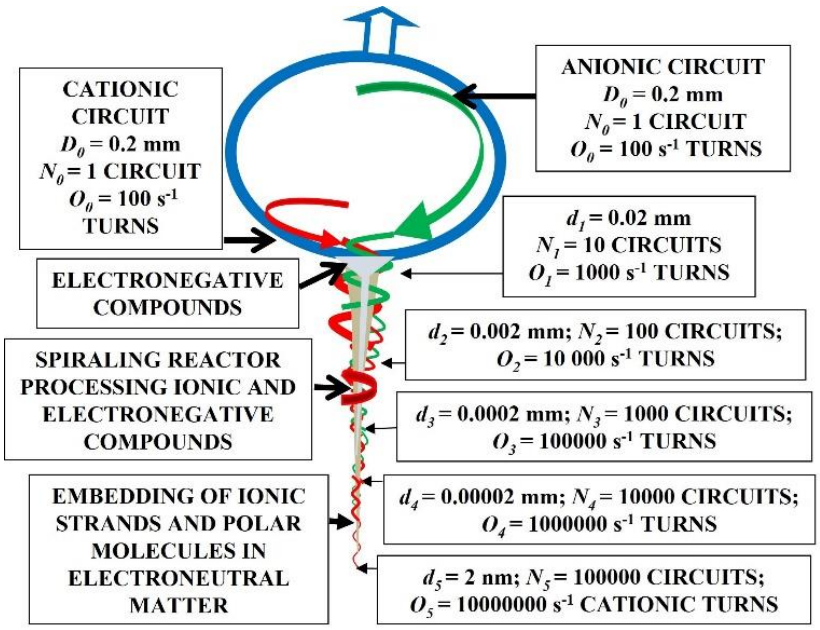

Figure 2. Illustration of a bubble vortex operating as a rotational reactor aggregating anionic strand (green), cationic strand (red), electronegative compounds (light blue) and electroneutral mater (gray); listed number of circuits N_0 and the frequency of turns O_0 in s^{-1} refers to photographed bubble rotational trace of diameter D_0 = 0.2 mm, while N_1, N_2, … N_5 and O_1, O_2, … O_5 refers to values calculated for non-viscous conditions.

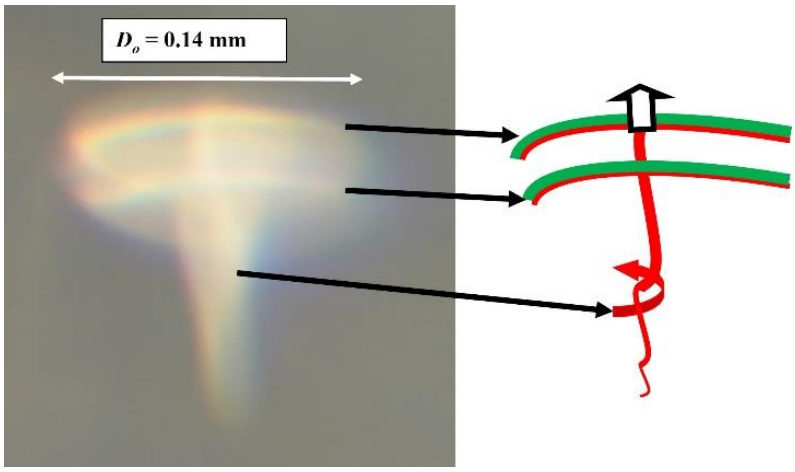

Figure 3. A trace of bubble forming a whirling, funnel like cationic reactor under the rising bubble of D_o = 0.14 mm; ionic strands are presented in right panel by red curve and red arrow that indicate cationic motion with L-twist; two green/red curves that indicate anionic/cationic motion with D-twist; experiment was conducted in real seawater under Tw = 30 ℃ and S = 8 g/kg; bubbles were produced by adding a few crystals of sea salt. Image was taken using Canon EOS 6D, and TAMRON 28–75 mm lens with reverse ring, t = 1/10 sec.

3.2. Generation of electronegative elements and combining them into polar molecules

Ionic hydrates revolving with a frequency of a million turns per second are expected to induce a significant friction that may cause detachment of electrons from the outer-covalent atomic shells of cations and other electropositive atoms that are dissolved in seawater. Then, detached electrons may be intercepted by electronegative elements as: H, N, C, O and P. These compounds have relatively low atomic mass, thus are effectively drown to bubble vortices (Figure 2). Rotational processing of such compounds should simultaneously activate charge neutralization [14] by attraction of elements having the opposite electric charge. Possible charge neutralization around revolving cationic hydrates, exposing positively charged hydrogen arms of water molecules outward, is presented in Figure 4. The activated processing may incorporate revolutions of hydrogen rotors bound to oxygen centers of mass [10] that attract electronegative atoms of O, H and P. These may form a negatively charged block of phosphate (H_3PO_4) i.e. the molecule that contains only a strongly electronegative elements. Such blocks form phosphate-sugar backbones in RNA and DNA.

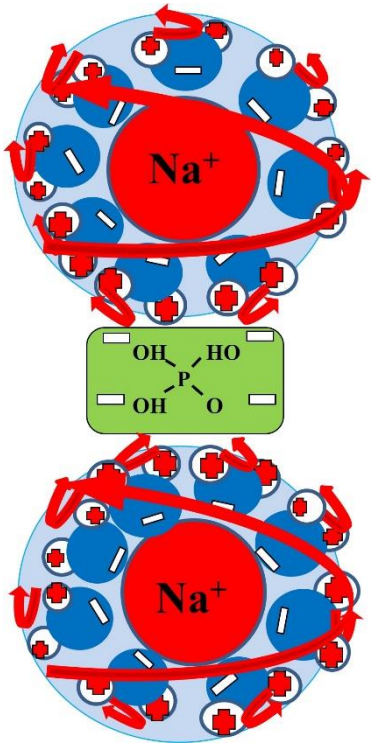

Figure 4. Simplified rotational-electric configuration of two sodium (Na^+) hydrates attracting electronegative atoms of hydrogen, oxygen and phosphorus assembling a negatively charged phosphate block (H_3PO_4) composed of electronegative elements.

Since cations combine rotational energy of a few positively charged hydrogen rotors (Figures 4, 5), cationic centers magnify their rotational momentums [10]. Considering that peculiarity, the cationic hydrates should be regarded as actively rotating and revolving spherical objects (Figures 4, 5) that are able to gather the overwhelming share of energy in seawater. Thus the energy transfers in seawater at molecular scale should have cationic-rotational nature. In contrast, anionic hydrates, which keep hydrogen rotors inward, are expected to perform passive or compensative rotational motions.

Electronegative atoms with aggregated electrons may be arranged into blocks as phosphate and winded into ringed pentagonal ribose as well as pentagonal blocks, such as found in nitrogenous bases of A, G in RNA and DNA. While rotationally and electrically compensative revolutions around anionic hydrates may aggregate, twist and close hexagonally ringed molecules, which are found in nitrogenous bases of C, G, A and U in RNA as well as in C, T, A and G in DNA. The above concepts may explain effective rotational-electric condensation of electronegative elements and assemblage of phosphorus and nitrogenous compounds that are processed inside the bubble vortices, as shown in Figures 4 and 5. These, electrically polar blocks of molecules might be then electrically attracted and positioned along the cationic flow and form polymeric chains of RNA or DNA. The stated concept may explain the combination of processes that are able to perform both selection and condensation of electronegative elements that are dissolved in seawater.

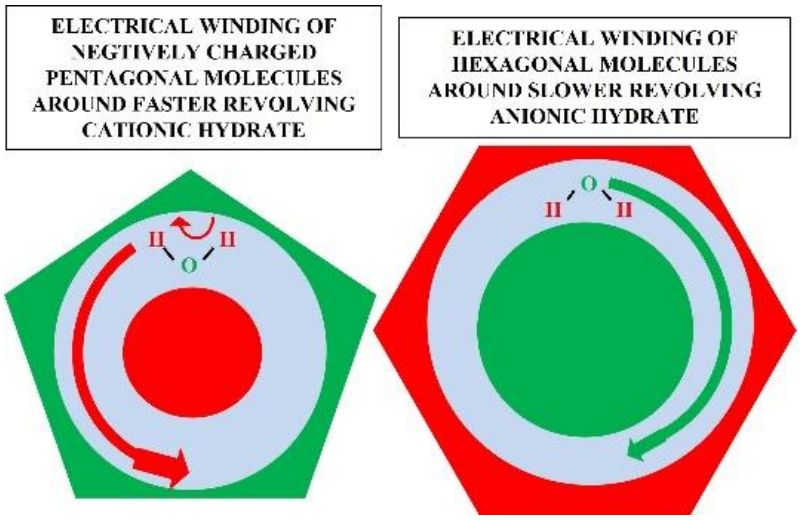

Figure 5. Cross section through cationic and anionic hydrates illustrating opposite direction of revolutions and opposite charge arranged around cation (red sphere) positioning several water molecules (blue ring) and winding pentagonal molecule with a negative charge as well as that conducted around anionic hydrate (green sphere and blue ring) winding hexagonal molecule.

3.3. The concept of bubble mediated polymerization of a single stranded RNA

If only a single cationic motion is developed and sustained by rising bubble, and then processed inside the bubble vortex, it may assemble a single stranded polymer as RNA. The expected stages of bubble mediated rotational processing may combine: 1) continuous acceleration and aggregation of cationic hydrates forming a single flow; 2) production of electronegative compounds inside bubble vortex; 3) selective condensation of electronegative elements around cationic centers of revolutions forming negatively charged phosphate blocks as well as pentagonal molecules; 4) generation of oppositely revolving anionic centers of revolutions resulting in winding hexagonal molecules with positive charge; 5) continuous positioning of polarized molecules along the cationic flow; 6) drawing the electroneutral matter into bubble vortices; 7) continuous thermal lamination of polar molecules in electroneutral materials and 8) perpetuation by cooling of molecules to water temperature (Figure 6).

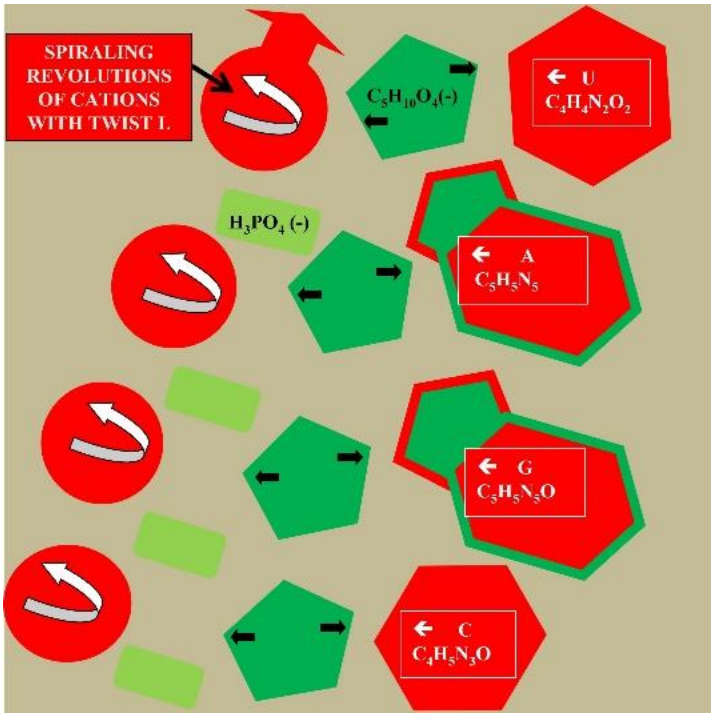

Figure 6. Formation of polymeric RNA along spiraling-revolving cationic flow (red spheres) aggregating blocks of negatively charged phosphates (rectangles), pentagonal sugar and nitrogenous bases (green) as well as positively charged hexagonal blocks (red), accompanied by lamination in electroneutral matter (gray color).

3.4. The concept of bubble mediated polymerization of a double stranded DNA

In the case of rising bubble that simultaneously develops and sustains two ionic flows, a double helix motion is assembled and undergoes a double-pirouette narrowing in the vortex. That may result in generation of electronegative compounds and assemblage of molecules having an oppositely directed feature. If generation of electronegative compounds is continuous, and results in production of polar molecules these as electrically polar blocks may be simultaneously arranged by both cationic and anionic/cationic flows (Figure 7). However, in both cases the spiraling and revolving cationic flow should play a leading role, since the compensative anionic/cationic flow needs to integrate carriers of rotation that is, efficiently spiraling and revolving cationic hydrates.

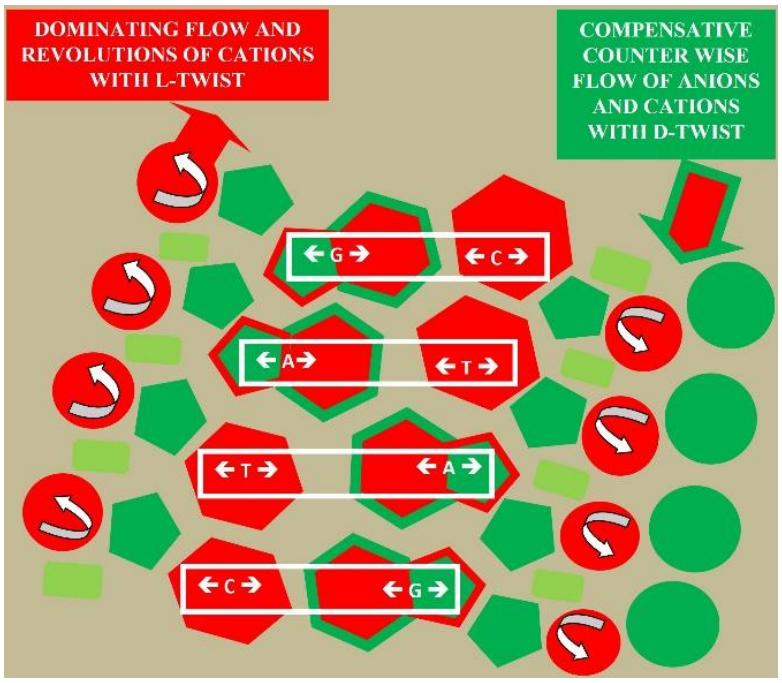

Figure 7. Formation of polymeric DNA by a spiraling-revolving cationic flow (red spheres) with L-twist, compensated by counter directed flow of anions/cations (green/red spheres) with D-twist, producing and positioning blocks of phosphates (squares) and pentagonal sugars as well as pentagonal molecules with a negative charge (green) along with hexagonal blocks of nitrogenous bases (red) gathering a positive charge, then embedded in electroneutral matter (gray color).

The stated concept suggests that spiraling flows of ions in RNA and DNA are conducted within channels (grooves), i.e. smaller managing a single cationic flow and about twice as large maintaining anionic/cationic flow. Those continuous, double-like-RNA antiparallel and oppositely directed ionic flows may produce sugar-phosphate and nitrogenous compounds as well as pair them into C:G and A:T bases. While pairing of bases may be governed by electrical attraction and tendency to attain, so call electro-neutrality, which is a basic electrical principle operating in seawater and in all ionic solutions [14]. The same system of cationic revolutions and spiral projection (replication) of single cationic or bi-ionic flows might be activated under a sufficient concentration of ionic hydrates and sufficient access to energy. Under such conditions a replicative ionic flows may be generated along with winding electronegative molecules and positioning them along oppositely directed and oppositely charged bi-ionic motions, as illustrated in Figures 6 and 7.

4. Preliminary discussion

Friction between rotating and revolving ionic hydrates in seawater may cause polarization of electropositive elements (donors of electrons), mainly provided by: sodium, magnesium, calcium, potassium and electronegative elements that attract free electrons (acceptors) as: hydrogen, oxygen, carbon, nitrogen and phosphorus. In addition, both categories of elements have relatively low atomic mass which gives them enhanced mobility, needed for drawing into the bubble vortices, and then

allowing them efficient condensation around cationic or anionic centers of revolutions. If assemblage of electrically polar blocks of molecules is conducted under the presence of electroneutral materials, these may form elongated polymers that retain loads of electrons incorporated to electronegative blocks and save the aggregated electric potential for further interactions.

It was documented that the total charge of matter drawn into sub-bubble vortices in seawater is positive [6,11]. However, when bubble burst at sea surface ejecting cationic droplets [11], these are suspended in a positively charged electric field in air [15]. Such airborne droplets develop negatively charged outer layers, such as found in bacteria cells [16] and compose envelopes in coronaviruses [17]. Intriguing is also a fact that the total structural charge of RNA in SARS-CoV-2 is positive [17], the same as charge detected for jet droplets emitted by bursting bubbles [11]. However, the net negative envelope in SARS-CoV-2 is probably punctuated by rotational motion of cations which may form spikes, thus in their centrally located regions a dominating imbalance of a positive charge is featured [17]. Such configuration of SARS-CoV-2 indicates that the positive charge incorporated to coronaviruses and RNA may be responsible for its rotational transmissions. Especially, the positively charged regions in spikes may firstly promote adhesion [17] and then conduct extremely efficient rotational-electric transition via negatively charged outer membranes protecting biological cells [16].

Since bubbles rising in seawater generate strong, spiraling and revolving cationic motion with L-twist and compensative anionic/cationic motion with D-twist, both pose antiparallel architecture that is consistent with configuration of L-twisted RNA and L/D-twisted DNA [18]. Therefore, that architecture is also consistent with the general symmetries found in nucleic acids [19]. Moreover, it indicates that enforcing of ionic motion in saline liquids might be mostly cationic-rotational and that transport of all ionic matter, including that conducted in all biological cells, should be induced as well as organized by inherently more prone to rotate cationic hydrates.

Hence, bubbles may form a stable RNA and/or DNA viral particles, these may be dispersed in seawater and impact waterborne organisms. The presented research revealed that rotational-cationic configuration of all viral cells including coronaviruses may promote electrostatic adhesion and then transition to bacteria or other biological cells [17]. For example, it was reported that viruses may kill even about 20% of the oceanic microbial biomass daily [20]. Considering that specific behavior of waterborne viruses it was also concluded that viruses play a major role in the overall geochemical cycling of elements in oceanic ecosystem [21].

Presented research supports the hypothesis that firstly emerged informative molecules of RNA in a very warm ancient ocean and may likely played the organizational role for polymerization of DNA [22]. For instance, laboratory experiments conducted under the water temperature range of 20–40 ℃ indicated that with increasing water temperature an increased tendency to form more single stranded, cationic flows was found. That supports the "RNA world hypothesis" [23] posing that RNA shaped the overall course of evolution towards DNA and impacted structural alignment of bacterial and cellular organisms [24].

5. Conclusions

The study of bubbles rotational motion in seawater allowed stating the following conclusions.

1. Bubbles rising in seawater accelerate and aggregate ionic hydrates to either a single cationic or bi-ionic spiraling-revolving flow.
2. Cations are surrounded by prone to rotate water molecules, thus gather more energy.

3. Motion of ionic hydrates in molecular scale is induced and carried by rotating cationic hydrates.
4. Cationic hydrates revolving within bubble vortices may generate electronegativity and condense polarized elements to blocks of phosphates, sugars as well as ringed nitrogenous bases.
5. Compensative revolutions around anionic hydrates may form hexagonal nitrogenous bases.
6. Oceanic bubbles may activate processes needed to polymerize electronegative RNA and DNA.

Conflict of interest

The author declares no conflict of interest.

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