Oxidative Chemical Hybrid Formulations for Internal Bleaching of Endodontically Treated Teeth

DIANA PASCALAU[1]*, MIRCEA CRISTIAN DUDESCU[2], VIOLETA MERIE[2], MARIUS PUSTAN[2], TRAIAN FLORIN MARINCA[2], DAN CRISTIAN IONEL[3]*, ANCA STEFANIA MESAROS[1].

[1]Iuliu Hatieganu University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Dental Propaedeutics and Aesthetics, 8 Victor Babes Str.,400000, Cluj-Napoca, Romania

[2] Technical University of Cluj-Napoca, Department of Mechanical Engineering, 28 Memorandumului Str.,400114, Cluj-Napoca, Romania

[3]Dunarea de Jos University of Galati, Faculty of Medicine and Pharmacy, 47 Domneasca Str., 800008,Galati, Romania.

This study aims to develop new biocompatible hybrid bleaching materials based on titanium dioxide (TiO_2), silica dioxide (SiO_2) and ascorbic acid (Aa) and to test the characteristics of the bleached teeth, by atomic force microscopy and compressive load at break analyses. The new bleaching agents have similar efficiency with sodium perborate but they are less aggressive towards the tooth than the peroxides. The efficiency of the novel bleaching system consists in lack of side effects, confirmed by mechanical tests.

*Keywords: ascorbic acid, internal bleaching, mechanical characteristics, silicon dioxide, titanium di*oxide

A non-vital tooth suffers changes in its optical characteristics and becomes prone to discoloration. Because the aesthetic demands are increasing yearly, the bleaching products industry developed very efficient materials in order to treat the discoloration [1]. The bleaching treatment is based on the chemical reaction of oxidation. The conjugated double bonds of the cromophore compounds are oxidated determining changes in teeth colour. For a non-vital tooth, internal bleaching is preffered. The internal bleaching procedure follows the *walking bleach* protocol [2,3].The most popular and efficient commercially available bleaching products consist in hydrogen peroxide, carbamide peroxide and sodium perborate. The major concern about these materials is the appearance of late complications [4-6] such as hypersensitivity, mucosal irritation, changes in enamel and dentine structure and micromorphological defects due to demineralization [7,8]. The changes of mechanical properties are leading to higher risk of coronal and root fracture. The most affected properties are surface morphology, texture and hardness. If the endodontic preparation is as minimal invasive as possible, there are great chances of reducing the fracture risk [9,30].

The paper proposes a novel approach for bleaching endodontically treated teeth using inorganic oxides with applications in both pharmaceutical and food processing industries, TiO_2 and SiO_2, respectively and to assess the potential changes in texture and surface morphology. TiO_2 is nontoxic and compatible with the human skin and mucous membranes [10,31,32]. The anatase crystalline form is used for pharmaceutical purposes more frequently than the rutile form. On the other hand, SiO_2 used in this study is known both as hydrophilic and inert filler material more likely than oxidizing agent. SiO_2 is used in the bleaching formulation as white hydrophilic filler.

Oxidative stress describes various deleterious processes resulting from an imbalance between protective antioxidants and damaging oxidants, such as reactive oxygen and nitrogen species. These species are also formed in physiology, reacting with cellular components in the process described as redox signaling [11,33,34]. The use of TiO_2 as oxidizing agent instead of the commercially available products could take advantage of the limited oxidative stress in dental environment with less potentially deleterious side effects. In adition to the two oxides, ascorbic acid was introduced in order to balance the oxidant/antioxidant local activity of the bleaching system, decreasing oxidation and leading thus to a mild bleaching process, less aggressive for dental structure.

Besides other inorganic oxides TiO_2 and SiO_2 nanoparticles were used as for coating microimplants or brackets in orthodontics as antimicrobial agents [12,35,36]. The influence of SiO_2 nanoparticles filler on the physical and mechanical properties of composite materials have been reported [13,37,38].

The presence of SiO_2 in hydrophilic mixture of mineral oxides, as mineral aggregate evaluated for antimicrobial effect on anaerobic bacteria isolated from infected root canals, is another argument for using this as hydrophilic filler in our bleaching formulations [14,39-41].

The aim of paper is to develop novel bleaching material formulations based on inorganic oxides mixed with antioxidant, used in a single step treatment. In order to evaluate the bleaching effect on the potential changes in texture and surface morphology of treated teeth, mechanical tests and atomic force microscopy analysis were performed.

Experimental part

Materials and methods

Materials used: food grade SiO_2 and 100% anatase TiO_2 (Degussa), ascorbic acid, artificial saliva and Tetrahydrate Sodium Perborate (Merck), Hydrogen Peroxide 35% (Ultradent), Sodium Hypochlorite 5.25% (Cerkamed), gutta-percha points, paper points and calcium hydroxide sealing paste (Meta Biomed), hybrid composite resin (GC Europe), temporary filling cement (Citodur, DoriDent).

Bleaching protocol

Sixty extracted monoradicular and pluriradicular human teeth were used in this study. The teeth were divided in 6 groups of 10 teeth each. Each group is formed of three types of teeth (premolar, molar and frontal teeth). Groups

**email: pascalau_diana@yahoo.com; Dan.ionel@ugal.ro*

Table 1
THE GROUPS TEETH SPECIMENS AND THE CORRESPONDING BLEACHING FORMULATION. COMPOSITION, ABBREVIATION AND COMPONENTS WEIGHT RATIO OF BLEACHING FORMULATIONS

Group teeth specimens	Bleaching formulation composition	Bleaching formulation abbreviation	Components weight ratio
Group 1	TiO_2 + Ascorbic acid + distilled water	TAa	T:Aa:W (0.3:0.1:0.1)
Group 2	TiO_2 + SiO_2 + Ascorbic acid + distilled water	TSAa	T:S:Aa:W (0.125:0.063:0.063:0.15)
Group 3	TiO_2 + SiO_2 + Tetrahydrate sodium perborate (P) + distilled water	TSP	T:S:P:W (0.125:0.063:0.063:0.25)
Group 4	Tetrahydrate Sodium Perborate + distilled water	P	P:W (0.8:0.3)
Group 5	Hydrogen peroxide 35% (Opalescence Endo 35%)	OE	OE 35%
Group 6	Control	C	-

1-5 were treated with five different bleaching formulations (table 1) while Group 6 is the control (endodontically treated, without bleaching). The teeth were selected based on predetermined inclusion criteria (vital teeth extracted on orthodontic purpose, sound dental crown) and exclusion criteria (having undergone any dental procedure before, cavities). The teeth were prepared for the endodontic procedure by cleaning with distilled water. The minimal invasive access cavity [15,16] was done on the occlusal surface of the pluriradicular teeth and on the oral surface of the monoradicular teeth. The mechanic treatment was performed using the Step-back technique with Kerr and Hedström needles. For the closure of canalar system the lateral condensation technique was performed using a sealing paste rich in Calcium hydroxide(Adseal, Meta Biomed, United States of America). A temporary cement was placed on the acces cavity (Citodur DoriDent, Wien, Austria).

Artificial staining was performed in order to simulate the appearance of discoloration. A solution of concentrated black tea (2 g in 100 mL distilled water) [17] was used to for the staining procedure. The treated teeth were immersed in the solution for 24 h.

The bleaching technique was started 24 h after staining. The temporary filling material was removed together with a 2 mm-thick part from the cervical canalar obturation. A 2 mm layer of glass-ionomer cement was placed in the gap in order to prevent root resorption. A certain quantity of bleaching material has been placed in the pulp chamber according to the Walking Bleach technique. Between treatment stages, all the specimens were kept in artificial saliva.

The novel materials were divided between the first three groups. In contrast, for groups 4 and 5 there were used commercially available bleaching products(P and OE).

At the end of the experiment, all the access cavities were obturated with a light-curing composite resin (G-aenial, GC, Europe).

X-ray diffraction analysis

X-ray diffraction (XRD) analysis was performed for characterizing crystalline structure of the purchased oxides. X-ray diffraction patterns were recorded using Inel model Equinox 3000 diffractometer, which operates in reflection with CoKa radiation (λ = 1.7903 Å). The difractometer equiped with CPS120 detector allows instantaneous diffraction signal detection at $90^o$with 0.08^o resolution. Samples were investigated on a rotating Al support to reduce the preferential orientation effects. Acquisition time for diffractograms was 10 min.

Mechanical properties

In order to evaluate the bleaching influence upon dental structures, the mechanical properties of the bleached specimens were determined, such as nanohardness, modulus of elasticity and the compressive load at break. The results were compared to previously reported values of endodontically treated teeth [18].

Atomic force microscopy investigations

The atomic force microscopy investigations were performed using a XE 70 microscope for nanohardness and modulus of elasticity determination. The mechanical characterization at nano scale is done by nanoindentation tests. The tests were carried out at room temperature with a 30% relative humidity. A TD21464 nanoindentor (stiffness: 156 N/m; frequency: 54 kHz; tip radius: < 25 nm; tip height: 103µm; thickness: 19 ∝m; length: 581 µm) was used for characterizing the samples [19].

The experimental research done in this study was performed at three different loads namely 20, 50 and 150 µN respectively. Four tests were performed for each load, in five different areas of each specimen. Before nanoindentation tests, each tooth was centered on a flat metal support, horizontal with the buccal surface facing upwards (fig. 1). A number of 54 teeth specimens has been investigated by AFM analysis. The results are the mean values of four tests in five different areas for each tooth and for each load [20].

Compressive load at break tests

Fig.1. The images of three teeth specimens prepared for AFM analysis

For the compressive load at break test it was used a universal testing machine (Instron 3366) with a cell load activated at a constant crosshead speed of 1mm/min. Each experimental group contained three types of teeth (incisors, premolars and molars). For each teeth type three specimens were tested, the reported data are the mean values of three measurements.

A number of 54 (n=9) teeth undergone the fracture resistance test. The teeth were immersed partially in acrylic resin (Duracrol, SpofaDental, Romania) filling a cylindrical container of 1,5 cm height and 1 cm in diameter. The root of teeth was immersed in acrylic resin until the cement-enamel junction as seen in figure 2 a.

The cylinder containing the specimen was introduced under a 45^{O} angle into a stainless steel holder (fig. 2 b). The holder was placed inside the machine and the load was applied to the oral cusp/oral surface of each specimen (fig. 2 c). The testing machine determined the moment of fracture by detecting the decrease in force measurement [21].

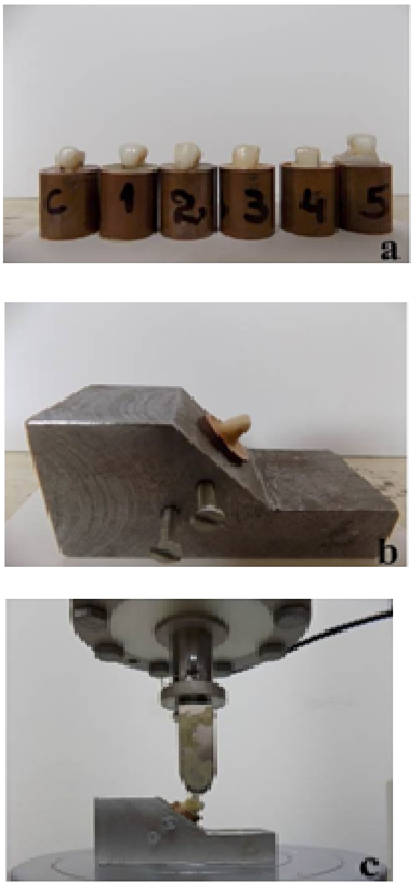


Fig. 2. The images of teeth specimens: belonging groups 1-5 and control (C) fixed in acrylic resin (a); placed in stainless steel holder under a 45^{O} angle (b); under compressive load at break test (c)

Results and discussions

XRD patterns of TiO_2 and SiO_2 samples are illustrated in figure 3. Indexing of XRD patterns was performed using JCPDS file (21-1272). X-ray pattern of TiO_2 indicates crystallization in tetragonal system from spatial group I41/amd characteristic for anatase. X-ray pattern of SiO_2 sample reveals an amorphous structure.

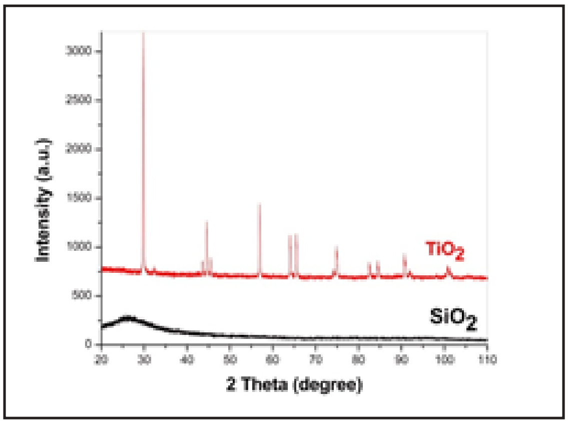


Fig. 3. XRD patterns of TiO_2 and SiO_2 samples

Mechanical properties

Atomic force microscopy analysis

The obtained results both from the topographical and mechanical points of view were interpreted using the XEI Image Processing Tool for SPM (scanning probe microscope) Data software. Tracks like those presented in figure 4 are obtained on the specimen surface after removing the loads.

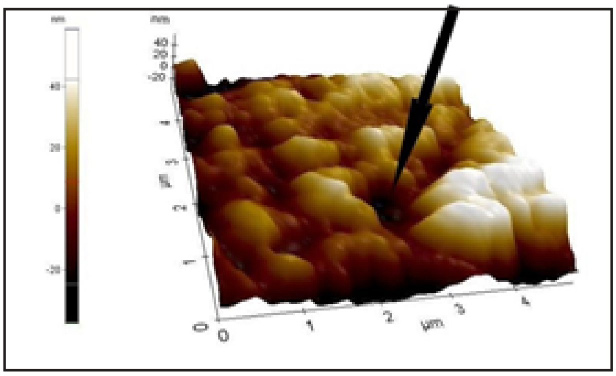


Fig.4. Track left on sample 1 belonging to group 1 surface by the tip of the nanoindentor

The force vs. Z scan curves are obtained after the indentation of the teeth specimens (fig. 5). These curves are interpreted using the Oliver and Pharr method for determining the nanohardness and the modulus of elasticity of the investigated teeth specimens (fig. 6).

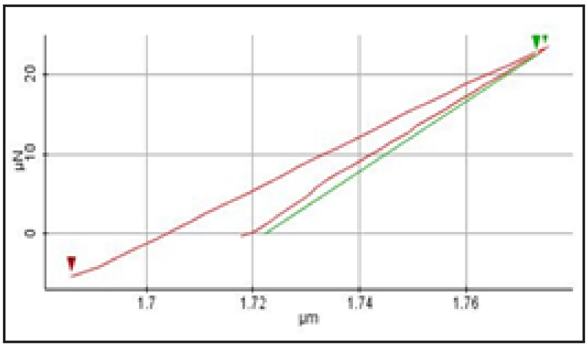


Fig.5. An example of the force vs. Z scan curve for the premolar 1.1 from Group 1

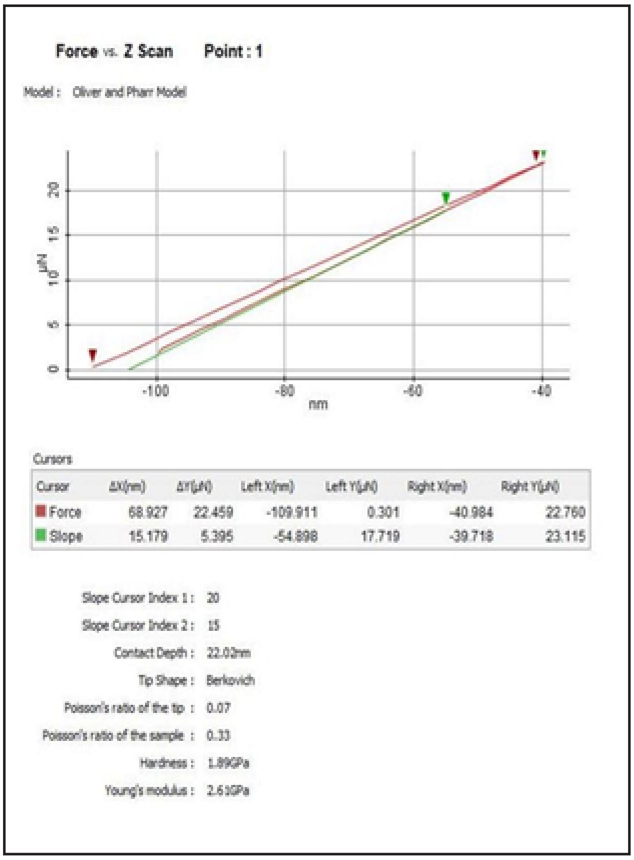
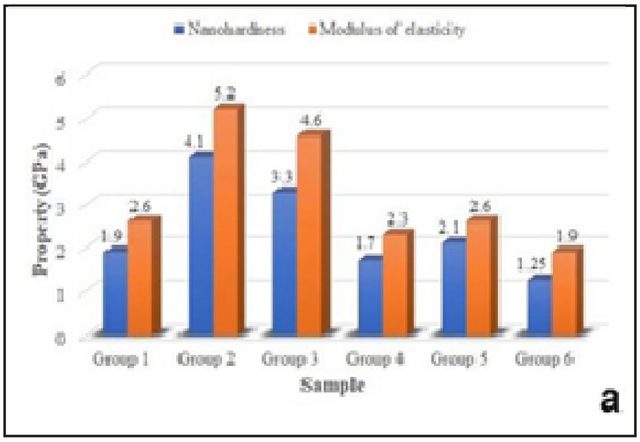
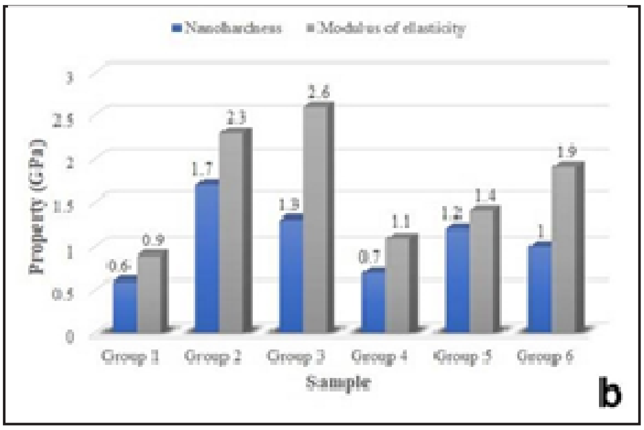


Fig. 6. Image of the XEI Image Processing Tool for SPM Data software for determining the nanohardness and modulus of elasticity of the premolar 1.1 from Group1

The mean values of nanohardness and modulus of elasticity of tested teeth specimens for each of the three different loads are displayed in figure 7.





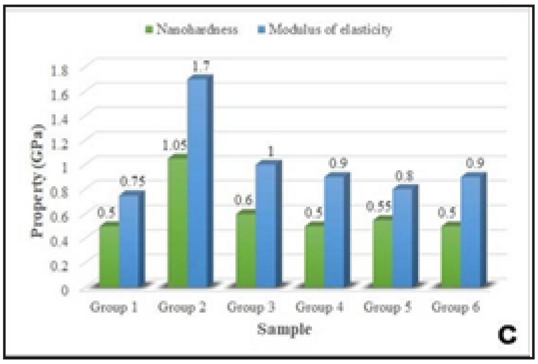


Fig.7. The mean values of the nanohardness and modulus of elasticity for the investigated Groups (1-5) and Control (Goup 6) teeth specimens at different loads: (a) 20, (b) 50 and (c) 150 μN

Compressive load at break

The compressive load at break (N) mean and standard deviation values of the experimental groups of endodontically treated and bleached teeth (groups 1-5) versus the control (group 6), endodontically treated only, without any bleaching treatment, are displayed in table 2.

Table 2

MEAN AND STANDARD DEVIATION OF THE COMPRESSIVE LOAD AT BREAK (STANDARD) (N) FOR THE TESTED GROUPS

Experimental groups n=9	Mean ± Standard Deviation		
	Anteriors	Premolars	Molars
Group 1	302.42± 57.45	320.77±60.43	492.32±93.5
Group 2	544.87±125.32	479.02±110.17	768.18±153.63
Group 3	332.24±35.88	502.09±54.25	996.63±99.66
Group 4	411.77±127.6	447.12±134.13	854.09±230.60
Group 5	345.38±23.83	395.90±25.73	584.35±35.06
Group 6	429.83±31.80	450.63±36.05	1020.64±81.65

It was used food grade 100% anatase TiO_2 whose crystalline structure was confirmed by XRD diffraction pattern. The most important redox processes on the surface of TiO_2 particles are: the reduction of oxygen (O_2) in air (eq. (3) and oxidation of water (eq. 4). When O_2 is reduced by one electron provided by TiO_2 (3), it becomes a superoxide radical ($O_2^{-}\bullet$) that is further reduced by one electron (4) or reacts with a hydroperoxyl radical ($HO_2\bullet$, i.e. protonated $O_2^{-}\bullet$) to form hydrogen peroxide (H_2O_2) [22]. One-electron reduction of H_2O_2 (5) produces hydroxyl radical ($OH\bullet$). The effect of H_2O_2 addition on the rate of $OH\bullet$ formation in aqueous suspension systems was studied for various TiO_2 crystalline forms [23]. The $OH\bullet$ formation rates were increased with the addition of H_2O_2 for rutile-containing anatase, and for rutile. The quite opposite tendency was observed for 100% anatase TiO_2, where the $OH\bullet$ formation rate decreased on H_2O_2 addition.

$$O_2 + e^- \rightarrow O_2^{-}\bullet \qquad (3)$$

$$O_2^{-}\bullet + 2H^+ + e^- \rightarrow H_2O_2 \qquad (4)$$

$$H_2O_2 + H^+ + e^- \rightarrow OH\bullet + H_2O \qquad (5)$$

The formation of superoxide radical ($O_2^{-}\bullet$) determines an oxidative stress in the system, leading to the bleaching effect of the surrounding medium. The main reason for choosing anatase TiO_2 is to prevent, as much as possible, supplementary radical reactive species formation, in order to make the oxidative process less aggressive on dental tissue. The Aa added in the formulations TAa and TSAa slows down the oxidative process by partially scavenging the reactive radicals, useful for a mild bleaching effect on non-vital teeth.

Figure 7 shows the variation of the hardness and the modulus of elasticity of the investigated samples. The two mechanical characteristics are decreasing with the increase in loads. However, a similar trend is observed regardless of the loads. The values of the tested samples are relatively close (of the same order of magnitude) to the control sample. This indicates that the whitening treatment does not lead to a significant change in mechanical properties of the teeth. In addition, nanohardness and modulus of elasticity may fluctuate because the teeth coming from different people have different intrinsic characteristics.

The fracture resistance values were similar to the control group. The results are similar with the values of untreated teeth found in literature, namely mean values of 502.5 N for anterior teeth [24], a range from 177.7 N to 445.38 N for premolars [25-27] and a range from 364.18 N to 1129 N for molars [28,29,42].

Group 5 recorded lower values of resistance, meaning that hydrogen peroxide alters the tooth's internal structure that leads to a lower value of fracture resistance. The higher resistance values of group 3 indicate the synergistic effect of the three bleaching agents mix (T, S and P) which allow satisfactory bleaching, being less aggressive on dental structure.

The obtained results regarding mechanical tests highlight the fact that the treatment using the bleaching formulations TAa and TSAa doesn't affect the dental structure of the tested teeth. Further studies should be performed in order to test other plausible side-effects, such as root resorption.

Further studies could involve the enhancement of TiO_2 internal bleaching effect by photosensitization. Prospective studies should be done on the protein content of human enamel influence on the mechanical properties from freshly extracted teeth and on root resorption after treaments with hybrid bleaching agents.

Conclusions

Results regarding the utility of the developed bleaching system reveal good bleaching effect on discolored non-vital teeth. The efficiency of the novel bleaching systems consists in reduction of side effects, confirmed by mechanical tests. The most effective bleaching results were achieved by formulations including TiO_2/Aa; TiO_2/SiO_2/Aa and TiO_2/SiO_2/small amount of sodium perborate. The obtained results in respect to the bleaching treatments performed in this study using both bleaching agent and the antioxidant, in certain ratio, concomitantly in a single treatment step show the efficiency of using them in this manner, rather than applying the antioxidant consecutively. This opportunity is very important as it leads to the shortage of treatment procedures.

Acknowledgement: This research was funded by Iuliu Hatieganu University of Medicine and Pharmacy, internal grant no. 4995/7/ 08.03.2016.

References

1.Da SILVA POBBE, P.O., VIAPIANA, R., SOUZA-GABRIEL, A.E., et al., J Dent, **36,** 2008, p. 935.
2.MACEY,DARE, L.V., WILLIAMSH, B., Int J Paediatr Dent.,**7**,1997,p. 35.
3.WATERHOUSE, P.J., NUNN, J.H., Quintessence Int., **27**, 1996, p. 447.
4.DIDIER, V.F., BATISTA, A.U.D., MONTENEGRO, R.V., FONSECA, R.B. et al., Int J Adhes Adhes, **47**, 2013, p. 141.
5.MADHU, K.S., HEGDE, S., MATHEW, S., LATA, D.A., BHANDI, S.H., SHRUTHI, N., J Int Oral Health, **5**, no**.**4, 2013, p. 49.
6.R GANESH, S ARUNA, M JOYSON, M MANIKANDAN, D DEEPA, J Indian Soc Pedod Prev Dent., **31**(1)**,** 17 (2013).
7.GOLDBERG, M., GROOTVELD, M., LYNCH, E., Clin Oral Invest., **14**, 2010, p. 1.
8.ALQAHTANI, M.Q., Saudi Dent J., **26**, 2014, p. 33.
9.MONGA, P.,. SHARMA, V, KUMAR, S., J Conserv Dent., **12**, no. 4, 2009, p. 154.
10.SIWINSKA-STEFANSKA, K., NOWACKA, M.,. KO1ODZIEJCZAK-RADZIMSKA, A, JESIONOWSKI, T., Dyes Pigments, **94,** 2012, p. 338.
11.TOURNEBIZE, J., SAPIN-MINET, A., BARTOSZ, G., LEROY, P., BOUDIER, A., Talanta, **116,** 2013, p. 753.
12.ZEGAN, G., ANISTOROAEI, D., GOLOVCENCU, L.,. CERNEI, E. R, DASCALU, C.G., CARAU, E.M., Rev. Chim. (Bucharest), **68**, no.9, 2017 p. 2052.
13.ALMASI, A, PORUMB, A., PODARIU, A. C., TODOR, L., TOFAN, S. A., POPOVICI, R. A., Rev. Chim. (Bucharest), **68,** no.1, 2017, p. 192.
14.ESIAN, D., MAN, A., POP, S., EARAR, K.,. BUDACU, C.C, CERGHIZAN, D., BUD, A., C. BICA, Rev.Chim. (Bucharest), **67**, no.6, 2016, p. 1207.
15.KALAY, T.S., YILDIRIM, T., ULKER, M., J Prosthet Dent., **116,** 2016, p. 404.
16.FARIA, A.C.L., RODRIGUES, R.C.S., Pereira de Almeida Antunes, R., Chiarello de Mattos, M.G, Ribeiro, R.F., J Prosthodont Res., **55**, 2011, p. 69.
17.GRIFFITHS, C.E.,. BAILEY, J.R, JARAD. F.D.,. YOUNGSON, C.C, J Dent., **36**, 2008, p. 54.
18.GAIKWAD, A.M.,SHAH, N.,RAM, S.M., J Contemp Dent.,**7**,2017, p. 97.
19.HEA, L.H., FUJISAWAB, N., SWAINA, M.V., Biomaterials, **27**, 2006, p. 4388.
20.CRAIG, R.G., PEYTON, F.A, J. D. Res, **37**, 1958, p. 661.
21.MONGA, P., SHARMA, V., KUMAR, S., J Conserv Dent., **12**, 2009, p.154.
22.Y NOSAKA, A NOSAKA, Identification and roles of active species generated on various photocatalysts, Photocatalysis and water purification: From fundamentals to recent application, Wiley-VCH Verlag Gmbh &Co, 2013
23.HIRAKAWA, T.,. YAWATA, K, NOSAKA, Y., Appl Catal A., **325**, 2007, p.105.
24.GABSEVICIUTE, D., JACINKEVICIUTE, L., SKIRBUTIS, G., J Cont Med A Dent., **5**, 2017, p. 4.
25.MINCIK, J., URBAN, D., TIMKOVA, S., URBAN, R., Int J Biomater, **1**, 2016, p.1.
26.COSTA, S., SILVA-SOUSA, Y., CURYLOFO, F et al., Int J Adhes Adhes, **50**, 2014, p. 211.
27.SCOTTI, N., ROTA, R., SCANSETTI, M et al., J Prosthet Dent, **110**, 2013, p. 376.
28.SCOTTI, N., FORNIGLIA, A., TEMPESTA, R.M. et al., J Dent., **53**, 2016, p. 82.
29.SALAMEH, Z., OUNSI, H.F., ABOUSHELI, M.N., SADIG, W., FERRARI, M., J Dent, **36**, 2008, p.513.
30.CIOATA, R.,BALAN,A., ANTOHE,M.E.,SAVIN,C., IGNAT,G., BASNO,A., Researches Regarding New Biomaterials Involved in Sports Mouthguard, Mat.Plast. **53**, no.1,2016, p.147-149
31.MINOVSKA, A., POPOVSKA, M., RADOJKOVA-NIKOLOVSKA, V., CVETANOVSKA STOJCHEVA, D., POPESCU, E., AGOP FORNA ,D., Study regarding the use of er: yag laser for initial treatment of periodontal disease**,** Rev. Chim.(Bucharest), **66**, no. 7, 2015, p.1052-1056
32.GRADINARU I., ANTOHE, M.E., IOANID, N., Contemporary therapeutic decisions in the treatment of various types of edentation, Romanian Journal of Oral Rehabilitation,8(2), 2016, p:44
33.BUHACEANU R., LUNGU N.C., , FORNA N.C., et all, Anew Class of Mesoionic4-(1,3-Dithiol-2-ylium)phenolates, Rev.Chim**.**(Bucharest)**,** **64**,no.8,2013,p.803-807
34.ANTOHE, M.E., AGOP FORNA, D.,DASCALU,C.G.,FORNA, N.C., The importance of observing the aesthetic requirements in partial edentulous rehabilitation - implications in medical-dental training,

International Journal of education and information technologies, Volume:10, p.199-203, 2016
35.BUHACEANU, R.,LUNGU, N.C., FORNA, N.C et all,The Influence of Bromine Substituent on Optical Properties of Some 1,3-Dithiolium Derivatives, Rev.Chim. (Bucharest),**64**, no.9,2013, p.960-964
36.ISTRATE,B.,MUNTEANU,C.,CRIMU, C.I., IACOB, S.S., MARCELIN, B., EARAR, K., Morphological and tribological aspects of some ZrO2 coatings on Mg-Ca biodegradable alloys,Indian Journal of Engineering and materials sciences, 23(6), 2016: 418-424
37.ISTRATE ,B., MARECI,D., MUNTEANU, C., STANCIU,S., CRIMU,C.I., TRINCA, L.C., EARAR, K.,In vitro electrochemical properties of biodegradable YSZ-Coated MgCa Alloy, Environmental engineering and management journal,15(5),2016,:955-963
38.BARBINTA ,C.A., EARAR,K., CRIMU, C.I., In vitro evaluation of the cytotoxicity of some new titanium alloys, Bioceramics, Vol25, Book series:Key Engineering Materials, Vol 587,2014,303
39.FORNA N, CIMPOESU N; SCUTARIU MM; et al, Study of the electro-corrosion resistance of titanium alloys used in implantology, Book Group Author(s): IEEE, Conference: 3rd International Conference on E-Health and Bioengineering (EHB) Location: Univ Med & Pharm, Iasi, ROMANIA Date: NOV 24-26, 2011
40.EARAR,K., CERGHIZAN,D., SANDU, A.V., MATEI, M.N., LEATA,R., SANDU, I.G., BEJINARIU, C., COMAN, M.,. The Role of Functional Polymers in the Optimization of the Acrylic Biomaterials Used in Removable Prosthetic Restoration - II. Assessment of traction test and antifungal activity. Mat.Plast., **52**,no.4, 2015,p.487-493
41 JUMANCA, D., GALUSCAN, A., PODARIU, A. C., BORCAN, F., Anti-inflammatory action of toothpastes containing Betulin nanocapsules, Rev.Chim.(Bucharest), **66**,no.12, 2014, p.1473-1476
42.ANTOHE, M.E., AGOP FORNA, D.,DASCALU,C.G.,FORNA, N.C., The importance of observing the aesthetic requirements in partial edentulous rehabilitation - implications in medical-dental training, International Journal of education and information technologies Volume: 10, p.199-203, 2016

Manuscript received: 11.01.2018