

ORIGINAL PAPER

Experimental physical methods and theories – then and now



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Introduction: A first evaluation of fundamental research into the physics and physiology of Ultra high dilutions (UHDs) was conducted by the author in 1994¹. In this paper we revisit methods and theories from back then and follow their paths through their evolution and contribution to new knowledge in UHD research since then.

Method: Physical methods and theories discussed in our anthology on UHD in 1994¹ form the basis for tracing ideas and findings along their path of further development and impact on new knowledge in UHD.

Results: Experimental approaches to probe physical changes in homeopathic preparations have become more sophisticated over past two decades, so did the desire to report results to a scientific standard that is on par with those in specialist literature. The same cannot be said about underlying supporting theoretical models and simulations.

Conclusion: Grant challenges in science often take a more targeted and more concerted approach to formulate a research question and then look for answers. A concerted effort to focus on one hypothesized physical aspect of a well-defined homeopathic preparation may help aligning experimental methods with theoretical models and, in doing so, help to gain a deeper understanding of the whole body of insights and data produced. *Homeopathy* (2015) 104, 305–310.

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A first review of models and experimental work on the physics of ultra high dilutions (UHDs) in 1994 surveyed the literature for scientifically based studies into UHD and presented findings presumably at the forefront of research at the time. A variety of experimental methods have been employed to elucidate mechanisms of possible physical modifications in high dilutions for use in homeopathic applications. At some point the notion of imprinting information from an original pure substance in a high dilution through the unique manufacturing process in homeopathy was formed and the imprint of information (memory of water) has become the most thought after effect in the study of the physics of homeopathy. In a review¹ on UHD in 1994, the authors discussed the most developed experimental scientific approaches used in the homeopathic research community at the time.² However, only a handful of these publications showed a systematic, scientifically

based approach and a documentation that would enable other scientists to retrace or repeat the work. Without attempting to make any judgement, this paper explores how the physical experimental methods and theories that were the buzz of the day (1994) evolved over time.

In a survey of the quality (and thus implied credibility) of research publications focusing on research into homeopathy in the physical sciences almost ten years later, Becker-Witt *et al.*³ were able to set clear minimal criteria on applied scientific methodologies that showed (not theorize) structural changes in solvents and a score board was established that introduced some objectiveness with respect to differentiating between quality of works.

In this brief review the experimental methods, models and findings discussed in 1994 were revisited and their further development since then was traced. Among the experimental methods discussed back then were investigations into ice crystallization, spectroscopy approaches such as UV, X-ray, Raman and nuclear magnetic resonance (NMR), and a number of theoretical models attempting to describe the possibilities of emerging features in UHD and the underlying physical mechanism that during the

potentization process that was thought to lead to such features.

Common to the physical methods applied at the time was the hypothesis (although rarely formulated as such) that a homeopathically prepared dilution has different, measurable physical properties than an equivalent normal dilution, or homeopathically prepared inert solvent, and this hypothesis holds for high dilutions as well as UHD.

Ice crystals

Early work by Bonet-Maury *et al.*⁴ and Boiron *et al.*⁵ indicated crystal structures in frozen state potencies that may contribute to the replication of such structures throughout the unique homeopathic potentization process. This gave structure, literally, to the idea of passing on a feature of the solute in form of a crystalline structure to its carrier medium (solution). The train of thought of preserved structures in the carrier medium (water, water-ethyl alcohol dilutions) diverged later on moving away from the difficult to detect very small ice crystal structure to more amorphous, non-crystalline patterns. The difference between a unique amorphous structure in water within a certain area or domain and that of the presence of a crystallized ice structure is how the OH-stretching behaves in these structures. For ice crystals the OH-stretching has a characteristic dominance in the spectroscopic band around 3200 cm^{-1} .

Large ice crystals in water are not too difficult to detect, however, small ones as they were thought to form during the succession process require some ingenious experimental investigation to be detected and to be clearly identify as crystalline structure. So, at some point of the homeopathic dilution process such crystalline structures were thought to form and then somehow maintain a thermodynamic stability throughout the dilution process such that new replicates of the crystalline structures can be formed. 'Formed' is here the key word because this process requires a starting point where a first crystalline structure is produced, opposed to microscopic ice crystals of unspecific sizes spontaneously popping up. Different original solutes ('mother tinctures') were thought to produce different crystalline structures, thus coding some of their characteristic feature into the specific crystalline form or configuration (other commonly used words used in this context in homeopathic literature are imprint, memory and epitaxy).

While the structure of small isolated water crystals (ice clusters) up to a size of a few tens of water molecules have been studied experimentally, respective implied structures were supported by theoretical models.^{6,7} The size range where aggregates of water molecules can start to form crystalline structures in liquid water has been resolved only very recently (2012). In a highly controlled water cluster nucleation experiment in liquid water, Pradzynski *et al.* were able to narrow down the onset of ice crystal formation, its early still amorphous precursor state, and the first evidence of the emergence of complete ice structured water clusters.⁸ In this work mid-infrared

spectroscopy (MIR) was used to discriminate the 3200 cm^{-1} OH-resonance. An onset of ice crystal formation was identified at a cluster size of 275 water molecules and its completion to a clear ice crystalline structure was found at a cluster size of 475 water molecules.

It should to be noted that IR absorption by clusters of this size (or any other energy uptake for that matter) can transform these crystalline objects back to some amorphous or random form. Details about the temperature and pressure stability of the crystalline form of these smallest seeds of ice crystals and their precursors are yet to be determined. The ice clusters had a sodium seed to facilitate the MIR spectroscopy and crystallization process, yet the final crystal structure appeared to be independent of the facilitating seed. While a small number of these nanoscale ice crystals may well be formed during the high-pressure phases of a succussion process, the excess thermal energy supplied to the liquid is more than enough to amorphousize their structure during equilibration.

Pure water is ideal to study the principle idea of succussion induced structures within the liquid phase, however, pure water is rarely used in practical homeopathic preparations. A Fourier Transform Infrared Spectroscopy (FTIR), again in the MIR range, was presented by Sukul *et al.* in 2005 using the more frequently used aqueous ethanol dilutions.⁹ This work was republished in other journals with minor variations over the years, but the main premises can be found in the one cited.⁹ Ice crystallization in a highly polar environment of ethanol is difficult to achieve and, in fact, the characteristic 3200 cm^{-1} OH-resonance was not observed in the ethanol solution. Instead, other shifts in the spectrum were reported in the succussed medium compared to the control. Up to now, the experiments were not repeated by other groups and the work was not cited in other FTIR work.

Succussion

Crystallization or structure formation, may it be amorphous within the liquid phase or nucleation from precipitated solute, is thought to be promoted via a succession process (potentization). David Auerbach from the Max-Planck-Institute of Fluid Dynamics in Göttingen, Germany, proposed a fluid dynamics based framework for the succession process.¹⁰ The mechanical mixing was discussed in terms of four distinct flow types occurring during the succession process; saddle, vortex, shear and diffusion flow; all very common in many mixing processes of liquids. Auerbach concluded that diffusion flow provides the most active mixing force in the preparation of UHDs while saddle, vortex and shear flow during the shock phases of the mixing process have a minor function in the active mixing of the liquid.

While the focus of the paper was to clearly lay down the principle forces at work responsible for mixing (increase of system entropy) in the succession process, it also pointed out the phases where other 'structures' are likely to be formed (local entropy reduction). Assuming that the closed mixing vial has an (ideally uncontaminated) air gap

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