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Raman Spectroscopy characterisation of 5C potency of homoeopathic drugs *Nux vomica*, *Thuja occidentalis* and *Nitricum acidum*

Alfonso Tramontana

University Rey Juan Carlos, Madrid, Spain, altramontana75@gmail.com

Giuseppe Acri

Department of BIOMORF, University of Messina, Messina, Italy, giuseppe.acri@unime.it

Lucia Denaro

Department of BIOMORF, University of Messina, Messina, Italy, lucia.denaro@unime.it

Massimo Mattozzi

Italian National Institute for Insurance against Accidents, Rome, Italy, m.mattozzi@inail.it

See next page for additional authors

Author(s) ORCID Identifier:

Giuseppe Acri: <https://orcid.org/0000-0002-8897-2853>

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Abstract

Background: The physicochemical characterisation of homoeopathic medicines remains a challenge. Raman spectroscopy is a promising tool for identifying structural modifications in the solvent matrix and specific vibrational "fingerprints" induced by the potentisation process. **Objective:** This study aimed to characterise three remedies (*Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum* - 5C potencies) using Raman spectroscopy to identify specific vibrational markers and evaluate the technique's ability to differentiate between different preparations within a complex matrix. **Materials and methods:** The drugs were analysed as crushed granules (solid state) and after dissolution in betamethasone disodium phosphate (liquid state). Raman spectroscopy was chosen for its high specificity and minimal water interference. Samples were standardised for particle size and pressure to ensure reproducibility, comparing results against pure excipient baselines (sucrose and lactose). **Results:** Analysis of the granules confirmed dominant peaks of the carbohydrate matrix (1063, 1127, 1450, and 2900 cm^{-1}). In the liquid phase, however, the three preparations exhibited unique vibrational signatures and significant spectral shifts. These differences, validated by statistical analysis of the signal-to-noise ratio, persist even at 5C potency levels, suggesting a stable interaction between the diluted component and the molecular probe. **Conclusion:** Raman spectroscopy provides valuable insights into the characteristic vibrational modes and functional-group interactions in homoeopathic medicines.

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Authors

Alfonso Tramontana, Giuseppe Acri, Lucia Denaro, Massimo Mattozzi, Maria Antonietta D'Avanzo, and Barbara Testagrossa



ORIGINAL ARTICLE

Raman Spectroscopy characterisation of 5C potency of homoeopathic drugs *Nux vomica*, *Thuja occidentalis* and *Nitricum acidum*

Alfonso Tramontana¹, Giuseppe Acri^{2,*}, Lucia Denaro², Massimo Mattozzi³, Maria Antonietta D'Avanzo³, Barbara Testagrossa²

¹ University Rey Juan Carlos, Madrid, Spain

² Department of BIOMORF, University of Messina, Messina, Italy

³ Italian National Institute for Insurance against Accidents, Rome, Italy

ABSTRACT

Background: The physicochemical characterisation of homoeopathic medicines remains a challenge. Raman spectroscopy is a promising tool for identifying structural modifications in the solvent matrix and specific vibrational “fingerprints” induced by the potentisation process. **Objective:** This study aimed to characterise three remedies (*Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum* - 5C potencies) using Raman spectroscopy to identify specific vibrational markers and evaluate the technique’s ability to differentiate between different preparations within a complex matrix. **Materials and methods:** The drugs were analysed as crushed granules (solid state) and after dissolution in betamethasone disodium phosphate (liquid state). Raman spectroscopy was chosen for its high specificity and minimal water interference. Samples were standardised for particle size and pressure to ensure reproducibility, comparing results against pure excipient baselines (sucrose and lactose). **Results:** Analysis of the granules confirmed dominant peaks of the carbohydrate matrix (1063, 1127, 1450, and 2900 cm⁻¹). In the liquid phase, however, the three preparations exhibited unique vibrational signatures and significant spectral shifts. These differences, validated by statistical analysis of the signal-to-noise ratio, persist even at 5C potency levels, suggesting a stable interaction between the diluted component and the molecular probe. **Conclusion:** Raman spectroscopy provides valuable insights into the characteristic vibrational modes and functional-group interactions in homoeopathic medicines.

Keywords: Homeopathic medicine, Raman spectroscopy, Vibrational frequencies

Introduction

Homoeopathy is one of the complementary and alternative medicines (CAMs) and is based mainly on the principle of “similia similibus curentur”,^{1,2} which holds that a medicinal substance that causes symptoms in a healthy person, when properly diluted and processed, can be used to treat similar symptoms in a sick patient.

However, the scientific investigation of homoeopathic preparations, particularly those in Ultra-High Dilutions (UHD), represents a significant challenge for analytical chemistry, as active dilutions may often

exceed Avogadro’s number (beyond 12C potency).³ It is difficult to experimentally verify the presence of the original medicinal substance in the UHD solution and it is sometimes speculated that the final homoeopathic medicines are only solutions of water and alcohol and may not have any biological activity.⁴

In this context, researchers have aimed to study UHDs in order to verify if source materials are present in the UHDs and possess biological properties after the potentisation process.^{5–8}

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*Corresponding author.

E-mail address: giuseppe.acri@unime.it (G. Acri).

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The homoeopathic dilution process is performed in steps, with each step involving a specific dilution ratio and succussion.⁹

Since the last 50 years, Raman spectroscopy has emerged as a pivotal tool for providing a unique “vibrational fingerprint” of molecular structures in a non-destructive manner.

This technique is based on analysis of inelastically scattered light¹⁰ and has been applied across different research fields, ranging from heritage to medicine.^{11–14} Raman spectra can provide information about the molecular environment.¹⁵

The aim of this study is to bridge the gap in comparative data on the vibrational modes of specific drug potencies (5C potency), such as *Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum*. The decision to focus this investigation solely on 5C potency stems from the need to evaluate spectroscopic responses under well-defined, controlled conditions. This potency provides an optimal model to test the sensitivity and reproducibility of Raman spectroscopy. Analysing this specific potency enables the establishment of a robust methodological baseline, essential for distinguishing the drugs’ vibrational signatures from the background matrix of excipients. Raman spectroscopy was selected for its high specificity in identifying molecular symmetry and bond dynamics, which are essential for assessing how active principles might influence the hydrogen-bonding network of the solvent or the crystal lattice of excipients such as sucrose and lactose. By analysing both the solid granules and their liquid dilutions, this present study aims to establish a protocol for the quality control and molecular identification of homoeopathic medicines.

Materials and methods

Homoeopathic medicine preparation

To ensure the highest degree of chemical purity and experimental reproducibility, all homoeopathic preparations analysed in this study—specifically *Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum* in 5C potencies were obtained as finished, ready-made commercial products from Ce.M.O.N. (Italy). The selection of these standardised medicines ensures that the samples were produced under strict industrial protocols, complying with the German Homoeopathic Pharmacopoeia (H.A.B.) and the European Pharmacopoeia (Eur.Ph.).

According to the manufacturer’s certification, each batch undergoes rigorous Good Manufacturing Practice (GMP) quality controls to ensure the absence of bacterial contamination and heavy metal residues. This standardised approach was chosen to provide

a reliable baseline for Raman spectroscopic analysis, ensuring that the detected vibrational signals are representative of the preparations themselves rather than unintended laboratory impurities.

The three homoeopathic medicine preparations considered for Raman measurements were *Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum* in granule form and 5C potencies. Each granule consists of a mixture of lactose and sucrose and contains the homoeopathic preparation (6 g per granule).

Two distinct steps were followed in the experimental measurements. In the first one, the granules were collected using latex gloves to avoid environmental contamination. For each homoeopathic preparation, five granules (30 g) were used. No chemical binders were used to prepare the samples. The granules were mechanically crushed into a fine, uniform powder by using a crushing machine (Jaw Crusher BZJC 502 – Labzee Laramie, WY 82072, USA) and placed into a specialised pellet holder. Three different spectra were collected, and the average spectrum was considered for each homoeopathic preparation, as detailed under “Raman Measurements”. A total of 21 samples were considered for Raman measurements.

In the second step, measurements were performed on a solution combining the homoeopathic preparation and Bentelan (AIC 019655152), a synthetic corticosteroid drug containing betamethasone disodium phosphate (4 mg/vial), corresponding to a concentration of 2 mg/mL. The choice of this formulation was based on previous findings demonstrating its therapeutic efficacy and physicochemical relevance in similar experimental models.⁸ For solution preparation, 5 granules were collected using latex gloves, placed in a vial and dissolved in 2 mL of bentelan (Alfasigma S.p.A., Bologna, Italy). Before the Raman analysis, the vial was sealed using parafilm and manually shaken ten times. For each homoeopathic solution, three Raman spectra were acquired, and the average spectrum was considered. Also, for the betamethasone disodium phosphate (2 mL), three Raman spectra were acquired, and the average spectrum was considered. Reference spectra for pure sucrose and lactose were retrieved from the instrument’s integrated spectral library.

Raman measurements

Raman measurements were performed at the BIOMORF Department of the University of Messina using a DXR-SmartRaman Spectrometer (Thermo Fisher Scientific, Waltham, MA, USA) with a 785 nm diode laser. All the Raman spectra were acquired

over the wavenumber range of 350–3400 cm^{-1} , with a resolution of about 2 cm^{-1} and irradiated with a laser power of 24 mW, coming out from a 50 μm spot. Prior to measurements, the DXR-SmartRaman spectrometer was calibrated using reference standards of known wavenumber provided by the manufacturer.

The pellet samples were accommodated into the appropriate sample holder, and the 180-degree sampling accessory for the DXR-SmartRaman Spectrometer was used for measurements. To obtain high signal-to-noise ratio (SNR) spectra, each Raman spectrum was obtained after collecting 8 sample frames, and the duration of each exposure for each frame was set equal to 15.0 s. The total acquisition time was 2 minutes for each spectrum.

The vials containing granules dissolved in betamethasone disodium phosphate solution were accommodated in their specific sample holder. The solutions of the homoeopathic preparation and Bentelan were analysed by using the 180 degree sampling accessory. In this step, a high SNR was achieved by collecting 16-sample exposures (each exposure duration: 30.0 s) for each Raman spectrum. In this case, the total acquisition time was 8 min.

In addition, three Raman spectra of 2 ml of betamethasone disodium phosphate (bentelan 4 mg/vial) were acquired, and as in this case, the average spectrum was determined.

All Raman spectra were saved both in the instrument's proprietary binary formats (.spa, Thermo Scientific OMNIC) for archival purposes and as comma-separated values (.csv, containing wavenumber and intensity matrices) for post-processing data analysis. All the Raman spectra were stored in both .spa and .csv formats, and the post-processing analysis was performed using Omnic for dispersive Raman 9.0 software and Origin 2018 (OriginLab Corporation, Massachusetts, USA). The spline method was used for curved baselines, based on a cubic polynomial interpolation using groups of four consecutive baseline points. Noise reduction was performed using Savitzky-Golay filtering, applied with an 11-point frame size (window length) and a 3rd-order polynomial.¹⁶ All obtained spectra were normalised by using the "Vector normalisation"¹⁷ tool available in Origin software. Each element of the vector represents the Raman intensity at a given frequency, and each point is divided by the vector norm to obtain the normalised spectrum.

$$\text{norm}_{\text{vect}} = \sqrt{s_1^2 + s_2^2 + \dots + s_n^2} \quad (1)$$

where s_i represents the intensity at each point.

Results

Homoeopathic pellet samples

In Fig. 1, the average spectra and standard deviation (SD) of *Nux vomica*, *Thuja occidentalis* and *Nitricum acidum* homoeopathic preparations in 5C potencies, in pellet form, are shown.

It can be observed that all the acquired spectra exhibit spectral features comparable to those of sucrose and lactose, representing the dominant signals of the excipients. In particular, the peaks obtained from the homoeopathic medicine preparation were compared with those of pure sucrose and lactose available in the instrument's integrated spectral library (Thermo Scientific OMNIC Spectrometer Library), retrieved from the literature. The results are reported in Table 1. The comparison with pure sucrose and lactose is fundamental to identify spectral variations that distinguish the homoeopathic remedy from the pure excipient matrix. These variations represent the 'vibrational signature' induced by the potentiation process.

The matching of pure sucrose and the average spectrum of *Nux vomica* was about 80%; a similar percentage value was obtained from the comparison between pure sucrose and *Thuja occidentalis*, while a matching of 90% was obtained from the comparison between pure sucrose and the mean spectrum of *Nitricum acidum*. Nevertheless, remedy-specific features were identified by evaluating the residual spectral differences and the characteristic vibrational modes corresponding to betamethasone disodium phosphate (e.g., specific phosphate and aromatic/steroid ring stretches) that deviate from the pure sugar baseline. The assignment of specific vibrational features to the homoeopathic drugs was based on identifying statistically reproducible spectral variations that emerged specifically upon adding the diluted remedy into the formulation matrix, compared to the pure excipient, available inside the spectrometer library. All three tested drugs share the same vehicle (betamethasone solution) and the exact same excipient matrix (sucrose and lactose granules). If the observed changes were merely due to a non-specific sugar – betamethasone interaction, all samples would display identical spectra. Instead, as detailed in Table 2, distinct and selective peaks emerge from individual preparations.

In all the analysed spectra no peaks other than sucrose and lactose ones appeared.^{18–23}

Homoeopathic granules dissolved in betamethasone disodium phosphate

In Fig. 2 the average Raman spectrum of betamethasone disodium phosphate and its SD are reported.

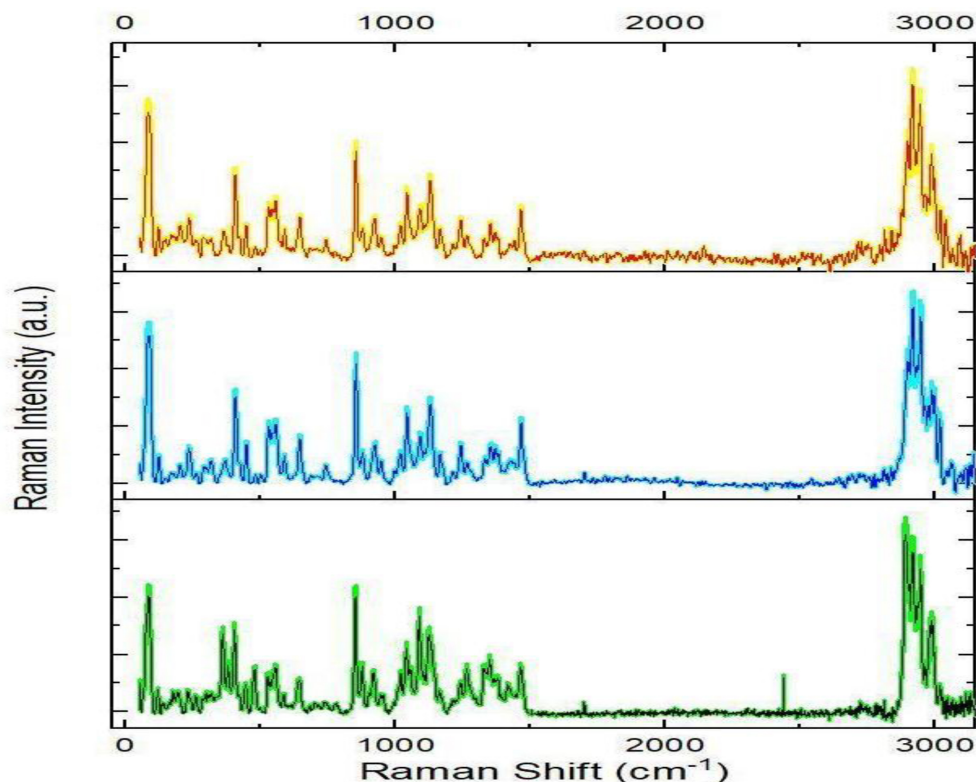


Fig. 1. Average spectrum and SD of homoeopathic medicines at 5C potency. *Thuja occidentalis* (black line, the SD is represented as green shadow), *Nux vomica* (blue line, the SD is represented as cyan shadow), *Nitricum acidum* (red line, the SD is represented as yellow shadow).

In Fig. 3, the mean spectra of homoeopathic substances dissolved in betamethasone disodium phosphate are shown.

Fig. 3 depicts an amplification of the Raman signal. This amplification also increased the background, bringing out peaks attributable to homoeopathic products.

In this case as well, the analysis of the Raman spectra confirmed that the main vibrational modes were attributed to sucrose and lactose, which are used as pharmaceutical excipients. At the same time, differences in peak presence and peak positions were observed. In particular, peaks are generally selective to a single homoeopathic preparation at each frequency (Table 2); the only exception is at 648 cm^{-1} , where a peak is present for both *Nux vomica* and *Nitricum acidum*.

Raman analysis of drugs in this study relies on the reproducibility of specific spectral parameters and peak profiles rather than on the appearance of new, high-intensity bands. As highlighted by the SD profiles (Fig. 3) and the qualitative peak assignments summarised in Table 2, the spectral differences between *Nux vomica* and *Thuja occidentalis* dissolved in the same standardised vehicle were proved to be reproducible, as confirmed by the consistent

SD profiles across independent replicates and high signal-to-noise ratios that significantly exceed baseline instrumental noise. These observations suggest that each of these homoeopathic preparations in 5C potency imparted a distinct spectral profile, potentially associated with subtle modifications in the solvation environment.

In Table 2, the dissimilarities detected in the obtained spectra are reported.

Discussion

The vibrational modes of three 5C potency homoeopathic medicines – *Nux vomica*, *Thuja occidentalis*, and *Nitricum acidum* – were characterised and compared using Raman spectroscopy. The choice of 5C potencies was primarily driven by the availability of standardised, ready-made commercial preparations (Ce.M.O.N., Italy) manufactured under strict GMP quality controls during the experimental phase. We recognise that potencies such as 6C, 30C, or 200C are widely used in clinical practice. Testing a broader range of potencies remains an important goal for our upcoming studies as we extend this experimental protocol. Two experimental setups were employed: anal-

Table 1. Raman peaks (cm⁻¹) of homoeopathic preparations at 5C potency. *Nitricum acidum*, *Nux vomica* and *Thuja occidentalis*, compared with the measured peaks of sucrose and lactose, as reported in literature.

<i>Nitricum acidum</i>	<i>Nux vomica</i>	<i>Thuja occidentalis</i>	Sucrose	Lactose
-	-	-	3338	-
-	-	-	3296	-
-	-	-	3272	-
-	-	-	3244	-
-	-	-	-	3128
-	3098	3097	-	3097
3092	3093	3094	-	-
-	-	3075	-	-
3065	3064	3066	-	3062
-	3058	-	-	3050
-	3044	3047	-	-
3039	-	3039	-	3040
-	-	3024	-	3023
3020	3018	3019	3014	-
-	-	-	-	3002
2997	2998	2996	2994	2995
2987	2987	2986	2985	2986
2974	2976	v.g.	-	2978
2971	-	2972	2972	2972
2962	2960	2962	2959	-
2945	2946	2945	2943	2946
-	2933	2934	2929	2935
2916	2917	2916	2913	2918
-	-	-	-	-
2898	2899	2889	-	-
2878	-	-	-	-
2861	2867	2861	-	-
2852	2849	-	-	2850
2839	2836	-	2841	-
-	-	-	2822	-
2813	2811	2810	-	-
-	-	-	-	1489
-	-	-	1474	-
-	-	-	-	1470
1464	1465	1462	1462	-
-	-	-	-	1456
1440	1438	1443	-	1444
1428	1426	-	-	1424
1423	1420	1415	-	1415
1410	-	v.g.	1411	-
-	1398	-	-	-
1393	-	1389	-	1393
1380	1380	1379	1378	1377 (1380)
1370	1370	1367	1367	-
-	-	-	-	1359
1351	1352	1348	1349	1344 (1349)
1339	-	1339	-	1336
1328	1331	1330	1327	1323 (1328)
-	-	-	1305	-
-	-	-	1293	1297
-	-	1274	1278	1273
1264	1264	1263	1262	1258 (1263)
1241	1242	1241	1239	1245
-	-	-	-	1231
1222	-	1222	-	1224
1212	1213	1216	1209	1219
-	-	-	-	1204
-	-	-	1189	1187
1180	1180	1180	1171	-
1165	1165	1162	1162	1164
-	-	-	-	1139 (1142)
1128	1128	1124	1125	1120

(Continued)

Table 1. Continued.

<i>Nitricum acidum</i>	<i>Nux vomica</i>	<i>Thuja occidentalis</i>	Sucrose	Lactose
-	-	-	-	1117
1110	1109	1104	1105	1100
1090	1091	1087	1089	1083 (1092)
-	-	-	1071	-
1050	1050	1054	1052	1049 (1054)
1042	1041	1039	1039	1037 (1041)
-	-	-	-	1030
1018	1018	1019	1014	1015 (1020)
-	-	1007	-	1005
995	995	993	993	-
981	-	-	-	978
-	-	-	967	-
-	-	952	-	950 (954)
946	946	943	946	-
-	-	-	-	935
923	924	918	922	-
-	-	-	913	912 (916)
-	-	901	-	900
878	878	877	871	873 (877)
852	853	851	850	847 (852)
-	-	-	-	821
-	-	-	-	814
-	-	-	-	798
-	-	-	-	793
-	-	-	780	776
-	-	-	-	768
-	-	-	-	760
-	-	-	-	753
-	-	-	-	746
742	740	736	738	738
-	-	-	-	725
709	708	711	-	-
695	701	702	701	-
682	686	683	680	-
-	-	-	641	635
616	623	-	-	621
602	-	-	-	-
588	587	584	585	-
572	-	572	-	568
555	555	554	552	555
543	545	537	-	535
-	-	-	526	526
-	-	-	-	510
-	-	-	497	-
479	480	477	475	478
-	-	-	-	454
445	446	443	443	445
-	-	-	-	438
420	421	421	-	421
-	-	-	403	400
379	368	377	-	378
362	351	358	365	357
-	-	-	347	-
-	-	-	336	337
315	315	315	315	-
294	298	292	297	295
286	289	284	284	283
259	260	258	257	260
233	233	235	231	239
-	-	229	-	-
220	-	-	219	-
201	200	197	-	190
-	-	192	-	-

* v.g. = visual graphic.

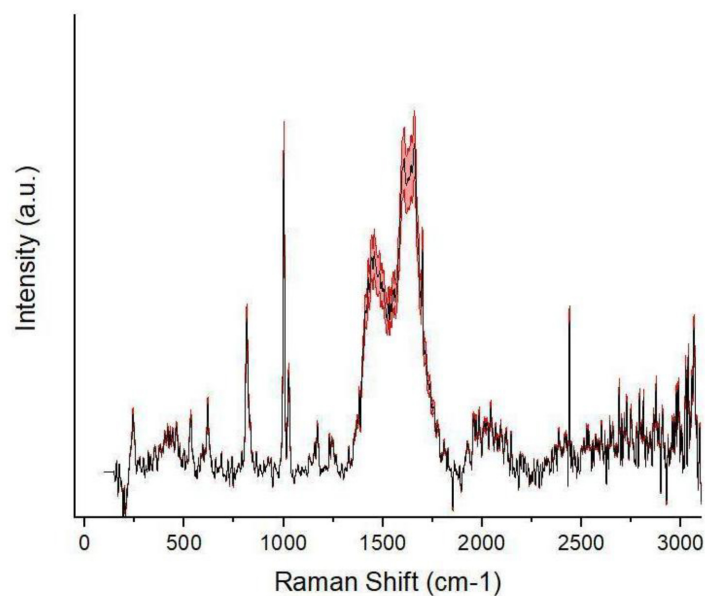


Fig. 2. Betamethasone disodium phosphate average Raman spectrum (black line) and its SD (red shadow).

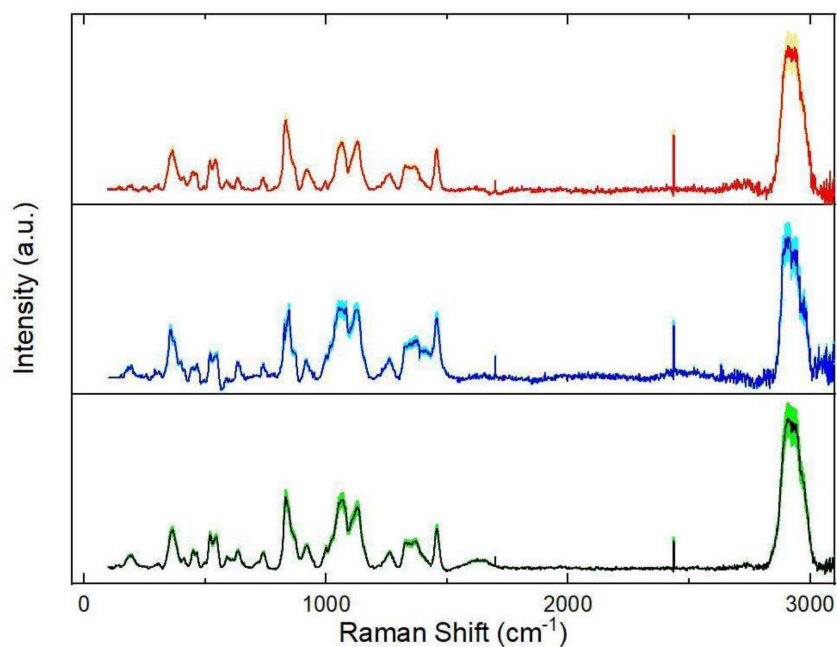


Fig. 3. Average Raman spectra and SD of homoeopathic medicines at 5C potency dissolved in betamethasone disodium phosphate: *Thuja occidentalis* (black line, the SD is represented as green shadow), *Nux vomica* (blue line, the SD is represented as cyan shadow), *Nitricum acidum* (red line, the SD is represented as yellow shadow).

Table 2. Dissimilarities were detected in the Raman spectra obtained from homoeopathic drugs dissolved in betamethasone disodium phosphate.

Frequency (cm ⁻¹)	<i>Thuja occidentalis</i> (5C)	<i>Nux vomica</i> (5C)	<i>Nitricum acidum</i> (5C)	<i>Betamethasone disodium phosphate</i>	<i>Sucrose</i>	<i>Lacose</i>
408	none	X	none	none	none	none
490	none	none	X	none	none	none
648	none	X	X	none	none	none
829	none	X	none	none	none	none

‘X’ represents the Raman peak presence.

ysis of the products in their pellet form and analysis after dissolution in 2 ml of betamethasone disodium phosphate.

In particular, the possibility of differentiation when they are dissolved in betamethasone disodium phosphate was considered and investigated.

The use of betamethasone disodium phosphate was intentional. In Raman investigations of drugs, using betamethasone disodium phosphate as a molecular probe enables observation of subtle microenvironmental shifts, owing to the high Raman activity and environmental sensitivity of its phosphate group. The reproducible spectral variations point toward potential modifications within the probe's solvation shell. However, because interactions between betamethasone and the sugar matrix (sucrose and lactose) cannot be completely ruled out at this stage, these observations should be considered preliminary. Further control studies evaluating betamethasone directly against pure excipient solutions will be essential to definitively isolate the remedy-specific contribution.

When granules of *Nux vomica*, *Thuja occidentalis* and *Nitricum acidum* in 5C potencies were dissolved in 2 ml of betamethasone disodium phosphate, an amplification of the Raman signal was observed in all the analysed spectra.

While the vibrational signals are predominantly dominated by the sucrose and lactose excipients, distinct spectroscopic features attributable to the homoeopathic preparations can also be identified in the liquid phase.

While the physical origin of these signals at ultra-high dilutions remains a subject of ongoing debate, our preliminary findings at 5C dilution indicate measurable spectral variations that warrant further investigation.

The experimental spectra obtained in this study reveal reproducible vibrational frequency features in 5C diluted preparations. While 5C potencies do not exceed Avogadro's limit, these preliminary findings demonstrate measurable spectral variations in low-concentration preparations that warrant further investigation. In particular, some peaks could be attributed to homoeopathic products. The peaks at 408 and 829 cm^{-1} can be assigned to *Nux vomica*, while the peak at 490 cm^{-1} can be assigned to *Nitricum acidum*. The peak 648 cm^{-1} is present in *Nux vomica* and *Nitricum acidum* homoeopathic dilutions but they are not visible in *Thuja*. It is interesting to note that no characteristic peaks are visible for *Thuja*. On the other hand, the spectral band conformation, ranging from 800 to 900 cm^{-1} , exhibits marked variations among all three dissolved preparations. The absence of distinct peak assignments and the complex overlapping in this spectral region represent a current limitation of

the present study. To overcome this constraint and resolve these overlapping spectral features, comprehensive band deconvolution will be carried out in future work.

This study provides a characterisation from a vibrational point of view of *Nux vomica* and *Nitricum acidum* drugs in 5C potencies by using Raman spectroscopy, while *Thuja occidentalis* does not exhibit distinct, isolated characteristic peaks in the analysed spectral region.

The analysis of solid granules identified only the excipient matrix fingerprint, not that of the drug, whereas the liquid-phase analysis revealed significant spectral modifications induced by the homoeopathic drug.

A reproducible increase in Raman scattering intensity, along with a refinement of specific spectral bands, was observed when the three drugs at 5C potency were combined with betamethasone disodium phosphate. These spectral variations suggest potential intermolecular interactions between the homoeopathic preparation and the corticosteroid probe, which may serve as a molecular sensor. While the stability of the standard deviation across replicates indicates that these signals exceed background instrumental noise, several limitations of this study must be acknowledged. Rather than reflecting a generalised response, the observed Raman/vibrational peaks can be unambiguously attributed to specific homoeopathic active ingredients.

Conclusion

It is concluded from the present study that Raman spectroscopy is a viable analytical tool for the molecular characterisation of homoeopathic preparations, providing distinct vibrational signatures. Further in-depth investigation with different drugs might be useful for characterising and even quantifying the purity of the medicine.

Funding

The Raman Spectrometer was purchased with PANLAB 2015 funds.

Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions

Alfonso Tramontana: Concepts, Manuscript preparation, Review.

Giuseppe Aciri: Concepts, Design, Literature search, Experimental studies, Data acquisition, Data analysis, Manuscript preparation, Manuscript editing.

Lucia Denaro: Data analysis, Manuscript preparation.

Massimo Mattozzi: Literature search, Manuscript preparation.

Maria Antonietta D'Avanzo: Literature search, Manuscript preparation.

Barbara Testagrossa: Concepts, Design, Literature search, Experimental studies, Data acquisition, Data analysis, Manuscript preparation, Manuscript editing.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Caractérisation par spectroscopie Raman de la dilution 5C des médicaments homéopathiques *Nux vomica*, *Thuja occidentalis* et *Nitricum acidum*

Contexte : La caractérisation physico-chimique des médicaments homéopathiques demeure un défi. La spectroscopie Raman est un outil prometteur pour identifier les modifications structurales de la matrice du solvant et les « empreintes » vibrationnelles spécifiques induites par le processus de potentialisation. **Objectif :** Cette étude visait à caractériser trois remèdes (*Nux vomica*, *Thuja occidentalis* et *Nitricum acidum* – dilutions 5C) par spectroscopie Raman afin d'identifier des marqueurs vibrationnels spécifiques et d'évaluer la capacité de la technique à différencier les préparations au sein d'une matrice complexe. **Matériels et méthodes :** Les médicaments ont été analysés sous forme de granules broyés (état solide) et après dissolution dans du phosphate disodique de bétaméthasone (état liquide). La spectroscopie Raman a été choisie pour sa haute spécificité et sa faible sensibilité à l'eau. Les échantillons ont été standardisés en termes de taille de particules et de pression afin d'assurer la reproductibilité, les résultats étant comparés à ceux d'excipients purs (saccharose et lactose). **Résultats :** L'analyse des granules a confirmé la présence de pics dominants caractéristiques de la matrice glucidique (1063, 1127, 1450 et 2900 cm^{-1}). En phase liquide, les trois préparations ont présenté des signatures vibrationnelles uniques et des décalages spectraux significatifs. Ces différences, validées par l'analyse statistique du rapport signal/bruit, persistent même à la dilution 5C, suggérant une interaction stable entre le composant dilué et la sonde moléculaire. **Conclusion :** La spectroscopie Raman apporte des informations précieuses sur les modes vibrationnels caractéristiques et les interactions des groupes fonctionnels dans les médicaments homéopathiques.

Raman-spektroskopische Charakterisierung der 5C-Potenz der homöopathischen Arzneimittel *Nux vomica*, *Thuja occidentalis* und *Nitricum acidum*

Hintergrund: Die physikochemische Charakterisierung homöopathischer Arzneimittel stellt nach wie vor eine Herausforderung dar. Die Raman-Spektroskopie ist ein vielversprechendes Werkzeug zur Identifizierung struktureller Veränderungen in der Lösungsmittelmatrix und spezifischer Schwingungsmuster, die durch den Potenzierungsprozess hervorgerufen werden. **Ziel:** Diese Studie hatte zum Ziel, drei Arzneistoffe (*Nux vomica*, *Thuja occidentalis* und *Nitricum acidum* – Potenzen 5C) mittels Raman-Spektroskopie zu charakterisieren, um spezifische Schwingungsmarker zu identifizieren und die Fähigkeit der Technik zur Differenzierung verschiedener Präparate innerhalb einer komplexen Matrix zu bewerten. **Material und Methoden:** Die Arzneistoffe wurden als zerkleinertes Granulat (fester Zustand) und nach Auflösung in Betamethasondinatriumphosphat (flüssiger Zustand) analysiert. Die Raman-Spektroskopie wurde aufgrund ihrer hohen Spezifität und minimalen Wasserinterferenz gewählt. Die Proben wurden hinsichtlich Partikelgröße und Druck standardisiert, um die Reproduzierbarkeit zu gewährleisten. Die Ergebnisse wurden mit Referenzwerten der reinen Hilfsstoffe (Saccharose und Lactose) verglichen. **Ergebnisse:** Die Analyse des Granulats bestätigte dominante Peaks der Kohlenhydratmatrix (1063, 1127, 1450 und 2900 cm^{-1}). In der flüssigen Phase zeigten die drei Präparate jedoch einzigartige

Schwingungssignaturen und signifikante spektrale Verschiebungen. Diese Unterschiede, bestätigt durch eine statistische Analyse des Signal-Rausch-Verhältnisses, bleiben selbst bei 5C-Potenzstufen bestehen, was auf eine stabile Wechselwirkung zwischen der verdünnten Komponente und der molekularen Sonde hindeutet. **Schlussfolgerung:** Die Raman-Spektroskopie liefert wertvolle Einblicke in die charakteristischen Schwingungsmoden und Wechselwirkungen funktioneller Gruppen in homöopathischen Arzneimitteln.

होम्योपैथिक औषधियों नक्स वोमिका, थूजा ऑक्सीडेंटलिस और नाइट्रिकम एसिडम की 5C पोटेंसी का रमन स्पेक्ट्रोस्कोपी द्वारा लक्षण वर्णन

पृष्ठभूमि: होम्योपैथिक दवाओं का भौतिक-रासायनिक लक्षण वर्णन एक चुनौती बना हुआ है। रमन स्पेक्ट्रोस्कोपी विलायक मैट्रिक्स में संरचनात्मक संशोधनों और पोटेंसी प्रक्रिया द्वारा प्रेरित विशिष्ट कंपनात्मक "फिंगरप्रिंट" की पहचान के लिए एक आशाजनक उपकरण है। **उद्देश्य:** इस अध्ययन का उद्देश्य रमन स्पेक्ट्रोस्कोपी का उपयोग करके तीन औषधियों (नक्स वोमिका, थूजा ऑक्सीडेंटलिस और नाइट्रिकम एसिडम - 5C पोटेंसी) की विशेषताओं का पता लगाना था, ताकि विशिष्ट कंपन चिह्नों की पहचान की जा सके और एक जटिल मैट्रिक्स के भीतर विभिन्न तैयारियों के बीच अंतर करने की तकनीक की क्षमता का मूल्यांकन किया जा सके। **सामग्री और विधियाँ:** औषधियों का विश्लेषण कुचले हुए दानों (ठोस अवस्था) और बीटामेथासोन डिसोडियम फॉस्फेट में घुलने के बाद (तरल अवस्था) किया गया। रमन स्पेक्ट्रोस्कोपी को इसकी उच्च विशिष्टता और न्यूनतम जल हस्तक्षेप के कारण चुना गया। पुनरुत्पादकता सुनिश्चित करने के लिए नमूनों को कण आकार और दबाव के लिए मानकीकृत किया गया, और परिणामों की तुलना शुद्ध सहायक पदार्थ आधार रेखाओं (सुक्रोज और लैक्टोज) से की गई। **परिणाम:** दानों के विश्लेषण ने कार्बोहाइड्रेट मैट्रिक्स के प्रमुख शिखरों (1063, 1127, 1450 और 2900 cm^{-1}) की पुष्टि की। हालांकि, तरल अवस्था में, तीनों तैयारियों ने अद्वितीय कंपन संकेत और महत्वपूर्ण स्पेक्ट्रल बदलाव प्रदर्शित किए। सिग्नल-टू-नॉइज़ अनुपात के सांख्यिकीय विश्लेषण द्वारा प्रमाणित ये अंतर, 5C पोटेंसी स्तर पर भी बने रहते हैं, जो तनु घटक और आणविक प्रोब के बीच एक स्थिर अंतःक्रिया का संकेत देते हैं। **निष्कर्ष:** रमन स्पेक्ट्रोस्कोपी होम्योपैथिक दवाओं में विशिष्ट कंपनात्मक मोड और कार्यात्मक-समूह अंतःक्रियाओं के संबंध में बहुमूल्य जानकारी प्रदान करती है।

Caracterización mediante espectroscopia Raman de la potencia 5C de los medicamentos homeopáticos *Nux vomica*, *Thuja occidentalis* y *Nitricum acidum*

Antecedentes: La caracterización fisicoquímica de los medicamentos homeopáticos sigue siendo un desafío. La espectroscopia Raman es una herramienta prometedora para identificar modificaciones estructurales en la matriz solvente y "huellas dactilares" vibracionales específicas inducidas por el proceso de potenciación. **Objetivo:** Este estudio tuvo como objetivo caracterizar tres remedios (*Nux vomica*, *Thuja occidentalis* y *Nitricum acidum* - potencias 5C) mediante espectroscopia Raman para identificar marcadores vibracionales específicos y evaluar la capacidad de la técnica para diferenciar entre distintas preparaciones dentro de una matriz compleja. **Materiales y métodos:** Los fármacos se analizaron como gránulos triturados (estado sólido) y después de su disolución en fosfato disódico de betametasona (estado líquido). Se eligió la espectroscopia Raman por su alta especificidad y mínima interferencia del agua. Las muestras se estandarizaron en cuanto al tamaño de partícula y la presión para garantizar la reproducibilidad, comparando los resultados con las líneas base de los excipientes puros (sacarosa y lactosa). **Resultados:** El análisis de los gránulos confirmó picos dominantes de la matriz de carbohidratos (1063, 1127, 1450 y 2900 cm^{-1}). En la fase líquida, sin embargo, las tres preparaciones exhibieron firmas vibracionales únicas y desplazamientos espectrales significativos. Estas diferencias, validadas por el análisis estadístico de la relación señal/ruido, persisten incluso a niveles de potencia 5C, lo que sugiere una interacción estable entre el componente diluido y la sonda molecular. **Conclusión:** La espectroscopia Raman proporciona información valiosa sobre los modos vibracionales característicos y las interacciones de los grupos funcionales en los medicamentos homeopáticos.

拉曼光谱表征顺势疗法药物马钱子 (*Nux vomica*)、侧柏 (*Thuja occidentalis*) 和硝酸 (*Nitricum acidum*) 的 5C 效价

背景：顺势疗法药物的理化特性表征仍然是一个挑战。拉曼光谱是一种很有前景的工具，可用于识别溶剂基质中的结构变化以及由效价化过程引起的特定振动“指纹”。**目的：**本研究旨在利用拉曼光谱法对三种药物（马钱子、侧柏和硝酸，均为 5C 效价）进行表征，以识别特定的振动标记，并评估该技术在复杂基质中区分不同制剂的能力。**材料与方法：**将药物以颗粒状（固态）和溶于倍他米松磷酸二钠溶液（液态）两种状态进行分析。选择拉曼光谱法是因为其具有高特异性和极低的水干扰。样品按粒径和压力进行标准化，以确保重现性，并将结果与纯辅料（蔗糖和乳糖）的基线进行比较。**结果：**颗粒状药物的分析证实了碳水化合物基质的主要峰值（1063、1127、1450 和 2900 cm^{-1} ）。然而，在液相中，三种制剂表现出独特的振动特征和显著的光谱位移。通过信噪比的统计分析验证了这些差异，即使在 5C 效价水平下，这些差异仍然存在，表明稀释组分与分子探针之间存在稳定的相互作用。**结论：**拉曼光谱为顺势疗法药物的特征振动模式和官能团相互作用提供了宝贵的信息。