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ORIGINAL PAPER

Electrical impedance and HV plasma images of high dilutions of sodium chloride

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This paper reports impedance data and high voltage plasma photographic plates of high dilutions of sodium chloride in water submitted to the homeopathic dilution and succussion up to 30cH. Extremely low concentrations of the original salt, even beyond Avogadro number, clearly differ from 'pure' water and; the action of sodium chloride on the electrical properties of water is inverted at high dilution. *Homeopathy* (2008) **97**, 129–133.

Keywords: High dilutions; Electrical impedance; Plasma discharge; Homeopathy

Introduction

Transport properties are extensively used in condensed matter physics to correlate with impurities present in a wide variety of materials. In semiconductor physics,[1] electrical resistivity, carrier concentration and impurity concentration are closely related so that determination of the former usually suffices for estimation of the 'doping' level. The literature on impurities in semiconductors has grown rapidly over recent decades due to the requirements of processing techniques for large-scale manufacture of highly complex devices and circuits. This interest arises because the fabrication technology of the modern electronic industry demands that the control of physical, chemical, optical and electrical properties of materials to high levels of precision since impurities (doping elements) in electronic materials remain active in the parts per million–parts per billion range.

Extension of these relationships between concentration of impurities and electrical properties to an extremely doping level, such as those encountered in homeopathic preparations, certainly requires a considerable amount of additional interpretation. This work employs impedance measurements to detect a possible correlation with low concentrations of sodium chloride diluted in water submitted to the homeopathic preparation technique.

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Homeopathy postulates that infinitesimal amounts of active substances diluted in water or alcohol produce substantial changes in living organisms. In physical terms, this is based[2,3] on two *Principles*, principle of Similars: *Similia Similibus Curentur* "like cures like" and the principle of minimum dose. The implication is that a potentially dangerous substance can be transformed into a beneficent remedy. For the present account we are not interested in the curative properties of substances but the supposed action of the preparation procedure.

Homeopathic medicines[4,5] are prepared by a sequence of dilution – potentisation steps: in the centesimal Hahnemannian (cH) scale, one part of an original solution, the *mother tincture*, is diluted in 99 parts of water then vigorously agitated (succussed) in a closed vessel to produce the 1cH *potency*, one part of 1cH treated by a repetition of this procedure produces the 2cH *potency* and so on. The procedure thus reduces the original concentration by two orders of magnitude per step so that, by successive dilutions, if we start with a 1 M original *mother tincture* solution, about 10^{23} atoms of the active substance diluted in water, the 1cH potency contains about 10^{21} atoms, 2cH about 10^{19} atoms, 11cH just 10 atoms and 12cH about 10^{-1} atoms. A number[6–8] of hypotheses have been raised in order to explain the effectiveness (or not) of the homeopathic procedure in terms of physics and chemistry models. These include transmission of information from the active substance to the water solution, a memory effect of water molecules and ansatz concerning placebo effects, subtle energies and fields; see Ref. 9 and references therein for an overview.

This work is not intended to raise new hypothesis but rather to investigate the electrical behaviour of sodium chloride 'doped' water in the 1cH–30cH potency range, which

roughly corresponds to the 10^{21}–10^{33} atomic range. Exploring the analogy with condensed matter physics, where well-established quantitative methods[10] are balanced with qualitative ones in order study/develop new materials and processes, we employ here electrical (impedance) measurements as well as qualitative images of the corona effect observed under high voltage (HV) exposure of the samples.

Experimental

Solutions

The mother tincture consists of 100 ml of a 1 M water solution of NaCl (MERCK, GR for analysis – purity greater than 99.5%); 1 ml was added to 99 ml of distilled water (1–2 MΩ cm) and submitted to a potentisation (*succussion*) cycle in a standard commercial machine programmed for 100 cycles in 33 s, resulting in 1cH potency. This dilution/succussion process was repeated producing 2cH and successive potencies, up to 30cH. All solutions, including intermediary potencies, were prepared in triplicate in 30 ml amber glass vessels (hydrolytic class 3) with a polypropylene stopper. The machine simultaneously handles four 30 ml bottles: three dilutions and one reference (succusse water).

HV plasma photography

HV plasma photography (Fig. 1) also termed bioelectrography, Kirlian photography or HV radiation photography, is the imaging record of a corona discharge effect.[11,12] HV is applied momentarily to the plate to make an exposure and the corona discharge between the object and the plate recorded onto the film. Similar images can be observed by HV corona discharges on bulk dielectrics and on thin films deposited on glass substrates.[13] The technique has many applications in science and industry, mainly as a surface treatment to improve polymer surfaces. Historically, this unconventional photographic process was associated to the conversion of non-electrical properties of living organisms into electrical ones, hence the term bioelectrography or even bioplasma as descriptive of the obtained images. Such controversial terminology is currently irrelevant: the same plasma discharge phenomena[12,14] can be observed both in organic as well as in inorganic systems, the main difference between these being the fact that, under the same experimental conditions (applied voltage, exposure times, etc.,) images of living organisms change whereas those of inorganic systems remain the same. Here the technique is used for a qualitative[14] comparison between successive cH potencies. A semi-quantitative measurement carried out directly on the recorded images was performed employing the MAG6 pocket magnifier (Graticules Limited, Maxta Measuring Systems Division, Tonbridge, England) and the ImageJ public domain software (National Institutes of Health – NIH, USA). The camera employed produces voltages up to 10 kV and exposure times between 1 and 3 s.

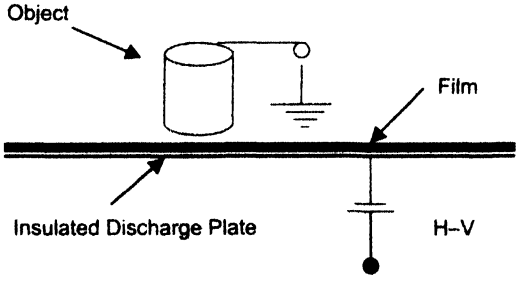

Fig. 1 The HV plasma photography experimental set up.

Impedance measurements

Impedance measurements of the high dilution samples were performed in the 10^{-4}–10^{+4} Hz interval employing an EG&G PAR computer-controlled high compliance voltage (100 V)/high resolution (0.05% of current range) Potentiostat/Galvanostat model 273A, operated in the impedance mode (M398 software). Data were recorded within 24 h of solution preparation.

Results and discussion

Fig. 2 shows the HV photographic plates of four different samples in the cH range and of the distilled water used in the preparation submitted to the equivalent number of succussions as the 30cH potency.

Direct correlation of the plates with the atomic concentration present in the samples deserves further investigation, probably including the analysis of a number of intermediate potencies. Nevertheless, it is apparent that distinct characteristics could be detected, depending on the examined potency. We distinguish three patterns: (a) according to the size of the corona discharge halo, (b) according to the density/concentration of the concentric lines and (c) according to the observed colour.

Following this classification, results indicate that the size of the halo and the density of lines increase with potency while the appearance of a reddish colour is independent of the dilution, being probably associated solely with the number of succussion cycles. Tables 1–3 provide a semi-quantitative summary of the HV results. Tables 1 and 2 show the density concentration of the concentric lines and the (absolute) size of the halo, respectively. Table 3 presents the "half-width", i.e., the width of the peak at half its maximum height. This measure is commonly employed in spectral analysis to characterise the definition of a peak. The profile measurements (Tables 1 and 3) were performed employing the ImageJ software whereas a pocket magnifier was used to determine the ring size (Table 2). All data represent average values obtained in a number of different regions of the HV photographic plates. Fig. 2f shows a typical plot profile obtained in the 24cH sample.

The impedance results of three sets of preparations are shown in Figs. 3–5. In general, all curves exhibit the same behaviour throughout the observed frequency range, approaching a common value at low frequencies and splitting to a constant value characteristic of the dilution factor at high frequencies. The first set (Fig. 3) consists of 1cH, 6cH, 12cH and 24cH dilutions, prepared from a common starting solution (mother tincture). For reference, impedance data of the distilled water employed in the preparation and the

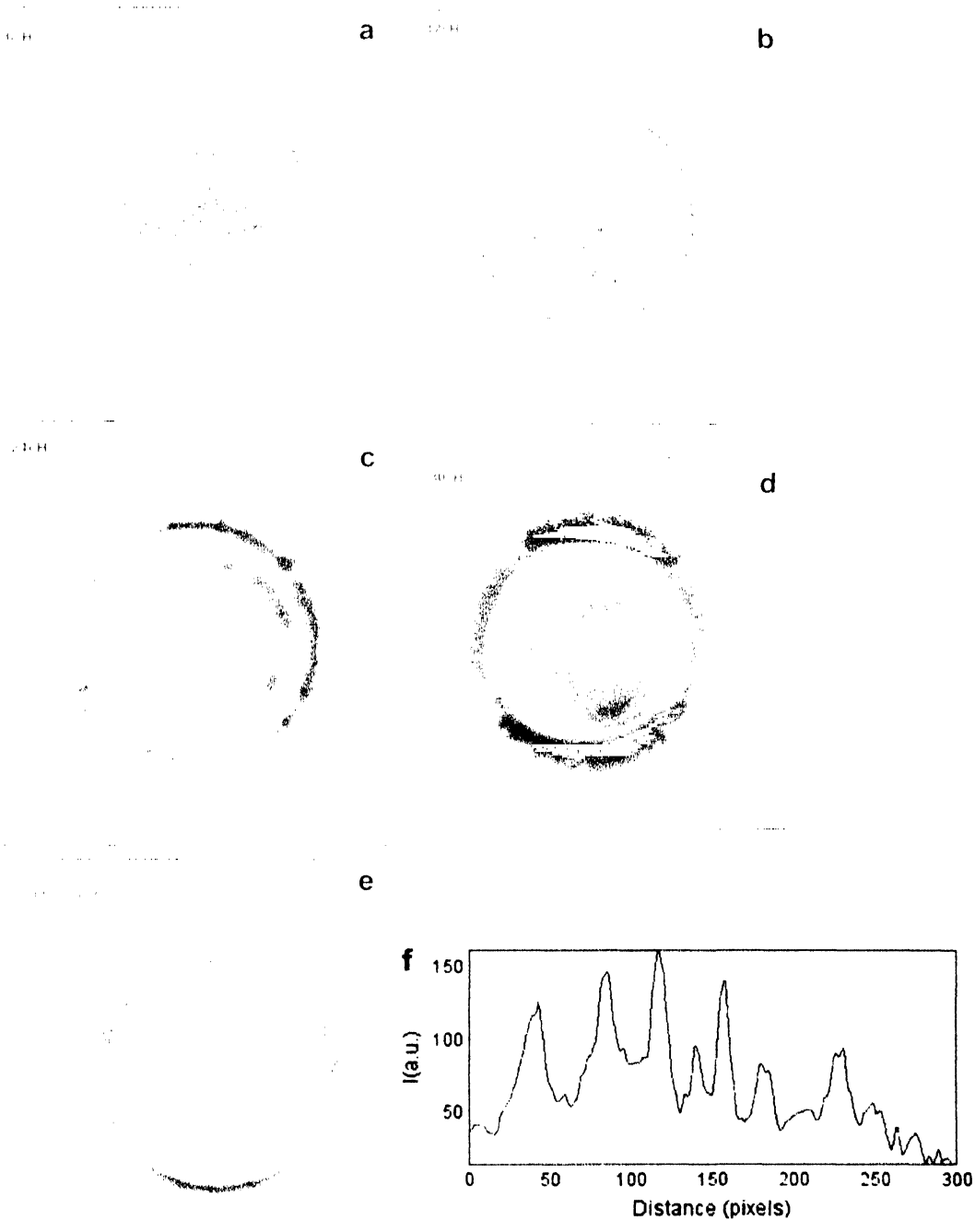

Fig. 2 (a–d) HV photographic images of four samples (6cH–30cH) submitted to homeopathic preparation and (e) distilled water (H_2O_Din) continuously succussed without dilution up to 30cH. (f) Typical ImageJ plot profile of sample of sodium chloride 24cH (Fig. 2c) and used to generate the data shown in Tables 1 and 3.

distilled water submitted to the same number of succussion cycles (termed H_2O_Din) of the 24cH sample are plotted along the frequency interval. The behaviour of the 1cH, distilled water, 6cH and 12cH curves can reasonably be understood in terms of conventional chemistry: impedance initially decreases due addition of Na and Cl ions (1cH curve) and increases as the water is depleted of ions. However, the increase in resistance due to simple agitation of the

Table 1 Line density/pixels × 100

Potency	*Minimum*	*Median*	*Maximum*
6cH	4	5	6
12cH	4	5	6
24cH	5.5	6.6	5
30cH	6	7	8

Table 2 Halo size (mm)

Potency	*Minimum*	*Median*	*Maximum*
6cH	12	15.2	20
12cH	17	19.3	20
24cH	15	18.7	21
30cH	19	22.1	24

Table 3 Peak half-width

Potency	*Half-width (pixels)*
6cH	10.5
12cH	10.5
24cH	8.5
30cH	27

distilled water and particularly the fact that the 24cH curve lies below the 12cH data is intriguing. A second set of solutions, including 30cH potency was prepared, results are shown in Fig. 4.

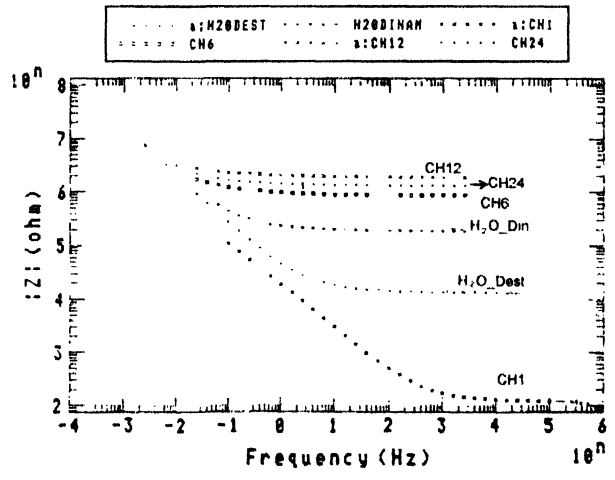

Fig. 3 Impedance measurements of 1cH, 6cH, 12cH and 24cH preparations; distilled water (H_2O_Dest) and succussed water (H_2O_Din) are also shown.

The general behaviour of the curves presented in Fig. 4 follows the pattern already observed (Fig. 3) and, most important, the 30cH lies below the 12cH curve, following the tendency shown by the 24cH curve in the previous set; furthermore, the impedance value corresponding to the 30cH potency is even lower than that of the 6cH. Finally, a third

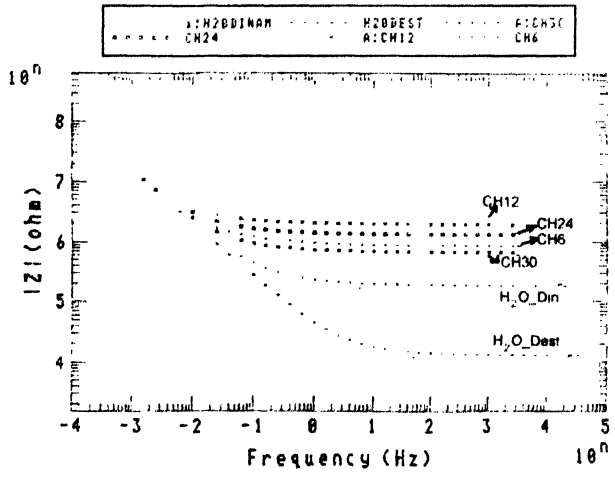

Fig. 4 Impedance *versus* frequency of 6cH, 12cH, 24cH and 30cH preparations; distilled (H_2O_Dest) and succussed water (H_2O_Din).

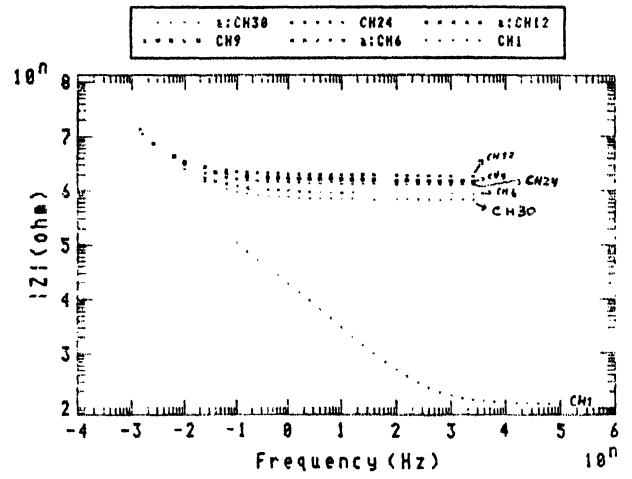

Fig. 5 Impedance *versus* frequency measurements of 1cH, 6cH, 9cH, 12cH, 24cH and 30cH preparations.

set of water solutions was prepared, including a 9cH concentration (Fig. 5).

The third set of preparations shows, again, that intermediate concentrations such as 6cH and particularly 9cH can be interpreted in terms of increase of impedance as a function of decrease of ionic concentration; however, a marked difference appears as the doping level approaches the Avogadro number, roughly corresponding to the 12cH potency. After this point, all the three sets exhibit a particular behaviour, indicating that an unusual mechanism is present. Fig. 6 synthesises the results, plotting the impedance values of the 6cH–30cH preparations at 100 Hz.

Conclusions

The homeopathic sequence of dilution and succussion clearly influences the electrical properties of water 'doped' with sodium chloride. Contrary to other electrical measurements[15] our results indicate that the homeopathic dilution procedure (beyond Avogadro number) markedly modifies electrical properties of solutions. Data obtained from

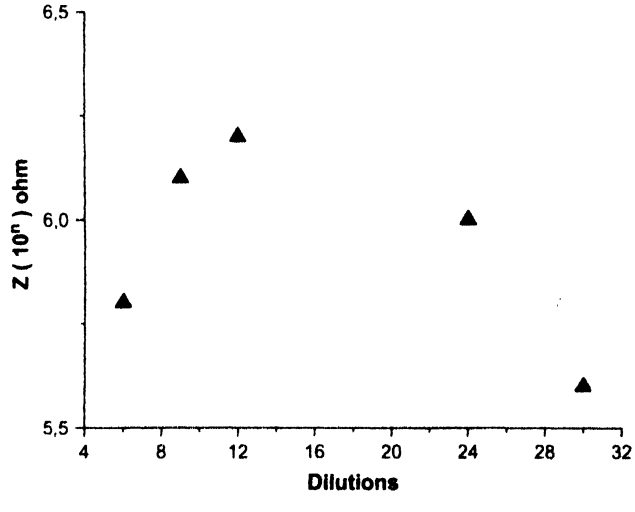

Fig. 6 Impedance values at 100 Hz of 6cH, 9cH, 12cH, 24cH and 30cH preparations of sodium chloride.

impedance measurements and HV plasma photography can be summarised as follows:

a. Interrelation between the corona discharge effect and the extremely low concentrations encountered in homeopathic preparations seems plausible after a detailed analysis comparing successive potencies.
b. Impedance of succussed and unsuccussed water differs by an order of magnitude.
c. Concentrations containing atoms of the active substance, such as 1cH, 6cH and 9cH show increasing impedance as a function of depletion of ionic content, as conventional theory predicts.
d. The 12cH potency (containing a mean of approximately one tenth of an atom of solute), roughly marks the transition to a solute concentration below Avogadro's number. It gives a maximum value of electrical impedance.
e. The action of sodium chloride on the electrical conductance of water is inverted at the higher dilutions; this phenomenon is inexplicable in terms of conventional chemical theory.

In short, the present data suggest that the HV plasma photography and the electrochemical impedance measurement can contribute to the understanding of the dilution/succussion procedures applied in the preparation of homeopathic medicines. Further research must include different doping substances, a large number of intermediate potencies and operation of the machine outside the usual Hahnemannian homeopathic protocol, in order to search for a continuous curve at the Avogadro boundary.

Conflict of interest

I declare that there are no personal nor institutional relationships that may constitute a conflict of interests.

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