

# The defining role of structure (including epitaxy) in the plausibility of homeopathy

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**The key stumbling block to serious consideration of homeopathy is the presumed “implausibility” of biological activity for homeopathic medicines in which the source material is diluted past Avogadro’s number of molecules. Such an argument relies heavily on the assumptions of elementary chemistry (and biochemistry), in which the material composition of a solution, (dilution factors and ligand–receptor interactions), is the essential consideration.**

In contrast, materials science focuses on the three-dimensional complex network structure of the condensed phase of water itself, rather than the original solute molecules. The nanoheterogenous structure of water can be determined by interactive phenomena such as epitaxy (the transmission of structural information from the surface of one material to another without the transfer of any matter), temperature–pressure processes during succussion, and formation of colloidal nanobubbles containing gaseous inclusions of oxygen, nitrogen, carbon dioxide, and possibly the remedy source material. Preliminary data obtained using Raman and Ultra-Violet-Visible (UV–VIS) spectroscopy illustrate the ability to distinguish two different homeopathic medicines (*Nux vomica* and *Natrum muriaticum*) from one another and to differentiate, within a given medicine, the 6c, 12c, and 30c potencies. Materials science concepts and experimental tools offer a new approach to contemporary science, for making significant advances in the basic science studies of homeopathic medicines. *Homeopathy* (2007) 96, 175–182.

**Keywords:** homeopathy; succussion; materials science; structure of water; epitaxy; nanobubbles

## Introduction

### Overview

The key stumbling block to serious consideration of homeopathy is the alleged “implausibility” of biological activity for homeopathic medicines in which the source material is diluted past Avogadro’s number of

molecules ( $6 \times 10^{23}$ ), because the remedy must be identical to the solvent. Negative studies of homeopathy are self-evidently correct from the skeptics’ perspective, because of this error.<sup>1</sup> The implausibility argument leads skeptics to ignore or reject positive evidence from numerous basic science, preclinical, and clinical studies showing effects of homeopathic medicines different from controls, in vitro and in living systems.<sup>2</sup> On the other hand, proponents predictably reject the negative and focus on positive studies, often uncertain how to address the black box nature of homeopathic medicines. Both skeptics and proponents of homeopathy have generally overlooked a large body

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of literature in the materials science field that could help resolve this impasse with systematic data.<sup>3</sup>

Thoroughly, established materials science concepts and research data render the implausibility hypothesis for homeopathy irrelevant. One example suffices. Diamond is the hardest material in nature and graphite among the softest. Yet they can be inter-converted with zero change of composition in microseconds.

The available studies enable significant hypothesis-driven advances in the rigorous study of the nature of homeopathic medicines. The purpose of this paper is to outline the key aspects of materials science considerations in developing experimental models for understanding homeopathic medicines and to summarize preliminary findings from hypothesis-driven studies in our laboratory on clinically known polychrests such as *Nux vomica* (*Nux vom*) and *Natrum muriaticum* (*Nat mur*).

### Materials Science Models for homeopathic medicine

Chemists and medical scientists largely continue to focus reductionistically on the presence or absence of specific molecular species present in water vapor or liquid water without consideration of the ways in which these species are organized in space. From a chemical perspective, the dilution aspects of remedy preparation are the key issue, because of a lack of source molecules for potencies at or beyond 12c or 24c  $\times$  ( $10^{-24}$  dilution). Even when chemists focus on water itself, they emphasize the fleeting stability of hydrogen bonding between given water molecules,<sup>4</sup> rather than the larger complex structural formations of water or the weaker forces that may favor formation of stable oligomeric and polymeric structures, involving the collective organization of many different water molecules within the condensed liquid phase.

In contrast, materials scientists focus on the organizational network arrangement of the water structures in three-dimensional (3-D) space. In a recent paper, Roy *et al.*<sup>3</sup> presented the detailed technical aspects of the materials science argument concerning ultradilute sols including homeopathic medicines at length. For materials scientists, the succussion aspects of remedy preparation are the key consideration. Temperature and pressure can modify such water structures, leading to nanoheterogeneity of larger structures of water molecule "clusters" within liquid water. Succussion introduces intense turbulence and changes in pressure in any solution,<sup>5</sup> as well as leading to the formation of nanobubbles in solution.

In brief, the plausibility argument for homeopathy is that liquid water, the primary solvent for source materials in which homeopathic medicines are made, is itself an anomalous substance and has many very different structures. As part of the natural nanoheterogeneity of water structure per se (as contrasted with its composition or the presence of solute molecules), processes such as epitaxy, pressure changes during succussion, formation of colloidal nanobubbles

containing gaseous inclusions of oxygen, nitrogen, carbon dioxide, and possibly the remedy source material, and electromagnetic field effects play a role in altering water structure. Previous work by Elia and Niccoli<sup>6</sup> and Rey,<sup>7</sup> using different technical methods, respectively, to release heat or light from homeopathic medicines in potency, point to the ability to disrupt what appears to be order or structure in remedy solutions as compared with remedy-free control solvents.

In terms of nanoheterogeneity, water can take on many possible oligomeric and polymeric structures, ie, form complex networks of water molecules in 3-D space, held together by various forces that include not only hydrogen bonds (relatively strong), but also van der Waals forces (much weaker). Even if specific molecules or small molecular complexes leave their places in the network, other water structure complexes can take their places within the network structure itself, thereby maintaining the overall nanostructures within the solution, in part via configurational entropy or electromagnetic forces maintaining organizational stability of the network.<sup>8</sup>

Notably, research in the field of complex systems and network science has shown that, within a highly complex network, loss or disruption of a given member or node, which is a point of interconnection with other members of the network (eg, a water molecule or small complex of water molecules) does not destroy or significantly disrupt the overall network organization.<sup>9,10</sup> With complexity in liquid water as a whole comes the capacity for overall stability that is not possible in the simpler organizational structures of water on which chemists usually focus.

Epitaxy is the transfer of *information*, not *material*, from the surface of one material, usually solid, to another, usually liquid<sup>11</sup>. The substrate (eg, remedy source material) acts as a seed crystal for the formation of the structure in the recipient surface material (eg, network organization of water structures). Semiconductor manufacturing often utilizes epitaxial growth to generate specific types of microtransistors and integrated circuitry. In addition to the original source material that uniquely contributes to remedy preparation, deliberate additives in homeopathic medicines, such as ethanol, and/or possible contaminants from succussion, such as silicates from glass container walls, may also stabilize the water molecule structures with their own epitaxial capabilities. Thus, epitaxy can interact with temperature–pressure factors to create unique patterns of information without the transfer of material.

In terms of "seeding" formation of informational structures within water, initial empirical observations on homeopathic medicines suggest that the passage of time between the original remedy preparation and the testing procedures can alter experimental findings. In calorimetric and thermoluminescence studies on homeopathic medicines, the time factor contributes to

differences in the magnitude and even the direction of the divergence between remedy and control solutions.<sup>4,12</sup> Overall, the behavior of homeopathic medicine liquids in terms of their structural properties in the basic science literature exhibits a somewhat unpredictable, self-organizing quality.

As additional data emerge, these lines of research may facilitate advances in understanding the nature and mechanisms of variability in clinical responsivity to homeopathic medicines.<sup>13,14</sup> Water is an hub molecule (a highly interconnected and influential molecule) in most of the biochemical reactions in the body.<sup>15</sup> In a more speculative but testable vein, seeding informational changes in body water at global and local levels<sup>16</sup> of scale could be one way in which homeopathic medicines interface with patients to induce patterns of system-wide and local healing responses.<sup>13</sup>

#### Implications of materials science models for basic science research methods in homeopathy

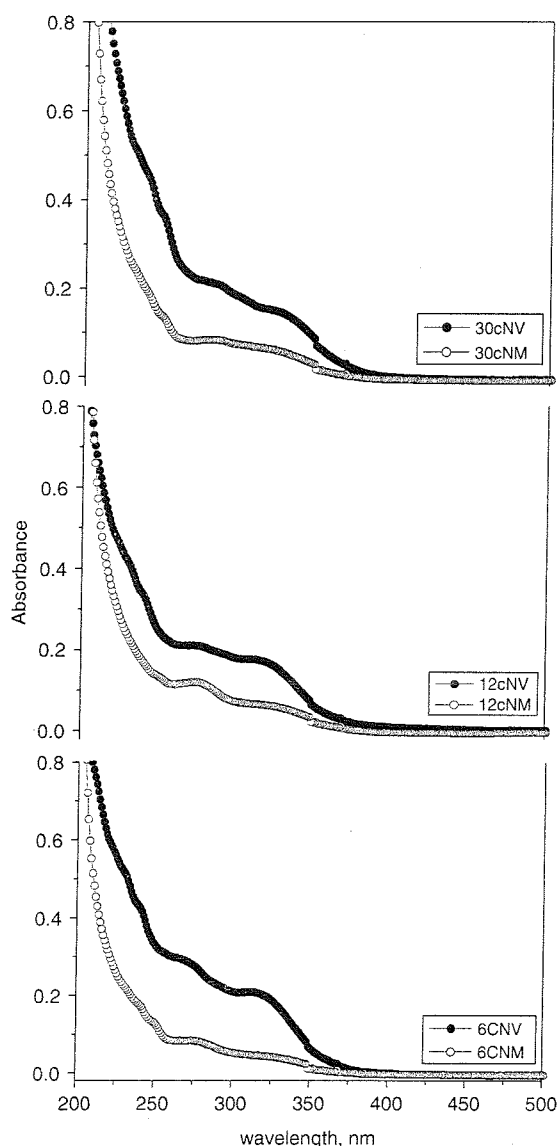
Materials science models for the nature of homeopathic medicines leads to more rational selection of specific methodologies for basic science studies. For example, many earlier studies of homeopathic medicines relied on nuclear magnetic resonance (NMR) techniques.<sup>17,18</sup> However, NMR spectroscopy provides information on structure of individual atoms in a pure molecule better than on complex networks of molecules. Technically, NMR also requires addition of substances to prepare a liquid for testing. The necessity of adding factors in the process of making observations can introduce unintended contaminants into the measurement process.

In contrast, the light scattering technologies of Raman spectroscopy and Fourier transform (FT) infra-red (IR) spectroscopy permit examination of remedy samples without fixatives or other potential contaminants. Furthermore, Raman and infra-red spectroscopic techniques allow the co-operative nature of structural differences to be detected. Recent studies<sup>19</sup> of microscopic dynamics of hydrogen bonded liquids indicate the existence of highly directional H-bonds, whose energy value normally range between  $\sim 8$  and  $25 \text{ kJ mol}^{-1}$  induces different chemical-physical properties and different local environments. As the mean lifetime of H-bonds is in the picosecond time-scale, such structures are considered as transient species in dynamic equilibrium.

Our recent work has established the importance of the structure of water on its properties,<sup>3</sup> we examined the structures of many water and alcohol-based homeopathic remedies. The results show that such materials can be easily distinguished from the pure solvent, and from each other, by the use of UV-VIS (ultraviolet-visual) and Raman spectroscopy, but Fourier transformed infra red (FTIR) spectroscopy proved insensitive to these differences. This opens up a

whole new field of endeavor for inorganic materials scientists interested in developing a scientific basis for the efficacy of homeopathic remedies. The assumption of this study is that the joint employment of the two methodologies: optical spectroscopic tools and electronic microscopic tools can furnish a closer reference picture for the comprehension of the structural changes in the liquid phase besides providing an independent understanding on the role of the 'active ingredient' in a homeopathic medicine.

Also we believe that our very preliminary efforts in using cryo-scanning electron microscopy (cryo-SEM) and cryo-transmission electron microscopy (cryo-TEM) may eventually possibly provide definitive



**Figure 1** Comparison of two different homeopathic medicines: *Natrum muriaticum* (NM) and *Nux vomica* (NV) showing representative UV-spectra demonstrating the differences between the remedies.

evidence of the presence, and the effects, of nanobubbles on homeopathic medicine studies.

## Preliminary studies of homeopathic medicines using Raman and infrared spectroscopy

### Method

A Food and Drug Administration-regulated homeopathic pharmacy (Hahnemann Laboratories, San Rafael, CA) prepared samples of two different test solutions in 16 ounce (450g), clear glass bottles [Type I borosilicate glass] previously annealed at temperatures between 600–700 °C for 15 minutes. One of the solutions, *Nat mur* (mineral: Sodium Chloride) and the other *Nux vom* (plant remedy, purchased as tincture from Boiron) were diluted by the standard Hahnemannian techniques in 95% ethanol and succussed: a 30c potency is diluted  $(1/100)^{30}$  or  $10^{-60}$  from the original material. They were hand-succussed by trained experts [<http://www.hahnemannlabs.com/preparation.html>]  $30 \times 20 = 600$  times during the manufacturing process. Each bottle was coded with an unique number, the bottles were shipped together by overnight courier in the same box, with temperature sensor.

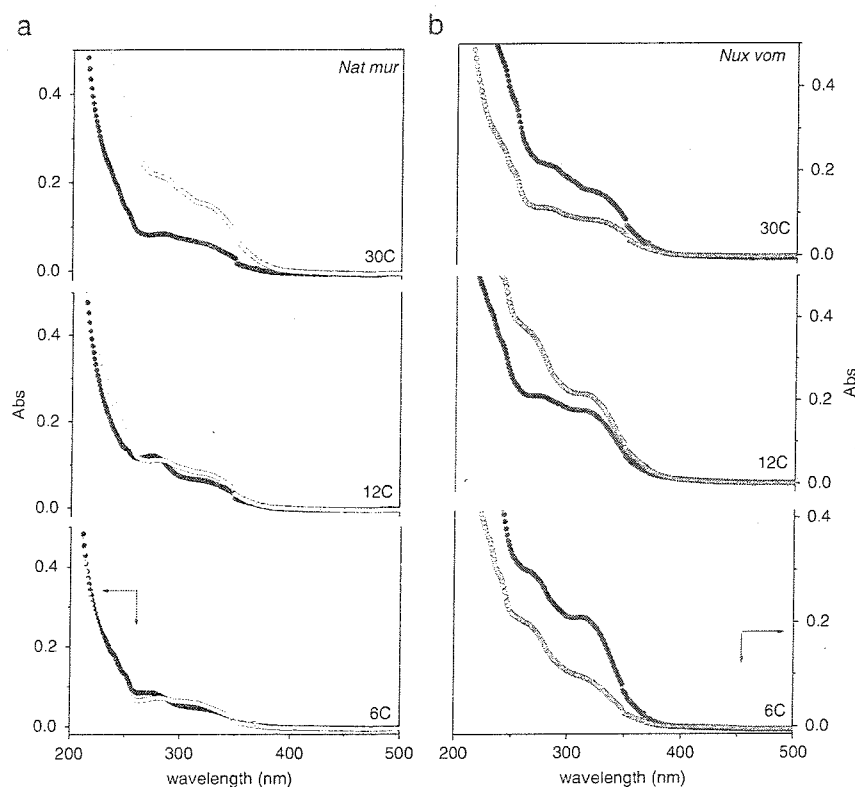
We have used UV–VIS, IR, FTIR, and Raman spectroscopy for the bulk “liquid” which in most cases

is either water or a mixture of water and ethanol (95% ethanol). UV–VIS spectroscopy and Raman spectroscopy proved to be useful tools to investigate the subtle but significant changes in the structural parameters in both water and alcohol based remedies. (For details refer to 20). While other techniques such as freezing point depression; acoustic loss spectroscopy, ellipsometry, viscosity, surface tension, have been explored and will eventually be used in depth to measure entirely different properties, we report here our experience with the major spectroscopic techniques which are widely available.

- (a) *UV–VIS spectrophotometer*: VARIAN, Model CARY 100, run in dual beam mode,
- (b) *FTIR spectrophotometer*: Thermo Nicolet, Model NEXUS 670, run in attenuated total reflection (ATR) mode, and
- (c) *Raman spectrophotometer*: Inphotonics, Model RS2000-3b-785, using an InPhotonics fiber optic immersion probe.

### Results

Nearly 200 runs were made to calibrate every step in the experimental configurations and procedures used for the different instruments. In the dual beam UV–VIS, the many experimental options are all tested separately to ensure that any differences within the data obtained on our samples are well above the



**Figure 2** Envelope of differences within a series of 10 preparations supplied of each Homeopathic medicine: *Nat mur* and *Nux vom*.

instrument noise measured in the calibration run data. The data are obtained largely at different times scales by different individuals gave consistent results. We note that at very low signal levels, instrument noise coupled with artificial computer generated sensitivity can produce data that are not reliable. Hence, we operate the instruments in the sensitivity ranges in which we sacrifice some precision for reproducibility. In the Raman spectrometer, careful attention is paid to the positioning of the probe within the sample container, and stray light is eliminated by turning off all the room lights whenever data are being collected. Details of this work are published elsewhere.<sup>21</sup>

One of the objectives in undertaking this work is to examine evidence which would suggest reliability of physical properties, assuming structural changes in solvents, especially in ultradilute and dilute sols, an excellent example of the class of materials being homeopathic remedies. For our study, we chose to study *Natrum muriaticum* and *Nux vomica*, obtained from Hahnemann Laboratories. Both *Nat mur* and *Nux vom* are prepared in 95% ethanol. Three types of analyses are presented:

- Comparison of specific homeopathic remedies with different potencies [*Nat mur* 6c, 12c, 30c, and *Nux vom* 6c, 12c, 30c].
- Comparison between two different remedies of the same potency [*Nat mur* vs *Nux vom* 6c, 12c, and 30c].
- Comparison of the two homeopathic remedies with *unsuccussed* and *succussed plain ethanol*.

Figure 1 shows a comparison of *Nux vom* and *Nat mur*, 6c, 12c and 30c, showing representative UV-spectra demonstrating the differences between the remedies. In Figure 2 (a), and (b) we show the envelope of differences within a series of 10 preparations of each remedy of *Nat mur* and *Nux vom*. The spectra show clear differences in the same potency of an individual remedy for both *Nat mur* and *Nux vom*.

A comparison was also made between the unsuccussed ethanol and the *Nat mur* and *Nux vom* samples as shown in Figure 3. The Roy et al paper<sup>3</sup>, on "structure of water" clearly evidence the role of succussion besides epitaxy and other temperature effects, on the structure of liquids. Under the "normal" succussing procedures, it can be argued that very considerable pressures (of the order of 10 kbar) could be generated as a result of the shaking. Dachille and Roy<sup>22</sup> showed that mere grinding in a mortar and pestle gives rise to high pressures up to 20 kbar, and the figures for force per unit area are strongly dependent on the size of the water particles and the velocity of the shaking. By analogy with similar liquids, such as ethanol, there will be many different structures of water formed both by the pressures generated in succussing in some combination with the epitaxy on any additives.

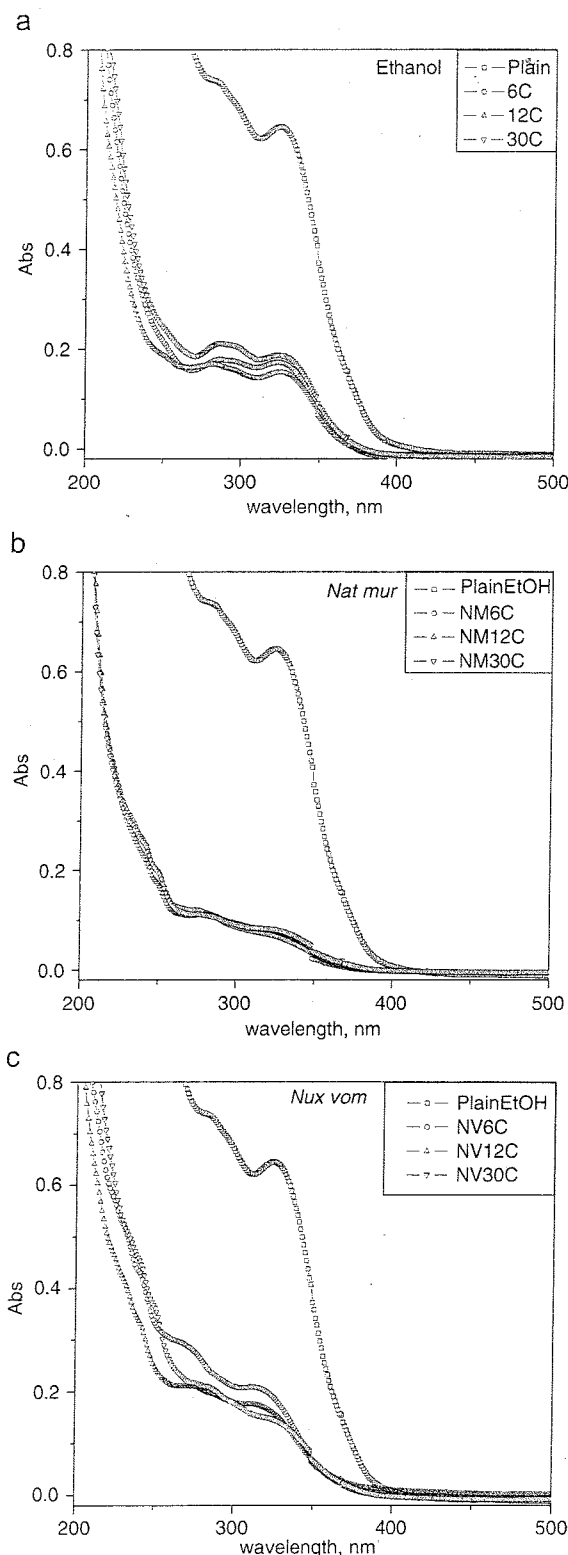
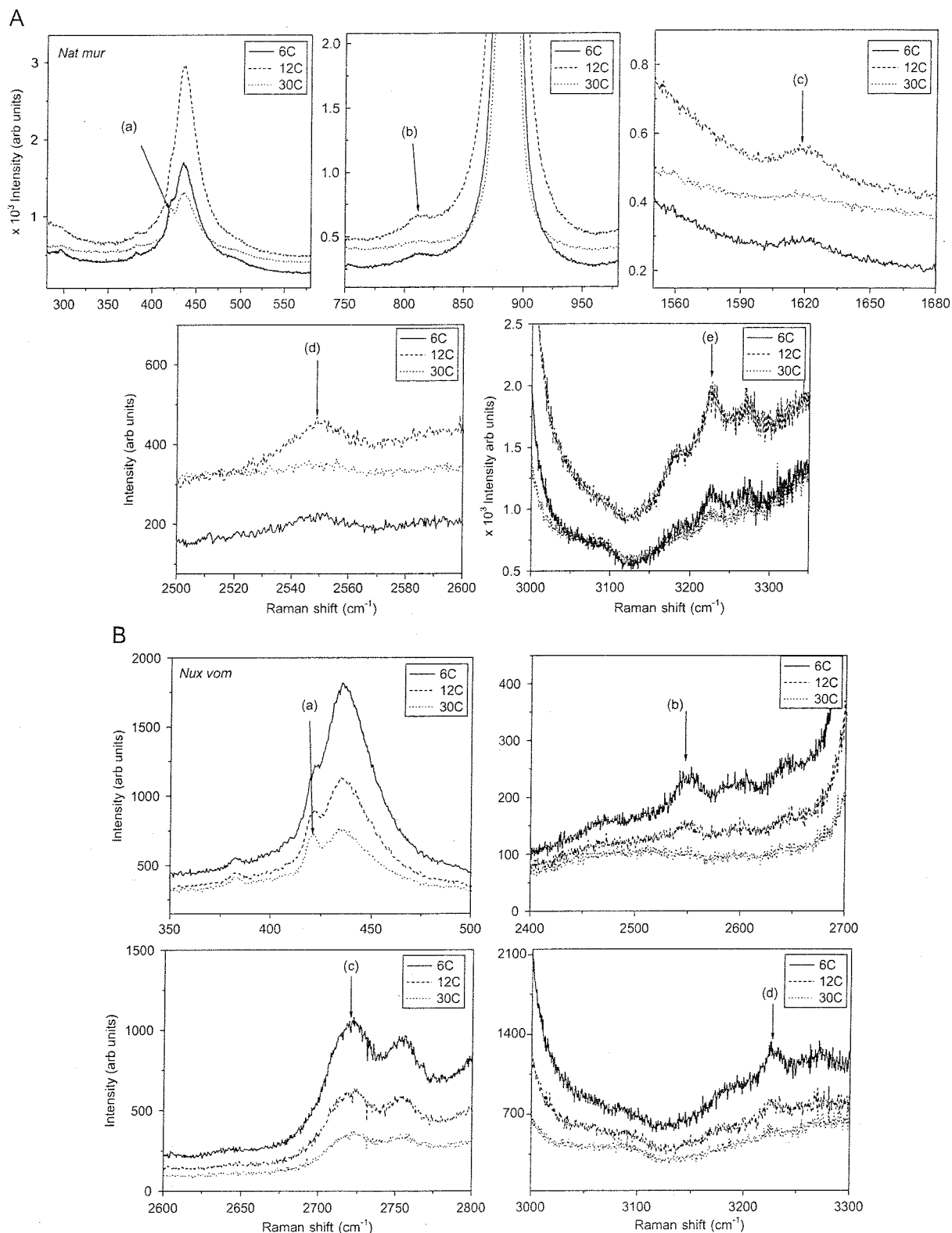


Figure 3 UV-VIS spectra of: (a) succussed and unsuccussed ethanol, (b) comparative UV-VIS spectra of *Nux vom* (NV) 6c, 12c, 30c with unsuccussed ethanol, (c) comparative UV-VIS spectra of *Nat mur* (NM) 6c, 12c, 30c with unsuccussed ethanol.



**Figure 4** Comparison of the Raman spectra of the same potencies, 6c, 12c and 30c, for two different homeopathic medicines. The differences in the peaks identified as (a)–(e) is clearly visible in 30c samples of *Nat mur* and *Nux vom*, compared to other diluting of the same medicine.

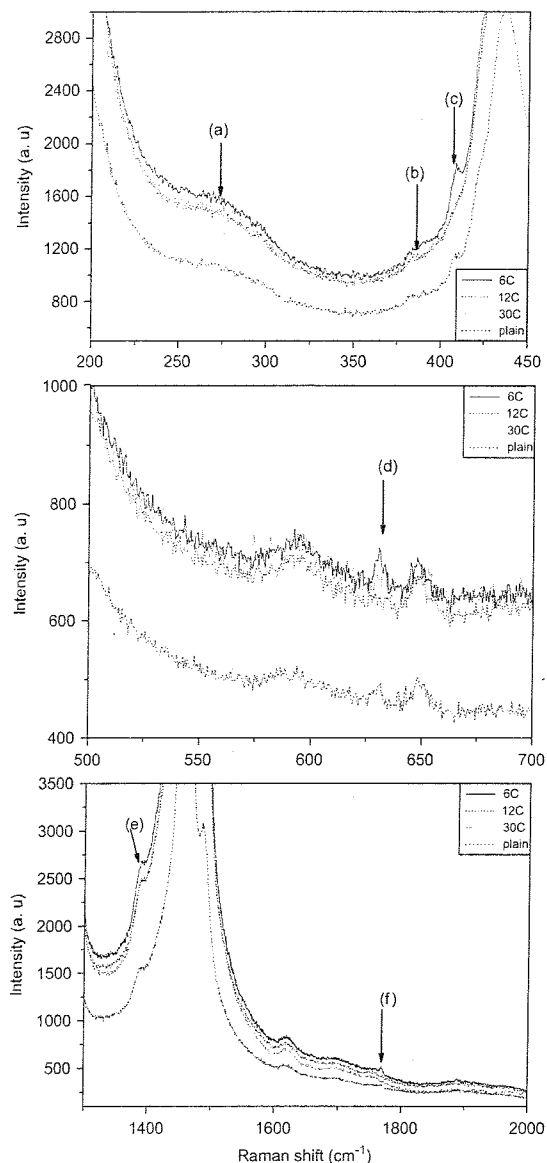
It may be noted from Figure 3 that the absorption spectra for unsuccessed ethanol is significantly different from: (a) the succussed ethanol and (b) succussed homeopathic remedies, *Nat mur* and *Nux vom*. The difference may be attributed to the variation in intra and inter-molecular association of ethanol and water and the generation of both transient and stable nanobubbles. The work of Tyrrell and Attard at Australian National University has proved beyond any doubt that nanobubbles do exist and persist.<sup>23</sup> FTIR Spectra (not shown here) from all the samples of *Nat mur* and *Nux vom* overlap neatly, clearly signifying that FTIR is not the most sensitive technique for analyzing the subtle structural differences in these types of samples.

Comparison of homeopathic remedies with different potencies using Raman spectroscopy is done on the two sets of homeopathic remedies: *Nat mur* and *Nux vom*. From the spectra shown in Figure 4, a clear distinction in the Raman active modes is noted between the two different remedies as well as among the different potencies of the same remedy. A clear distinction is shown in the spectral peaks from the different potencies, peak positions identified as (a), (b), (c), (d) and (e) in the Raman spectra of *Nat mur* samples show significant structural changes. While the existence of distinct structural changes in *Nat mur* and *Nux vom* remedies is clear from the Raman spectra, significant structural changes are also noted in the spectra of *Nux vom* between the different potencies, 6, 12 and 30c, peak positions are identified as (a), (b), (c), and (d) in Figure 4b. Further, since all the homeopathic medicines were prepared in 95% ethanol, we analyzed the Raman spectra of unsuccessed and succussed ethanol shown in Figure 5. Note that 6c potency of the succussed ethanol show distinct structural variations.

## Conclusions

Materials science provides a conceptual and empirical foundation for future research on the nature of all the dilute sols including homeopathic medicines in the physical plane. Processes such as epitaxy, temperature-pressure induced changes in water structure, and nanobubble formation offer testable hypotheses for understanding homeopathic medicines. Although hypotheses regarding seemingly unmeasurable "subtle energies"<sup>24</sup> and/or macro-entanglement phenomena<sup>25,26</sup> may help explain the fuller nature of homeopathic medicines, the available evidence also suggests that homeopathic medicines can exhibit qualitatively and quantitatively different structural properties from those of unsuccessed or succussed solvents. Even in the case of subtle energies, initial findings indicate the possibility of measuring changes in liquid structure properties from the materials science perspective.<sup>27,28</sup>

The convergence of data from different experimental models suggests that it is feasible to study the nature of



**Figure 5** Raman spectra of plain ethanol and succussed 6c, 12c, 30c. Note that peak positions identified from (a)–(f) are prominent only in 6c sample. Also note that the intensity of peaks in the unsuccessed ethanol is significantly lower than the succussed samples.

homeopathic medicines using available basic science tools, notably here, Raman spectroscopy and ultra-violet–visual absorption (UV–VIS) spectroscopy. Reproducibility of findings is feasible within the same Raman equipment, but, not across different Raman spectrophotometers from the same manufacturer at different geographic locations, even for materials other than homeopathic medicines. Fourier transform infrared (FT-IR) spectroscopy cannot differentiate different homeopathic medicines or different potencies of the same remedy from one another. Transmission and structural electron microscopy are promising options for testing the nanobubble hypothesis.

Finally, the materials science perspective provides a possible translational bridge from the emerging complex systems/network science models for clinical responses to homeopathic treatment<sup>5,12,13,29–32</sup> to another level of organizational scale, ie, the network structure of the homeopathic medicines themselves. Given the holistic quality of clinical diagnosis and remedy selection in homeopathy, the articulation of holistic (complex network) rather than reductionistic models for both the clinical healing process and the nature of homeopathic medicines is heuristically appealing.

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## Conflicts of interests

Dr Bell serves as a consultant to Standard Homeopathic Company/Hyland's Inc., which did not provide any direct financial support for the research discussed in this paper.

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