

## ORIGINAL PAPER

# Nuclear Magnetic Resonance characterization of traditional homeopathically manufactured copper (*Cuprum metallicum*) and plant (*Gelsemium sempervirens*) medicines and controls



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**Background:** NMR proton relaxation is sensitive to the dynamics of the water molecule H<sub>2</sub>O, through the interaction of the spin of the proton (<sup>1</sup>H) with external magnetic and electromagnetic fields.

**Methods:** We measured dilution and potentization processes through measurements of <sup>1</sup>H spin-lattice T<sub>1</sub> and spin–spin T<sub>2</sub> relaxation times. In order to interpret the recorded fluctuations in T<sub>1</sub>- or T<sub>2</sub>-values, experimental data were linearized by investigating how the area under a fluctuating time = f(dilution) curve (dilution integral or DI) changes with dilution. Two kinds of fitting procedures were considered: chi-square fitting with a goodness-of-fit probability, and least absolute deviations criterion with Pearson's linear correlation coefficient.

**Results:** We showed that fluctuations are not attributable to random noise and/or experimental errors, evidencing a memory effect quantifiable by the slope of the DI = f(dilution) straight line. For all experiments, correlation coefficients were found to lie above 0.9999, against 0.999 for random noise. The discrimination between experimental slopes and slopes associated with random noise data was very good at a five-sigma level of confidence (i.e. probability  $3 \times 10^{-7}$ ). Discrimination between experimental slopes at a five-sigma level was possible in most cases, with three exceptions: gelsemium aqua pura v gelsemium dilution (four-sigma); copper aqua pura v gelsemium aqua pura (four-sigma) and copper simple dilution v gelsemium simple dilution (three-sigma). All potentized samples show very good discrimination (at least nine-sigma level) against aqua pura, lactose or simple dilution. It was possible to transform the associated relaxation times into a molecular rotational correlation time  $\tau_c$  and an average spin–spin distance d. Our experiments thus point to a considerable slowing down of molecular movements ( $\tau_c > 1300$  ps or T = 224–225 K) around water molecules up to a distance

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of 3.7 Å, values. It was also possible to rule out other possible mechanisms of relaxation (diffusive motion,  $^{17}\text{O}$ - $^1\text{H}$  relaxation or coupling with the electronic spin,  $S = 1$ , of dissolved dioxygen molecules).

**Conclusion:** There is clear evidence that homeopathic solutions cannot be considered as pure water as commonly assumed. Instead, we have evidenced a clear memory effect upon dilution/potentization of a substance (water, lactose, copper, gelsemium) reflected by different rotational correlation times and average H...H distances. A possible explanation for such a memory effect may lie in the formation of mesoscopic water structures around nanoparticles and/or nanobubbles mediated by zero-point fluctuations of the vacuum electromagnetic field as suggested by quantum field theories. The existence of an Avogadro's 'wall' for homeopathically-prepared medicines is not supported by our data. Rather it appears that all dilutions have a specific material configuration determined by the potentized substance, also by the chemical nature of the containers, and dissolved gases and the electromagnetic environment. This sensitivity of homeopathically-prepared medicines to electromagnetic fields may be amplified by the highly non-linear processing routinely applied in the preparation of homeopathic medicines. Future work is needed in such directions. The time is now ripe for a demystification of the preparation of homeopathic remedies. *Homeopathy* (2017) **106**, 223–239.

**Keywords:** Nuclear Magnetic Resonance (NMR) relaxation; Copper; Cuprum metallicum; *Gelsemium sempervirens*; Water; Homeopathy; Potentization; Dynamization

## Introduction

Recent studies indicate that homeopathically-prepared medicines (HMs) contain source nanoparticles (NPs),<sup>1–4</sup> silicates<sup>3,5,6</sup> and other, less well-characterized structures.<sup>7</sup> Homeopathy is a traditional medicine used worldwide for more than 200 years. Recent RCT-literature audits<sup>8,9</sup> continue to confirm a possible specific effect of homeopathic treatments. Nevertheless, sceptics insist that HMs are placebos containing no active material in any form.<sup>10</sup>

This debate about plausibility and evidence<sup>11</sup> can only be settled by fundamental research. Sceptics tend to focus on dilutions beyond Avogadro's number derived from bulk source material and ignore the actual manufacturing process, which is more than simple dilution. It is instead a step-by-step trituration in lactose (for water insoluble material) or potentization (for water soluble material), a process also called "dilution-dynamization". The well-defined trituration process (Ph-Eur 4.1.2)<sup>12</sup> is performed with a 100% porcelain spatula, mortar and pestle. The lactose is added part by part and it takes a full hour for one trituration, arriving at a final dilution of one part starting material with 99 parts lactose. For soluble material, the dynamization process is performed using a certified machine. The norm is to apply 100 calibrated vertical shocks at each dilution. The dilution process may involve one part material for nine parts solvent (D or X potency) or one part material for 99 parts solvent (C potency). The containers are always pharmaceutical grade soda-lime-silicate glass ISO-719, ISO4802-1, Ph-Eur 3.2.1. For CH potencies a new container is used at each step, whilst Korsakov potencies are prepared within the same container at each dilution step.

Nanotechnology researchers have begun to recognize similarities between the traditional, crude, mechanical attrition manufacturing techniques of homeopathy and the top-down approaches for making nanostructures from insoluble source materials used in modern nanotechnology.<sup>1,2,4</sup>

Previous publications by Demangeat<sup>7,13</sup> using NMR relaxation have revealed the involvement of nanobubbles in nanometric superstructures in high potentizations.

The purpose of the present exploratory study was to discover whether specific NMR relaxation times (T1-T2) could be measured in full lines of CH dynamizations of a metal (copper) and of a plant substance (Gelsemium), compared with a solvent control, a potentized lactose control or a control prepared by simple dilution.

## Materials and methods

**Rationale:** We chose copper as the initial source material for HMs because it has already been characterized by previous authors,<sup>1</sup> because of the well-known role of copper in the mitochondrial enzyme cytochrome c oxidase,<sup>14</sup> and because there is an extensive homeopathic literature published on this homeopathic medicine including a randomized controlled trial.<sup>15–29</sup> In order to obtain data to compare with those from a metal, we chose a plant tincture, *Gelsemium sempervirens*, as a soluble second source material; this was because there is a precise definition of this stock,<sup>30</sup> as well as an extended homeopathic literature including references to objective epigenetic changes caused by this homeopathic medicine.<sup>17–20,30–40</sup> For both medicines, particles were identified even in very high homeopathic potentizations.<sup>41</sup>

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