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Combined-Correlated Methods Applied to the Analysis of Dental Prostheses Materials Quality

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1. Introduction

Over time, there were a multitude of researches and solutions concerning dental prosthetics, which was in its turn subjected to a major revolution at the time of a new procedure emergence, namely oral implantology. Today, millions of dental implants are used as oral implantology providing the possibility of using additional pillars that may be inserted wherever needed. Thus, a wide range of edentations that not long ago were benefiting only of mobilizable or mobile solutions can be approached today by fixed prosthetic restorations. From the point of view of a simple classification the prosthetic parts can be attached exclusively upon implants (pure implanter) or can be mixed (dental-implanter).

Prosthetic works upon implant may replace from a single tooth to an entire arcade. They can be made of various materials: metal-acrylate or metal-ceramics. Metal-ceramics works (with porcelain antagonists) are preferred today for their structure rigidity. Acrylic works present the benefit of shocks damping, but they are not resistant enough. The abutment applied on the implant represents the trans-mucous component and the implant package is covered in order to rebuild the aspect of a natural tooth. The hexagonal shape of the implant's end prevents the abutment rotation and the contact surface between this and the implant is especially important especially in the process of occlusion with upper arcade. The dentist may reshape some part of the abutments used in implantology today, while the micro-prostheses edges may be placed sub gingival without being followed by complications. Also, upon an implanter support we can create the so called prosthesis upon implant, which is a mobilizable prosthetic device. On a small number of implants, the prosthesis with special aggregation systems can be manufactured, systems that confer much higher stiffness and support to the prosthesis on implant than to the usual prosthesis.

Artificial teeth are usually included in one of the following situations: *single maxillary mobile prosthesis*, with noble alloys as antagonists, acrylic or diacrylic resins, in order to prevent their accelerated wear; *alveolar ridge*; *rubbed off or periodontal antagonists*; or the case when there is a *single dental prosthesis or a metal bridge on the antagonist arcade*.

Wherever would be the position of teeth in prosthetic area, artificial teeth are defined by characteristics related to color, shape, dimension and occlusal shape. Besides for the frontal teeth the order of importance is color, shape, height and width. From the material point of view, the used artificial teeth are consisting of PMMA co-polymerized by reticular agents and usually these are provided with an increased resistance to cracking by using a greater amount of reticular agents. In the contact zone with the prosthetic basis, a lower concentration of reticular agent is recorded, than in the incisal, respectively occlusal areas, in order to facilitate the chemical connection to the polymers in the prosthetic basis. To provide the most physiognomic aspect, artificial teeth use a large range of pigments and to increase resistance of teeth, they are treated with inorganic micro-particles.

For long-term successful performance of all dental implant types the following general factors should be considered: biomaterials, biomechanics, dental evaluation, medical evaluation, surgical requirement, healing processes, prosthodontics, laboratory fabrication, post insertion maintenance. All practitioners involved in patient care should be knowledgeable regarding these factors and their interrelationships.

Standards of dental practice would suggest the following general contraindications for the above three categories of dental implants: debilitating or uncontrolled disease, pregnancy, lack of adequate training of practitioner, conditions, diseases or treatment that severely compromise healing, e.g., including radiation therapy, poor patient motivation, psychiatric disorders that interfere with patient understanding and compliance with necessary procedures, unrealistic patient expectations, unattainable prosthodontic reconstruction, inability of patient to manage oral hygiene, patient hypersensitivity to specific components of the implant.

Teeth used in treatment with telescopic prostheses should be covered generally with porcelain or noble metals crowning and require extended preparations. By help of implants, abutments can be created upon which different structures connected to the skeletal or fixed prosthesis are applied. Nowadays, fixed implantologic prosthetics is dominated by screw fixing but prosthetic works can also be cemented.

In dentistry there were used non-metallic materials to manufacture dental prostheses even since ancient time. Nowadays, three groups of non-metallic materials are used:

- organic (different plastics);
- inorganic (ceramics);
- composites (organic + inorganic).

It is well known that plastics are non-metallic compounds produced in a synthetic way. These are generally made of organic parts that can be modeled (in the plastic phase) in various shapes and then harden creating rigid bodies. As ideal properties of a non-metallic material used for prostheses manufacturing, we may enumerate the following: they should have the color and shade of the tissue they are replacing, to posses transparency or be translucent, properties that allow its esthetic reproduction; to avoid the color and transparency change after manufacturing or within the oral environment; not shrink or expand, nor to distort during processing or afterwards in the oral environment; to present elasticity and abrasion resistance; to be waterproof for the fluids in the oral cavity preventing the occurrence of an unpleasant halitosis or taste disorders; food and other materials should not adhere to the processed surface, once introduced in the oral cavity, allowing the same hygiene procedure as the oral dental tissues; to present a small density and high thermal conductivity; lamination temperature should be much higher than the temperatures of all liquids and foods introduced in the oral cavity.

Presently, the properties of the polymers used in manufacturing prostheses are enhanced along three directions: by **radio-opacity**; by **increasing impact resistance** and respectively by **increasing rigidity**.

Radio-opacity can be obtained by introducing organic components of bromine that determine the plasticity increase, water absorption and respectively a decrease of material rigidity. By means of additive phase separation (organic component based on bromine) during the paste phase, we are able to obtain a transition temperature around 110 °C and a rigidity of 2,0 GPa preserving at the same time the esthetic properties and reaching a high radio-opacity degree.

Increase of shock resistance can be obtained by homogenization during the paste stage of two or three different polymers. For increasing the rigidity and shock resistance, we know from dedicated literature that some types of fibers were experimented (glass, alumina, carbon, Kevlar) used to reinforce PMMA or Bis-GMA resins.

From the properties of acrylic thermo-polymerizable resins, the most important are the following: **structure** (from structural point of view methyl polymetacrylate consists of linear polymerized macro-molecular chains); **porosity** (in resin's structure air inclusions of small or bigger dimensions may appear and microscopically determined); **spherical inclusions,** small, inside PMMA (these may appear as a result of too fast heating of acrylate paste and a temperature increase over 100°C, thus, boiling and monomer evaporation determine the bubbles occurrence inside PMMA); **different shapes inclusions,** small, countless, distributed along the entire thickness of the acrylate (this type of porosity is due to the insufficient compression of the acrylate paste); **different shapes inclusions**, big, distributed along the entire thickness of the acrylate (the cause of their presence is due to lack of homogenization of acrylic paste, distorted distribution of monomer or too high variation of polymer molecular mass); **water absorption** (phenomenon is evaluated by weight increase of acrylate sample, which was assessed per resin surface unit, immersed in water at 37^0C for 24 hours and then well dried; **solubility** (evaluated by determining the weight diminishing per resin surface unit, immersed in water for 24 hours and well dried); **volume variations** (during polymerization process the following physical phenomena take place successively: thermal expansion, contraction of polymerization and finally thermal contraction); **thermal expansion** (is due to the temperature difference between the environment and the 60°C temperature of the water meant for polymerization); **contraction of polymerization** (these is generated by the methyl polyacrylate that presents a 21% volume decrease during polymerization); **thermal contraction** (occurs during the pattern cooling phase and is limited by PMMA adherence to the pattern margins, but the most important of the thermal properties is the thermal expansion coefficient which is evaluated at $81 \cdot 10^{-6}$/deg. Thermal conductivity of PMMA is low, the thermal conductivity coefficient being $4{,}5 \cdot 10^{-4}$ cal · cm^{-1} · s^{-1} · deg^{-1}).

As far as the *mechanical properties* of the acrylic resins are concerned, the most important are the following: **hardness** (Knoop hardness is 20 times lower than that of dentine (65) or enamel (300)); **bending resistance** (compression resistance is approx. 75 MPa; traction resistance is approx. 52,5 MPa; abrasion resistance is low, being a major inconvenient for these resins).

The most known *chemical properties* are: **corrosion** (PMMA presents a high chemical inertia, being very stable in the oral cavity- still an unfavorable evolution in time is possible so that the initially translucent resin becomes opaque and yellow and due to micro-cracks occurred in time, the mechanical resistance is also lowered); **biological properties** (ceramics consists of metallic and non-metallic components – oxides, nitrites, silicates).

Introducing ceramics in dentistry, as it is or as lead material on metallic support is due first to their outstanding esthetic qualities as well as to the fact that it is an inert material, very well tolerated by tissues. From chemical point of view, ceramics is a complex silicate. The basic raw materials in its composition are: feldspar, quartz and kaolin. Beside these basic components, ceramics also contain a large range of ingredients only in pure state, because of the multiple requirements related to color, resistance, fragility, insolubility, translucence.

2. Performing the mastication process

Mastication is the process used to food fragmentation, salivation and food bulk formation, lubricated and prepared for deglutition. Mandible and upper maxillary take part in the mastication process by means of dental arcades, jaws, lips and tongue. By contracting the oro-facial musculature the food particles are maintained on the teeth occlusal surfaces while the tongue separates the large particles from the small ones, brings the large ones back to the grinding areas and creates the food bulk. Salivary mucin is the binder that helps shaping the food bulk and is the necessary lubricant both in the mastication process and the deglutition one. [1]

The active factor of mastication is the mandible, driven by the mastication muscles by the complex performed motions. The complexity of mastication motions are explained by the temporal-mandible anatomical shape and the various possibilities of masticating muscles combined action.

During mastication, significant forces are developed (pressures of 15- 20 kgf), representing a real danger for the soft tissues and also for the hard tissues participating in this process.[1]

Maintaining the integrity of the tissues involved in mastication is accomplished by structural and mechanical factors and by a very accurate coordination of the mastication motions assured through the nervous system, based upon considerable sensorial information.

The change of any of the morphological or functional components perturbs the mastication process at a certain extent, according to the importance of the affected component. [1].

The main motions of the mandible (opening-closing, anterior-posterior, lateral right-left), related to the three planes in space are harmoniously integrated in the mastication function, according to an individual pattern characteristic for each individual.

Due to the fact that mastication is part of the hard approachable functions, it is necessary to use adequate research methods.

According to some researchers (Gillings, 1967), one of the ways of recording the mandible kinematics uses electronic transducers, based on photo-sensitive elements (photocells) sensitized by one or more bright spots connected to the inferior incisors. The results appear synchronously with the recording, as time functions, on the amplifying-recording device paper.[1]

The device and the conceived recording method, performed and applied by Prepeliceanu and his collaborators (1970 – 1971) allows the simultaneous recording of the three directions of mandible motions performed during the mastication process (opening-closing, anterior-posterior, lateral right-left), aspects observed in fig.1.[1]

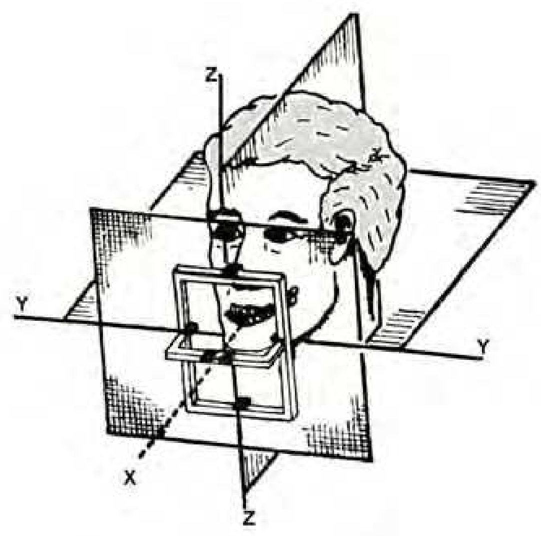


Fig. 1. Schematics of mandible motions recording [1]

From the multiple research performed by a team of specialists it was established that the motions performed by the mandible during the mastication process are integrated in the mastication cycled developed on vertical-oblique trajectory, with a transversal lateral component and also oblique, accompanied by gliding at occlusion level. Also there was found the existence of some friction motions in the occlusion process, especially performed in the final phase of the mastication process. Additionally we observed lateral gliding motions as well as combinations between lateral and thrust motions, accompanied by friction between the cuspidian slopes, due to functional requirements of shearing and grinding food, especially the most consistent and fibrous ones. Though these motions have low amplitudes, of the order of millimeters, they are differentiated from individual point of view, due to the structure of mastication system of the analyzed subject.

Another series of researchers assessed the mastication system as a system with a very complex neural-muscular activity, based upon conditioned reflexes, and that the development of this action cannot be considered as a chain of reflexes, independent of the occlusal guide influence. This aspect is confirmed also by the fact that in the most part of the mastication process, direct dental contacts take place and this way the influence of the occusal guide in guiding the mandible mastication motions cannot be ignored.

In mastication process, besides the mechanical action of the dental arcades, an important part is played by the saliva. Saliva is the secretion product of three pairs of big glands located within the thickness of the oral cavity sides- parotid, submaxillary and sublingual glands – and of numerous small glands situated in the mucous covering this cavity. There is classical accepted that saliva consists of 99,4% water and 0,6% solid substances, from which 0,2% inorganic and 0,4% organic. Saliva composition is variable in a very large range, according to the glands, debit from one subject to another or even for the same subject at different moments in time.

3. Biocompatibility issues of implants and dental prosthesis

Biomaterials class is different from the other classes of materials due to the *biocompatibility* criterion, which is defined as the biomaterials property that after their implantation in a living organism, they do not trigger adverse reactions and are accepted by the surrounding tissues. So, the biomaterial should not present toxicity or should not produce inflammatory reactions when introduced in the human body as an implant. According to a more general and officially approved definition (Williams, 1987), a material with an optimal biocompatibility is the one that do not determine any tissue adverse reaction. Also, the implanted material is expected to withstand any physiological strain without showing any substantial dimensional change, shape alteration or any other catastrophic event. The implants should resist to any degradation or corrosive attack of the physiological or nutritional fluids. Their constituent materials must be resistant to oppose any force applied to them during their designed life cycle. Biocompatibility of an implant depends upon several factors like: patients' general health state, age, tissue permeability, immunologic factors and implant characteristics (material roughness and porosity, chemical reactions, corrosion properties, toxicity).

A great importance for the human tissues is presented by the development of electrochemical corrosion processes in blood serum at 37°C temperatures. When the material is introduced inside the body we should consider two aspects. One is the influence of the physiological environment that may change the material nature and properties. The other is the effect of the implant material and of each of its degradation products upon the physiological fluids and tissues. We must highlight the fact that the chemical action of the physiological fluids does not involve just some chemical reactions of ionic exchange or oxidation-reduction reactions with the consisting molecules of a given biomaterial, but above all these the interaction of an impressive number of food substances, still unknown, that operate at the level of complex substances and are able to selectively attract specific ions, creating a physical-chemical unbalance state inside the material. Thus the material may sustain various chemical or physical degradations.

In order to determine the biocompatibility of the materials used in dental prosthetics and implantology a questionnaire was conceived, which was filled in by a human subjects' sample with prosthetic works made of the same type of acrylic material. Based on the questionnaire's answers and suing a module of the software developed on Fuzzy logic, we accomplished the analysis of the materials used in manufacturing dental prosthetics works. The result of the analysis is materialized in a graphic presenting the analyzed dental material biocompatibility by means of percents, for the selected subjects' sample.

The first stage in biocompatibility analysis by Fuzzy logic consisted in introducing initial data in a main window (fig.2) considering the most two important causes leading to materials incompatibility: *nourishment and health* of the studied human subjects. Graphics were made at a percent scale of 1 to 100.

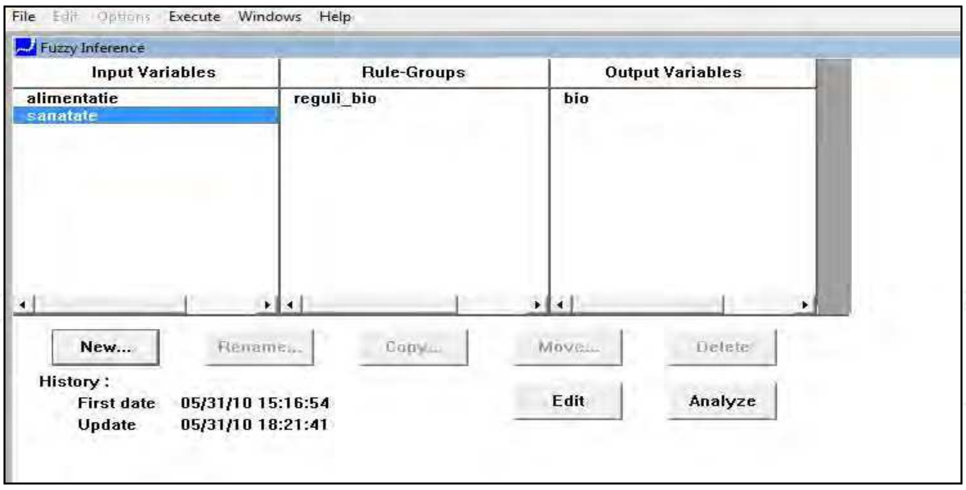


Fig. 2.

To each of the two variables may correspond from 2 to *n* concepts. Thus, for the "nourishment" variable we considered as valid the following concepts: "soft food", "hard food", "acid food" and "sweets". For the second variable "health" we established the concepts: "bad", "average" and "good". The graphics corresponding to the two variables are shown in fig.3 and fig.4.

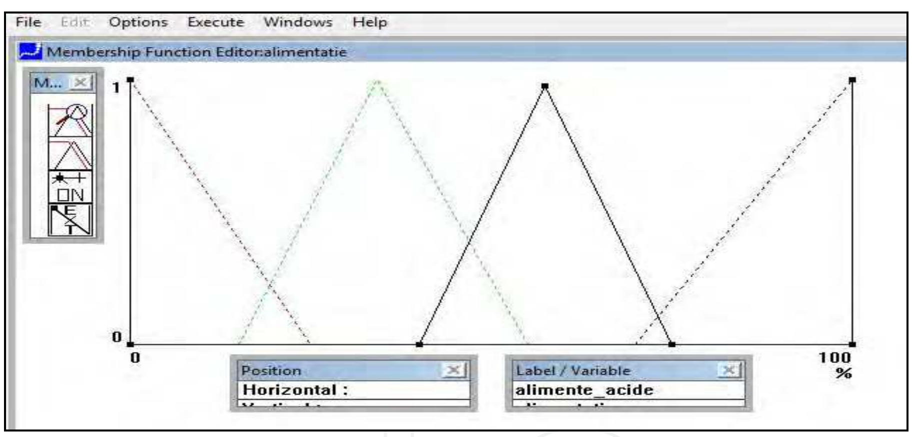


Fig. 3.

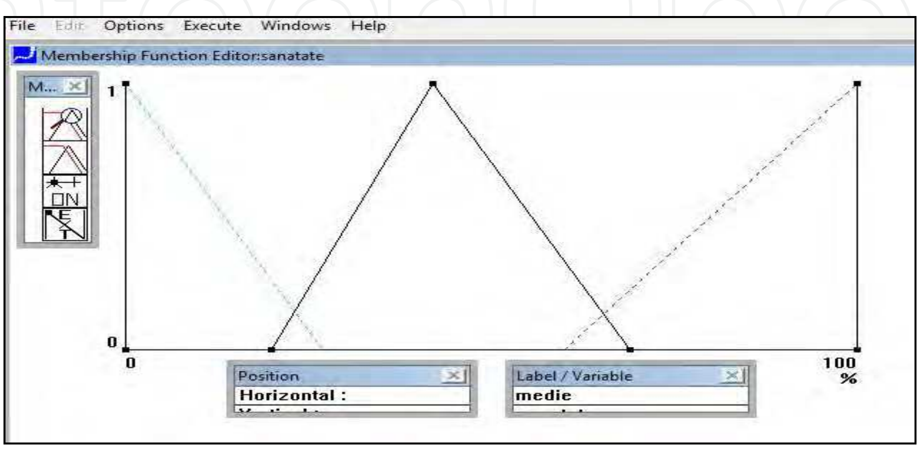


Fig. 4.

Fuzzy analysis continued with the second stage, introducing final data, where we established a single variable as being biocompatibility ("bio") with the following concepts: "null", "partial" and "total". Fuzzy type analysis assumes the compilation of initial data and of the final ones based upon the definition of certain rules that are presented in a separate window. Prior to starting the fuzzy analysis process we checked on software basis all the introduced data and rules to avoid the errors during analysis.

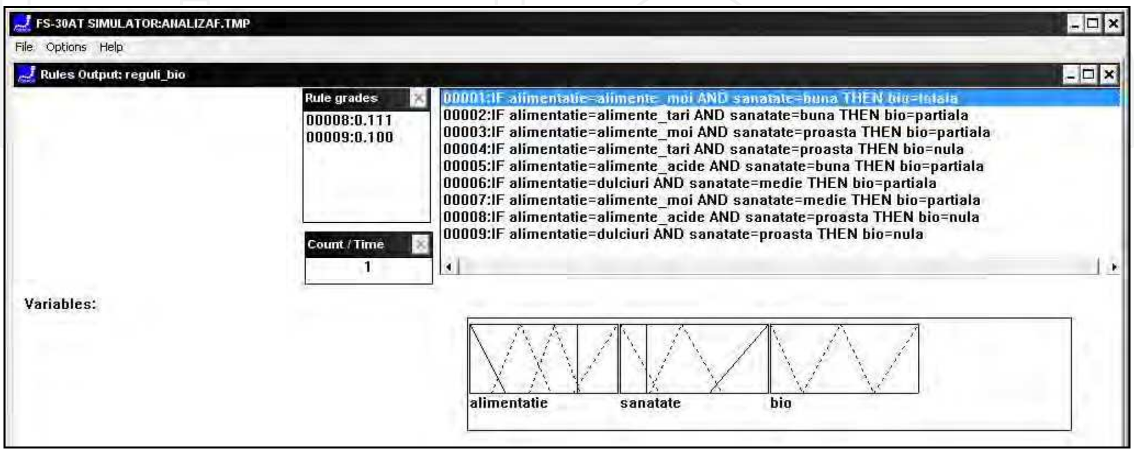


Fig. 5.

The last stage, concerning the analysis results was performed using a soft simulator that calculated based upon the numerical values and established rules, the percentage of studied material biocompatibility. The obtained results reveal the fact that the biocompatibility level stage is remaining at low values due to the health state and nourishment style of the investigated sample of subjects.

4. Polymerization process of restoration materials samples – Microscopic analyzes

The experimental setup used for the microscopic analysis of the polymerization dental materials samples consists of a digital microscope Keyence VHX-600 type, with objective magnification between 500x and 5000x, an object field of 0, 25 mm^2 and software suitable for the assessment studies and surface quality measurements, roughness, 3D representations. The used samples were manufactured in the same conditions and assessed according to the same procedures.

Fig. 6. Keyence VHX-600 digital microscope (first two pictures) and mechanical testing system for dental samples

Most of the restoration materials should withstand forces during manufacturing or mastication, so the mechanical properties are important in understanding and predicting the material behavior under load. Because a single mechanical property cannot represent a quality measure, the application of the involved principles in a range of mechanical properties is essential, especially considering the human factor implication.

One of the most important applications in dentistry is the study of the forces applied to teeth and dental restorations. The maximum forces recorded by strain gauges and telemetry devices reach 250 to 3500N. The forces developed in the dental occlusion for an adult subject decrease from the molar area towards the incisors, reaching forces values from 400 to 800N, upon the first and second molar.

Of the same importance for the study of forces developed in the natural teeth occlusion, is the determination of stress and strains in the restoration type works, such as insertions, fixed connections, partial and total prostheses. One of the first investigations of the occlusion forces shows that average biting force in patients with replacement of first molar is determined at 250N for the restored part and 300N for the opposite side, in comparison to the average biting forces for permanent teeth, reaching 665N for molars and 220N for incisors. In a different study, forces measured for patients with partial prostheses are form 67 to 235N. Generally, the force in women bite is 90N smaller than the one applied by a man.

These studies indicate that the mastication force on the first molar with a fixed connection is approx. 40% of the force exerted by the patients with natural teeth.

Recent measurements performed by help of strain gauges devices are much more accurate than those performed with other previous equipments, but generally the conclusions are the same. These measurements concluded that the forces distribution between the first premolar, second premolar and first molar in a complete dentition can be established as approx. 15%, 30%, and 55% of the normal force.

From the point of view of the polymerization process, an important aspect is represented by the polymerization time, which is a parameter affecting the mechanical characteristics of the prosthesis teeth, dental restorations or implants. Polymerization time for the composite diacrylic polymerizable resins cannot be measured based on viscosity changes. Approximately 75% of the process takes place in the first 10 minutes, the reaction continues slowly for 24h. The sub-polymerized layer at the surface has an internal conversion ratio of approx. 25%.

By comparing some materials used for artificial teeth construction we may notice that in the case of *dental acrylate* (having the following characteristics – compressive strength of 84 MPa, elastic modulus of 1700 MPa and elasticity limit of 55 MPa) this is used in dental technique offices in 80% situations unlike the ceramics materials which are present only in 20% of situations. *Duropont composite material* (having the characteristics – compressive strength of 90 MPa, elastic modulus of 1600 MPa and elasticity limit of 45 MPa) presents a highly superior hardness to the presently used acrylates. Unlike these, the duropont composite polymerizes in 6 atm external pressure conditions and even if it does not show the *cromasit* hardness, the favorable price makes it the most used material for dental prosthetic works.

During the performed tests we manufactured some working samples with the same size and volume.

First working samples were made of **TE-ECONOM** material and were polymerized for various time intervals (5 min, 6 min, 7 min and respectively 9 min) and monitoring the photo-polymerization process in order to avoid other environmental influences.

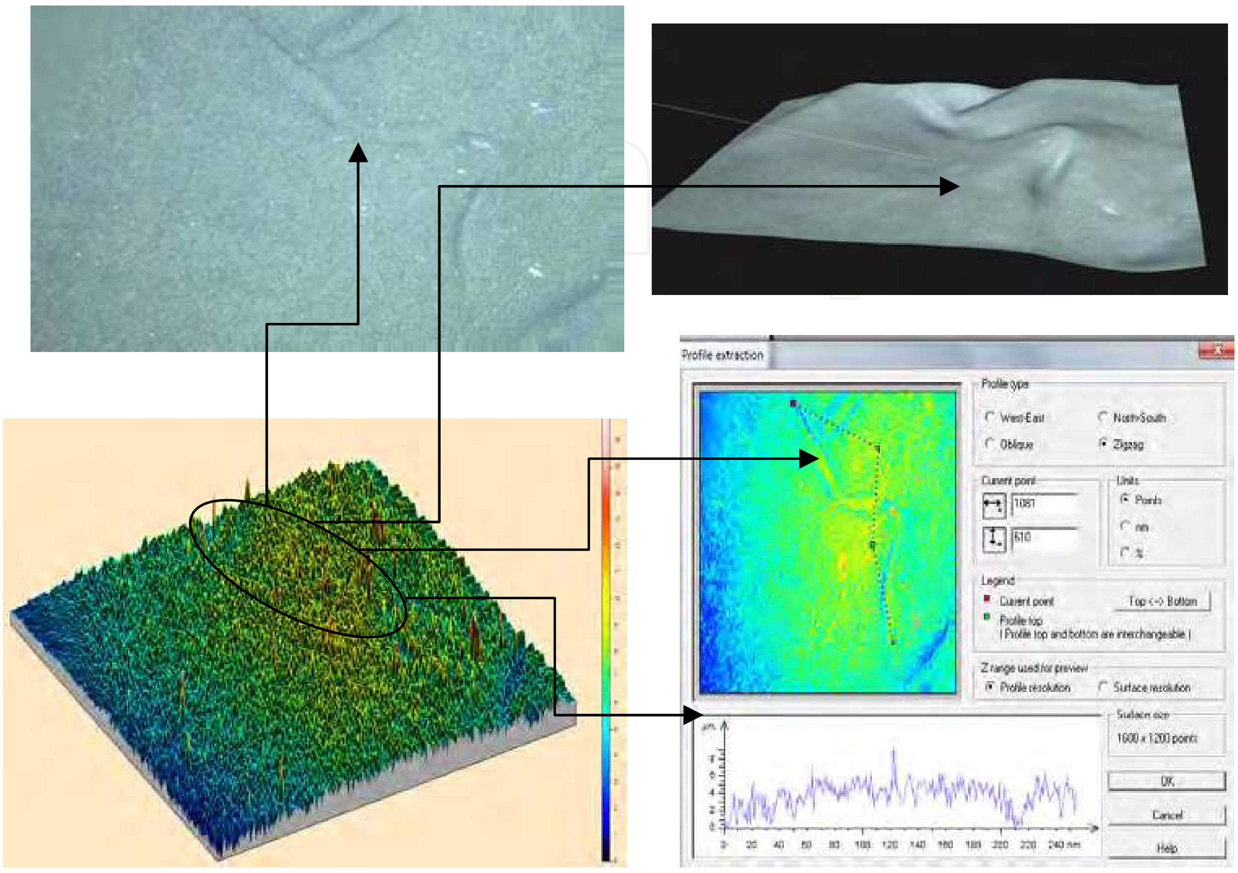


Fig. 7a. Sample 1 (TE-ECONOM) structure, photo-polymerization time of 5 min (500x digital microscope)

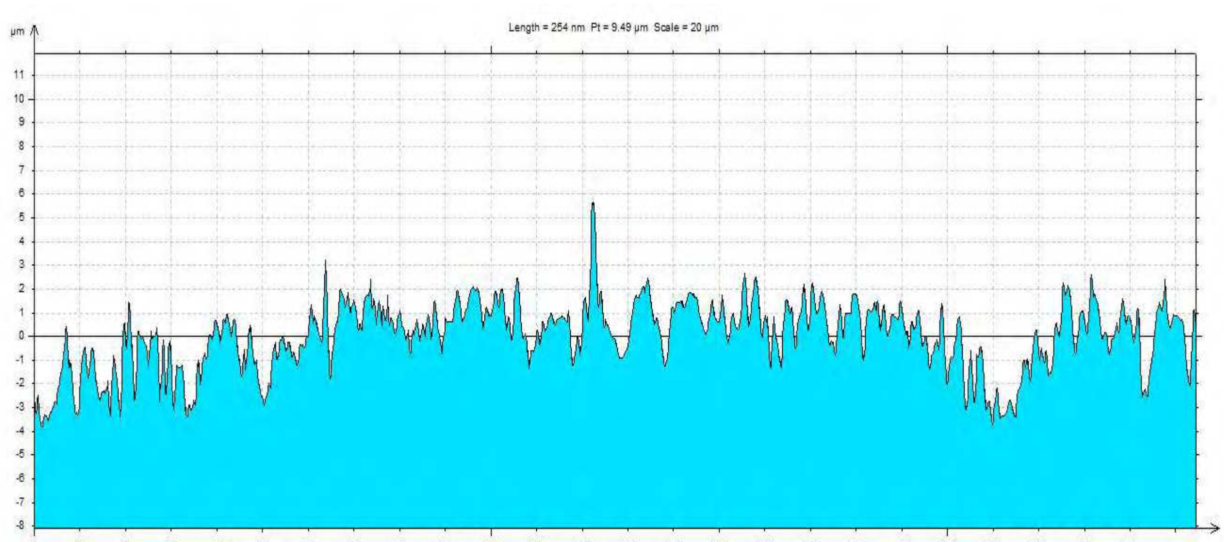


Fig. 7b. Roughness profile variation in the area marked for sample 1

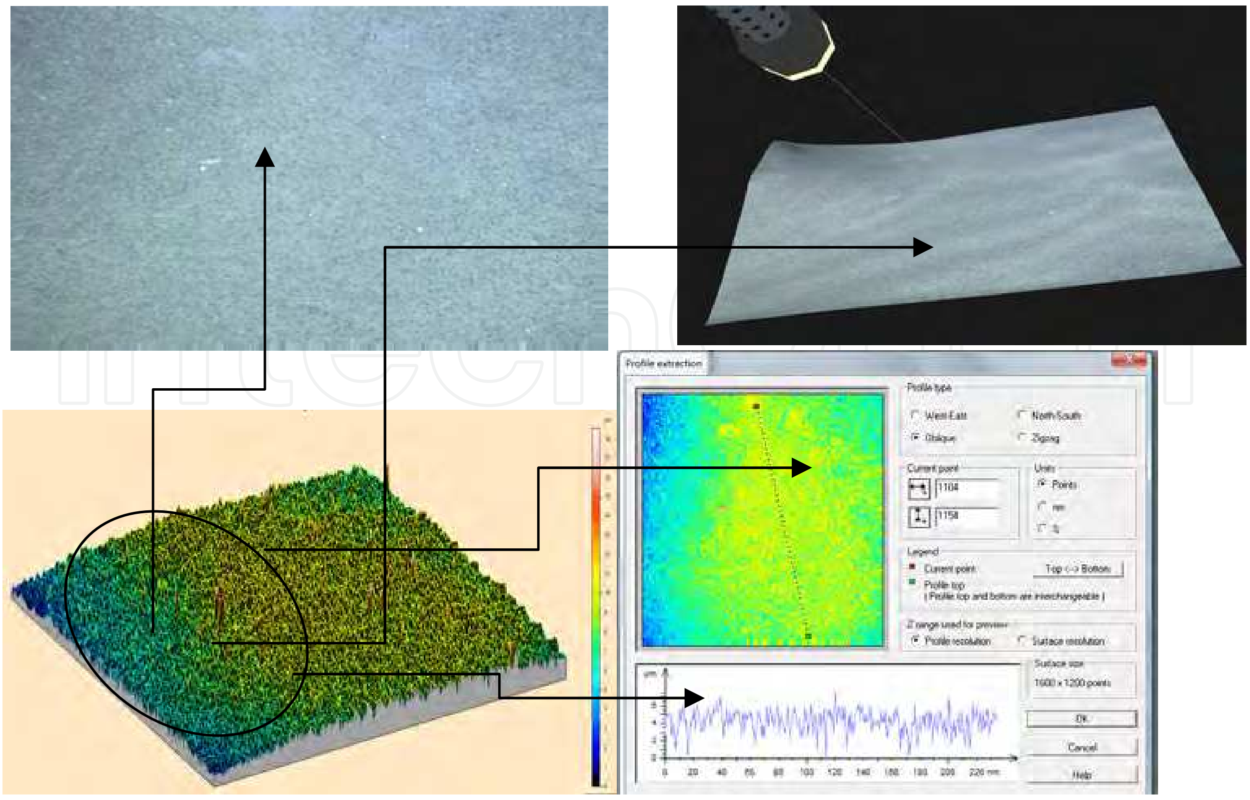


Fig. 8a. Sample 2 (TE-ECONOM) structure, photo-polymerization time of 6 min (500x digital microscope)

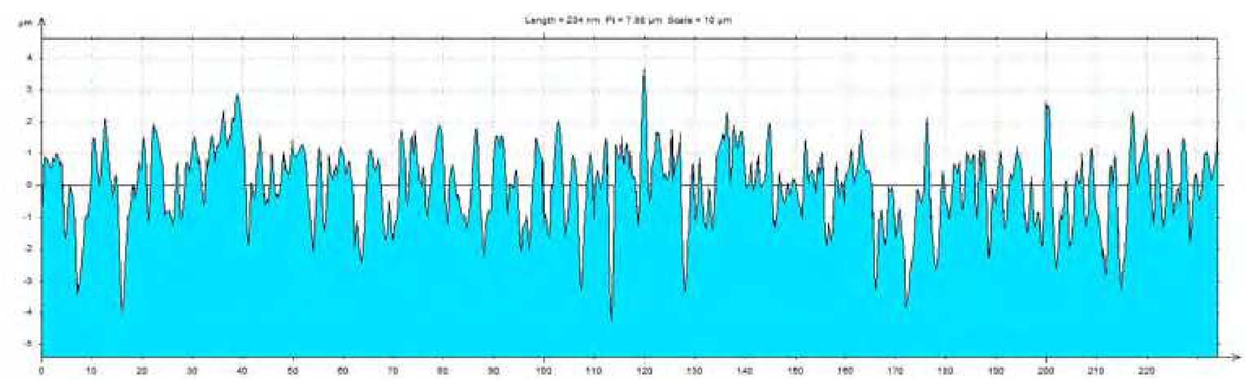


Fig. 8b. Roughness profile variation in the area marked for sample 2 (TE-ECONOM)

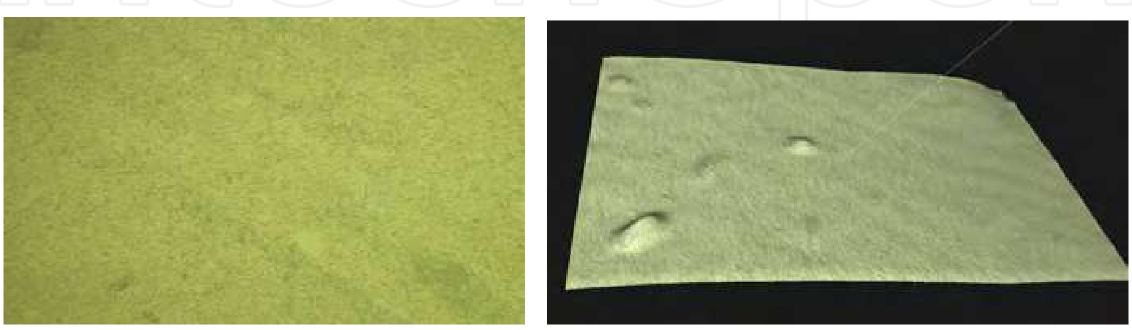


Fig. 9a. Sample 3 (TE-ECONOM) structure, photo-polymerization time of 7 min (500x digital microscope)

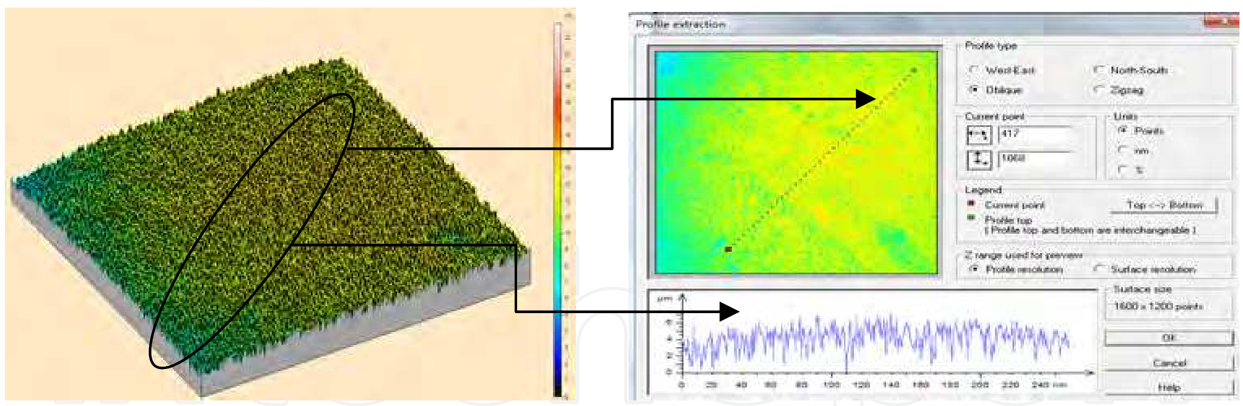


Fig. 9b. Sample 3 (TE-ECONOM) structure, photo-polymerization time of 7 min (500x digital microscope) and analyzed by MountainMap software

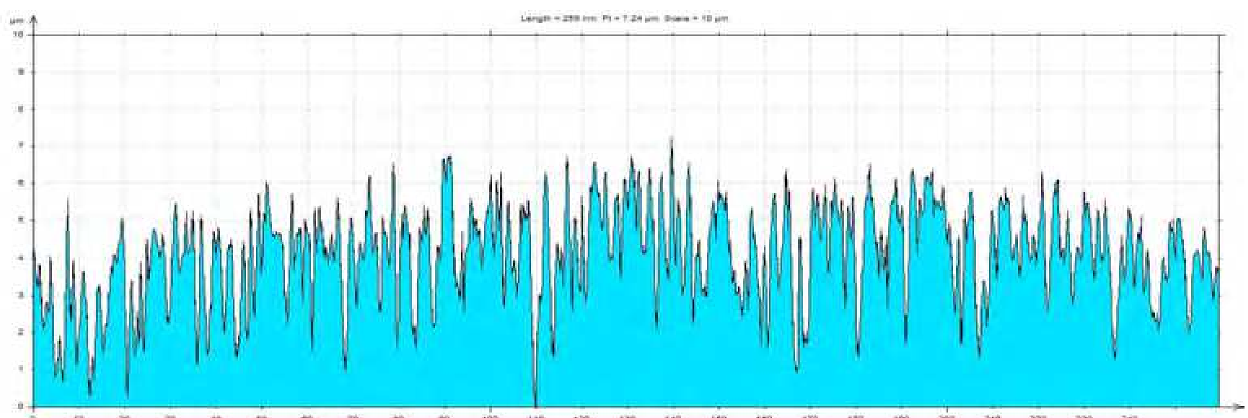


Fig. 10. Roughness profile variation in the area marked for sample 3 (TE-ECONOM)

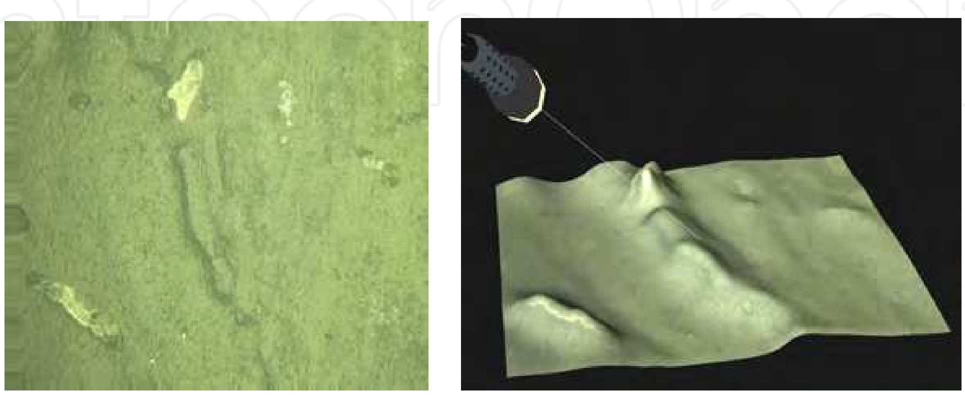


Fig. 11a. Sample 4 (TE-ECONOM) structure, photo-polymerization time of 9 min (thickness 4mm) (500x digital microscope)

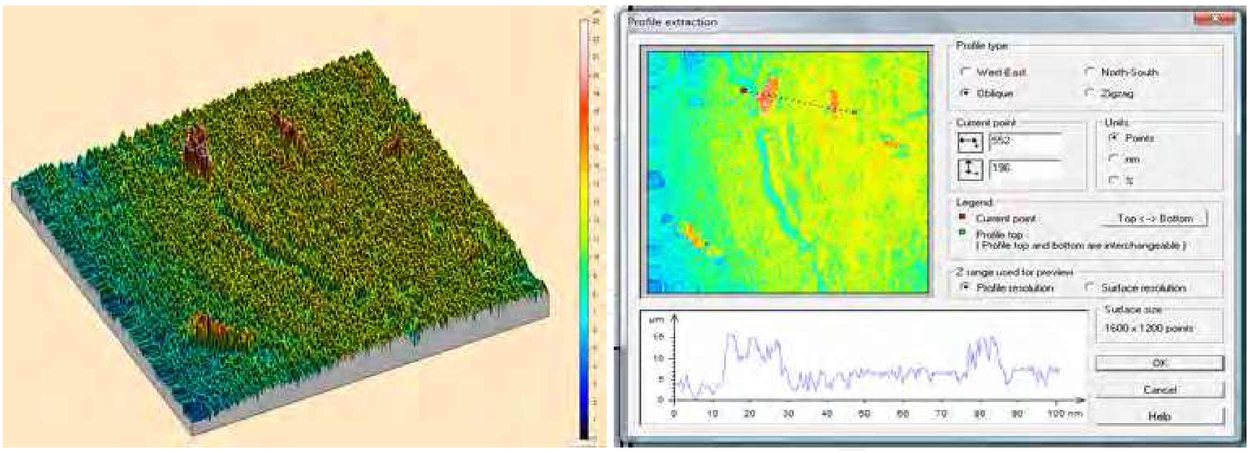


Fig. 11b. Sample 4 structure, photo-polymerization time of 9 min (thickness 4mm) (500x digital microscope) and analyzed by MountainMap software

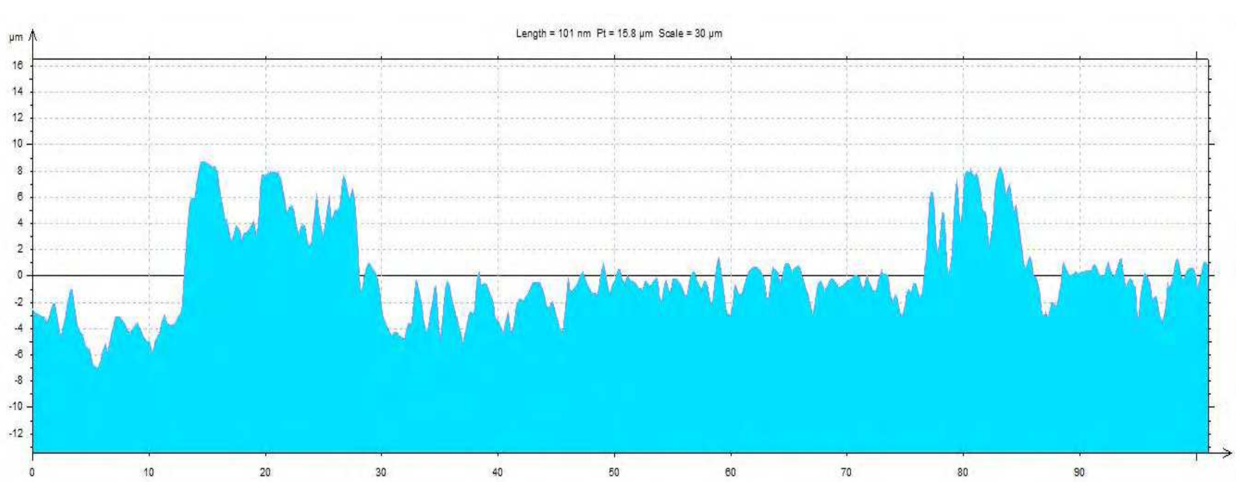


Fig. 11c. Roughness profile variation in the area marked for sample 4 (TE-ECONOM).

For the second set of samples the material we used was: **VALUX-PLUS,** and the chosen time intervals were the same – 5, 6, 7 and 9 minute.

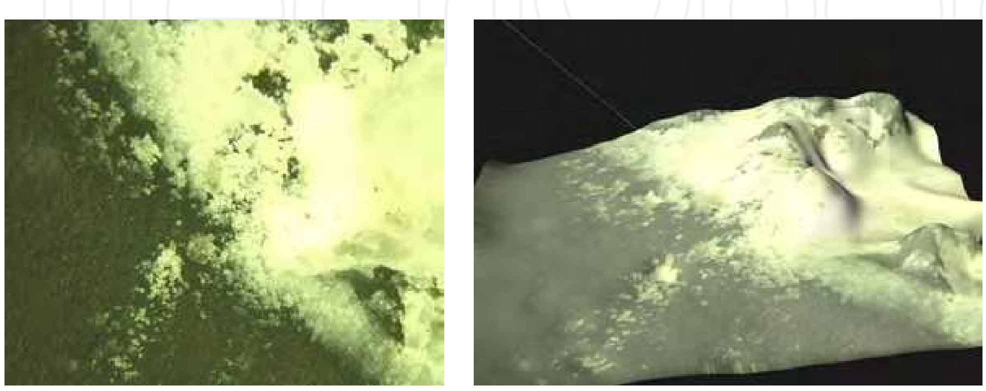


Fig. 12a. Sample 1 VALUX-PLUS structure, photo-polymerization time of 5 min (thickness 4mm) (500x digital microscope)

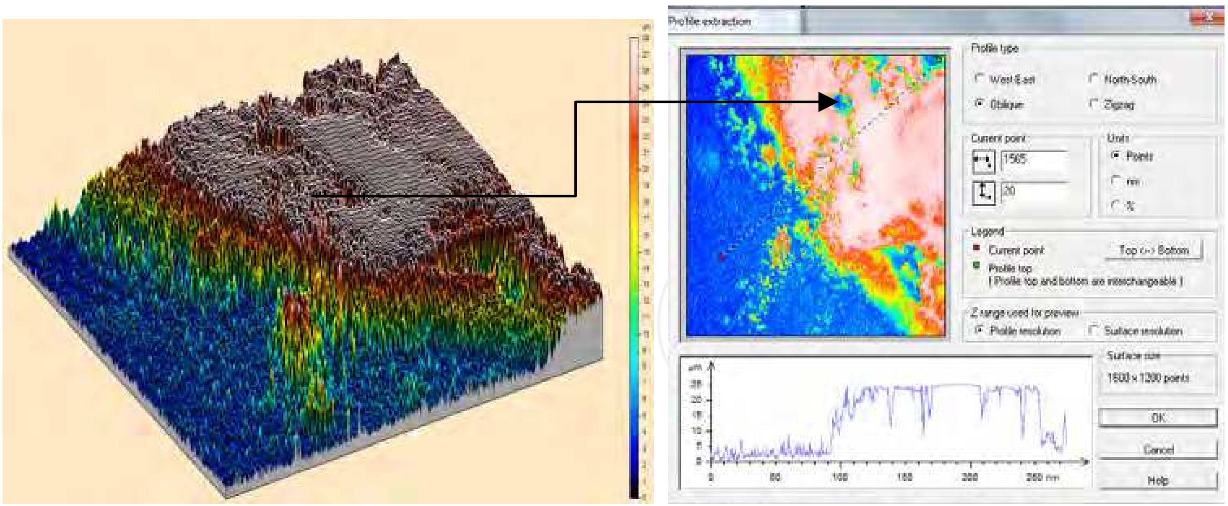


Fig. 12b. Sample 1 **VALUX-PLUS** structure– photo-polymerization time of 5 min (500x digital microscope) and analyzed by MountainMap software

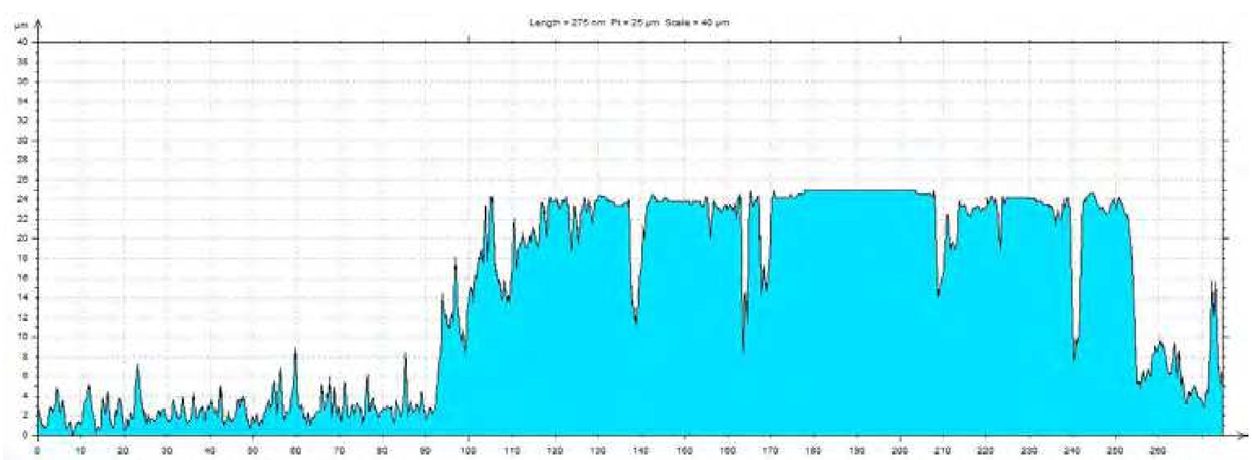


Fig. 12c. Roughness profile variation in the area marked for sample 1 **VALUX-PLUS**

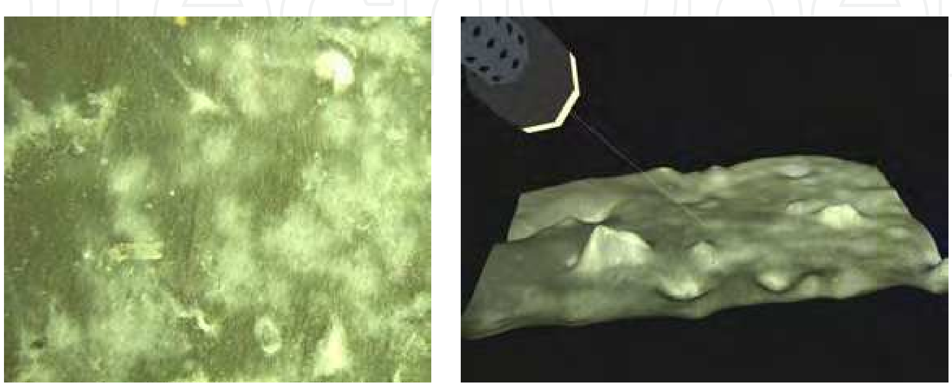


Fig. 13a. Sample 2 structure VALUX PLUS- photo-polymerization time of 6 min (500x digital microscope)

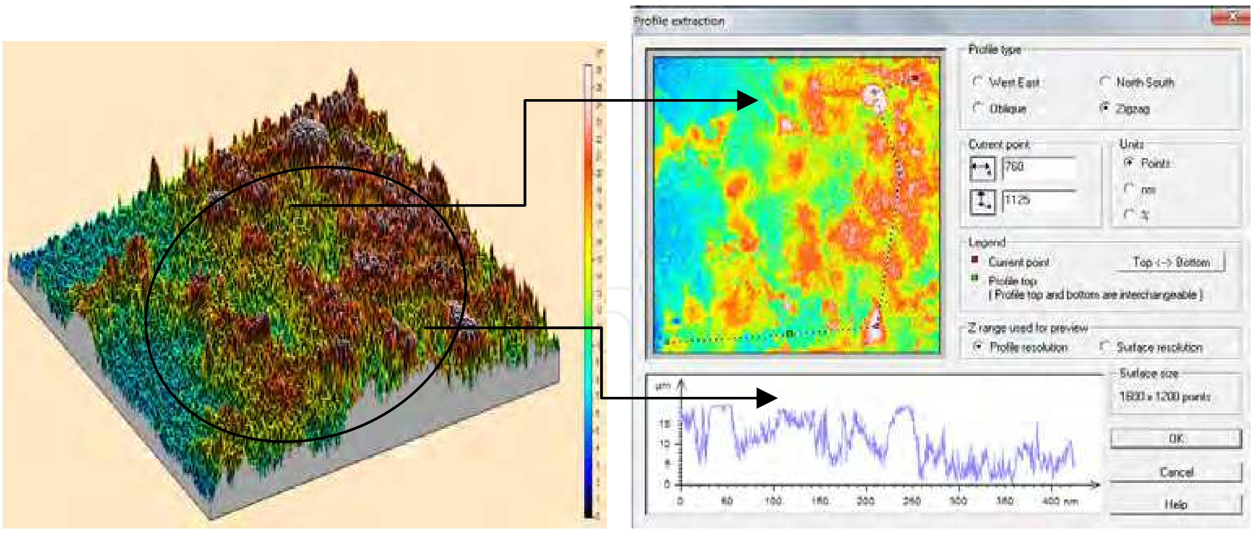


Fig. 13b. Sample 2 structure VALUX PLUS- photo-polymerization time of 6 min (500x digital microscope) and analyzed by MountainMap software

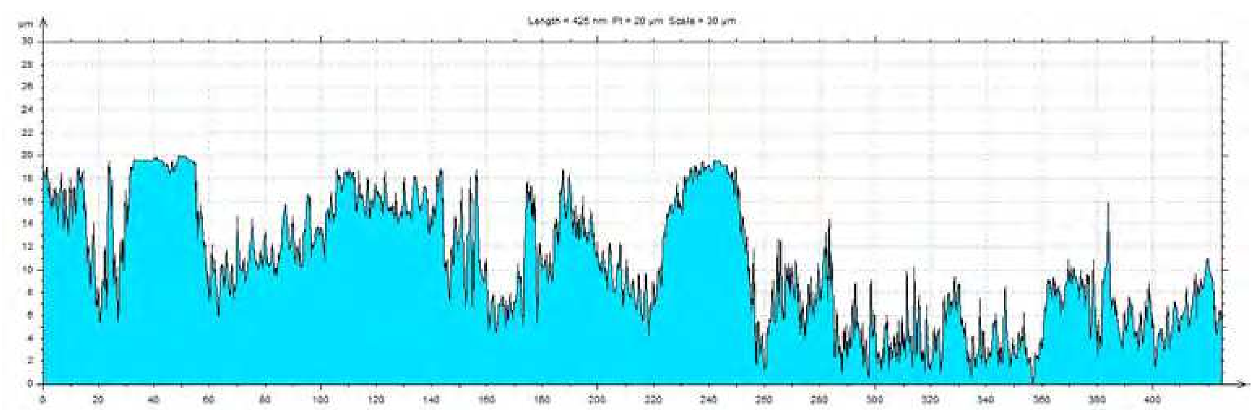


Fig. 13c. Roughness profile variation in the area marked for sample 2 VALUX PLUS

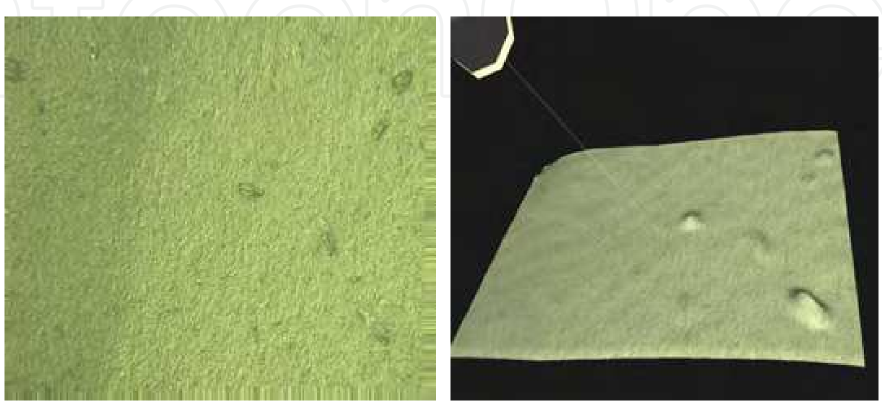


Fig. 14a. Sample 4 structure VALUX PLUS – photo-polymerization time of 9 min (thickness 4mm)

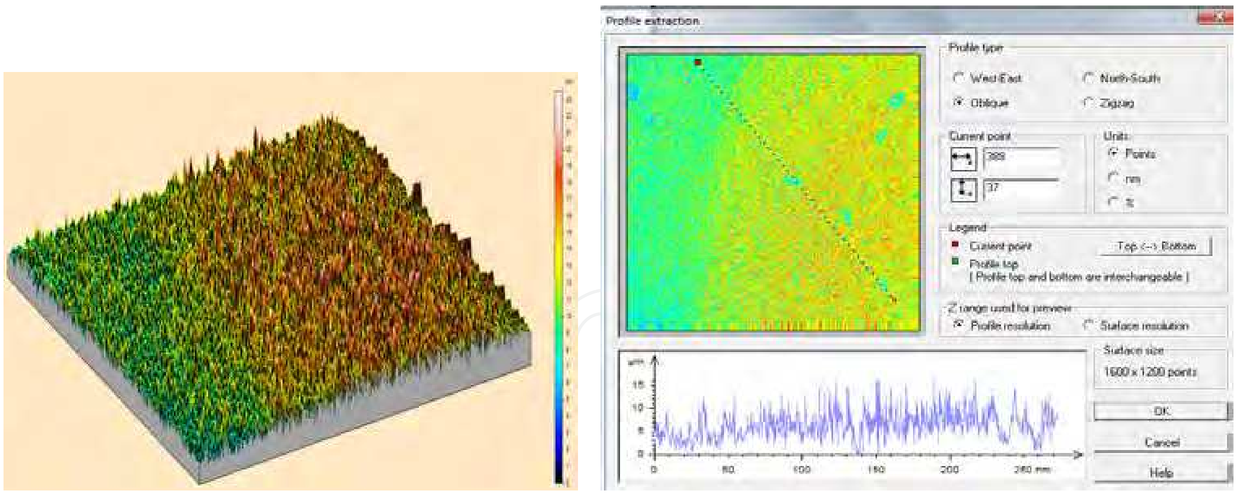


Fig. 14b. Sample 4 structure VALUX PLUS – photo-polymerization time of 9 min (thickness 4mm) and analyzed by MountainMap software

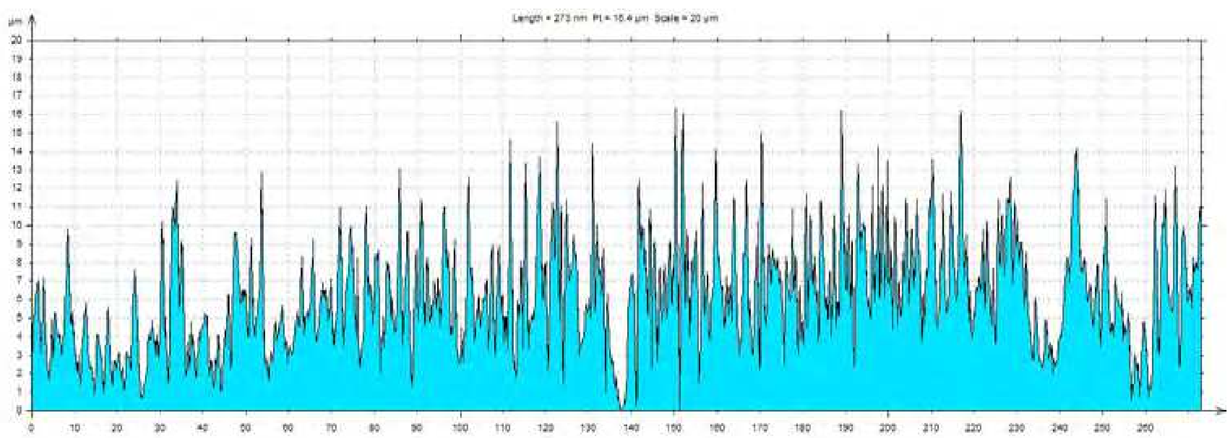


Fig. 14c. Roughness profile variation in the area marked for sample 4 VALUX PLUS

The third set of samples was made of: **Concise – 3M** self-photo-polymerization composite that was subjected to the same photo-polymerization methods (5, 6, 7 and 9 minutes)

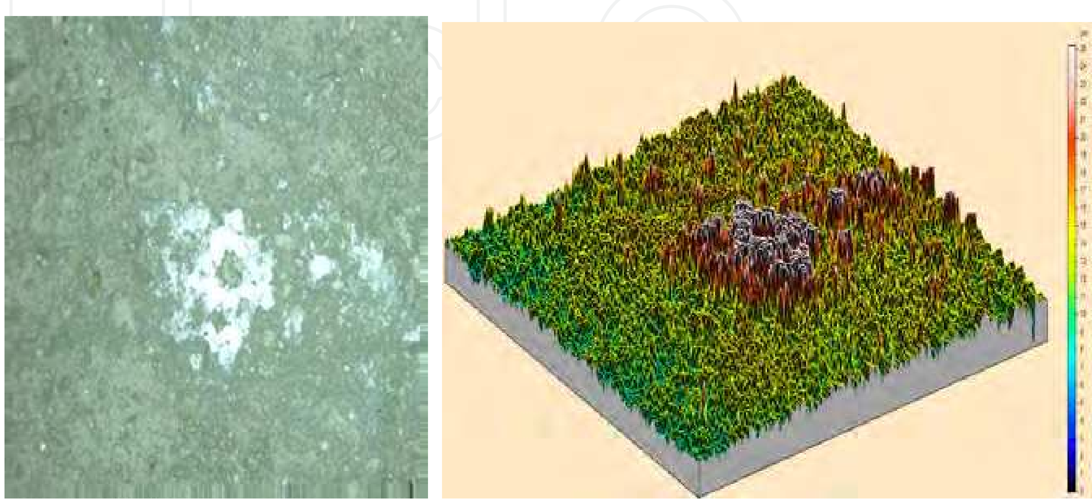


Fig. 15a. Sample 1 structure CONCISE 3M – photo-polymerization time 5 minutes

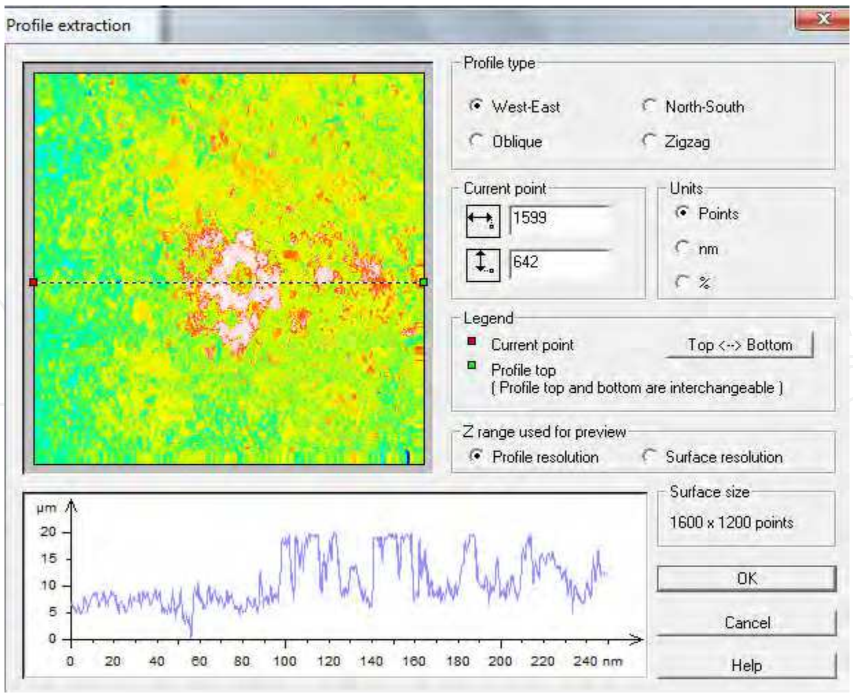


Fig. 15b. Sample 1 structure CONCISE 3M – photo-polymerization time 5 minute and analyzed by MountainMap software

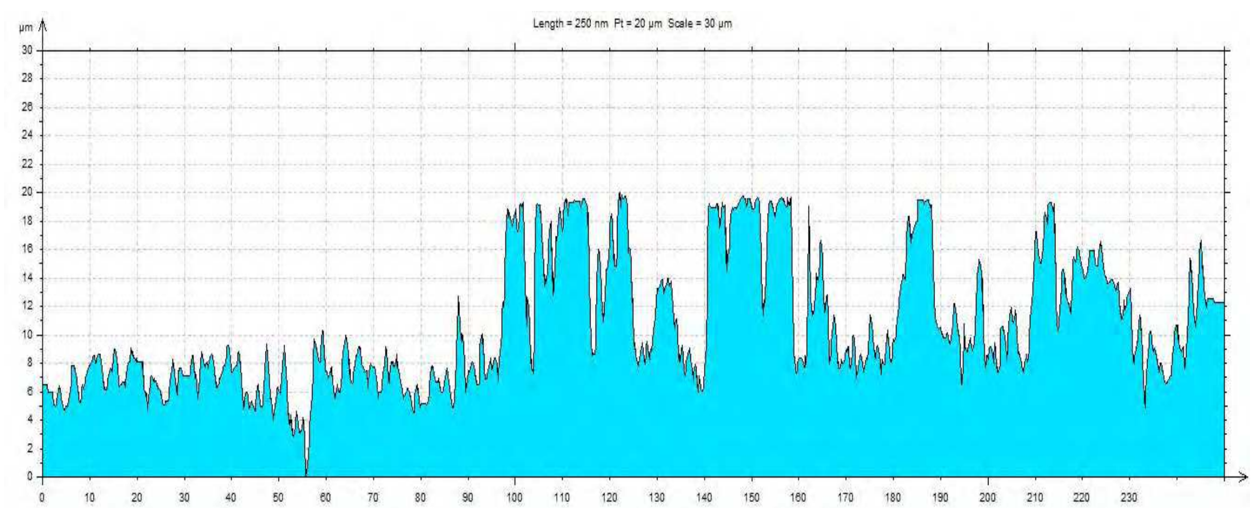
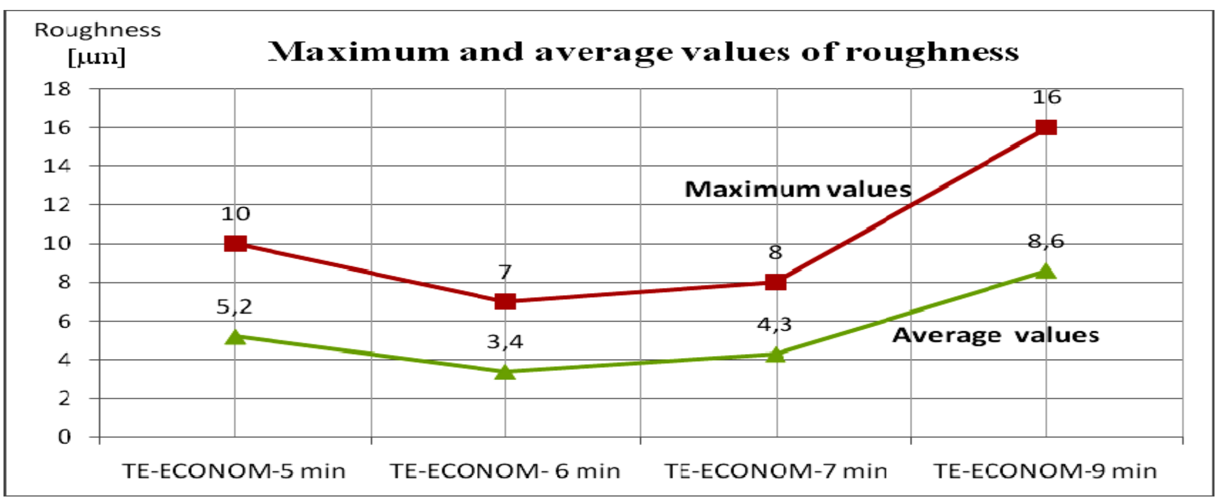


Fig. 15c. Roughness profile variation in the area marked for sample CONCISE 3M

From the performed measurements presented above we may observe the following:

- According to the materials polymerization degree we notice changes in their aspect depending on the photo-polymerization time interval;
- For Valux plus material we observed an incomplete polymerization due to the white spots upon the material surface, while for all the TE-ECONOM samples, the photo-polymerization was uniform, there were no white spots on the material surface;
- The two materials surfaces are very different, as for valux plus the surface does not appear entirely homogeneous, while for TE-ECONOM, the surface is much more homogeneous and uniform;

- The tested materials withstand very well the applied forces considering that: these analyzed materials resisted up to a 2300 N force, the equivalent of a 117 MPa strain for Valux Plus, respectively 2500 N, the equivalent of a 127 MPa strain for TE-ECONOM;
- Tests also performed on duropont composite materials showed they are able to withstand, according to the load type, centric or eccentric, forces of: 1600 N equivalent of a 48,9 MPa strain for centric compression, respectively of 1000 N equivalent of an 82,77 MPa strain for eccentric compression. All these results are determined considering that the bite force of a human being may reach the maximum value of 270 N;
- We also noticed based on the surfaces profile analysis that the photo-polymerization process determining the best surface quality must take place along a 6 min time interval for TE-ECONOM material and respectively along 9 minutes for Valux Plus material. As far as CONCISE 3M is concerned, regardless of the photo-polymerization time, the surface aspect presents an extremely changeable profile, which requires a prior processing. (fig.16.)



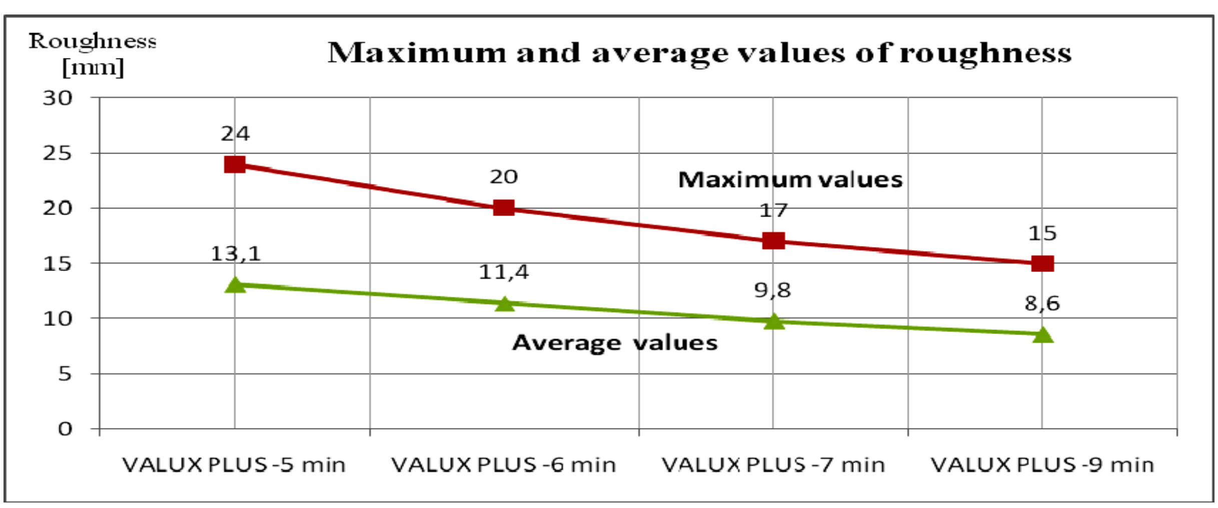


Fig. 16. Diagrams of roughness values

5. Microscopic analysis of edible substances upon the structure, quality and aspect of the dental prosthetic elements surfaces

In order to test the behavior of prosthetic elements in aggressive environments, prosthesis teeth presented in fig.17 were thoroughly cleaned up and introduced in washed and dried recipients, without any trace of impurities. Glass recipients, each carefully labeled, were filled with the following substances shown in fig.18:

- Water and sugar, concentration 50 %; water and salt, concentration 50 %; coke at room temperature; cold instant coffee concentration 1:1; vinegar; oil; alcohol (concentration 45%); grapefruit juice; orange juice; hot tea.

Fig. 17. Prosthesis teeth to be experimentally analyzed

Fig. 18. Recipients with substances used to test prosthesis teeth

As preponderant substances in human nourishment we established a number of 10 edibles that affect more or less the biocompatibility of restoration materials used in dental technique. These are:

- *Drinkable water with sugar, concentration 50%. Water* is a colorless, transparent, odorless and relatively tasteless liquid, having an average content of mineral substances (calcium carbonates, magnesium, sulfate salts). *Sugar* is some kind of carbohydrate mostly used being sucrose, a crystalline white solid. It is used to sweeten or improve taste of beverages or foods.
- *Salted water, concentration 50 %. Kitchen salt* is a solid, ionic, crystalline substance that contributes to the increase of intracellular osmotic pressure and blood pressure due to sodium ions and represents a basic preservative and spice in nourishment.
- *Coke* is a soft drink made of decocainized coke leaves. Name comes from two of the ingredients: coke leaves and cola beans. The distinctive "cola" flavor comes mainly from the sugar, orange oil, lemon oil and vanillin mixture, the rest of the ingredients having only minor contributions.
- *Instant soluble coffee, highly concentrated. Instant soluble coffee* is a black colored beverage containing caffeine, obtained of roasted coffee beans, ground and chemically processed containing PP vitamin (nicotinic acid or niacin). Coffee beans are the fruits of some plants from *Rubiaceae* family with two important varieties like *Coffea arabica* and *Coffea canephora*, first having superior quality beans. Coffee quality is also influenced by the place of cultivation, storage and the way the coffee beans are roasted.
- *Vinegar (acetic acid)* is an organic chemical compound that appears as a colorless liquid with a characteristic pungent odor that can be mixed in any proportion with water. Melting and boiling temperatures are 16,7 °C and respectively 118,2 °C. It is processed by acetic fermentation of alcohol diluted solutions, dried distillation of wood or oxidizing acetic aldehyde. Vinegar contains acetic acid in a 3–9% concentration.
- *Oil* is a fat liquid of vegetal, animal, mineral or synthetic origin, insoluble in water and lighter than water, used in nourishment and also industry, etc.
- *Tzuica (concentration 45 %)* is a Romanian traditional beverage obtained by plums fermentation and distillation.
- *Grapefruit juice. Grapefruit* is a citric fruit, big, round, yellow or rosy colored (*Citrus paradisi*), with juicy and bitter pulp, appreciated for the enzymes rich content stimulating digestion; it is obtained by pomelo and various types of oranges hybrids.
- *Orange juice. Orange* is a citric, round fruit, orange colored, with juicy and sweet-sour taste, appreciated for the rich content in active substances (hesperidins, pectin), acids (ascorbic acid, citric), alkaloids (betadine), sugars (fructose, galactose), vitamins (B2, B1, B6 and C), minerals (iron, calcium, magnesium, phosphorus, potassium, sodium, zinc.
- *Green tea with tangerines extract.* This is a type of tea obtained from *Camelia sinensis* leaves. Due to the rich content in theine and caffeine it is an excellent antioxidant, diuretic, cerebral stimulator, stimulator of fat burning process and anticancer factor protection. Mandarin extract is rich in A and C vitamins, pectin, beta carotene and esters.

Teeth were maintained in substances considered as aggressive environment for 7 days, at constant temperature and without contact to solar rays, then they were extracted and microscopically examined.

Recordings of the prosthesis teeth images before the experiments were taken, writing down the day and hour when they were introduced in the aggressive environment and there were pictures taken after the experiments (fig. 19). Further on the study on the digital microscope was performed in order to draw the conclusions concerning the experimental results.

Fig. 19. Prosthetic elements after experiment, isolated and labeled.

In order to establish an analysis methodology of prosthesis behavior, made of acrylic material with respect to the use by the human factor and to some surface tests, we selected a digital microscope VHX 600 Keyence type to visualize the structure changes at the level of active or support surfaces and respectively a universal machine for fatigue testing to determine the eccentric compression force.

The acquired images by help of the digital microscope with the video cam were stored in a database in order to be processed using a specialized software (Adobe Photoshop) in order to observe as many as possible characteristics of the analyzed prostheses surfaces.

These characteristics refer to the quality of the materials surfaces, dimensions or color to emphasize the possible deformations, deposits or excavations, existence of scratches, contact at the combined surfaces metal-acrylate or porcelain.

The acquisition methodology of the recordings consists of the following stages:

- we set the prosthesis teeth after the experiments on the microscope plate and captured a wide range of images to analyze, this way creating the microscopic images database;
- we analyzed then the prosthesis surfaces by help of a software dedicated to the digital microscope and processed the images to obtain other characteristics.

The stage of image acquisition and processing consisted of capturing images step by step (using *fine depth*) of the analyzed surface, reconstruction of their composition and saving the resulted 2D image. For each sample we captured 2-3 2D images (on various areas) and 2 images in 3D according to the analyzed surface.

The first analyzed sample was the one introduced in the mixture of *green tea with tangerines extract*. Due to the fact that the green tea has a high content of theine, caffeine and vitamin C we notice slight traces of corrosion upon the analyzed surface.

Corrosion occurs as a chemical reaction between the dental material and the aggressive environment. Analyzing the surface we can see that as a follow of the corrosion, the material lost its shine on the affected areas and we observed changes in color. The analysis was performed on 3 zones of the sample surface as shown in fig.20- fig.25.


Fig. 20. Zone I in depth

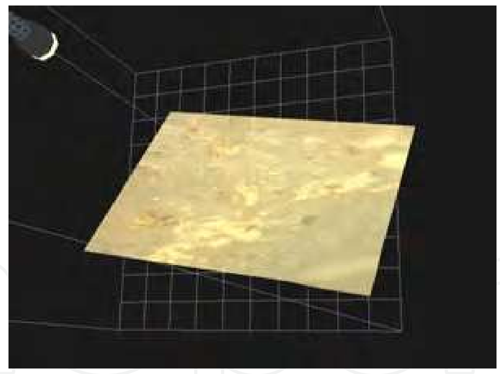


Fig. 21. Zone I – 3D


Fig. 22. Zone II in depth


Fig. 23. Zone II – 3D


Fig. 24. Zone III in depth

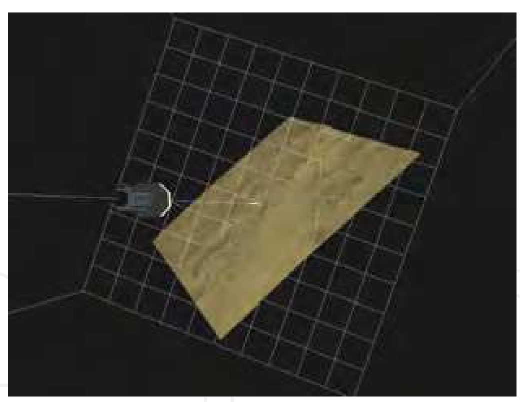


Fig. 25. Zone III – 3D

In all three analyzed areas upon the tooth surface we notice, due to the pigment in the tangerines extract, a series of deposits (stains) with reddish aspect. This is due to the adherence of the aggressive liquid upon the tooth surface.

The sample kept in *orange juice* presents on most of the analyzed surface several deposits with oily character given by pectin and esters quantity (essential oils) which are components of the orange extract. The liquid adhered to the tooth surface creating locally a sticky film. In fig. 26 and 27 we may observe the aspect of the sample surface.

Fig. 26.

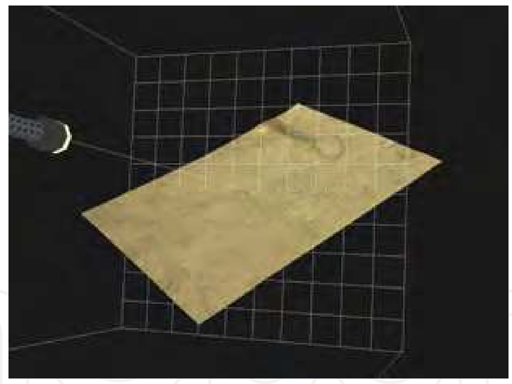


Fig. 27.

For the sample kept in *soluble coffee* the effects are really visible. Due to the high concentration of soluble coffee (1 teaspoonful to 1 teaspoonful of water) and its strongly acid character we notice in 28 .... 32 that the aggressive liquid adhered to the tooth surface leaving coffee traces as granules. This thing happened due to van der Waals forces and hydrogen links between the tooth surface and the aggressive environment. We also can notice changes of the dental material color on the surfaces where the coffee adhered.

Fig. 28. Zone I in depth

Fig. 29. Zone I 3D

Figure 30 shows the soluble coffee granule, intact, adhering on the surface layer of the dental material.

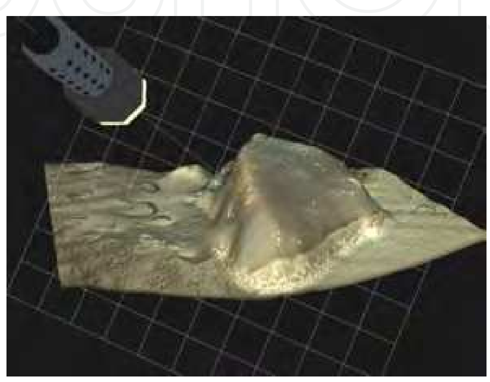


Fig. 30. Zone I 3D - light

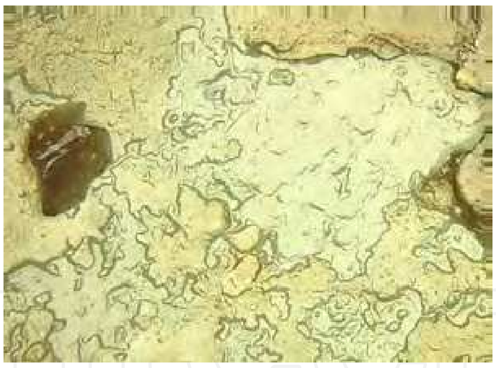


Fig. 31. Zone II in depth

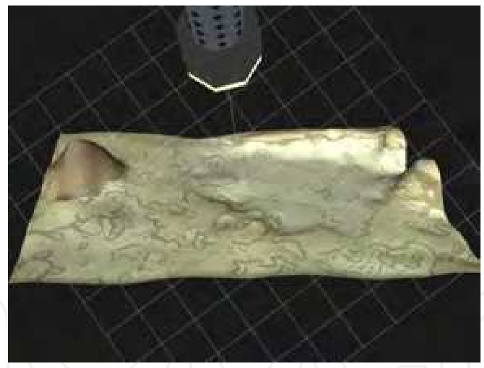


Fig. 32. Zone II 3D -light

Unlike the previous sample where the effects of the instant coffee are clearly visible as deposits upon the material surface, the sample kept in *coke* presents some corrosion traces on the dental surface determining the change of surface structure by losing shine. We captured images from 2 areas of the analyzed surface that were analyzed in depth as shown in fig. 33- 36.

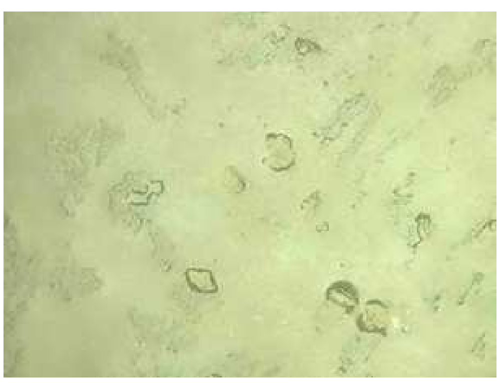


Fig. 33. Zone I in depth

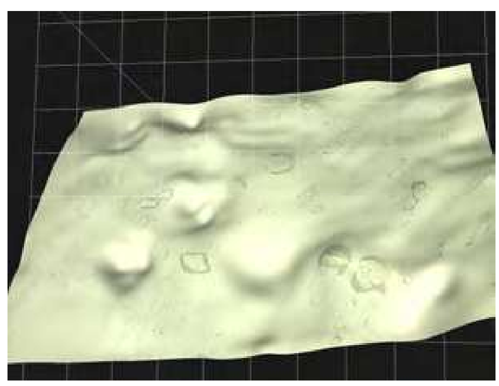


Fig. 34. Zone I 3D

Fig. 35. Zone II in depth

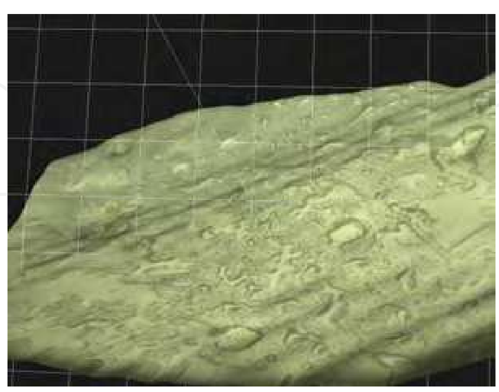
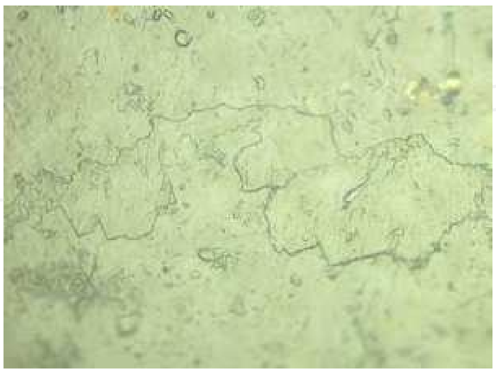


Fig. 36. Zone II 3D

For the sample kept in *acetic acid (vinegar)* the corrosion effects are really visible. Thus, in the first captured images, fig. 37 and 38, we may notice that the material adhered to the tooth surface, creating local deposits. In fig. 39 and 40, images 2D and 3D captured in depth we found local corrosions in plane on the dental material surface due to the acid character of vinegar.



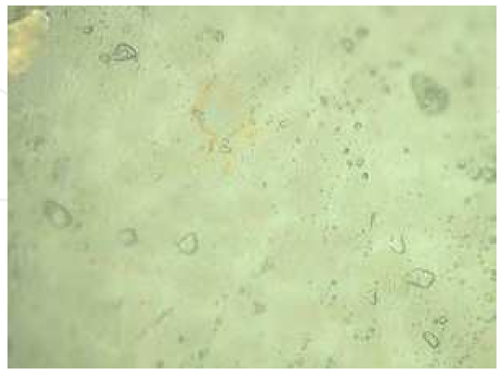


Fig. 37. Zone I normal

Fig. 38. Zone II normal

Also in depth analysis reveals local stains and loss of shine.

Fig. 39. Zone III in depth

Fig. 40. Zone III 3D

Unlike the previous samples where the aggressive liquids created stains or erosions of the studied material, for the sample kept in *salted water (NaCl)* – 50% we could notice deposits in parallelepiped crystals shape. Thus, following the image analysis we could see the NaCl granules that crystallized at air contact and adhered due to van der Waals forces to the studied dental material surface. Van der Waals forces act between all the close enough molecules and with stable electronic shells, without sharing electrons or transfer them between these particles. The behavior of dental material in salty solution, concentration 50% is represented in fig. 41 .... 44.

Fig. 41. Zone I in depth

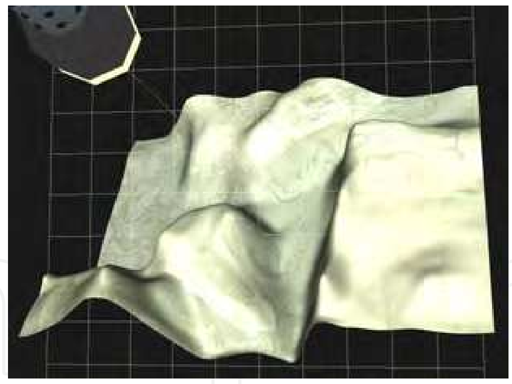


Fig. 42. Zone I 3D

Fig. 43. Zone II in depth

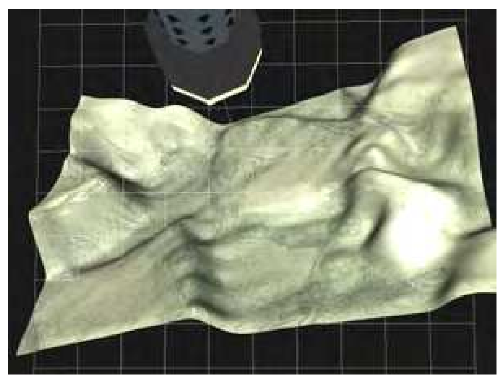


Fig. 44. Zone II 3D

In case of samples kept in *water with sugar*, concentration 50%, we notice that sugar at air contact crystallized in shape of white prismatic granules that created white deposits on the tooth surface. These deposits emerged due to a certain component of the refined sugar: an additive called E220 (sulfur dioxide). We also captured 4 images (2D and 3D) from two areas of the surface presented in fig. 45... 48.

Fig. 45. Zone I in depth

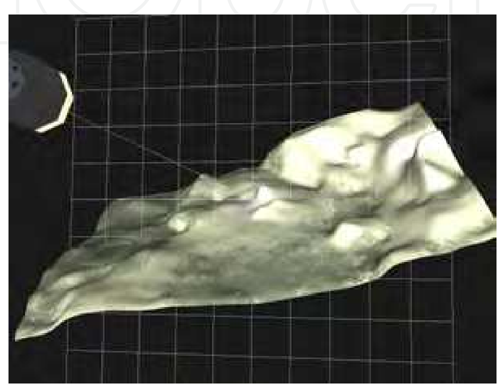


Fig. 46. Zone I 3D

Fig. 47. Zone II in depth

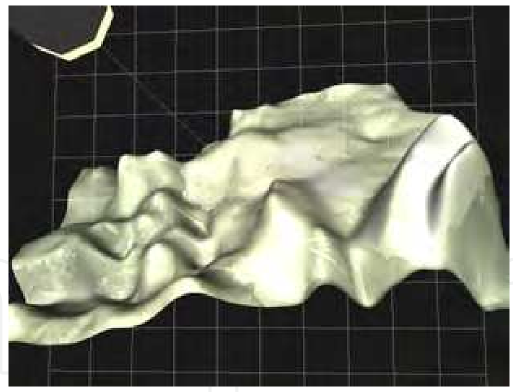


Fig.48. Zone II 3D

For the samples kept in *tzuica*, concentration 45% we captured three images (two in 2D and one in 3D). Following the image analysis we may notice some deposits upon the tooth surface and local chromatic changes due to alcohol. This is shown in fig. 49 ... 51 presenting the behavior of the dental material subjected to the action of alcoholic aggressive environment.

Fig. 49. Zone I normal

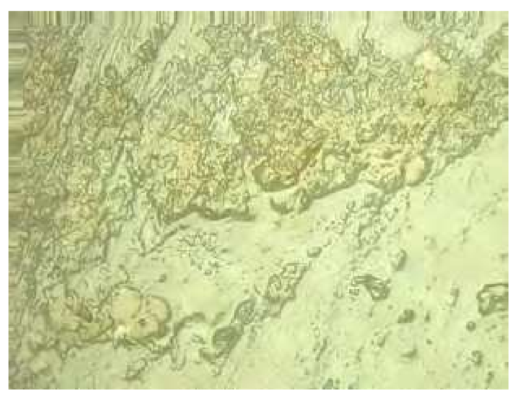


Fig. 50. Zone II in depth

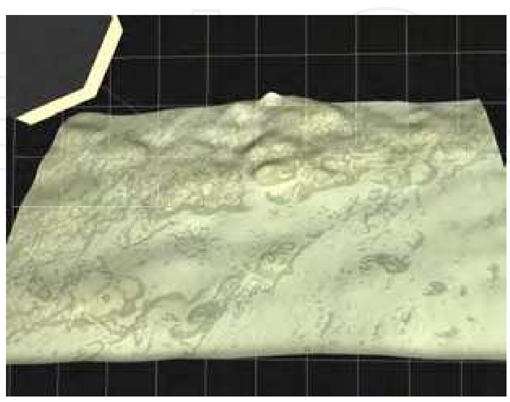


Fig. 51. Zone II 3D

Again, following the image analysis we found that the sample kept in *sunflower oil* resisted best to the action of the aggressive environment. Thus, the oil does not have damaging effects upon the material used in prosthetics; it creates though some oily deposits due to esters on the tooth surface. Fig. 52 and 53 reveal best this aspect.

Fig. 52. Zone I in depth

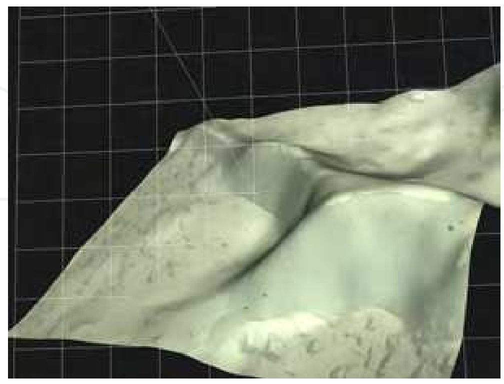


Fig. 53. Zone I 3D

6. Conclusion

Analyzing the benefits of composite materials based upon resins, used as dental materials, we may find the following: they do not include Hg; due to a suitable edge adjusting and a volume constant in time they do not allow deposits in the contact area between the two materials (root and tooth); there is a biocompatibility with the human organism; they obtain very hard materials with high mechanical resistance and consequently at least 20 years life cycle; the hardness of these materials being below the one of the dental enamel it does not scratch the antagonist teeth during mastication; the hardening reaction of these materials used in the dental office for root canals takes place in a few minutes, which proves to be very comfortable to the patient; the reticulation reaction of the polymerizable materials may take place without any chemical reaction with a reticular agent, only if exposed to a UV radiations lamp, meaning there is no toxicity for the human factor.

Among the disadvantages of using composite materials as dental materials we may list the following: situation when the hardening agent is not entirely consumed in the polymerization reaction and it may become toxic to the human body, triggering local inflammation; composite materials may sustain some mechanical damage due to forces occurred during mastication or due to important temperature changes, and if it is used in visible areas, it may present the fluorescence phenomenon when using a certain type of light radiation.

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8. References

Albrektsson, T. & Wennerberg, A. (2004), *Oral implant surfaces: part 1 – review focusing on topographic and chemical properties of different surfaces and in vivo responses to them.* Int. J. Prosthodont. 17, 536–543.

Anders Palmquist, Omar M. Omar, Marco Esposito, Jukka Lausmaa and Peter Thomsen (2010) *Titanium oral implants: surface characteristics, interface biology and clinical outcome,* J. R. Soc. Interface 2010 7, S515-S527 doi: 10.1098/rsif.2010.0118.focus;

Baritz M., Cotoros D., Cristea L.,(2010) *Analysis of dental implants behavior in mobilizing prosthesis*, The 12th WSEAS International Conference on MATHEMATICAL and COMPUTATIONAL METHODS in SCIENCE and ENGINEERING (MACMESE '10) Faro, Portugalia 2010;

Baritz M., Cotoros D., Moraru O., (2007) *Virtual and Augmented Reality Used to Simulate the Mechanical Device*, Annals of DAAAM &Proceedings of 18th International DAAAM Symposium, ISBN 3-901509-58-5;

Bratu D., s.a. (1994) *Materiale dentare-Materiale utilizate în cabinetul de stomatologie*; Editura Helicon;

Cotoros D. (2010) *Analyses by image processing of surface quality of mobile skeletal dental prosthesis*, International Conference on CNC Technologies, Bucharest, Romania, May 05-07, 2010

Cotoros, DL. et al. (2009) *Aspects concerning impact tests on composites for rigid implants*, WORLD CONGRESS ON ENGINEERING, London England, Pages: 1658-1661

Grosu L., s.a. (1983) *Biosistemul orofacial*, Cluj- Napoca, Ed.Dacia,.

http://www.digitalsurf.fr/en/index.html accessed oct.2010

Ieremia L., Dociu I., (1987) *Functia si disfunctia ocluzala*, Editura Medicala, Bucuresti, Romania,;

Lussi A., (2006) *Dental Erosion From Diagnosis to Therapy*, Copyright 2006 by S. Karger AG www.karger.com, ISSN 0077–0892 ; ISBN 3–8055–8097–5;

M Navarro, A Michiardi, O Castaño and J.A Planell, (2008), *Biomaterials in orthopaedics,* J. R. Soc. Interface 2008 **5**, 1137-1158, doi: 10.1098/rsif.2008.0151;

Rajeswari Ravichandran, Subramanian Sundarrajan, Jayarama Reddy Venugopal, Shayanti Mukherjee and Seeram Ramakrishna, *Applications of conducting polymers and their issues in biomedical engineering* J. R. Soc. Interface 2010 7, S559-S579 first published online 7 July 2010; doi: 10.1098/rsif.2010.0120.focus;

Regenio M, et al. (2009) *Stress distribution of an internal connection implant prostheses set*, Stomatologija, Baltic Dental and Maxillofacial Journal, 11, 2009,

Regenio Mahfuz Herbstrith Segundo, Hugo Mitsuo Silva Oshima, Isaac Newton Lima da Silva, Luis Henrique Burnnet Junior, Eduardo Goncalves Mota, Liangrid Lutiani Silva, (2009), *Stress distribution of an internal connection implant prostheses set: A 3D finite element analysis,* Stomatologija, Baltic Dental and Maxillofacial Journal, 2009; 11 (2): 55-59;

Rogozea L. et al. (2009), *Ethical Aspects in Bioengineering Research*, WSEAS Conference on Instrumentation, Measurement Circuits and Systems, China.

Stanciu A., Cotoros D., Baritz M., Florescu M. (2008), *Simulation of Mechanical Properties for Fibre Reinforced Composite Materials*, Theoretical and experimental aspects of continuum mechanics, WSEAS Cambridge;

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The book "New Technologies - Trends, Innovations and Research" presents contributions made by researchers from the entire world and from some modern fields of technology, serving as a valuable tool for scientists, researchers, graduate students and professionals. Some practical applications in particular areas are presented, offering the capability to solve problems resulted from economic needs and to perform specific functions. The book will make possible for scientists and engineers to get familiar with the ideas from researchers from some modern fields of activity. It will provide interesting examples of practical applications of knowledge, assist in the designing process, as well as bring changes to their research areas. A collection of techniques, that combine scientific resources, is provided to make necessary products with the desired quality criteria. Strong mathematical and scientific concepts were used in the applications. They meet the requirements of utility, usability and safety. Technological applications presented in the book have appropriate functions and they may be exploited with competitive advantages. The book has 17 chapters, covering the following subjects: manufacturing technologies, nanotechnologies, robotics, telecommunications, physics, dental medical technologies, smart homes, speech technologies, agriculture technologies and management.