

The “memory of water”: an almost deciphered enigma. Dissipative structures in extremely diluted aqueous solutions of the homeopathic medicine.

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Abstract

In the last decade, we have dealt with following topic: is it true, from the physico-chemical point of view, that water treated following the particular procedure characteristic to the homeopathic medicines preparation (leading inexorably to systems without any molecule different from the solvent) is a “new water” really “different” from the initial one? The answer to this question comes out to be positive, unexpectedly in the frame of the current scientific paradigm, but strongly supported by a plethora of experimental results. The used measurement methodologies are well established physico-chemical techniques: flux calorimetry, conductometry, pHmetry and galvanic cell electrodes potential. Moreover, the analysis of the experimental results vs. the “arrow of time” was astonishingly relevant. In fact, in a totally unexpected way, the measured physico-chemical parameters are evolving in time. The water solvent exhibits physico-chemical properties experimentally measurable that are largely changing as a function of: the “lived path”, the solute previously dissolved, and the time. In particular we evidenced two new experimental phenomena (both totally unpredicted) that characterise the homeopathic dilutions: the presence of a maximum in the measured physico-chemical parameters vs. the samples age, and their dependence on the volume in which the homeopathic dilution experiments its ageing. All these new experimental results are strongly indicating the presence of an extended and “ordered” dynamics involving the whole liquid water molecules.

Keywords: homeopathy, calorimetry, conductivity, pH, dissipative structures

“Memory of water” is a journalistic expression, used for the first time in the French newspaper *Le Monde*, just after the publication (1988) of the famous Jacques Benveniste’s paper on the international scientific journal *Nature* [1]. In this paper he evidenced, by biologic proofs, that “homeopathic dilutions” of substances (i.e. so much diluted to not contain anymore molecules of the substance initially diluted in the water solvent) are able to induce biological effects - in a statistically significant way – totally typical of the substance initially solved in it. So, the coloured expression of “memory of water” was a journalistic, extreme and fanciful synthesis of a phenomenology basically not explained until nowadays, but that is finding in recent scientific publications some possible ways to experimentally validate the reality of a whole new class of physico-chemical new phenomena concerning liquid water [29].

In fact, it seems that it is really possible to obtain physico-chemical information depending on the recent or remote “history” of a water sample (Prigogine should say: breaking of the temporal symmetry), almost like it happens in the case – surely better known – of the magnetic materials (Prigogine should say: breaking of the spatial symmetry) [2]. The fact that the so called memory of

water, evocated after the publication of Benveniste's research group paper, is connected to the capacity of this kind of solvent, many variable complex system, to be influenced also by very tiny perturbations, such as mechanical or electromagnetic actions, in such a way to move away from the initial equilibrium conditions, seems more and more unquestionable. The term "memory of water", in this meaning, becomes comprehensible and acceptable in the frame of Irreversible Processes Thermodynamics paradigms completely accepted by the scientific establishment due to the Chemistry Nobel Prize (1977) Ilya Prigogine [2].

In the last ten years [5-14], our research group investigated this problem from the point of view of the physico-chemical properties of water when this last is treated following the original and particular procedure characteristic to the homeopathic medicines preparation: iterative dilutions (of specific solutes of medical interest) followed by specific agitations (successions). This method leads inexorably to systems without any molecule different from the used solvent, which in our case is the pure water. The "new water" obtained in such a way may be really "different" from the initial one? Answering to this question was our challenge and we can say in advance that the answer, surely unexpected but strongly supported by the experimental results, comes out to be affirmative. We are encouraged in our investigations because in the meantime, other research groups came to the same conclusions thanks to differently based experimental works and following other methodologies [4, 19-24] – and last but not the least thanks to Giorgio Piccardi, the founder of the Italian physico-chemistry, with his pioneering and nowadays historical works concerning fluctuating chemical reactions [25-28]. In this context, it is possible to affirm that the critical mass of experimental data [29] necessary to evidence a new class of physico-chemical phenomena of the water, to be extensively experimented and interpreted in the next years, has been reached now.

The experimental methodologies used for our investigations were chosen as the most efficient among the many tested. We are giving a short list of them, without entering in the technical aspect, but emphasizing that they are well established physico-chemical methodologies: flux calorimetry, conductometry, pHmetry and galvanic cell electrodes potential.

The worst difficulty of the preliminary work, which lasted for many years, was exactly the selection of the most enlightening experimental methodologies and the establishment of the optimal experimental conditions. On the other side, it was not less difficult to evaluate the contribution of the impurities released by the used glass vessel to the measured experimental values. In fact, this problem of the impurities has been the principal objection generally arisen probably due to the strong prejudice in what concern the possibility that the followed procedures might really change the physico-chemical nature of the solvent water.

In the graphics of Fig.1-3, one can see that the presence of impurities (released by the glass vessels) is obviously giving a significant contribution to the physico-chemical state of the prepared dilutions, but not relevant with respect to the unexpected contribution (much higher than the range of the experimental errors) of the auto-organisation process of the water molecules (which are far from the thermodynamic equilibrium, as we will see further) triggered by external perturbations (such as for example repeated dilution and iterative succussions).

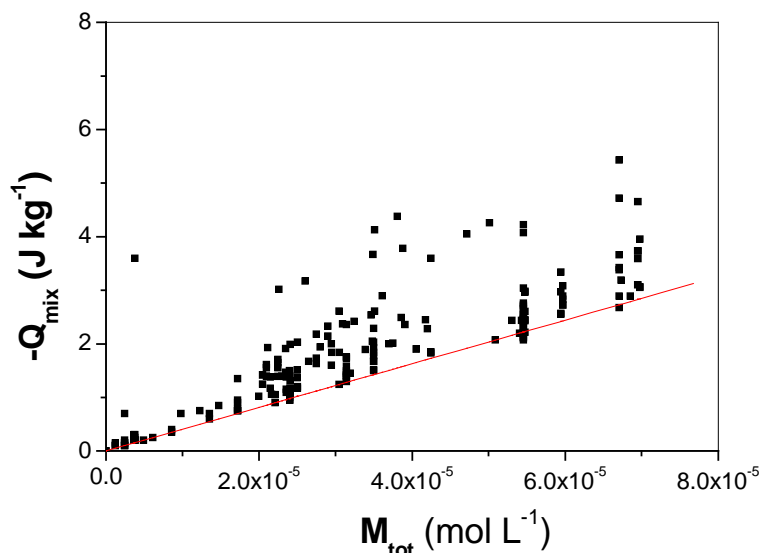


Fig. 1. Heat of mixing, Q_{mix} , vs. concentration (determined by analytic methods) of the impurities, M_{tot} , released by the glass vessels. Black symbols: heat of mixing of homeopathic solutions with sodium hydroxide, NaOH, 0.01 M (Mol Kg^{-1}); Red line: heat of mixing of aqueous solutions containing only the same amount of impurities determined in the homeopathic solutions.

It is worthily to mention that the absolute values of the heat of mixing with sodium hydroxide determined using the homeopathic solutions are systematically higher than the correspondent heat of mixing determined only by the “chemical” contribution originated from the glass vessels.

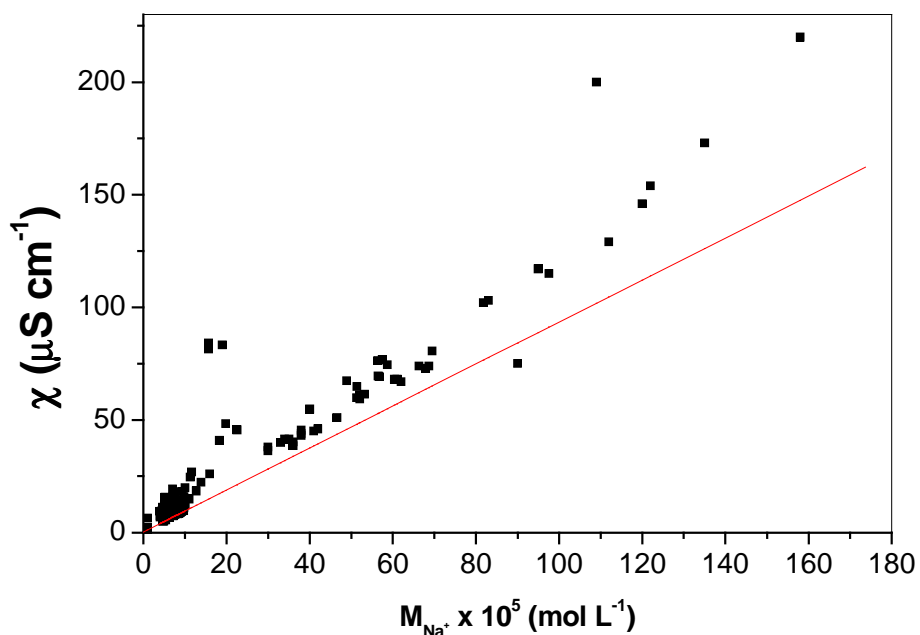


Fig. 2. Specific conductivity, χ , vs. concentration (determined by analytic methods) of the impurities, M_{Na^+} , released by the glass vessels. Black symbols: specific conductivity of the homeopathic dilutions; Red line: specific conductivity of aqueous solution containing only the same amount of impurities determined in the homeopathic solutions.

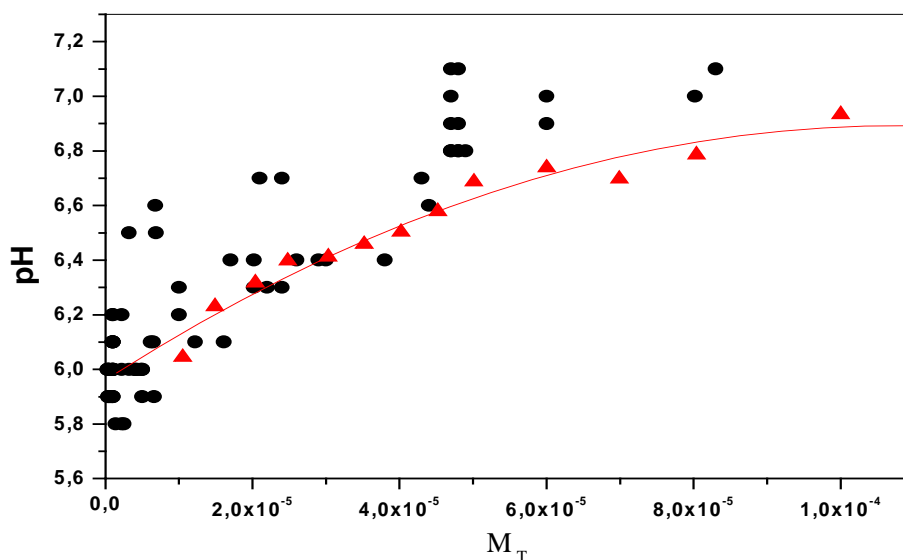


Fig. 3. pH values vs. concentration (determined by analytic methods) impurities, M_T , released by the glass vessels. Black symbols: pH of homeopathic dilutions; Red symbols: pH of aqueous solution containing only the same amount of impurities determined by analytic methods in the homeopathic solutions.

Considering the three reported graphics, it is possible to understand: i) how the impurities contributions were taken into account and ii) the extremely relevant contribution of “something” different from any possible chemical origin. This is a preliminary result that, hardly reached, cleared out the experimental methodologies from dangerous misunderstandings: in fact, it allowed us to proceed for collecting further information and insights on the nature of the “homeopathic dilutions” [5-14].

It is important to emphasize here that from the studies conducted until now we were not able to determine quantitative reproducibility and to deduce significant information concerning the influence of the different degrees of homeopathic dilutions (CH) or the nature of the active principle (solute) on the variations magnitude of the measured physico-chemical quantities: for this reason the experimental data reported in the figures are non characterised by CH or active principle indication.

An extremely stimulating result, very important to understand the complicated system under study, was to discover – not without a certain amount of serendipity – that the physico-chemical properties of the homeopathic remedies depend on time. The fact that the numerous experiences were performed during many years, naturally introduced the time parameter. Exactly the analysis of the

experimental results vs. the “arrow of time” was of unexpected relevance [8-11], and it led to the idea that the system under observation (homeopathic solutions) is a closed system (able to exchange only energy with the external environment), far from the thermodynamic equilibrium, which seems to allow that some structures, with a local order higher than that one of the water around them, may emerge from chaos (“dissipative structures”).

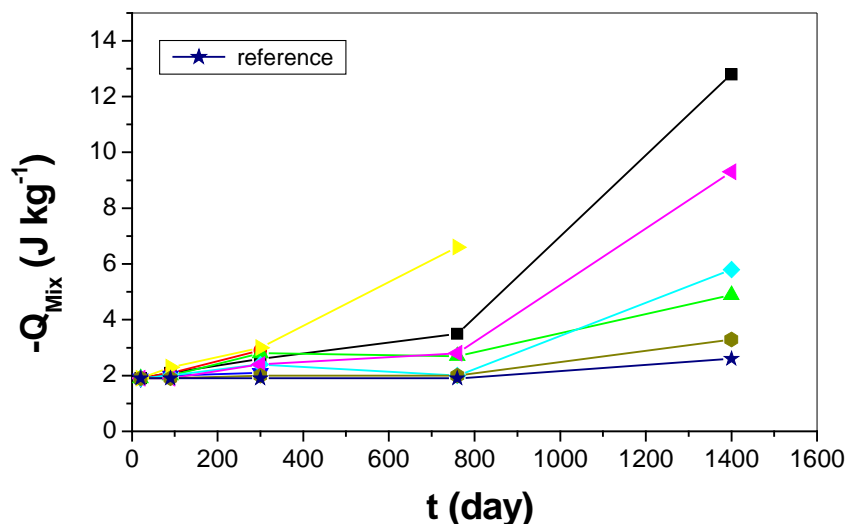


Fig. 4. Heat of mixing, Q_{mix} , vs. the samples age, t for six homeopathic solutions.

As can be seen from Fig. 4 and 5, in a totally unexpected way, the investigated physico-chemical parameter is increasing with time. In other words, the ageing is modifying the physico-chemical nature of the homeopathic solutions.

It is now a must to demand ourselves something very important: what is the interpretation of this new characteristic of the homeopathic solutions connected to their evolution in time. We are simply observing a system looking for an energetic minimum and then for a new equilibrium in a slow kinetic process or it is something totally different? From Fig.4 and 5 we deduce that the temporal variations of the reported parameters are very slow, because there are necessary many months to evidence them unambiguously; however, this temporal behaviour mismatch with the idea of a simple slow kinetic. In fact, following the *reductio ad absurdum*, if should exist an energetic minimum toward which the system could go, it would be impossible that during the geological times, since the water exists, it had not reached this hypothetical minimum.

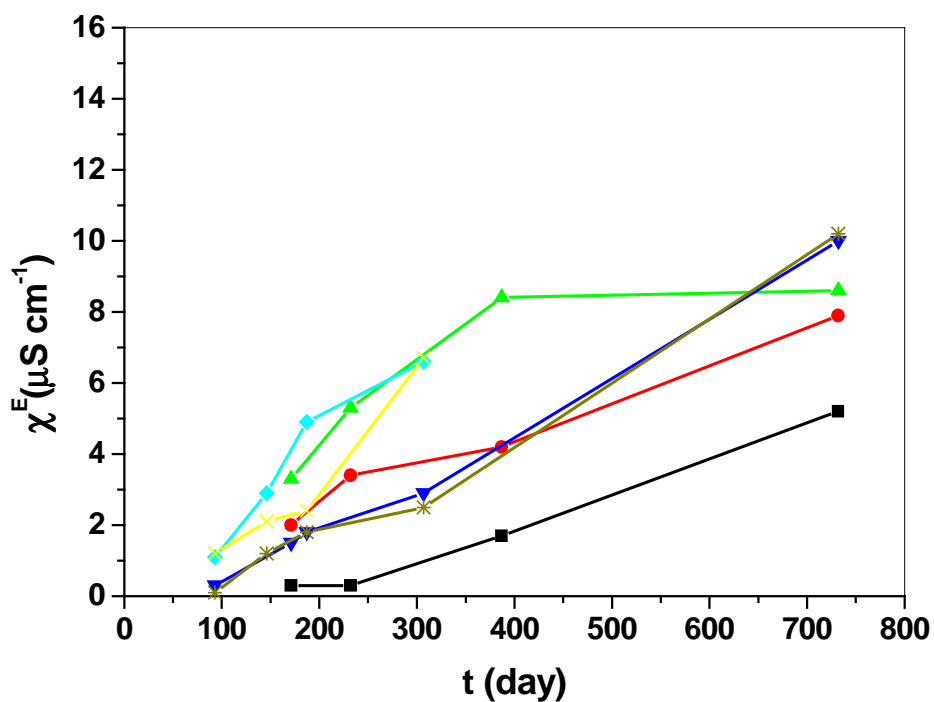


Fig. 5. Excess specific conductivity, χ^E ($\mu\text{S cm}^{-1}$) (defined as the experimental difference among the experimental χ value and the contribution furnished to this parameter by the impurities presence, χ^{chem}) vs. the samples age, t , for six homeopathic solutions. Each studied sample has its own peculiar χ^E vs. t dependence in the frame of a similar qualitative behaviour that is an increment of χ^E in time.

Moreover, as shown in Fig. 4 and 5, for both parameters (specific conductivity and heat of mixing with alkaline solutions) is observed an increasing in time. Therefore a correlation among them is predictable.

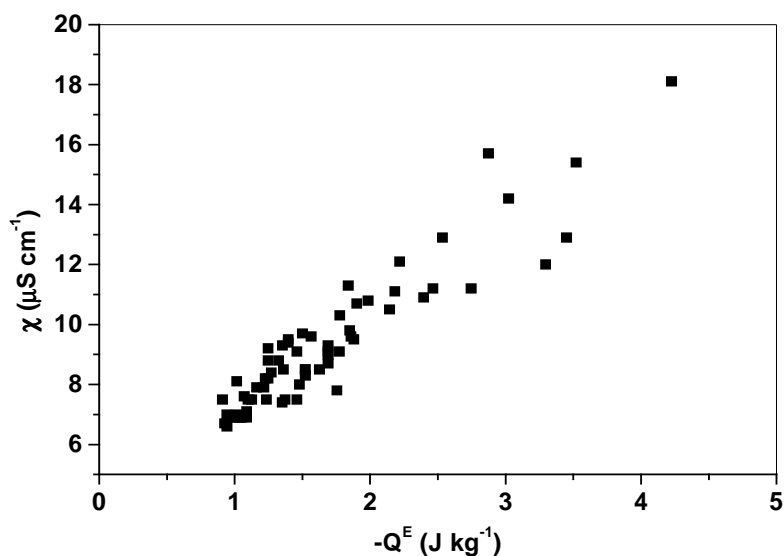


Fig. 6. Specific conductivity, χ , vs. excess heat of mixing, $Q_{\text{mix}}^{\text{E}}$ (that is the difference among the experimental Q_{mix} value and the contribution furnished to this parameter by the presence of impurities), for a certain amount of homeopathic solutions.

In effect, the correlation among the specific conductivity and the heat of mixing with alkaline solutions, as shown in Fig. 6, not only exists, but it seems to be linear; in other words, these two parameters are sensitive to one cause only. This result pushes us to investigate the nature of the possible mechanism able to increase contemporaneously the electrical conductivity and the heat of mixing with alkaline solutions, after the procedure of repeated dilutions and successions.

The descriptive model proposed in the following, in spite of its simplicity, is in agreement with the experimentally observed ageing effect.

A reasonable explanation of the electrical conductivity increasing after the preparation and ageing procedure may be based on the so called “hopping mechanism”, proposed by C.J.T. Grotthuss (1806) [3] to explain the much higher mobility (about 5 times) of the cations H^+ and OH^- (always present in the liquid water due to its autoprotolysis) in comparison with other cations of comparable ionic radius.

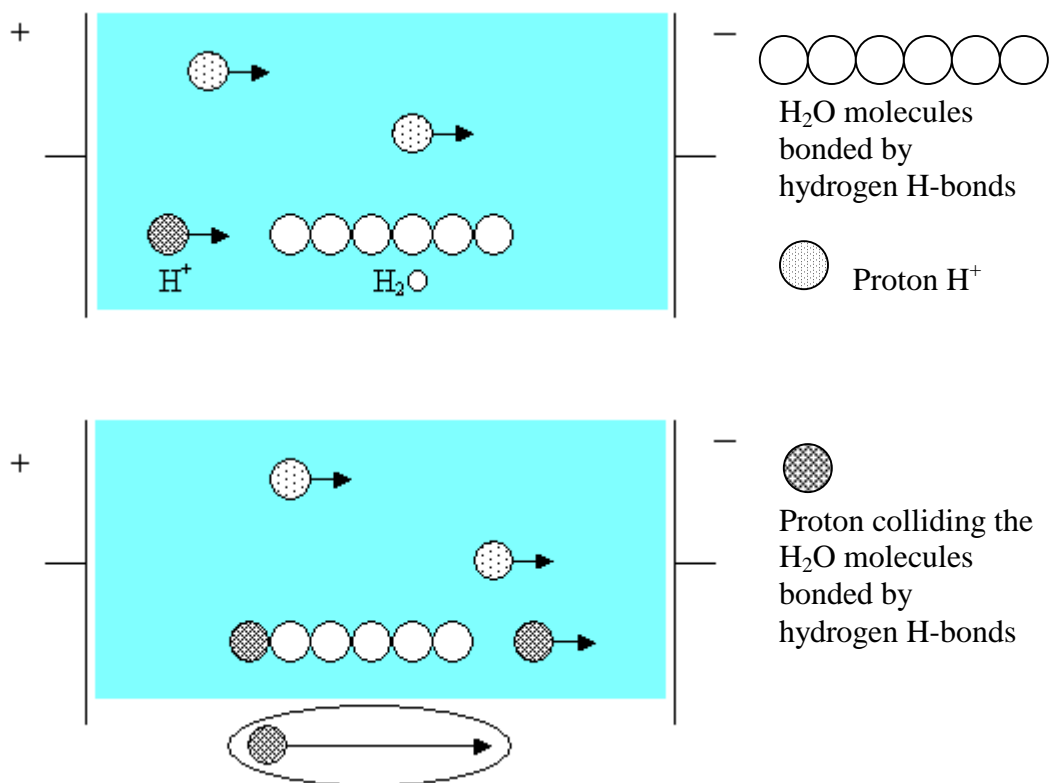


Fig. 7. Schematic representation of the Grotthuss hypothesis of the proton (H^+) hopping mechanism used to explain the much higher mobility (defined as the ionic drift velocity under a unitary gradient of electrical potential V cm^{-1}) of the cations H^+ and OH^- belonging to the water ($\text{H}_2\text{O} = \text{H}^+ + \text{OH}^-$) in comparison with other cations of comparable ionic radius.

If H_2O molecular clusters are present in the solution, bonded by hydrogen bonds, the hydrogen ions H^+ colliding them experiment the “hopping” phenomenon (Fig. 7): the water molecules caught the ion H^+ at one end of the cluster (that for the sake of simplicity was considered linear) and release instantaneously at the other end of the cluster another ion H^+ . For these ions the drift velocity under an electrical potential gradient (measure of the conductivity) results strongly increased in comparison with that of the great majority of ions which are not meeting the H_2O molecular clusters. Higher is the number of the clusters and/or their length, higher is the conductivity value. The correlation among electrical conductivity and heat of mixing with alkaline solutions, on the contrary, should be the consequence of the H_2O clusters breaking, due to the pH variation, as schematised in Fig. 8.

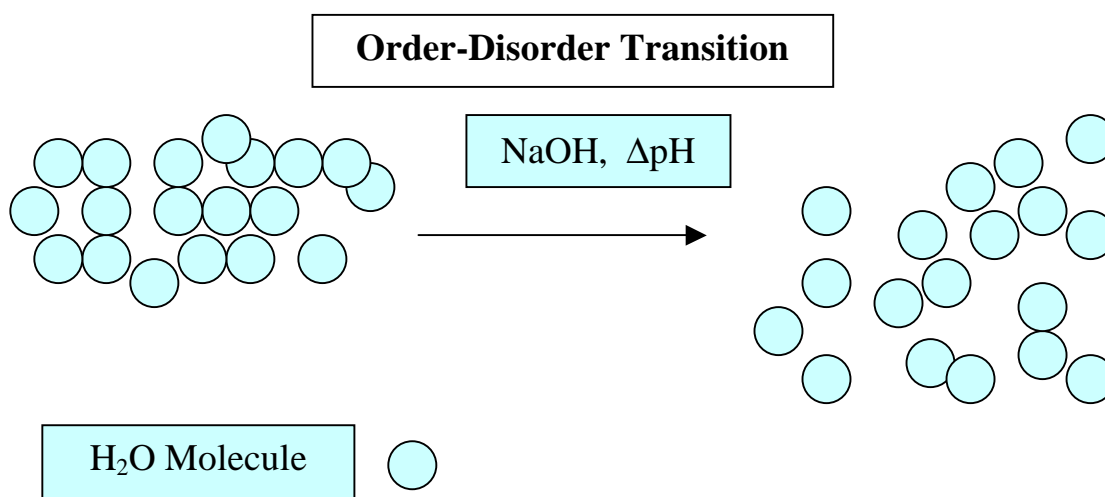


Fig. 8. Schematic representation of the phenomenon of molecular clusters breaking, caused by the pH variation during the experimental procedure of determining the heat of mixing with hydroxide solutions (NaOH) 0.01 M (mol Kg^{-1}) inside the calorimetric cell. The experimental procedure consists in mixing a homeopathic dilution (that we suppose richer in H₂O molecular clusters than the “standard” water solvent) with an alkaline solution. The following pH variation seems to determine exactly a breaking of the H₂O clusters hydrogen-bonded, determining a transition Order \rightarrow Disorder. This is experimentally evidenced by the increasing of the heat of mixing with respect to the “normal” water having just a few molecular clusters.

Higher the number of the clusters is and major their dimensions are, more is the measured thermal effect (Fig. 8).

The two experimental phenomena explanations, in effect, witness the same thing, that is they are both sensitive to the number and/or dimensions of the clusters.

Let us come back to the question: are we measuring the presence of stable clusters looking for an energetic minimum, or of instable clusters constituted by dissipative auto-organised structures in far from equilibrium condition, status in which they should remain or move away as function of their ability to exchange energy with the external environment.

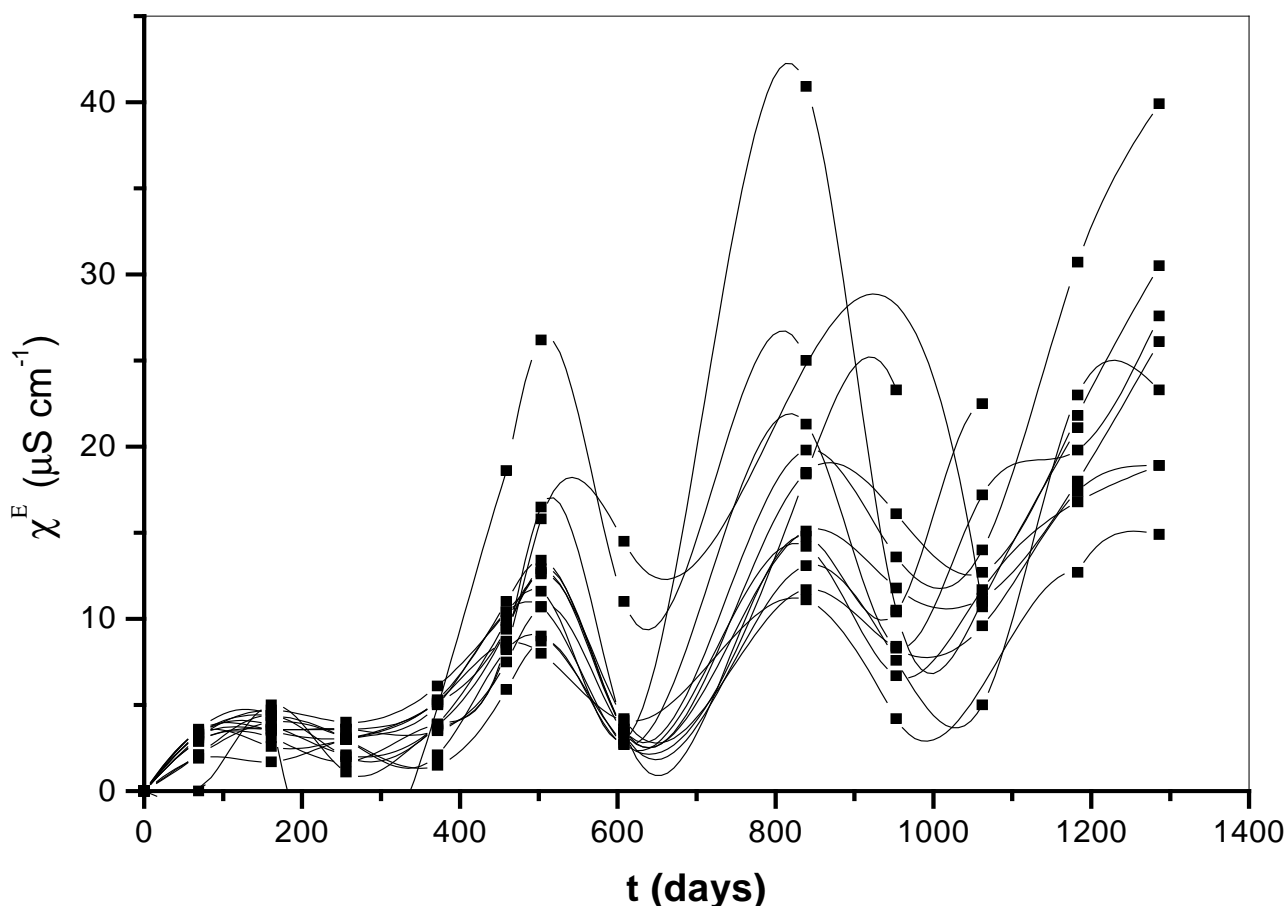


Fig. 9. Specific excess conductivity, χ^E , vs. the samples ageing, t . Each curve describes the temporal evolution of Arnica Montana (AM) samples, obtained by different homeopathic dilutions from the same "mother tincture". There is no specific correlation between the χ^E behaviour and the specific CH of the samples. This χ^E dependence on time cannot be explained in the frame of the classical physico-chemistry.

We have already emphasized that the hypothesis of systems slowly evolving towards new equilibrium states is not coherent with the experimentally individuated phenomenology. In particular, the hypothesis of systems even if very slowly evolving towards a minimum, evidently contrasts with two of the new experimental phenomena (both extraordinarily unexpected) characterising the homeopathic dilutions:

- a) the presence of a maximum in the dependence of the physico-chemical parameters vs. the samples age (Fig. 9);
- b) the dependence of the physico-chemical parameters (apart the age) also on the volume in which the homeopathic dilution experiment its ageing (Fig. 10).

In particular, the last phenomenon (b) is absolutely anomalous and inexplicable in the current paradigm [14], seeming to be in sharp contradiction with the classical concept that an intensive physical quantity (as the one here measured) cannot depend on the volume. Therefore, it is evident

that we are in the presence of a phenomenology which cannot be explained in the frame of the classical thermodynamics.

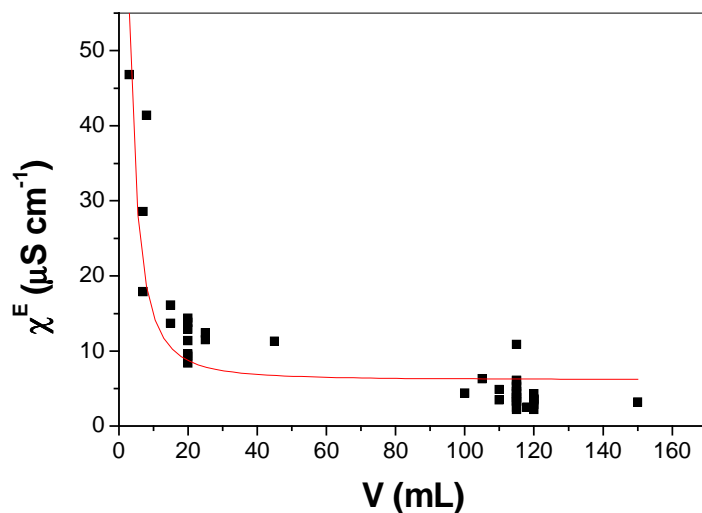


Fig. 10. Excess specific conductivity, χ^E , vs. ageing volume, V . Each point represents the value of χ^E for each single dilution, experimentally determined at the same age. There is a very strong variation of the parameter, about one order of magnitude, for the systems aged in very little volumes. This volume dependence cannot be explained in the frame of the classical physico-chemistry.

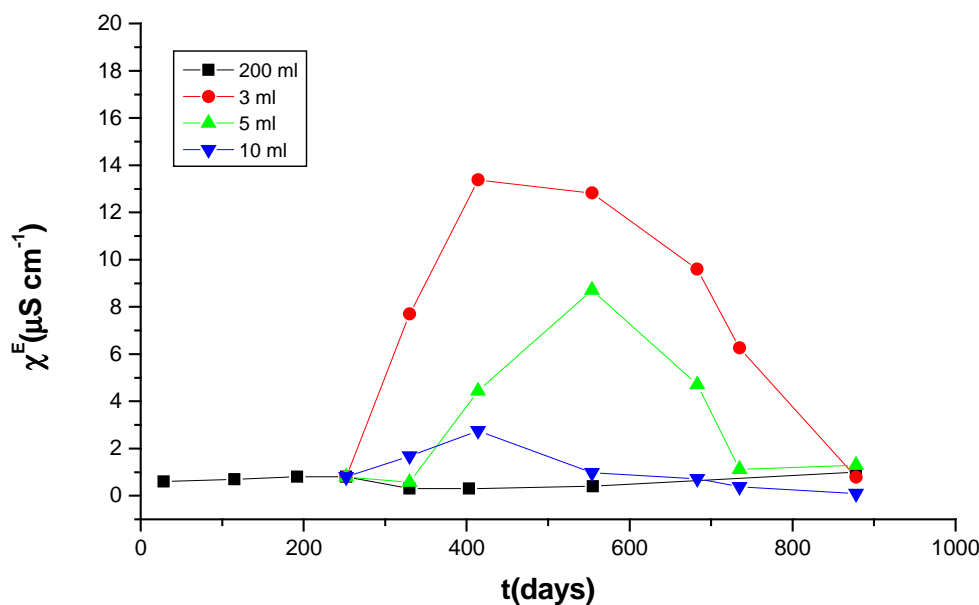


Fig. 11. Excess specific conductivity, χ^E , vs. the samples age, t . In this experiment, a homeopathic dilution of Arnica Montana was let ageing for about 250 days in a volume of about 200 ml. At this point 18 ml were picked up and divided in three different recipes of equal shape, containing 10 ml, 5 ml and 3 ml, respectively. The four obtained samples, 182 ml, 10 ml, 5 ml and 3 ml, were studied vs. time. Their temporal evolution was dramatically influenced by the perturbation induced by the repartition in smaller volumes. In particular the higher volume of 182 ml was not experiencing particular temporal variations due to its volume

decreasing, while in the case of the smaller volumes, a colossal temporal evolution was triggered, depending strongly on the starting point.

In Fig. 11 the temporal evolution of the excess specific conductivity of 4 sample systems is shown. The samples were obtained as following: an aqueous system highly diluted was divided in 3 smaller volumes at a certain “age”. As one can see, the χ^E behaviour in time of the samples having small volumes is strongly different with respect to that of the “mother tincture” with a higher volume. The bigger volume sample does not experiment relevant modifications vs. time, while each new system of smaller volume chooses its own different way to evolve, in the frame of a common behaviour characterised by the presence of a maximum. This means that the evolution vs. time depends on the initial state (in this case: large or small volume), which means, in a certain sense, that the systems have the “memory” of the initial conditions.

Another example of this “memory” of the system is visible from the experimental data of Fig. 12 reporting the temporal evolution of the excess specific conductivity for a system of samples obtained by the same “mother tincture” by bi-distillate water dilutions, without succession, in different dilution ratios [13]. As one can see, also in this case the systems evolution in time is strongly conditioned by the specific initial conditions, with temporal variations characterised by very different maximum and slope values.

Therefore, it is evident again that the past story influences the evolution of the “pure water” system.

The apparent contradiction among the concept of intensive quantity, as the specific conductivity and the heat of mixing are, and the experimentally evidenced dependence on the volume may be solved if considering that inside the solutions are present molecular clusters constituted by water molecules connected by hydrogen-bonds, in far from equilibrium conditions. They can remain or move away from their instable equilibrium state, dissipating energy coming from the external environment; practically they should be “dissipative structures” as described by Prigogine [2].

It is interesting to evidence that the spontaneous formation of molecular clusters in water is foreseen by the Coherent Quantum Electrodynamics (Coherent QED) without introducing the existence of hydrogen-bonds: this theoretical formulation (G. Preparata, E. Del Giudice, et al.) is able to predict precisely the physico-chemical properties of the water [15-18, 29], much better than other theories, and the introduction of the “arrow of time” in this frame should bring to very interesting results.

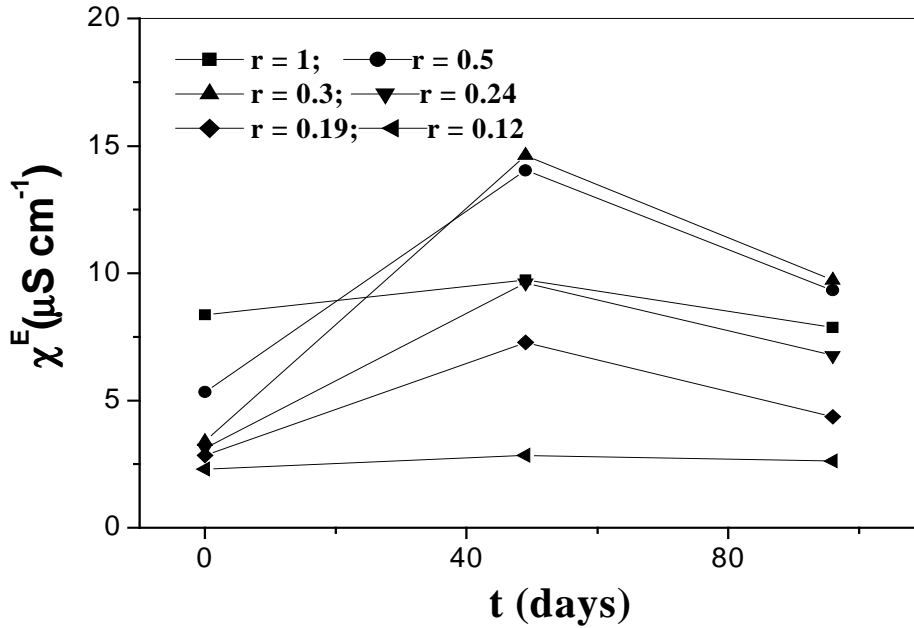


Fig. 12. Excess specific conductivity, χ^E , vs. age, t , of the samples obtained by a simple dilution of the “mother tincture” with bi-distillate water (without succussion) in different dilution ratios (r) as indicated in the figure legend. The volumes of the studied solutions were the same. The temporal evolution of the various systems, perturbed only by the simple dilution without succussion, is strongly dependent by the new starting state. In particular, the system experiencing a dilution 1:1, $r = 0.5$ (final volume is twice the initial one) exhibits an initial χ^E value strongly lower than the solution from which it was obtained, assuming then, in a very short time (about 45 days) χ^E values exceptionally higher with respect to the “mother tincture”, reaching moreover a sharp maximum.

In this case, the applied perturbation, is fixing also a strongly different starting point, apart the different temporal evolution.

“Volume Effect”

In the following we propose an empirical model, super-simplified, that in principle seems able to go explain the data reported in Fig. 10 and Fig. 11, that is the unexpected measured dependence of the physico-chemical parameters on the volumes used.

A first hypothesis trying to rationalize the experimental results can be to suppose that the solutions, after their strong agitation (succussion), enter in a far from equilibrium state, remaining there or getting even farther by dissipating energy in the form and amount necessary to stay in the far from equilibrium state. Then, supposing that the energy is exchanged in a radiant way, we can farther suppose that, for a given flux of dissipated energy ($W\text{ cm}^{-2}$), the same number of dissipative structures would be formed, even if contained in different volumes. In this frame, in average, at any given age, small volumes of water exhibit a higher “concentration” of dissipative structures in comparison with larger volumes (Fig.13). The physico-chemical parameters suitable

to reveal these structures, that is electrical conductivity and heat of mixing, are in fact themselves functions of the number, size and shape of the dissipative structures.

We can conclude as following:

- the parameters whose values results “in excess” (in general: variable with the history of the solvent in time) are certainly correlated with the dynamics of super molecular (mesoscopic) structure of the water solvent;
- the temporal evolution of the parameters is not connected to the research of an energetic minimum;
- an empirical interpretation, consistent with all experimental data collected until now, may be furnished supposing the presence of dissipative structures.

The succession may be exactly the trigger for the spontaneous formation of dissipative structures, that is the emergency of new dynamics. The temporal evolution may be connected with the variation of the number, dimension or the shape of the dissipative structures: in fact, it is well known, in the frame of Thermodynamic of Irreversible Processes, that the temporal evolution of the systems depend on the initial conditions and on the way the systems chose to evolve.

All great amount of new experimental data is converging toward the validation of the statement that water, at least in the context of the procedure normally experienced in the homeopathic medicine production, really shows a “memory”. That is the water solvent shows physico-chemical properties experimentally measurable that are varying as function on the “lived path”, on the solute previously dissolved, and on the passed time, too.

All these indicate without any doubt the presence of an extended and “ordered” dynamics involving the whole liquid water molecules, that seems to be something much more complex than normally thought, a banal and chaotic cluster of “molecular balls”.

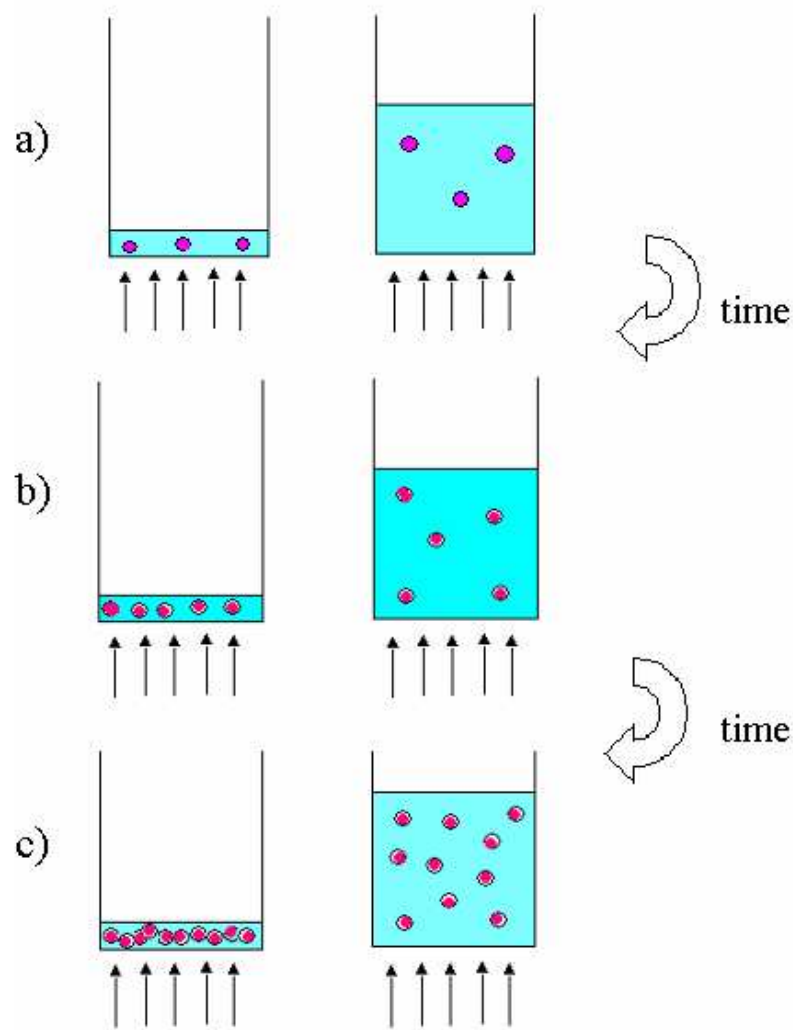


Fig. 13. Schematic representation of a possible temporal evolution of a homeopathic solution, showing a variation of intensive quantities such as χ^E ($\mu\text{S cm}^{-1}$) and Q_{mix}^E (JKg^{-1}) vs. the ageing volume.

An initial hypothesis is that at the time zero, the two vessels, of equal shape and volume, contain two identical homeopathic dilutions (same age, same active principle, same CH dilution) with no experimentally measurable effects determined by dissipative structures, because of their small number (Fig. 13 a). Let us suppose the same formation efficiency (and/or increase in size) for the dissipative structures in the two systems (small volume and large volume), with the same conditions of energetic flux. By the effect of this second hypothesis, the number and/or size of the dissipative structures is almost the same in the two containers, at any given time (Fig. 13 b and c). So, it follows that when the dissipative structures are numerically increasing, their concentration is much higher in the small volume than in the large one. Consequently, intensive quantities such as those measured, χ^E ($\mu\text{S cm}^{-1}$) and Q_{mix}^E (JKg^{-1}), that are sensitive to the structure concentration, will show a temporal behaviour that depends on the volume.

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Data ultimo salvataggio: 19/11/2007 9.38
Autore ultimo salvataggio: SCUOLA MEDICINA OMEOPATICA
Tempo totale modifica 1 minuto
Data ultima stampa: 04/12/2007 18.08
Come da ultima stampa completa
Numero pagine: 17
Numero parole: 4.531 (circa)
Numero caratteri: 25.827 (circa)