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# Investigation and comparative survey of some dental restorative materials

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We report investigations by fluorescencense and infra-red absorption spectroscopy of some dental restorative materials. We obtained the weight of the chemical elements comprised in the inorganic matrix which represents the base compound for dental materials. From the IR spectra we concluded that all the investigated materials have a band corresponding to the silica anion.

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## 1. Introduction

After a tooth has been damaged or destroyed, restoration of the missing structure can be achieved with a variety of treatments. Restorations may be created from a variety of materials, including amalgam, gold, porcelain, and composite [1-3]. Small restorations placed inside a tooth are referred to as "intracoronal restorations". These restorations may be formed directly in the mouth or may be cast using the lost-wax technique, such as for some inlays and onlays. When larger portions of a tooth are lost, an "extracoronal restoration" may be fabricated, such as a crown or a veneer, to restore the involved tooth.

When a tooth is lost, dentures, bridges, or implants may be used as replacements [4]. Dentures are usually the least costly, whereas implants are usually the most expensive. Dentures may replace complete arches of the mouth or only a partial number of teeth. Bridges replace smaller spaces of missing teeth and use adjacent teeth to support the restoration. Dental implants may be used to replace a single tooth or a series of teeth. Though implants are the most expensive treatment option, they are often the most desirable restoration because of their esthetics and function. To improve the function of dentures, implants may be used as support [5,6]. Those methods are more expensive and present some kind of risk concerning tolerance for the patient. The best attitude is prevention, to avoid special biocompatibility situations of medical treatment. Restoration materials present a high interest for investigation studies, in order to improve their physical, chemical and biological properties. It is recognized today and well known that we do not dispose yet, of an `ideal material` for general use of dental restoration. For responding to the exactingness and demands about the dental structures, the `ideal material` used for coronary definitive filling must fulfill some conditions, as follows: do not irritate the dental pulp and must adhere to the enamel and dentin; must be insoluble and to resist for masticator forces in use; must not suffer modifications during the strengthening process and after strengthening; an expanding coefficient and thermo contraction similar to the strong tissues, convenient time for strengthening; thermo and electric conductibility similar with the dental strong tissues; no special conditions of storing, be prepared, applied and finished easily – those being most important properties for those materials.

In the present day use, none of the materials for coronary filling do not entertain all the conditions enumerated above, as is mentioned elsewhere [7], so the motive of the interest for studding properties of the restoration dental materials and to improve them [8].

## 2. Description of the studied materials

The purpose of the present study is to establish a link between the inorganic and organic phases for dental restoration materials. This link is very important, because the strength and long lasting for the restoration work, depends on it. This link, realized by bonding agent, presumes mechanic and chemical action.

As in other studies is shown, this link is influenced by the geometric shape of the filling particles, composition and the presence of the `impurities` [9], [10].

As well, the presence of pores on restoration work surface after polymerization process, presume premature decay, roughness for the surface because of substance mass loosing by friction. Finally, this action is causing strength decay of the whole restoration work. On the surfaces exposed to strong masticator forces, small pores of the material surface encourage small fissures (cracks) through mass material and under filling macro – particles as well [9,10].

Under time passing, in the oral cavity, the decay of the restoration work is caused by mechanical or chemical factor or suddenly thermal regime changes, which are very frequent. Molecular groups of metacrylat non – reactive during polymerization process, decays easily, causing mass loss from the resin of the restoration work. The presence of some elements as strontium, lanthanum, or barium may improve some properties of the restoration material. On the other side, exposing these materials to hydrolytic corrosion may induce fissures to the mass material [9,10].

Another aspect is that porous surfaces for the restoration work, under time passing, encourages color change of the material, because of food remain deposits or bacteria action. As the polymerization process is not totally completed, all those side effects mentioned before are encouraged. So, for the material, a total smooth surface is requested and the motive of high interest to investigate it.

We will briefly discuss the investigated materials, together with a short description of their usage.

### 2.1 Glassionomers

These are materials of filling with the advantage of having the color of the tooth and they contain: strontium, phosphate and fluoride ions. They are mixtures of tips of glasses and organic acid. Although the glassionomers have the color of the tooth, their translucidity diverts. The fillings with glass ionomers are less esthetic comparing with the composite resins. This filling material interacts with the enamel and dentin and let the dental strong structures to remineralise at the filling interface. The glassionomer contains and supply fluoridation over time, which helps the prevention of the dental cavity and general decay [11-13].

a) Glassionomer Cement CX Plus. It is a glassionomer cement, radio opaque and recommended for the cementation of the crowns, bridges, inlays or fixing the orthodontic devices. The special features of this material comprise excellent manipulation properties, small thickness, less sensibility during the time of strengthening process and increased time of work. It also releases fluoride [14].

b) GC Fuji II LC (Improved). It is a glassionomer radio opaque which strengthens during the photo polymerization process. It is indicated for restoration of IV-th and V-th classes cavities, peculiar for cervical erosions and the radicular cavity, fillings of the temporary teeth, corono-radiculary reconstructions, cases where is necessary the radio opacity, fillings to the old people, base or liner [14].

c) GC Fuji IX. It is a radio opaque glassionomer which restorates the distal teeth. It was realized for the following indications: -I-st, II-nd classes fillings at the permanent and temporary teeth, intermediary fillings and base material for smaller requirement to the I-st, II-nd cavities using the filling technique “sandwich”, V-th cavities and the surface of the teeth root fillings, corono-radiculary reconstructions [14].

### 2.2 Dental composites

These are white fillings realized of quarts resins (glasses and porcelain) and usually contain certain substances susceptible to photopolimerization. They are physiognomic, durable and an alternative to amalgam fillings. In the past, the white fillings were placed only on frontal teeth, but recently these dental composites materials were conceived to resist to pressure and mastication. These photopolimerizable dental composites are the most physiognomic and can be inserted for one appointment [11-13].

### 2.3. Esthet X

It is a filling material with an organic matrix modified with the liberation of fluorine. Esthet X was conceived to be shiny like the natural enamel with a high resistance to fracture and a small rate of abrasion. It has a long time of manipulation and offers an adhesion and closing margins very secure [14].

## 3. Results and discussion

Glass ionomers are dental cements used for dental restorations; most of them consist of two compounds to be mixed: one – solid state as powder and the other one (can be two) - liquid state [1]. The solid compound consists of an inorganic matrix and quantitative speaking is the base material for the whole restoration work. The liquid compound is of organic nature (organic acid), with the important role of bounding the solid particles through polymerization reactions which are catalytically or photo–chemically initiated. Members to this category are the following materials: Fuji IX, Fuji II LC and Glassionomer CX plus.

On the other side, composite resins like Esthet X are complex materials, having two base compounds (the resin and inorganic filling particles), a bounding agent and also initiators, stabilizers, and pigments. Visible light, chemical reaction or photo–chemical reaction may initiate the polymerization process.

All samples, from both categories have been investigated in the final phase, as long term dental restoration work in oral cavity.

Because liquid compounds do not present peculiar analytical problems, just the solid compounds have been investigated.

a) Qualitative and quantitative elementary investigation using electronic scattering microscope and analytic detector.

The samples of dental materials have been covered with carbon using covering equipment manufactured by Polaron, model CA 74625. The prepared micro particles have been investigated by fluorescent spectroscopy with X rays. The study has been performed using a scattering electronic microscope, manufactured by JEOL, model JSM – 6480 LV, fitted with a spectrometer for X rays, using energy dispersion method (EDS), manufactured by INCA x – Sight model 7574.

The fluorescence spectra for samples of Esthet X, Fuji IX, Fuji II LC and Glass-ionomer CX Plus are presented in Figs. 1-4, and the weights of found chemical elements are synthesized in Table 1.

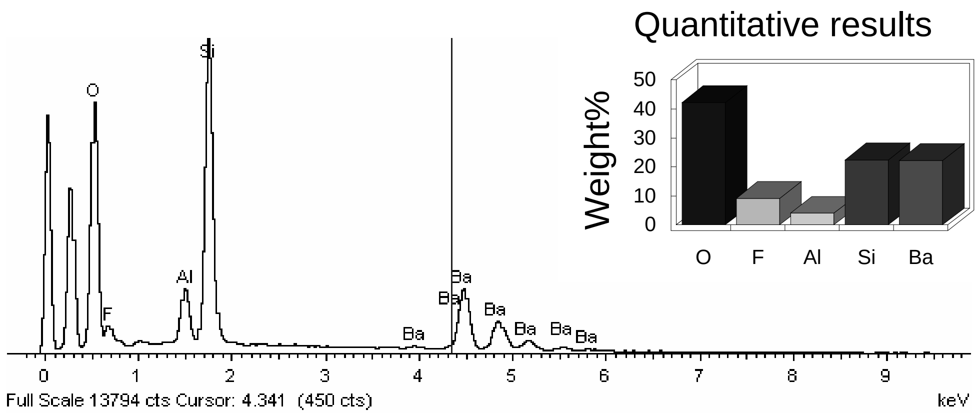


*Fig. 1. Fluorescencense spectrum of the Esthet X.*

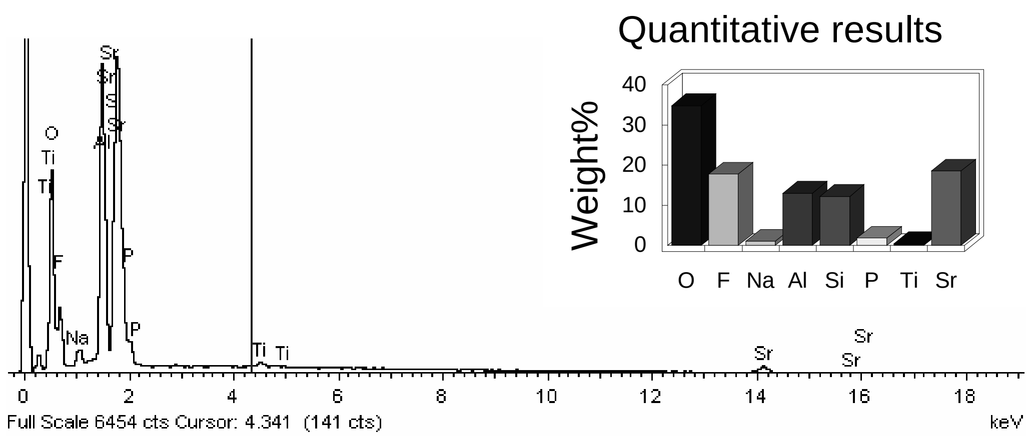


*Fig. 2. Fluorescencense spectrum of the Fuji IX.*

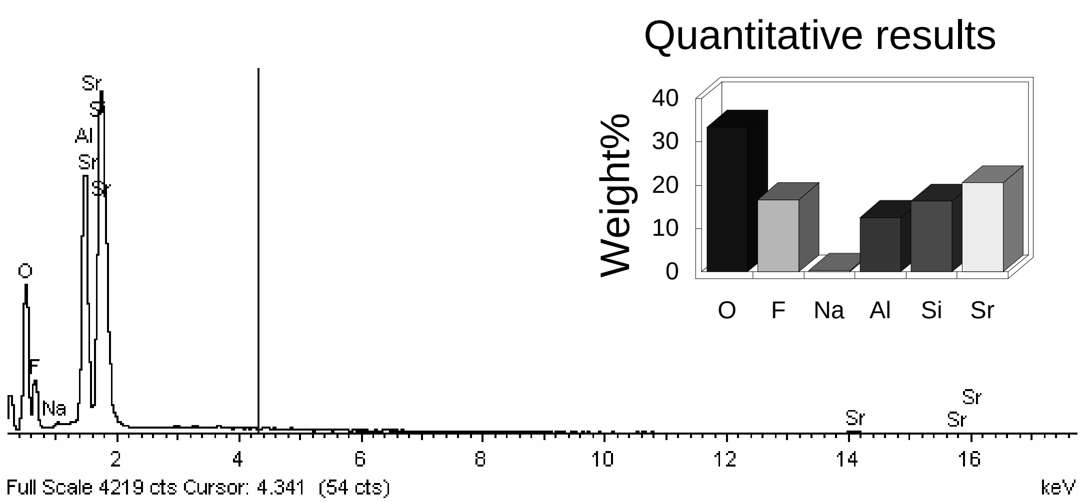


*Fig. 3. Fluorescencense spectrum of the Fuji II LC.*

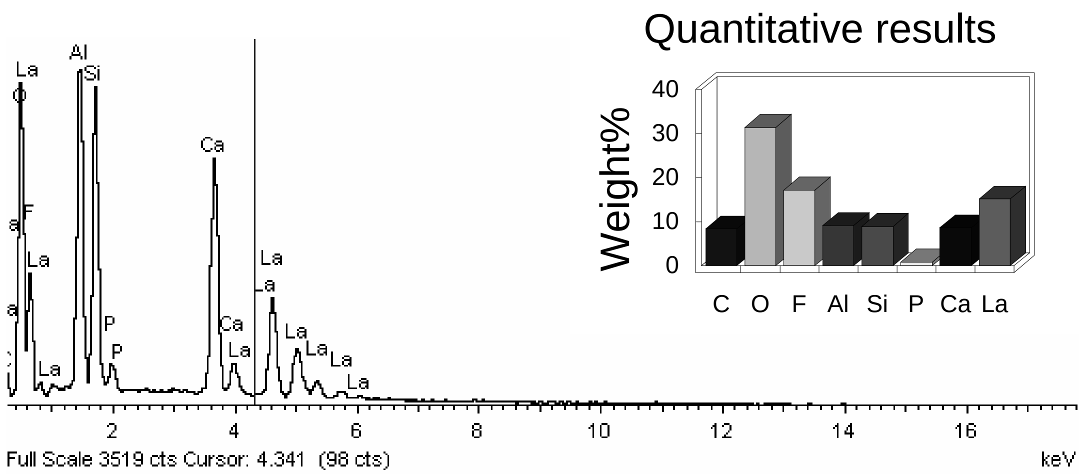


*Fig. 4. Fluorescencense spectrum of the Glassionomer CX Plus.*

*Table 1. Weight of the chemical elements in samples of Esthet X, Fuji IX, Fuji II LC and Glass-ionomer CX Plus.*

| Element | Weight% | | | |
|---|---|---|---|---|
| | Esthet X | Fuji IX | Fuji II LC | Glass-ionomer CX Plus |
| O K | 42.17 | 34.88 | 33.42 | 37.71 |
| Si | 22.39 | 12.25 | 16.36 | 9.31 |
| Al | 4.05 | 13.00 | 12.57 | 10.45 |
| F | 9.12 | 17.82 | 16.67 | 14.00 |
| P | - | 1.86 | - | 1.01 |
| Sr L | - | 18.61 | 20.59 | - |
| Ca | - | - | - | 9.79 |
| Ba L | 22.28 | - | - | - |
| Na | - | 1.10 | 0.38 | - |
| Ti | - | 0.48 | - | - |
| La | - | - | - | 17.74 |
| | 100 | 100 | 100 | 100 |

From Table 1 we may notice that all the samples contain Oxygen, Aluminum, Phosphorus and Fluoride, the biggest quantity of Fluoride being present in samples of Fuji.

b) Investigation by IR absorption spectroscopy.

IR spectrum for 'Esthet X' material (Fig. 5) presents bands corresponding to a matrix of two components: one inorganic and the other one organic.

*The organic compound* is represented by a medium intensity band, corresponding to 1723 $cm^{-1}$ for carbonyl vibration (C=O) and the band of 1166 $cm^{-1}$ for C-O. Both of them are evidences for spectra of acrylic elastomers obtained by polymerization or copolymerization of acrylic esters, such as methyl acrylic, ethyl or butyl. The band of 827 $cm^{-1}$ belongs to the group $CH_3$ from monomer methyl acrylic (vibration of methyl group) [13]. We have no evidence for monomers of the ethyl acrylic or butyl, because we do not find any IR bands of 851, 840, and 738 $cm^{-1}$ for the investigated spectrum. Bands of 2927 and 2851 $cm^{-1}$ belong to methyl group $CH_2$ from acrylic elastomer [17], [18].

*The inorganic compound* is represented by the strongest line of the spectrum, for the value 1086 $cm^{-1}$, responding to silicates. As a final result of the elementary investigation performed with the electronic microscope, we conclude that the dental material "ESTHET X" is an acrylic elastomer based on the monomer 'methyl acrylic' conditioned with an inorganic compound, such as barium, fluoride or aluminum silicate.

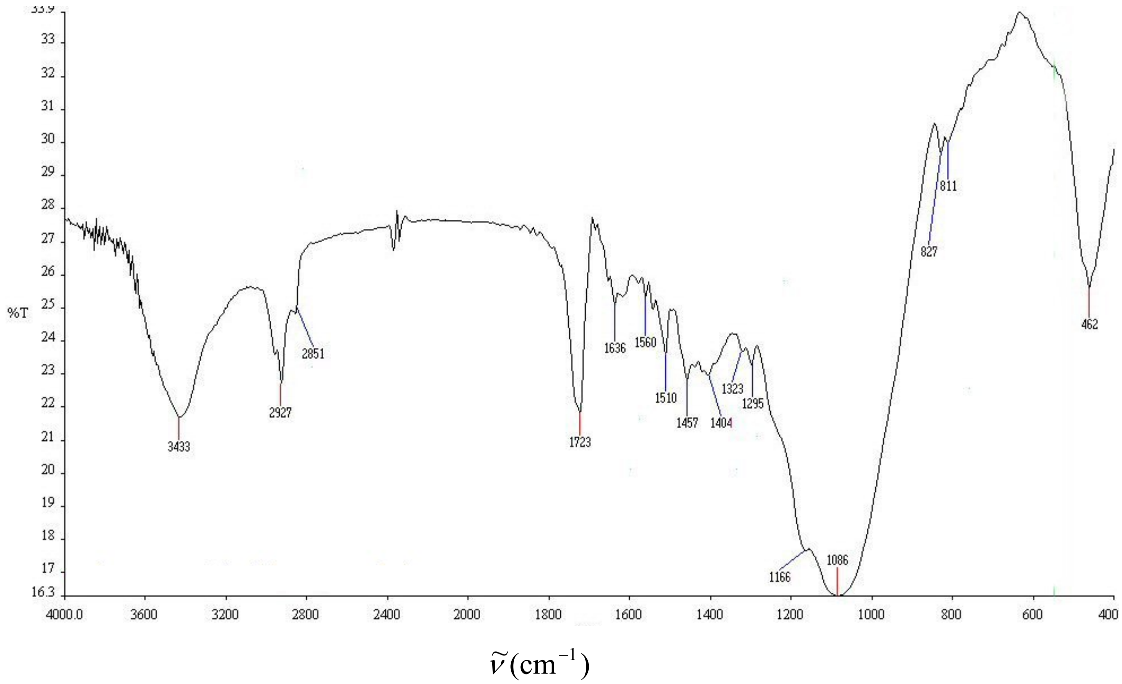


*Fig. 5. IR Spectrum for Esthet X.*

IR spectrum for dental materials 'Fuji IX' and 'Glassionomer CX Plus' presented in figures 6 and 7 presents a large number of lines responding to an inorganic matrix (the large one, from 1005 $cm^{-1}$ – are silicates), metal oxides (lines from range 400 – 500 $cm^{-1}$ or 1600 – 1750 $cm^{-1}$) and lines 2851, 2925 $cm^{-1}$ confirm that inorganic matrix is conditioned with an acrylic polymer. The balance between the two compounds, inorganic respectively organic compounds, is favorable to the first compound, it is estimated concentration being between 93-96%.

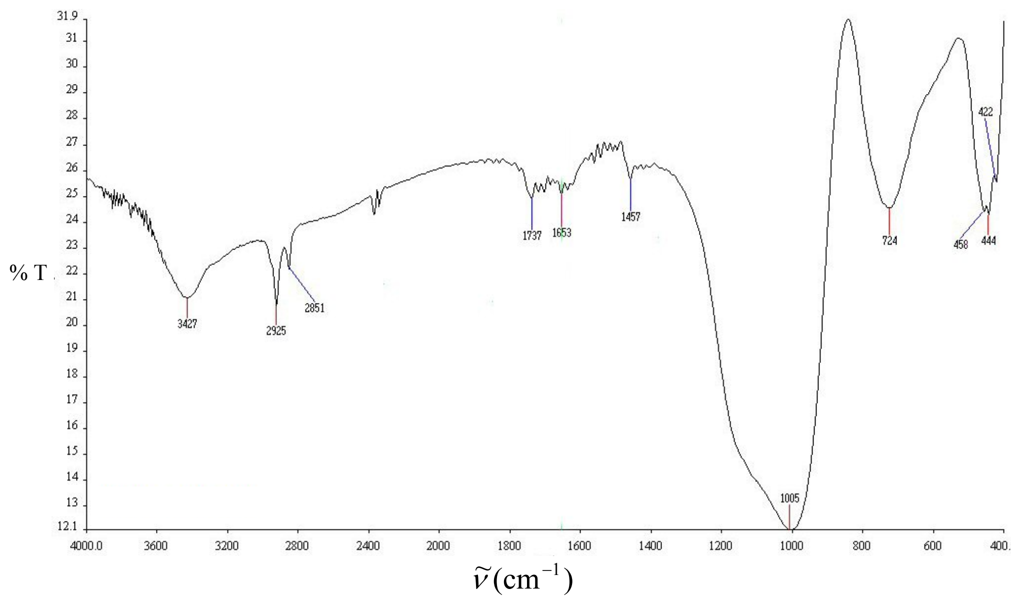


*Fig. 6. IR Spectrum for Fuji IX.*

IR spectrum of the Glassionomer CX Plus has the same configuration with the IR spectrum of the Fuji IX.

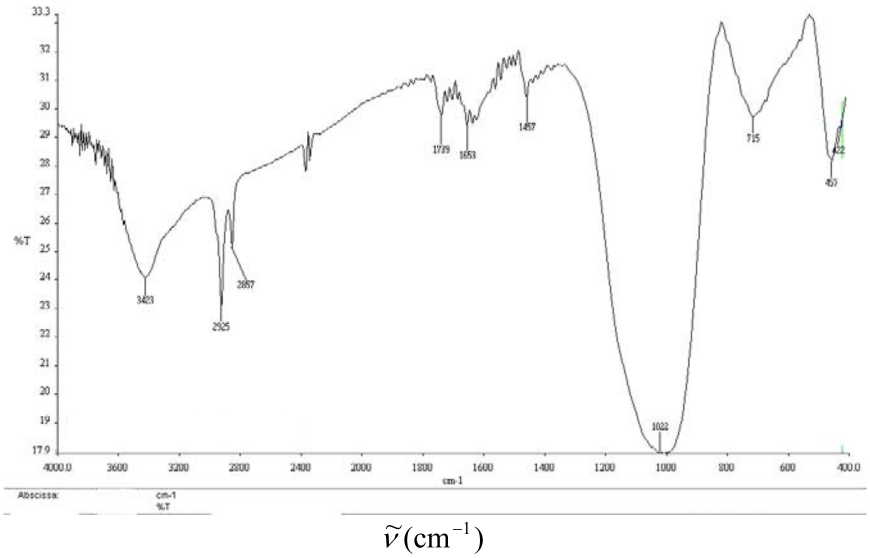


*Fig. 7. IR Spectrum for the Glasionomer CX Plus.*

The matrix of the IR spectrum for Fuji II LC, Fig. 9, is of inorganic nature, the intense band in the range of 850 – 1250 $cm^{-1}$, being characteristic for materials of silica type.

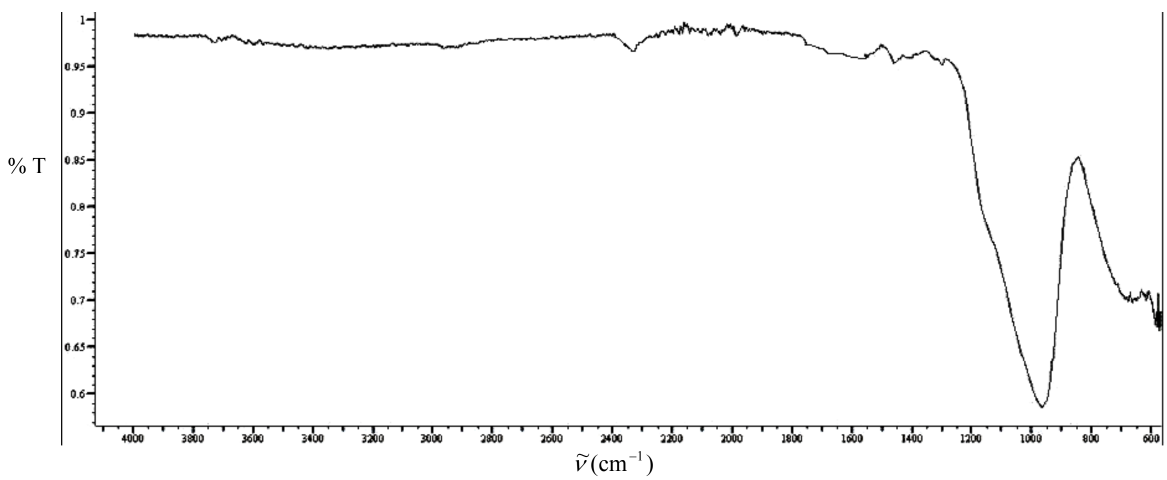


*Fig. 8. IR Spectrum for Fuji II LC.*

We also conclude that the intense band in the range 850 – 1250 $cm^{-1}$ which we found for all four investigated dental restorative materials correspond to the silica anion. We stated this fact by comparison with the IR spectrum of an inorganic glass sample depicted in the figure 9.

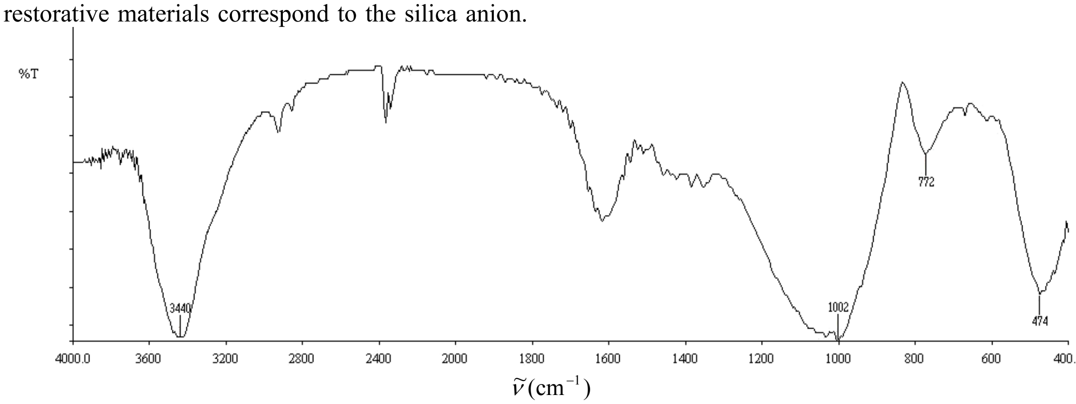


*Fig. 9. IR Spectrum for an inorganic glass sample.*

## 3. Conclusions

Supervising the interaction of the dental materials with the human tissues, especially biocompatibility and bounding reaction, as well the prediction of the side effects which may appear in time, as stability, inhibition of demineralization and improving remineralization by fluorine relist, presume a deep knowledge of the physico–chemical properties. In this way, as a first step, a qualitative and quantitative chemical investigation has been performed for the inorganic matrix which represents the base compound for dental materials. For a complete investigation of the composites dental materials as structure or time passing changes for compounds interaction of the matrix, are highly recommended X Ray Crystallography, Nuclear Magnetic Resonance (RMN) and electronic microscopy investigation methods [20]. We hope that results obtained by this application will be relevant for the present day interest and trend for improved dental restoration materials.

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