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Research Article

Action of a Cleaning Agent on Saliva Contaminated Zirconia: Study by Nuclear Magnetic Resonance Spectroscopy and Energy Dispersive X-ray Microanalysis

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Abstract

Objectives: The first condition to obtain a long-lasting bond of the surface of a zirconia prosthesis is a surface free of contaminants. Many methods used chemical or mechanical procedures are proposed to decontaminate zirconia surfaces.
The purpose of this study is to investigate the action of a Chemical Product (CP) as a cleaning method for dental zirconia ceramic contaminated by saliva.

Methods: Molecular structures of the CP and saliva are first determined. After having contaminated the zirconia with artificial saliva, the contaminated zirconia is coated with CP and rinsed in an appropriate way, there will be analyses of the surface condition of the zirconia.
Liquid-phase nuclear magnetic resonance (NMR) spectroscopy and energy dispersive X-ray spectrometry (SEM/EDX) were performed to examined the interaction between artificial saliva and zirconia with and without the CP.

Results: Phosphorus NMR analyses on samples of a mixture of saliva and CP clearly demonstrated the affinity of saliva phosphate groups with CP.
In the presence of zirconia, phosphorus NMR analyses of the rinse solution with and without CP also showed that saliva phosphates had a much greater affinity with CP than with saliva. In the presence of CP, saliva phosphates bound to zirconia are stripped off and complex with the chemical product of the study.

Significance: There is an interaction between CP saliva. The phosphorus contain in saliva are capted with a cleaning decontaminant effect allowing a long-lasting bond to zirconia surfaces.

Keywords: Zirconia, Saliva contamination, Cleaning agents, Nuclear magnetic resonance spectroscopy, Energy dispersive X-ray analysis.

Introduction

The surface of a zirconia prosthesis must be prepared before applying an adhesive. The first condition for adhesion is to obtain a surface free of contaminants [1].
During the try-in procedure of the prosthesis, the bonding

surface might become contaminated by saliva reducing the adhesion between the zirconia and the adhesive. Cleaning the saliva-contaminated ceramic surface prior to adhesive sealing is an essential step in achieving a long-lasting bond [2-4].

The different cleaners must decontaminate the surface of the zirconia by removing organic residues, which promotes a stronger bond of the resin cement to the zirconia [5]. Cleaning with water, alcohol (70% to 96% isopropanol), 2% chlorhexidine, phosphoric acid, sodium hypochlorite at 4%, and 7.5%, decontaminants such as plasma, and alumina abrasion are some of the well-known methods used to remove surface contamination from zirconia [6]. However when certain cleaners comes into contact with zirconia, an interaction may occur between zirconia and the cleaners. As phosphoric acid used, an interaction occurs between zirconia and phosphorus, leaving an inorganic phosphorus residue on the surface that prevents the adhesive from bonding to the zirconia surface.

The studies generally compare decontaminants to then observe which surface is the cleanest and most conducive to better adhesion [7-9] but also to the durability of the seal [3]. Different types of tests are performed to estimate the bond strength. It must be considered that the type of test can partly influence the result [10]. For Comino-Garayoa [11] it is difficult to compare different mechanical studies of materials even if they are carried out with the same test method because there are multiple variables often unspecified, especially if they are intraoral simulation.

There are commercial decontaminants such as Ivoclean (Ivoclar Vivadent). Ivoclean is an alkaline solution of highly concentrated zirconium oxide particles that has an affinity for phosphates contaminating the surface of the ceramic, absorbs them like a sponge, and they will be eliminated with a rinse of water. For Feitosa, Ivoclean shows a strong affinity for phosphate groups present in saliva, which react with the surface of the zirconia and the results obtained are equal to those of a control group of uncontaminated zirconia [3].

The purpose of our study is to highlight this mode of action: how Ivoclean binds to saliva and thus allows for the decontamination of the zirconia prosthetic surface. Our hypothesis is that it must be free of phosphate contaminants but also of traces of Ivoclean allowing its reactive groups to adhere to an adhesive cement.

Materials and Methods

We propose 2 components to meet our objectives:

1-Study by liquid-phase nuclear magnetic resonance (NMR) spectroscopy of the interaction between Ivoclean and artificial saliva after having determined the molecular structures of Ivoclean and artificial saliva.Complementary verification by Energy Dispersive X-ray Spectrometry (SEM/EDX).

2 -Study of the result of the action of Ivoclean on zirconia by liquid phase NMR techniques. To do this, after having contaminated the zirconia with artificial saliva, then in a 2nd step coated the contaminated zirconia with Ivoclean and rinsed in an appropriate way, there will be analyses of the surface condition of the zirconia.

Material

Zirconia

The zirconia used is Zenostar (Ivoclar-Vivadent, Schaan,Liechtenstein), based on zirconium oxide but also composed of aluminum oxide and yttrium oxide (in a proportion of 6.5 to 8%) in powder form. The size of the powder grains is 0.50µm.

Ivoclean

The decontaminant used is Ivoclean (Ivoclar-Vivadent, Schaan,Liechtenstein)- lot numbers Z05MNY, expiration date 06 19 2025 and Z07CKT, expiration date 07 18 2026.

Artificial Saliva

. In a water substrate, the following elements are added:

- Sodium phosphate dibasic anhydrous 3.90 mM
- Sodium chloride 4.29 mM Potassium chloride 17.98 mM
- Calcium chloride 1.1 mM
- Magnesium chloride hexahydrate 0.08 mM
- Sulfuric acid 0.05 mM
- Sodium bicarbonate 3.27 mM

The percentage of the different mixtures made is chosen after several trials to obtain the best compromise between the NMR signal intensities of the decontaminant interacting with zirconia and artificial saliva

Methodology

Liquid-state NMR

Liquid state NMR experiments are recorded on a BRUKER NEO 600 MHz UltraShield spectrometer equipped with a 5 mm QCI $^{1}H\{^{13}C, ^{31}P, ^{15}N\}$ ATMA cryoprobe.

^{1}H, ^{13}C and ^{31}P NMR experiments were carried out at 298 K. Experiments were processed with BRUKER TopSpin software version 4.2.

^{1}H and ^{13}C NMR chemical shifts are reported in ppm relative tetramethylsilane (δ = 0 ppm) and are calibrated against the residual proton and natural abundance carbon resonances of the respective deuterated solvent as internal standard. ^{23}Na NMR chemical shifts are referenced to the signal of sodium chloride (δ = 0 ppm) as external standard. ^{31}P NMR chemical shifts are expressed in ppm relative to 85 % H_3PO_4.

Different liquid NMR techniques are used and tests are performed in different solvents. We work in particular on 1D and 2D NMR analysis:

- Proton ^{1}H,
- Carbon ^{13}C,
- Phosphorus ^{31}P,

• Sodium ^{23}Na.
2D DOSY ^{1}H (Diffusion-ordered spectroscopy) which seeks to separate the different constituents of a mixture according to their diffusion coefficient, their molecular mass.
2D COSY ^{1}H- ^{1}H (Correlated Spectroscopy) a multidimensional experiment that indicates which proton is coupled to which other proton. The transverse peaks obtained on 2D spectrum are coupled protons.
2D HSQC ^{1}H- ^{13}C (Heteronuclear Single Quantum Coherence): an experiment that makes it possible to determine the protons bound to carbons through one chemical bond.
2D HMBC ^{1}H- ^{13}C (Heteronuclear Multiple Bond Correlation):this experiment makes it possible to determine the protons bound to carbons through two or three chemical bonds and eventually makes it possible to highlight correlations between protons.
2D HMBC ^{1}H- ^{31}P (Heteronuclear Multiple Bond Correlation) to possibly highlight correlations between protons and phosphates
2D NOESY ^{1}H- ^{1}H (Nuclear Overhauser Effect Spectroscpy: which makes it possible to visualize the spatial proximity between the different protons of the molecule but also the exchange phenomena.

Energy dispersive X-ray spectrometry (SEM/EDX)
The SEM/EDX analysis seemed to us to be of great interest to compare with NMR data. On the Scanning Electron Microscope (SEM), FEG FEI Quanta 250 Scanning Electron Microscope (Thermo Fisher Scientific) in low vacuum mode (100 Pa pressure) using a 20 kV acceleration voltage and the backscatter electron detector, the EDX analysis is performed using the EDAX GENESIS software of the EDAX Octane Elect plus (EDAX Inc., Mahwah, New Jersey, United States). EDX spectra are collected from the samples using common procedures and elemental analyses (wt% and atomic %) are performed.

Results

Ivoclean
Components of Ivoclean
The chemical formula of the different components (water, polyethylene glycol, sodium hydroxide, urea modified polyurethane, phenol red, pigment blue) is first determined.

NMR analysis of Ivoclean.
These analyses are essential to know its molecular structure.

a- Proton analysis in the solvent D_2O (D_2O ^{1}H)
There are 3 different peaks on the spectrum:
- water at 4.69 ppm
- CH_2 of polyethylene glycol at 3.62 ppm
- polyurethane modified urea at 2.64 ppm.

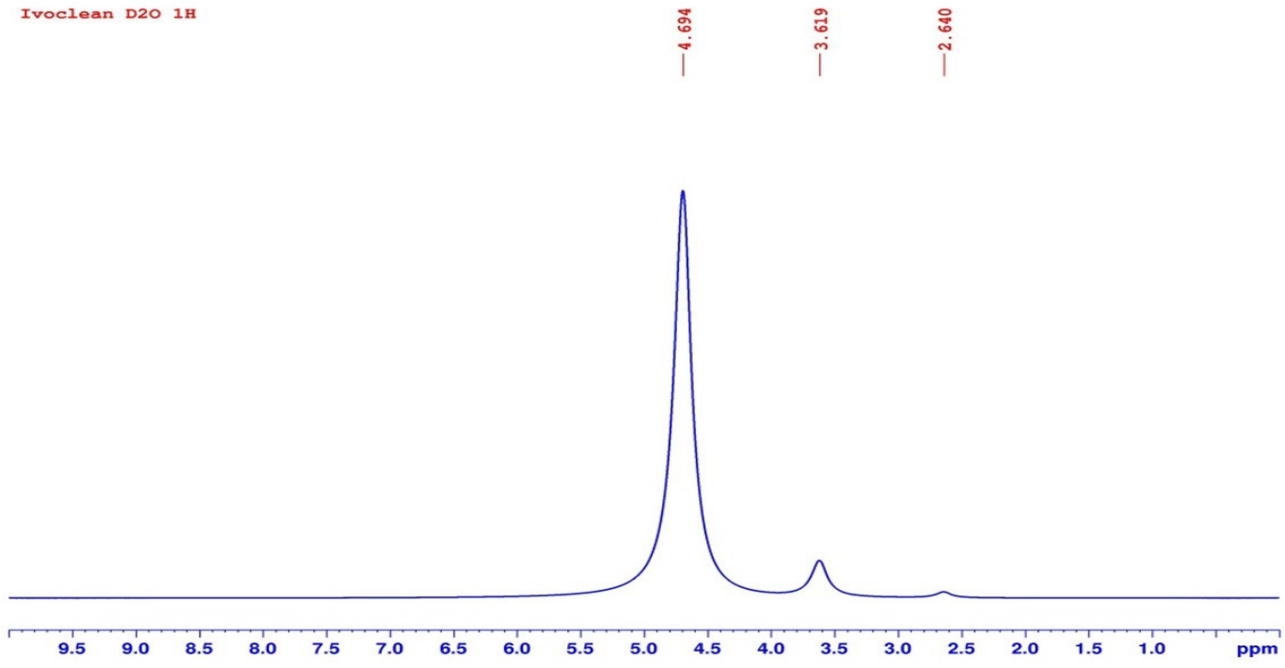


Figure 1: 1D ^{1}H NMR spectrum of Ivoclean (solvent D_2O)

Analysis of the proton in the deuterated chloroform solvent $CDCl_3$ ($CDCl_3$ ^1H)

When D2O is used as a solvent, the mobile protons (NH or OH) will deuterate, i.e. they exchange with the deuterated solvent, and become ND or OD and we no longer see them. Also an analysis is also made with the deuterated chloroform $CDCl_3$ as a solvent and the NH or OH remain NH or OH.

We can identify on the spectrum the signals corresponding to:

- protonated solvent at 7.28 ppm
- phenol red with its aromatic peaks at 6.8 and 7.7 ppm
- water at 4.78 ppm
- polyethylene glycol at 3.66 ppm
- polyurethane modified urea at 2.63 ppm
- sodium hydroxide at 1.97 ppm

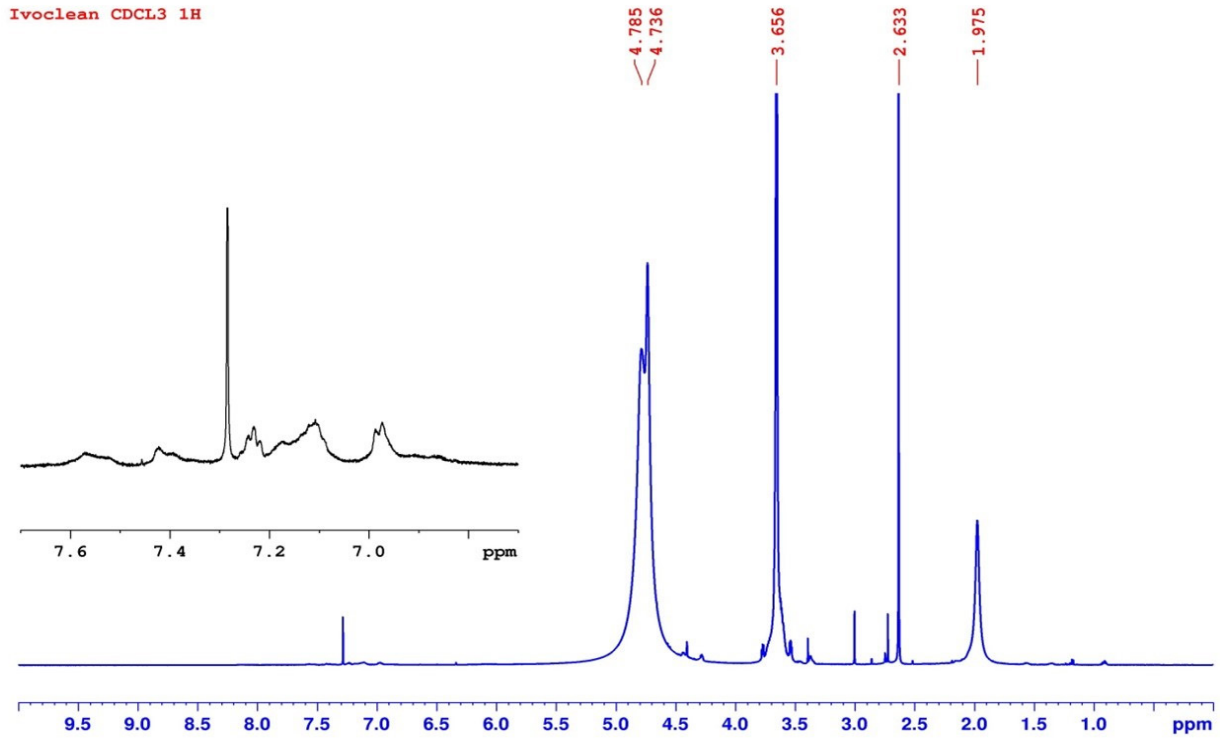


Figure 2: 1D ^1H NMR spectrum of Ivoclean (solvent $CDCl_3$)

2D DOSY ^1H analysis (solvent $CDCl_3$)

2D DOSY (Diffusion-ordered spectroscopy) analysis allows the components of a mixture to be separated according to the molecular mass. Therefore, constituents of Ivoclean can be confirmed based on their molecular weight. The larger the molecule, the slower it diffuses. We have the value of the diffusion coefficient of the molecules that we see on the ordinate (diffusion axis).The intensity of the signals is adjusted according to the elements being sought, as some have strong signals while others are weaker.

To do this, we will look for the intense signals (high level) then the signals of lower intensity (low level).

2D DOSY ^1H (high level)

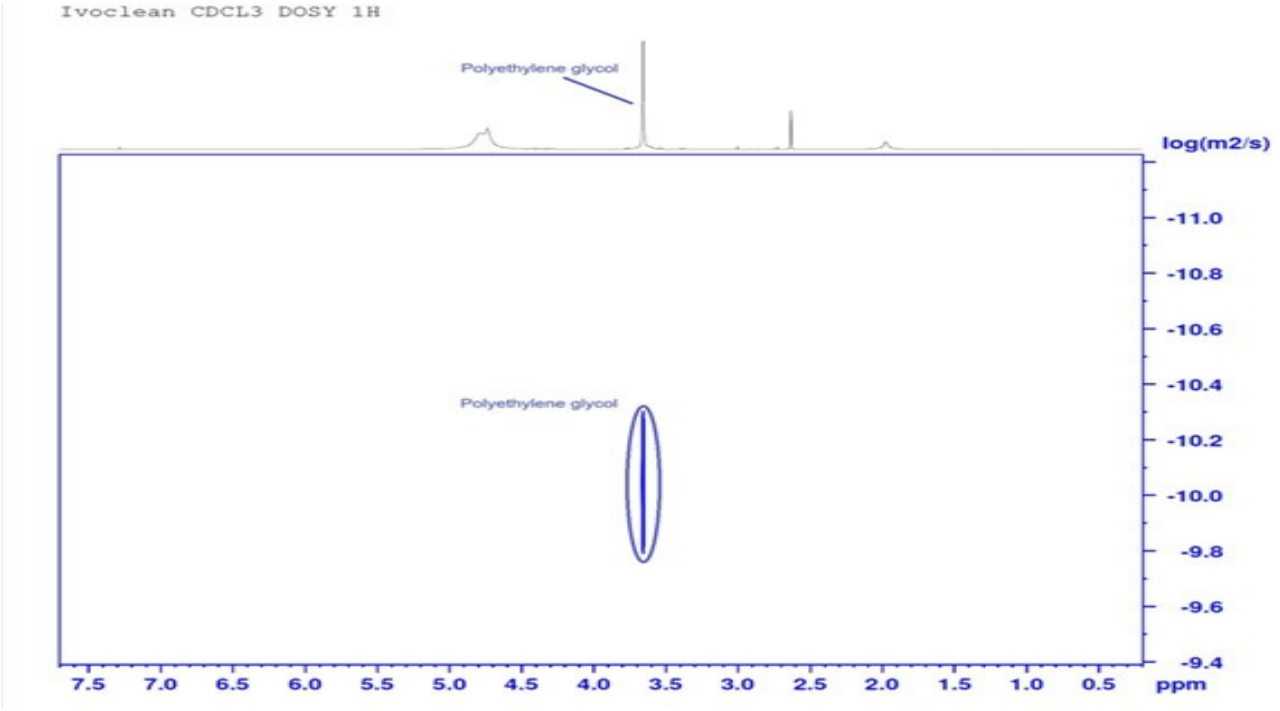


Figure 3: 2D DOSY ^{1}H NMR spectrum of Ivoclean (High level) (solvent $CDCl_3$) Polyethylene glycol is clearly visible.

Here appear the other components of lower concentration:

- phenol red
- polyethylene glycol.
- sodium hydroxide
- polyurethane modified urea

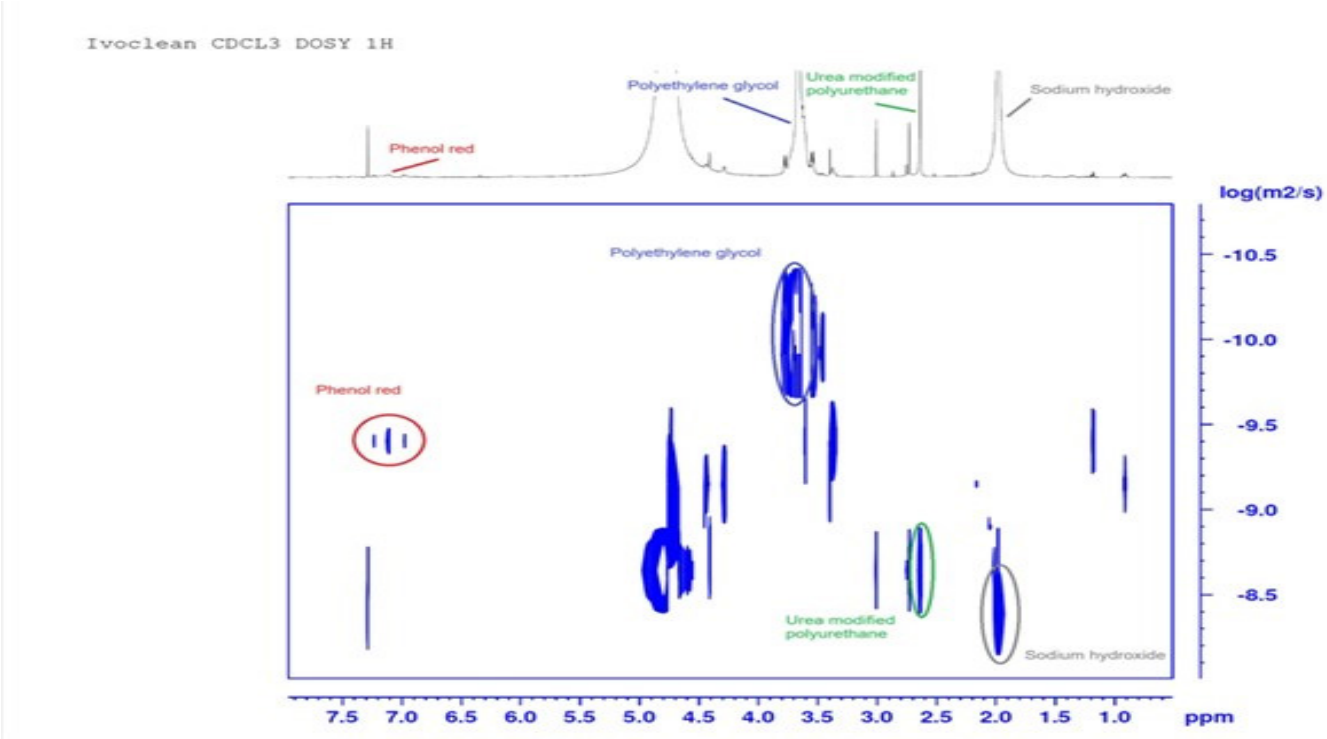


Figure 4: DOSY ^{1}H NMR spectrum of Ivoclean (Low level) (solvent $CDCl_3$)

2D HMBC ^{1}H-^{13}C analysis

HMBC ^{1}H-^{13}C (Heteronuclear Multiple Bond Correlation) allows the identification of carbon-bound protons through two or three chemical bonds

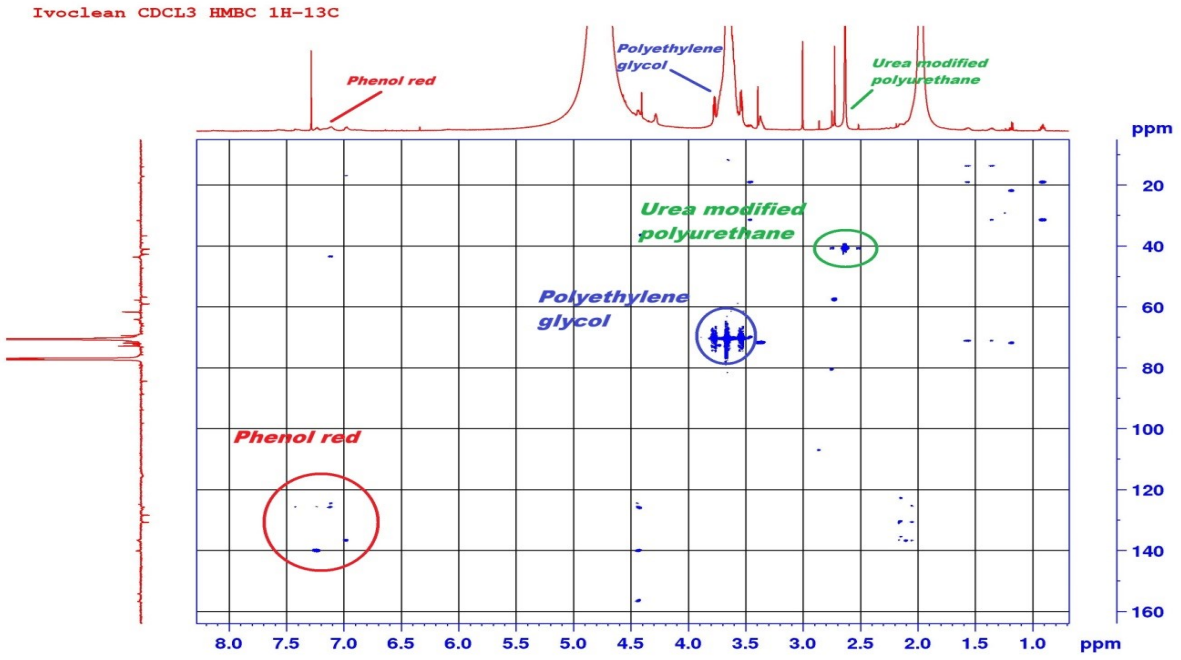


Figure 5: 2D HMBC ^{1}H-^{13}C NMR spectrum of Ivoclean

On the HMBC ^{1}H-^{13}C spectrum, we can see correlation spots between the protons (6.5 and 8.5ppm) and the carbons (120 and 145ppm) of phenol red.

We can also see correlation spots between the protons and carbons of polyethylene glycol (3.6 and 70.5ppm) and modified urea polyurethane (2.6 and 41ppm).

2D COSY ^{1}H-^{1}H analysis

The COSY ^{1}H-^{1}H analysis (Correlated Spectroscopy) makes it possible to identify protons bound to other protons through two or three chemical bonds.

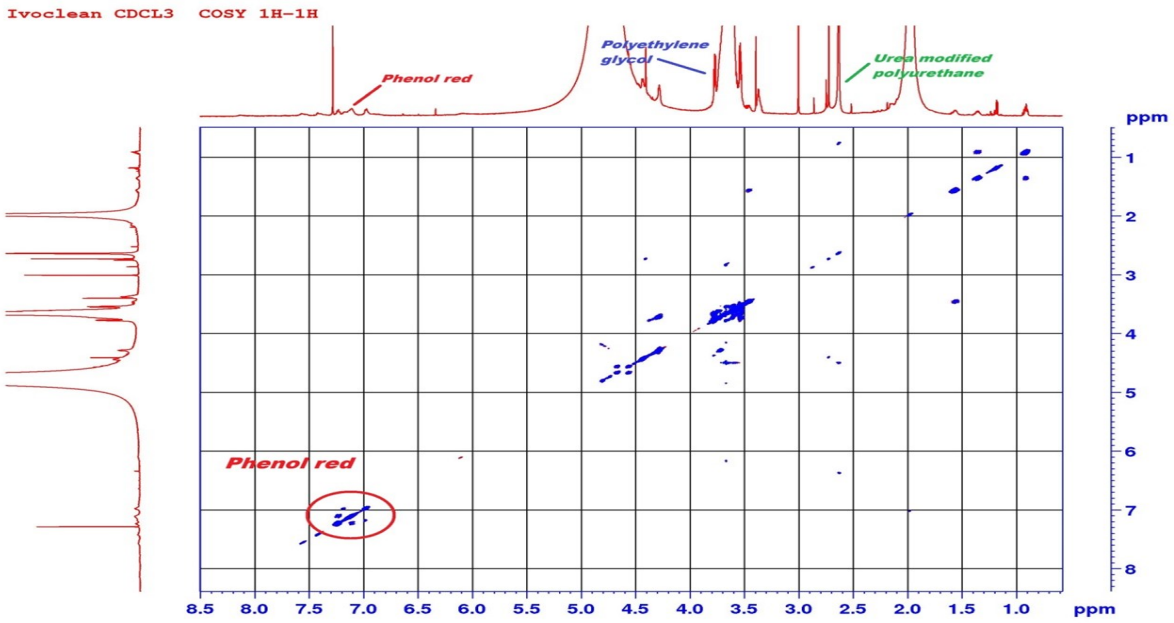


Figure 6: 2D COSY ^{1}H- ^{1}H NMR spectrum of Ivoclean

On the COSY ^{1}H-^{1}H spectrum, we can see the correlation spots between the aromatic protons of phenol red that resonate between 6.5 and 8.5 ppm.
The signals at 3.6 ppm correspond to the -CH_2- of polyethylene glycol, at 2.6 ppm of the polyurethane-modified urea and do not give correlation tasks.

2D NOESY ^{1}H-^{1}H analysis

In the NOESY ^{1}H-^{1}H (Nuclear Overhauser Effect Spectroscopy) analysis, the off-diagonal correlation tasks make it possible to visualize the spatial proximity between the different protons of the molecule but also the exchange phenomena.

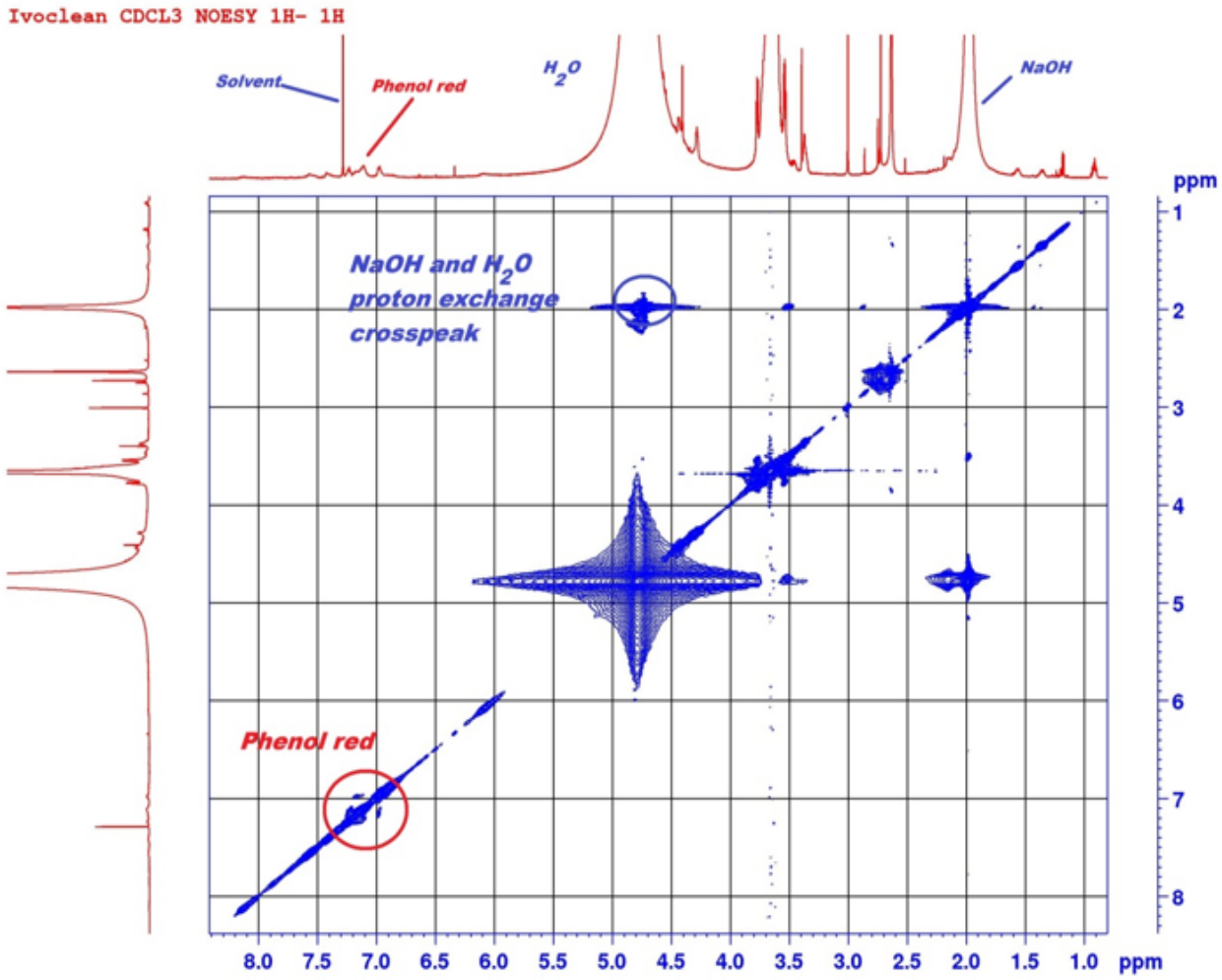


Figure 7: 2D NOESY ^{1}H-^{1}H NMR spectrum of Ivoclean

On the 2D NOESY ^{1}H-^{1}H of Ivoclean we observe an intense off-diagonal spot (4.75ppm) which corresponds to the exchange of a mobile proton of one of the constituents of Ivoclean with water.

2D HSQC ^{1}H-^{13}C analysis

The analysis HSQC ^{1}H-^{13}C (Heteronuclear Single Quantum Coherence) is used to determine single-bond proton-carbon correlations.
There is a very clear peak in CH_2 in polyethylene glycol, aromatics in phenol red and modified urea.
We do not see sodium hydroxide or zirconium dioxide, which have no carbon and we do not highlight the aluminium oxide Cobalt $CoAl_2O_4$ which has neither carbon nor proton.

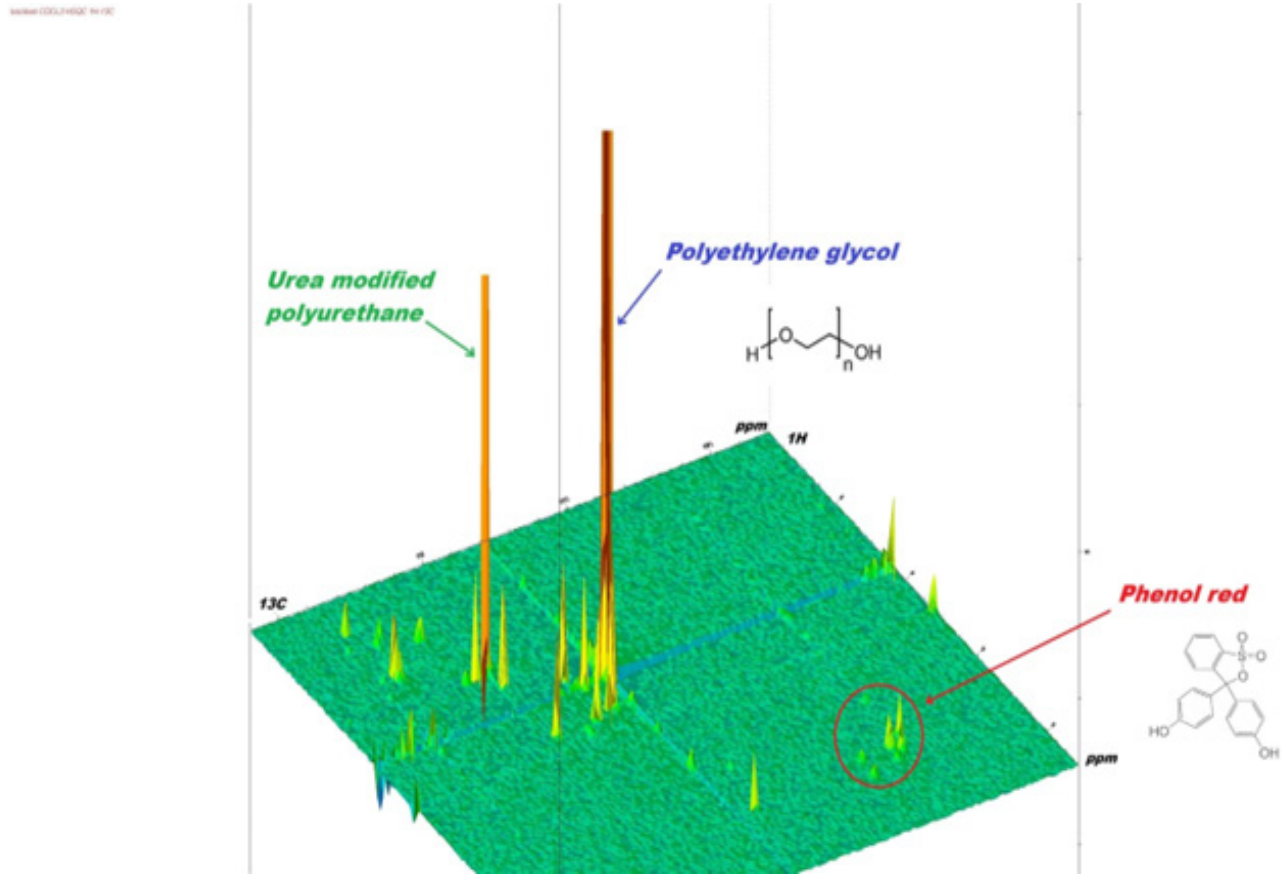


Figure 8: 2D HSQC ^{1}H ^{13}C NMR spectrum of Ivoclean

Analysis of Sodium Hydroxide in D_2O solvent

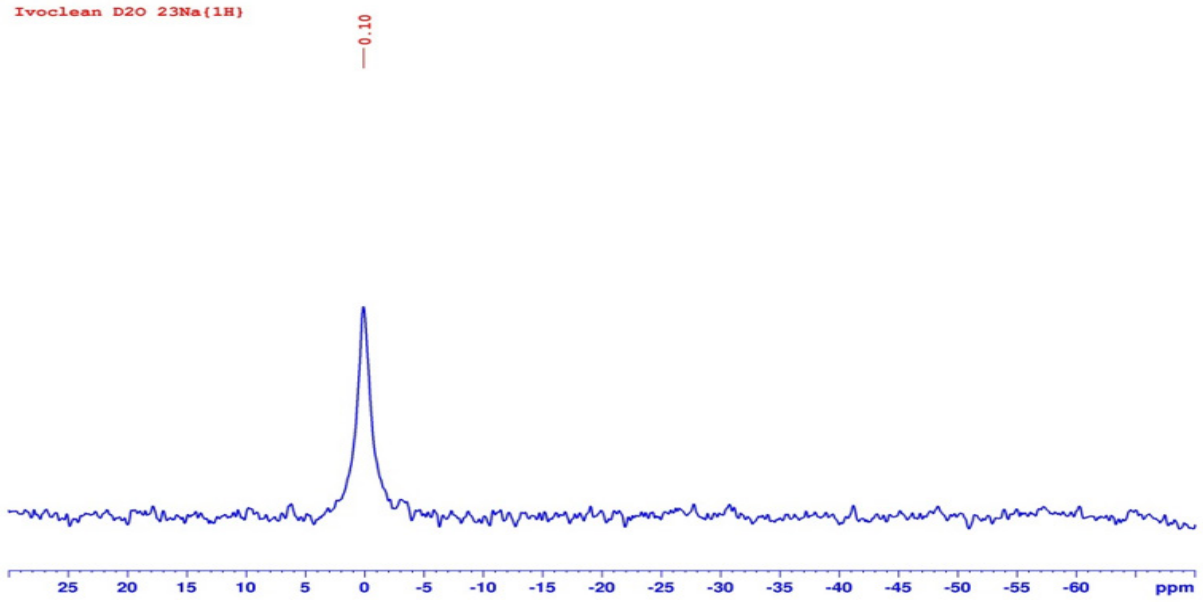


Figure 9: Sodium Hydroxide NMR spectrum of Ivoclean

Sodium hydroxide is well observed (peak at 0.1ppm).

Analysis of Phosphorus ^{31}P decoupled ^{1}H (solvent D_2O)

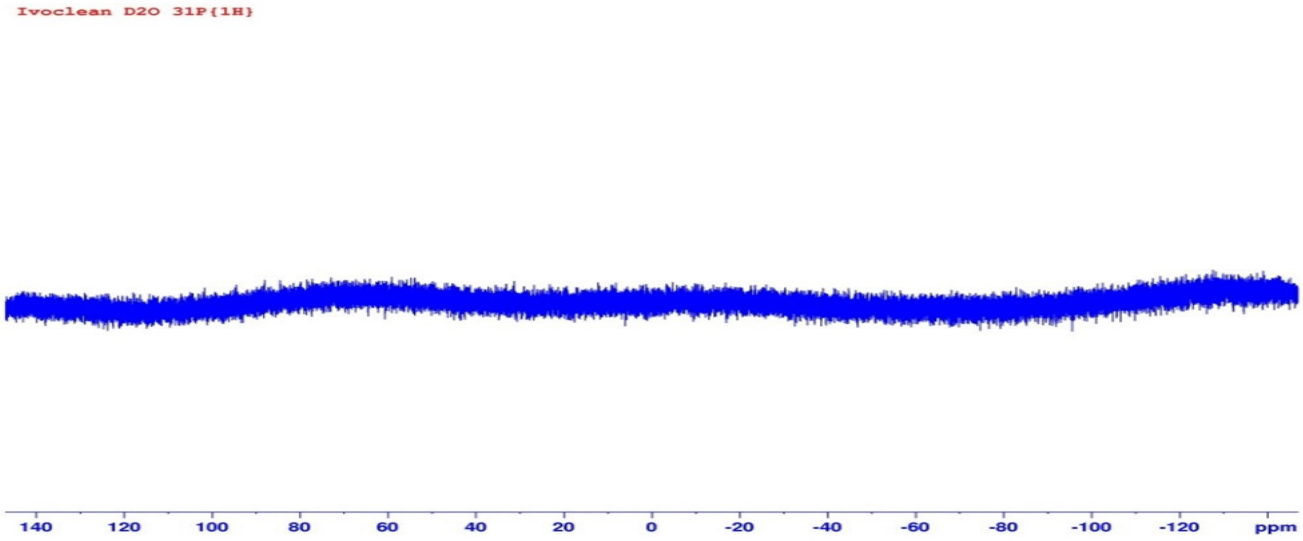


Figure 10: Phosphorus ^{31}P decoupled ^{1}H NMR spectrum of Ivoclean

The analysis is done for 5 mns on a cryoprobe and the phosphorus is not highlighted, which makes it possible to verify that the Ivoclean has no phosphorus constituents.

►These different techniques make it possible to detail the molecular structure of Ivoclean and then to be able to analyze possible molecular interactions with other products.

Energy Dispersive X-ray Spectrometry (SEM/EDX) analysis of Ivoclean

This micro-analysis allows us to confirm the proportions of the constituents of Ivoclean.

Ivoclean is placed on a carbon pad for analysis.

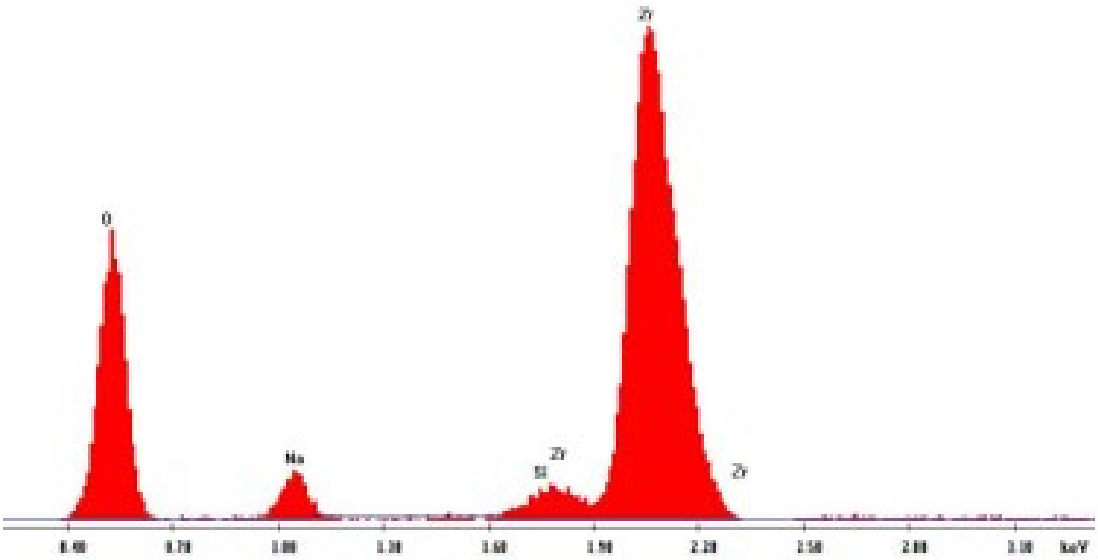


Figure 11: Energy dispersive X ray spectrum of Ivoclean

Constituents (elements)	Weight %	Atomic %
O (Oxygen)	50.27	82.21
Na (Sodium)	3.68	4.19
Si (Silicon)	0.61	0.57
Zr (Zirconium)	45.44	13.03
Total	100.00	100.00

Table 1: Weight and atomic percentages of main constituents (elements) identified with energy dispersive X-ray microanalysis of Ivoclean

EDX analysis estimates the average composition of Ivoclean to be 50.27 wt% O, 45.44 wt% Zr, 3.68 wt% Na, 0.61 wt% Si (fig.11, Table 1). Phosphorus is not detected.

Artificial saliva

NMR Analysis of Artificial Saliva

As with Ivoclean, these analyses are essential to know the molecular structure.

Proton analysis in solvent D_2O

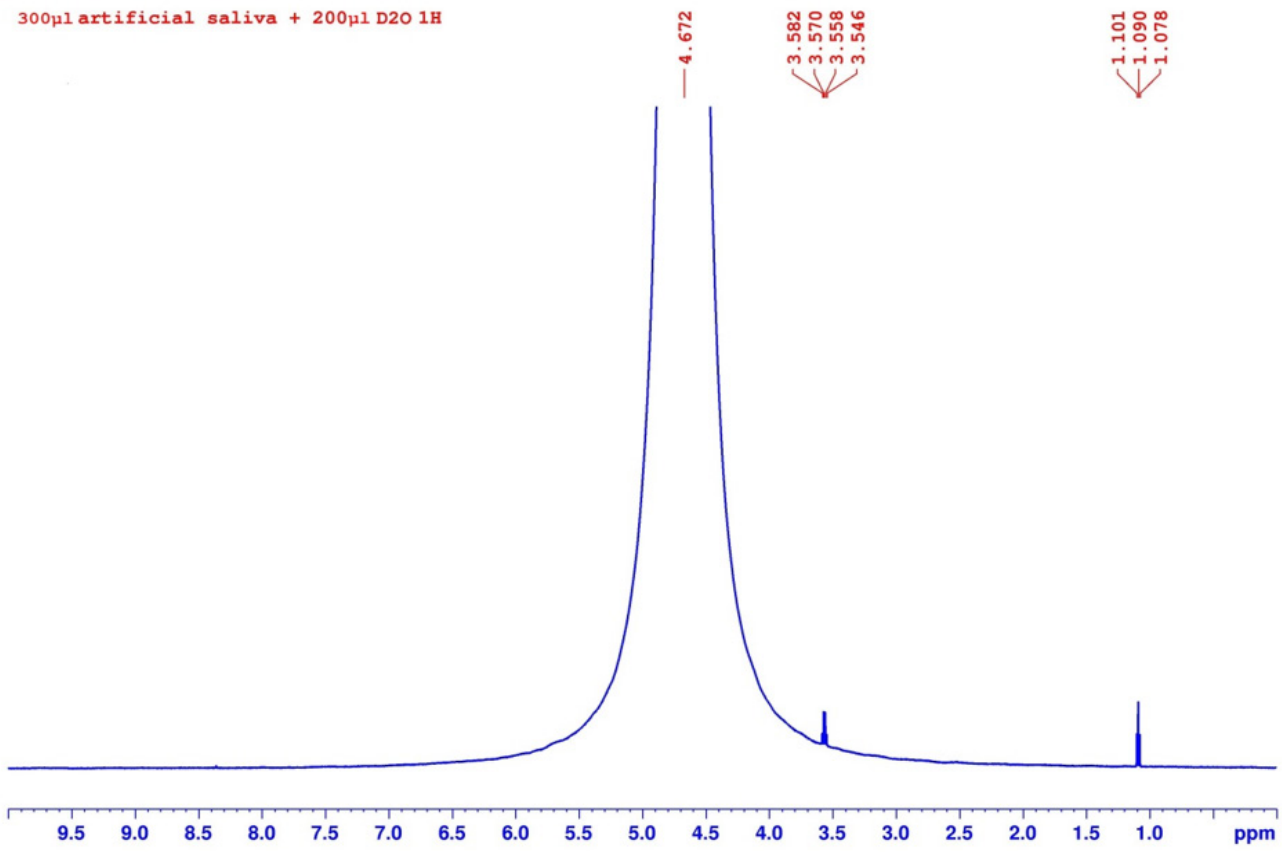


Figure 12: 1D proton NMR spectrum in solvent D_2O

We especially note on the spectrum the peak of water at 4.69 ppm.

As there is a lot of water in the composition of the saliva, the other protons are less visible nevertheless we can see 2 other peaks.

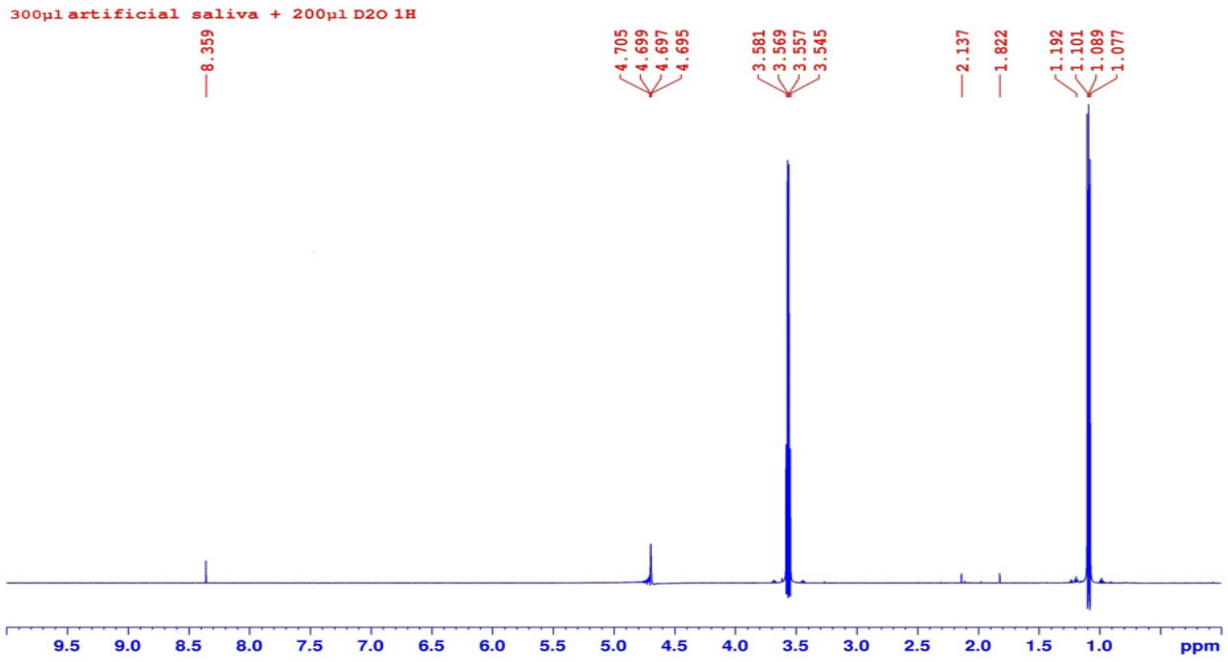


Figure 13: 1D proton NMR spectrum with water signal presaturation sequence

On a 1D proton spectrum with water signal presaturation sequence. We find the signals corresponding to the contaminants (triplet and quadruplet of ethanol).

Analysis of Phosphorus decoupled proton $^{31}P\ \{^{1}H\}$ (solvent D_2O)

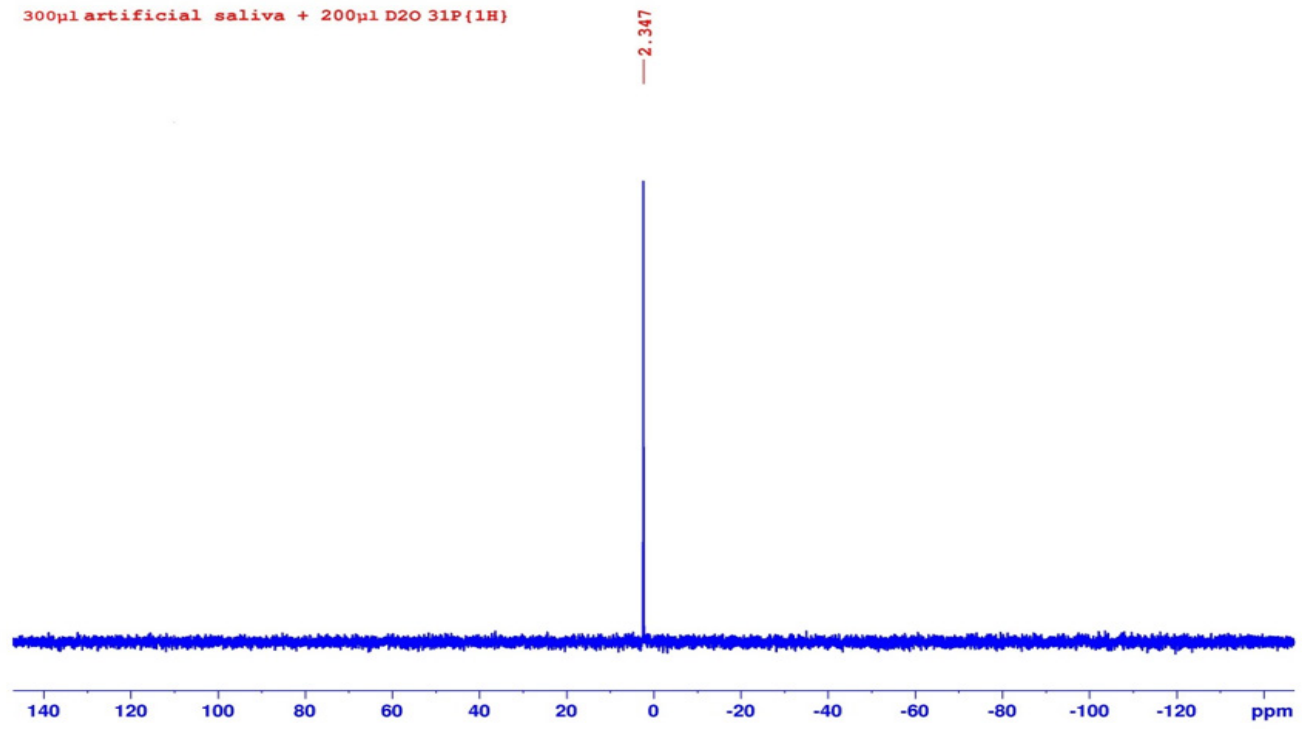


Figure 14: Phosphorus decoupled proton $^{31}P\ \{^{1}H\}$ NMR spectrum (solvent D2O)

The peak phosphorus is identified at 2.35 ppm which corre- sponds to the phosphates of artificial saliva.

Analysis of carbon decoupled proton ^{13}C {^{1}H} (solvent D_2O)

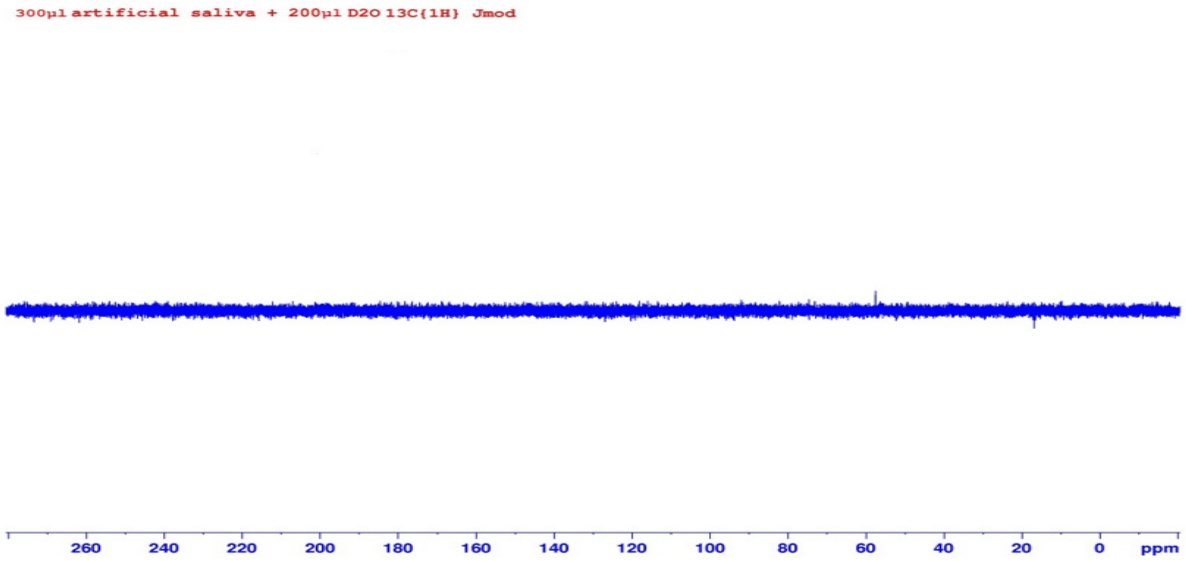


Figure 15: ^{1}H-^{13}C Carbon decoupled proton NMR spectrum (solvent D_2O)

This analysis allows us to verify that there is no carbon. Arti- ficial saliva has no carbonaceous constituents.

Analysis of Sodium decoupled proton (solvent D_2O).

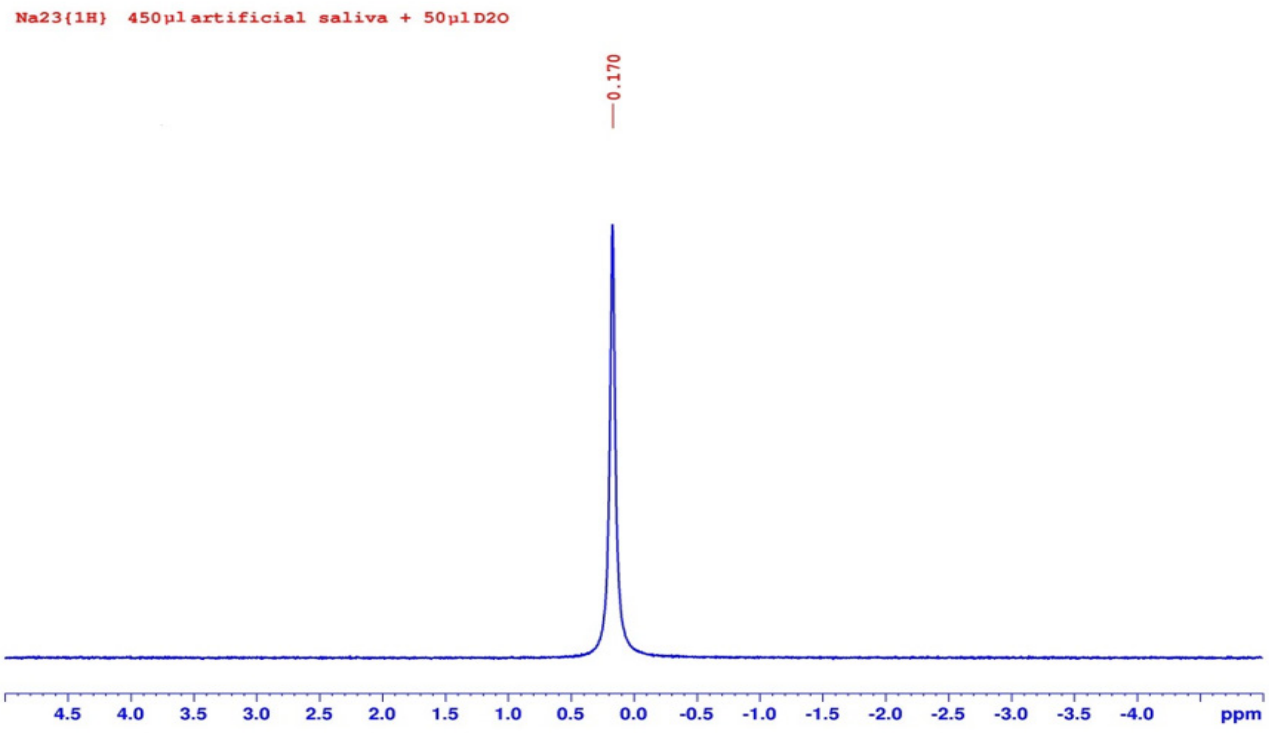


Figure 16: ^{23}Na decoupled proton NMR spectrum in solvent D_2O

The peak sodium hydroxyde is identified at 0.17 ppm.
► These various analyses make it possible to detail the molecular structure of artificial saliva and then to be able to analyze possible molecular interactions with other products.

Energy Dispersive X-ray Spectrometry (SEM/EDX) Analysis of Artificial Saliva
Artificial saliva is placed on a carbon pad for analysis.

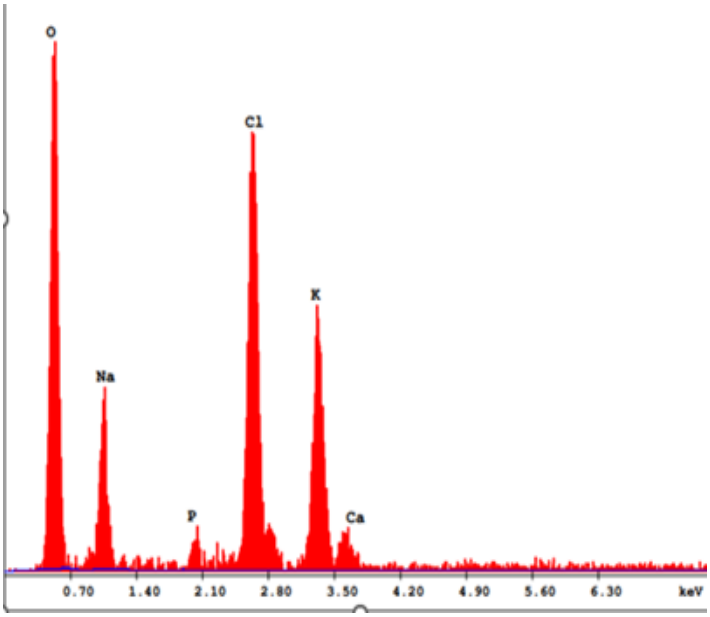


Figure17: Energy dispersive X ray spectrum of artificial saliva

Constituents (elements)	Weight %	Atomic %
O (Oxygen)	52.40	69.70
Na (Sodium)	7.92	7.33
P (Phosphorus)	1.08	0.74
Cl (Chlorides)	21.93	13.17
K (Potassium)	15.53	8.45
Ca (Calcium)	1.14	0.61
Total	100.00	100.00

Table 2: Weight of main constituents (elements) identified with energy dispersive X-ray microanalysis of artificial saliva

EDX analysis estimates the average composition of the artificial saliva to be 52.40 wt% O,7.92 wt% Na, 1.08 wt% P, 21.93 wt% Cl, 15.53 wt% K, 1.14 wt% Ca (fig.17, Table 2).

NMR analysis of the interaction between Ivoclean and artificial saliva

Analysis in phosphorus decoupled proton ^{31}P {^{1}H} in the solvent D_2O with 300 µl of saliva and 100 µl of Ivoclean.
When Ivoclean is added to saliva (red spectrum), there is a shift in frequency of the phosphorus peak of 3.4 ppm (width half height 12Hz) compared to saliva alone (blue spectrum) at 2.35 ppm (width half height of 3 Hz) .
On the other hand, there is a difference in the width of the phosphorus peak.

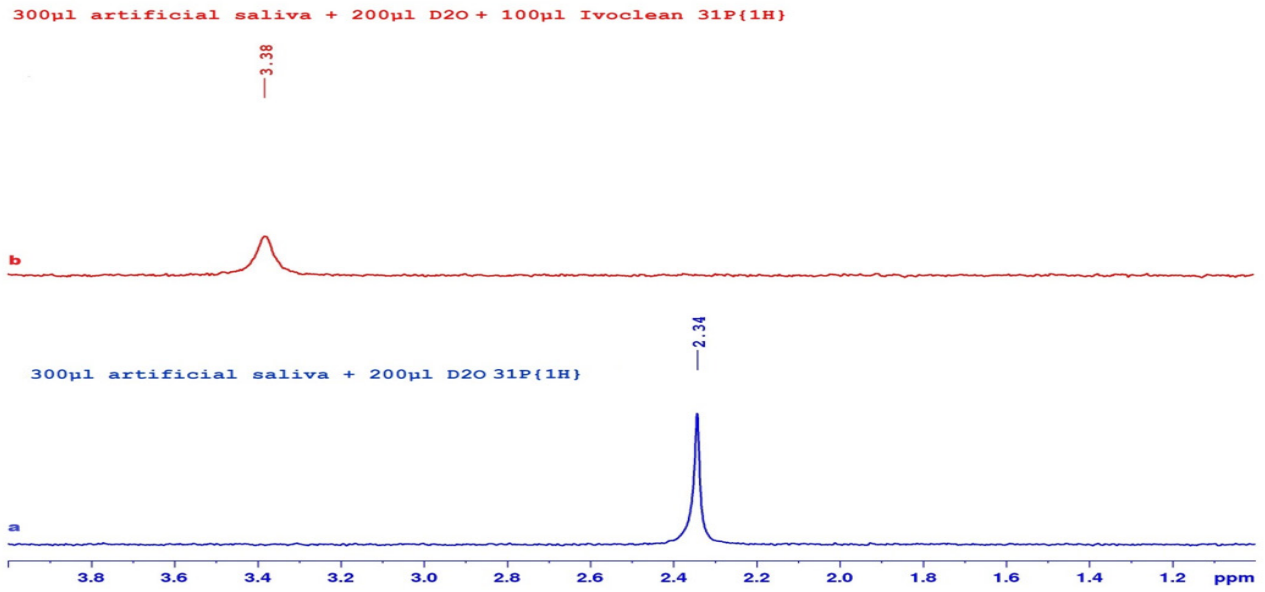


Figure 18: phosphorus decoupled proton NMR spectra ^{31}P {^{1}H} of Ivoclean and artificial saliva

►This highlights an interaction between the phosphorus contained in the saliva and Ivoclean (complexation of sodium phosphates in saliva and Ivoclean).

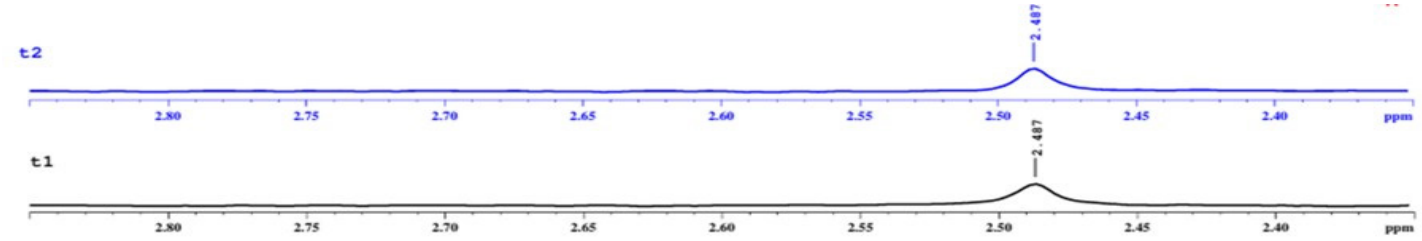
NMR Analysis of the Interaction of Ivoclean with Artificial Saliva on Zirconia

The objective is to highlight the interactions between zirconia and saliva phosphates and then the interactions between zirconia, saliva phosphates and Ivoclean.
For this purpose, we analyse:
- suspensions of zirconia powder with saliva in deuterated water at a rate of 300 µl of saliva and 200 µl of deuterated water at a rate of 10 mg of zirconia,
- suspensions of zirconia powder with saliva in deuterated water at a rate of 300 µl of saliva, 50 µl of Ivoclean and 200 µl of deuterated water at a rate of 10 mg of zirconia.

These suspensions are each analysed at:
- T1 after preparation,
- T2 at 15 mns .

Then, a deuterated water wash is performed on the samples and the washed solution analyzed. All suspensions and washing solutions are analyzed by phosphorus NMR because phosphorus has been previously recognized as a marker of interaction between saliva and Ivoclean.

Analysis of phosphorus decoupled proton ^{31}P {^{1}H} in the D_2O solvent with 300 µl of saliva on zirconia.
Sample without Ivoclean



We can observe on the spectra a signal that resonates at 2.49 ppm which corresponds to the phosphate compounds of saliva.

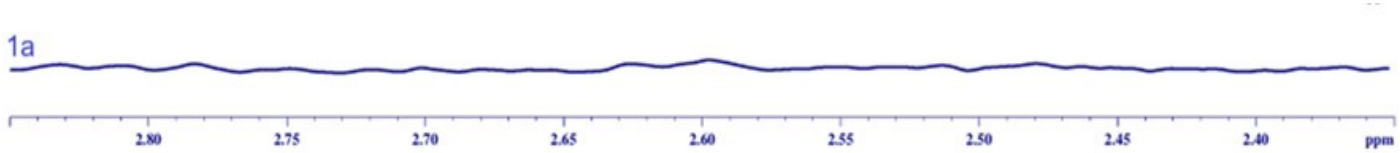
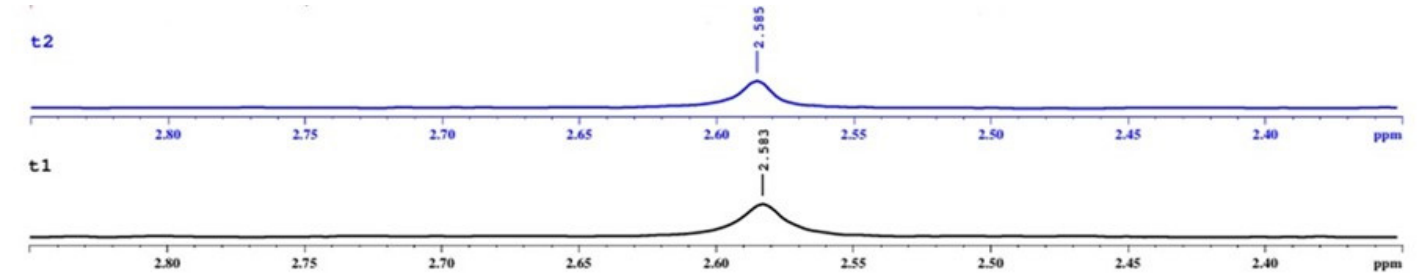


Figure 19: NMR spectrum phosphorus decoupled proton ^{31}P {^{1}H} solution1a without Ivoclean

After washing, solution (1a) no longer contains phosphate compounds because they are complexed with zirconia. They remain attached to the zirconia, so there is no one in the rinsing fluid and we don't have a signal from the phosphorus.

Sample with 50 µl of Ivoclean



A signal can also be observed on the spectra that correspond to the phosphate compounds in the saliva.

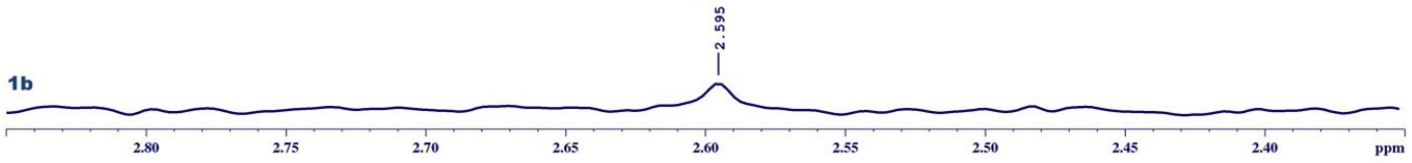


Figure 20: NMR spectrum phosphorus decoupled proton ^{31}P {^{1}H} solution1b with 50 µl of Ivoclean

After washing, solution (1b) still contains phosphate compounds in contrast to (1a).
Ivoclean has complex itself with saliva, the latter having more affinity with Ivoclean than with zirconia. It is therefore found in the rinsing solution.

Demonstration of the higher affinity of saliva with Ivoclean than with zirconia.
1-Analysis with 300ul saliva + 200ul D_2O :
There is an intense peak that corresponds to the phosphates in the saliva at 2.3ppm (see spectrum blue).
2-Analysis with 300ul saliva + 200ul D_2O +10 mg of zirconia:
There is a much less intense peak and slightly shifted in frequency at 2.52ppm, this is due to an interaction between the phosphates in the saliva and the zirconia. The phosphates in the saliva bind to the zirconia (see spectrum red).
3-Analysis with 300ul saliva + 200ul D2O +10 mg of zirconia +100 ul from Ivoclean:
This addition of Ivoclean in the previous mixture results in a chemical displacement and width halfway up the 3 peaks 2.34ppm and 4.5Hz; 2.49ppm and 5Hz; 3.43ppm and 13Hz.
We observe a shift in frequency of the peak observed previously and its widening.
This displacement corresponds to the interaction of Ivoclean with saliva (see spectrum green), even in the presence of zirconia.
►Ivoclean therefore binds preferentially to saliva.

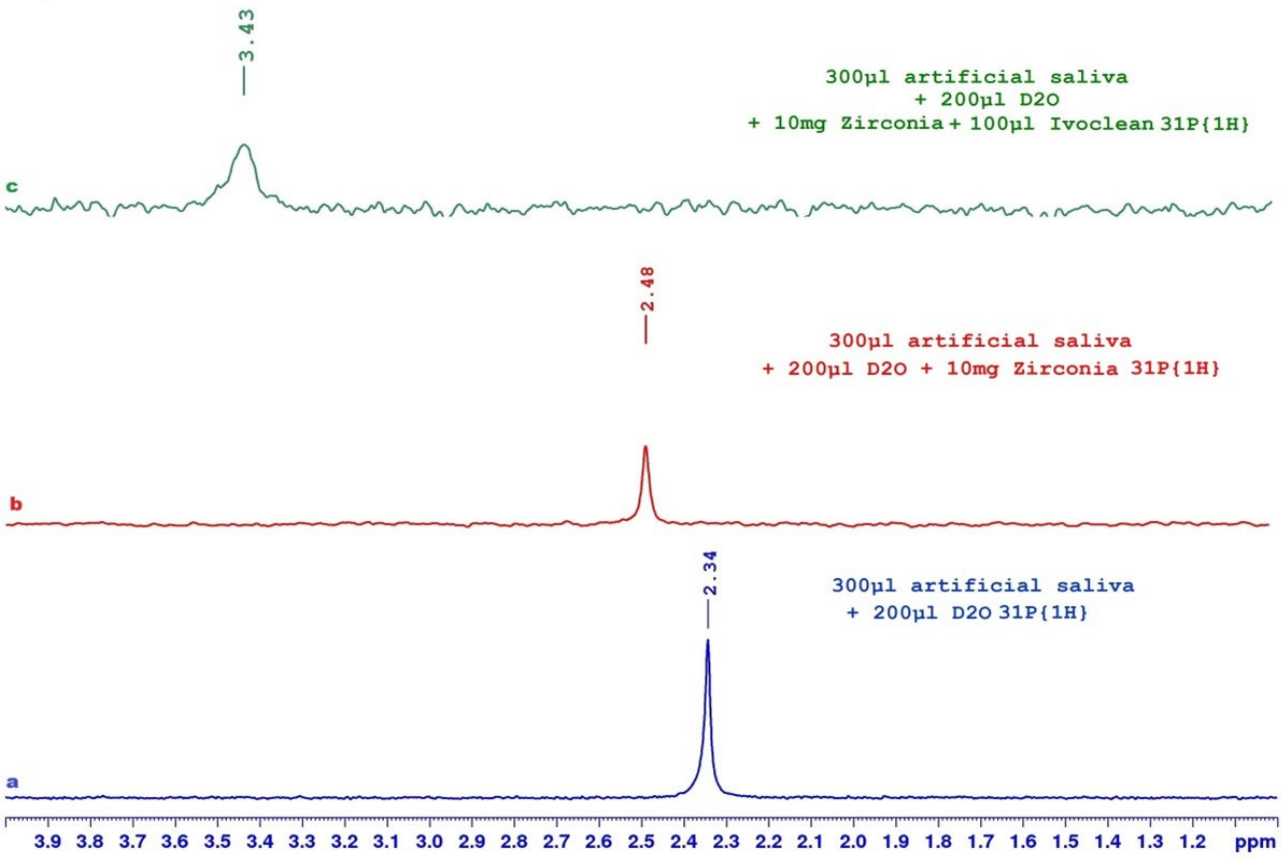


Figure 21: NMR spectra phosphorus decoupled proton ^{31}P {^{1}H} of:
-artificial saliva (blue)
-artificial saliva and zirconia (red)
-artificial saliva, zirconia and Ivoclean (green)

When in contact with Ivoclean, the saliva that adhered to the zirconia interacts with Ivoclean and detaches from the zirconia.

Discussion

In our study numerous NMR analyses have been performed

to detail and understand the molecular structure of Ivoclean and saliva. This made it possible to study their possible molecular interactions.

NMR phosphorus provides a "marker" to determine how Ivoclean interacts with saliva. Being present in artificial saliva and not in Ivoclean, phosphorus is chosen as a marker. The marker then makes it possible to recognize the interactions of the 2 substances with the zirconia. NMR shows that when there is saliva and then Ivoclean on the zirconia, the saliva binds to the Ivoclean and does not remain on the zirconia. There is a higher affinity of saliva with Ivoclean than with zirconia.

The NMR spectrum phosphorus decoupled proton of saliva (fig.18) allows to visualize a peak that resonates at 2.34 ppm and corresponds to the phosphates in saliva. When 100 µl of Ivoclean is added to the initial solution, a chemical shift difference of 1 ppm is observed (new signal at 3.38 ppm) and the previous signal widens. These two characteristics reveal an interaction between the phosphates in saliva and Ivoclean.

If no interaction existed, a single peak around 2.34 ppm would be observed at the end of the mixture.

In the analysis that brings saliva and zirconia into contact (fig.19, NMR spectrum phosphorus decoupled proton), there is no difference between the spectra taken at different times (T1: after preparation, T2 at 15 mns). A signal is observed at 2.49 ppm which corresponds to the phosphates in saliva. After rinsing, the solution is analyzed for phosphorus decoupled proton and no peaks indicating the presence of phosphorus are detected. The phosphates in the saliva remained complexed to the zirconia. The rinsing did not decontaminate the zirconia.

In the same analysis presenting this time saliva, zirconia and Ivoclean, it is noted after rinsing, unlike the saliva, zirconia analysis without Ivoclean, a signal that resonates at 2.59 ppm, corresponding to the phosphates of the saliva (fig.21) that are eliminated during rinsing.

Ivoclean has captured the phosphates bound to zirconia.

To confirm these results, additional decoupled proton phosphorus analyses are conducted with different concentrations of the study products (fig.21).

The addition of 10 mg of zirconia to 300 µl of saliva induces a chemical shift difference of 0.15 ppm and a slight broadening of the signal (fig.21b). This translates an interaction between saliva phosphates and zirconia.

The addition of 100 µl of Ivoclean causes a more significant chemical shift (1ppm), characteristic of the complexation of saliva phosphates with Ivoclean (fig.21c).

These results corroborate the previously obtained results.

Numerous studies have already worked on the Ivoclean [2-4,9,12-16]. Based on the meta-analysis of S Shirazi [4], Ivoclean decontamination significantly increases the adhesion forces of saliva-contaminated surfaces to the same level as uncontaminated surfaces under all conditions studied. A direct comparison of argon plasma with Ivoclean showed that the cleaning paste was more effective at removing saliva contamination [2].

For Radain, by absorbing phosphate contaminants from saliva, this decontaminant can recover the strength of the bonds on zirconia in 20 seconds [15].

Feitosa, with studies which investigate the influence of cleansing methods after saliva contamination and aging conditions (thermocycling and water storage) on zirconia shear bond strength (SBS) with a resin cement suggest that Ivoclean was able to maintain adequate shear bond strength values after TC and 150 days of storage, comparable to the uncontaminated zirconia. The study demonstrates that Ivoclean shows a strong affinity for phosphate groups present in saliva, which react with the surface of the zirconia [3].

For Genc, sandblasting, Ivoclean, and Ivoclean after sandblasting applications were found to deliver significantly higher (P 0.05) adhesion compared with air-water, pumice, and alcohol applications. Following airborne particle abrasion, intaglio surfaces of zirconia restorations should best be cleaned using Ivoclean [9].

Conclusion

This study provides a new approach in the field through NMR, demonstrating that there is an interaction between the phosphorus contained in saliva and the tested cleaning agent, Ivoclean, through the complexation of sodium phosphates present in both saliva and Ivoclean. Ivoclean interacts with the saliva that adheres to zirconia. The saliva having more affinity with Ivoclean than with zirconia, rinsing allows, after applying the cleaning agent to the contaminated zirconia, to clean the surface of the zirconia of all contamination.

The action is therefore valid regardless of the support, prosthetic or dental.

Conflict of Interest Statement

The authors declare no conflict of interest.

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