

ORIGINAL PAPER

Solvatochromic dyes detect the presence of homeopathic potencies



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A systematic approach to the design of simple, chemical systems for investigating the nature of homeopathic medicines has led to the development of an experimental protocol in which solvatochromic dyes are used as molecular probes of serially diluted and agitated solutions. Electronic spectroscopy has been used to follow changes in the absorbance of this class of dyes across the visible spectrum in the presence of homeopathic potencies.

Evidence is presented using six different solvatochromic dyes in three different solvent systems. In all cases homeopathic potencies produce consistent and reproducible changes in the spectra of the dyes.

Results suggest that potencies influence the supramolecular chemistry of solvatochromic dyes, enhancing either dye aggregation or disaggregation, depending upon dye structure. Comparable dyes lacking the intramolecular charge transfer feature of solvatochromic dyes are unaffected by homeopathic potencies, suggesting potencies require the oscillating dipole of solvatochromic dyes for effective interaction.

The implications of the results presented, both for an eventual understanding of the nature of homeopathic medicines and their mode of action, together with future directions for research in this area, are discussed. Homeopathy (2016) 105, 55–65.

Keywords: Homeopathic potencies; Solvatochromism; Aggregachromism; Solvatochromic dyes; Intramolecular charge transfer; Supramolecular chemistry; Dye aggregation and disaggregation

Introduction

There is no doubt that a plausible and testable hypothesis for the mode of action of homeopathy and, by implication, an understanding of the physico-chemical nature of homeopathic potencies, would profoundly enhance homeopathy, both as an area of legitimate scientific study and as an effective medical approach.

Research at the molecular level has the advantage over other approaches in that it can ask the kinds of searching and detailed questions necessary to arrive at fully testable hypotheses as to the *modus operandi* of homeopathy.

With this view in mind a programme of investigation aimed at developing well-defined chemical systems capable of detecting consistent and replicable effects of serially diluted and agitated solutions has been initiated. Specifically, a simple chemical system utilising environment sensitive solvatochromic dyes¹ has been developed. Solvatochromic dyes are sensitive to, and can be used to follow, a range of solution dynamics through changes in their absorbance spectra which, conveniently, occur in the visible portion of the electromagnetic spectrum.

The system described below demonstrates not only that homeopathic potencies have *in vitro* effects which can be measured, but also because the system is both simple and versatile, very specific questions can be asked about what molecular effects potencies are having in solution and what their ultimate nature might be.

Whilst a range of chemical and physical systems have been employed in the past in the study of homeopathic medicines, including UV-spectroscopy,² nuclear magnetic resonance spectroscopy,³ thermoluminescence,⁴ high

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Received 12 March 2015; revised 18 June 2015; accepted 12 August 2015

voltage plasma visualisation,⁵ solution conductivity⁶ and micro-calorimetry,⁷ together with theoretical studies,⁸ little consensus has emerged as to the nature of the homeopathic stimulus. Results suggest potencies may be electromagnetic in nature,⁹ or that they may involve and exploit the intrinsic ability of water to form complex hydrogen bonding networks.¹⁰ They may have their origins in quantum electrodynamics,¹¹ quantum entanglement,¹² complexity theory¹³ or stochastic resonance.¹⁴

The present approach has grown out of a recognition that a number of criteria need to be fulfilled if homeopathic potencies are to be studied in a way that provides results that are (i) significantly above background noise and (ii) allows the development of systems that can be manipulated to reveal the effect of one variable at a time. The criteria are essentially two fold. The first involves the stability of homeopathic potencies. Whilst firm evidence is lacking, it is a commonly held belief that potencies are sensitive to ultraviolet light, X-rays and strong magnetic and electrical fields.¹⁵ For this reason it was felt that any putative detection system should avoid UV-spectroscopy, thermoluminescence, NMR and high voltage plasma visualisation. Conversely, little is known about how potencies can be effectively destroyed. Heat is commonly held to be effective, but again evidence is lacking.¹⁶ The destruction of potencies is important if one is to avoid cross-contamination where glassware and other container materials are re-used. For this reason the current study has employed disposable containers in all situations where cross-contamination is a potential problem.

The second group of criteria revolves around the issue of the control of variables. Ideally any detection system should be one in which the variables involved can be addressed individually. In this way specific questions can be asked and specific answers obtained. A well-defined and simple detection system is therefore highly desirable, especially if the system is capable of providing different types of information.

With these criteria in mind a detection system involving solvatochromic dyes has been developed. In brief, changes have been found to occur in the absorbance spectra of these dyes in the presence of homeopathic potencies. In turn it has then been possible to make certain inferences as to the specific action of potencies in solution.

A system in which homeopathic potencies are added to solutions of solvatochromic dyes is simple, versatile, and involves a very small number of components and operational steps. In addition, the system is sensitive to changes in a wide range of solution dynamics including solvent polarity, solvent-solute binding patterns, and supramolecular interactions between solute molecules.

To date six different solvatochromic dyes have been investigated, three positively solvatochromic and three negatively solvatochromic (Figure 1).

An overview of solvatochromic dyes

Solvatochromic dyes are characterised by possessing an electron donating group and an electron accepting group

with an electron delocalised system in-between.¹⁷ For negatively solvatochromic dyes the ground or resting state is zwitterionic with a formal charge at either end of the molecule. On absorption of light an electron travels from one end of the molecule to the other to form an excited polar, but uncharged, state (Figure 2). Whilst the lifetime of the excited state is of the order of picoseconds this rapid electron oscillation occurs constantly under the influence of absorbed light. Importantly the wavelength of the absorbed light is influenced by the environment in which the dye is placed. Conversely, for positively solvatochromic dyes the ground or resting state is uncharged. On absorption of light an electron travels from one end of the molecule to the other to form an equally short-lived charged excited state (Figure 2). Again the wavelength of the light absorbed is dependent upon the nature of the environment in which the dye is placed. Negatively and positively solvatochromic dyes behave differently and complementarily to each other in a number of ways. These are important in relation to the results obtained with potencies reported below.

Negatively solvatochromic dyes absorb at longer and longer wavelengths (bathochromically shifted) as solvent polarity decreases. For example ET30 (Figure 1) absorbs at 450 nm in water, 550 nm in ethanol and 650 nm in *tert*-butyl alcohol.¹⁸ In addition these dyes tend to increasingly aggregate as solvent polarity decreases producing aggregates that are bathochromically shifted with respect to monomer (unaggregated material), a phenomenon known as aggregachromism.¹⁹ These bathochromically shifted species take the form of 'steps' in solution and are known as J-aggregates²⁰ (Figure 3).

Conversely, positively solvatochromic dyes absorb at shorter and shorter wavelengths (hypsochromically shifted) as solvent polarity decreases. For example BDN (Figure 1) absorbs at 614 nm in water, 564 nm in ethanol and 537 nm in *tert*-butyl alcohol.²¹ These dyes tend to increasingly aggregate as solvent polarity decreases producing aggregates that are hypsochromically shifted with respect to monomer,²² in contrast to that seen with negatively solvatochromic dyes. These hypsochromically shifted species take the form of 'stacks' in solution and are known as H-aggregates²³ (Figure 3).

Dyes ET33, ET30 and BM produce J-aggregates in solution; dyes BDN, NR and PB produce H-aggregates.²⁴

Results reported below exploit these complementary properties of positively and negatively solvatochromic dyes.

In addition, dyes ET30, ET33 and BDN bind divalent cations²⁵ to produce optical changes which can also be utilised to demonstrate effects of homeopathic potencies.

Precautions taken in this study

The experimental protocols followed in the course of this study have focused on a number of different practical issues which need to be discussed before results are presented (for details see [Materials and methods](#) section). The first involves the use of disposable cuvettes. Whilst

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