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The Effect of (C7H6O2,C6H8O7, C2H4O6) Acids on Microstructure of FPL and FP Dental Ceramics

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Abstract:

Sixteen ceramic disk specimens (10mm) hight, and (8mm) thick were made from Felspatic Lucite (FPL) ($K_2O.Al_2O_3.4SiO_2$), and Flouropatite ceramic ($Ca_{10}P_6O_{24}F_2$). The specimen were then immersed in citric acid ($C_6H_8O_7$), tartaric acid ($C_2H_4O_6$), and benzoic acid ($C_7H_6O_2$) at (37) C^o for (50,100,150,200) hours. Microstructure of the specimens was detected using SEM before and after the immersion, it has been found that FP dental glass ceramic microstructure is more stable than FPL composite dental ceramic in the tested food acids, and citric acid has the largest damaging effect on both FP, and FPL.

Key Words:- Dental Ceramic, Food acids, Etching.

Introduction:

Dental ceramic is a nonmetallic inorganic structure primarily containing compounds of oxygen with one or more metallic or semi-metallic elements such as Al, K, Ca, and Si [1-4]. Two concepts must be regarded about dental ceramics(1) highly aesthetic dental ceramics are predominantly glassy, and higher strength substructure ceramics are generally crystalline, and(2) the history of development of substructure ceramics involves an increase in crystalline content to fully crystalline[5-8]. The change from glassy crystalline dental ceramic can be achieved either by addition of ceramic filler particles to form a composite material[9]. Filler particles are added to the base glass composition to improve mechanical properties and to control optical effects such as opalescence, color, and opacity such as Felspathic Lucite (FPL) ($K_2O.Al_2O_3.4SiO_2$) dental ceramic which contain two phases; Felspathic glassy phase ($K_2O.4SiO_2$) and (40-55%) Lucite crystalline phase (Al_2O_3) [10,11].The second way to add crystalline filler particles to a predominantly glassy dental phase are grown inside the glass object (prosthesis or pellet for pressing into a mold) after the object has been formed [12-13]. After forming, the glass object is given a special heat treatment causing the precipitation and growth of crystallites within the glass. Because these fillers are derived chemically from atoms of the glass itself, it stands to reason that the composition of the remaining glass is altered as well during this process termed ‘ceraming’. Such particle-filled composites are called glass-ceramics [14-20]. Dicor or fluoraoatite (FP) (Ca10 P6O24 F2) is the first commercial glass ceramic available for fixed prostheses, contained filler particles of a type of crystalline mica (at-55vol%).More recently, a glass-ceramic containing 70 vol% crystalline lithium disilicate filler has been commercialized for dental use[21,22].The potential erosive effect of acidic food additives on all dental ceramic has not been clearly documented [23], so this research tends to study and compare between the effect of citric acid (C6H8O7), tartaric acid (C2H4O6), and benzoic acid (C7H6O2); which are the mostly used food acids in soft drink like different kind of juices, seven up and cola drinks on microstructure of felspathic lucite(FPL) crystalline filled dental ceramic, and flourapatite(FP) dental glass ceramic.

Experimental Part:

Sixteen ceramic disk specimens(10mm) hight, and (8mm) thickness were made from Felspatic Lucite (FPL) (K2O.Al2O3.4SiO2) Vivadent AG company, and Flouropatite ceramic (Ca10P6O24F2) IPS Empress Esthetic company. The specimen were then immersed in (4,5,6)% concentration of citric acid (C6H8O7), tartaric acid (C2H4O6), and benzoic acid (C7H6O2) at (37)C^{o} for (50,100,150,200) hours. Microstructure of the specimens was detected using SEM before and after the immersion.

Results and Discussion:

Dental ceramic is the most preferred restorative materials thanks to their bio-compatible structures, perfect esthetic results and the capability of being used in various dental applications[5]. Although dental ceramics are generally recognized as bio-compatible materials, but they have a porous structure means it will affect by any contact with chemicals such as acidic food, sour fruit and drinks [12], this effect has been thourghly studied in this research by detecting microstructure of two different types of dental ceramic which are (i) FPL composite dental ceramic, and (ii) FP dental glass ceramic with SEM before and after immersing in citric acid (C6H8O7), tartaric acid (C2H4O6), and benzoic acid (C7H6O2) at (37)C^{o} for (50-200) hours. Figure(1) illustrates SEM images of the two concerned dental ceramics.

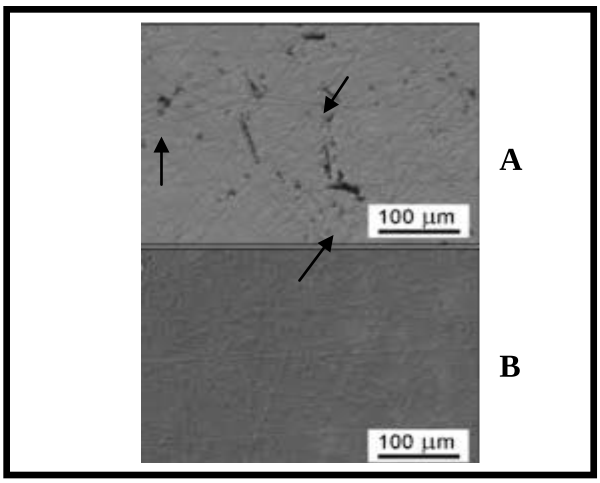

Figure (1) SEM Images of (A) Feldspathic Lucite FPL composite dental ceramic, (B) Fluorapatite FP dental glass ceramic

From the figure above ;it is easy to notice the following differences between FPL (fig 1 A) and FP (fig 1 B) dental ceramics:

Microstructure of FP (B) dental glass ceramic is much smoother than FP (A) dental composite ceramic, this is due to the fact that glass ceramics are a class of materials where in a large number of ultra small crystallites are dispersed in a glassy matrix[10]. This smoothness will effect on chemical resistance of both types since any increase in surface roughness of ceramics generally effect on the penetration of ceramic restorations with chemical agents, eventually affecting on clinical success of dental ceramic.

Figure (1A) shows microstructure of FPL dental composite ceramic, we clearly saw the embedded Lucite (Al_2O_3) particles (refers by arrows) through the feldspathic ($K_2O.4SiO_2$) the good dispersion of (Al_2O_3) phase through the ceramic matrix means more grain boundaries between the two phase, these boundaries will be the weakest points when the restorations be in contact with chemicals.

Food acids are added to make flavors sharper, and also acts as preservatives and antioxidants. Common food acid include citric, tartric, and benzoic acids among several other acids [12]. These three acids are a common ingredients in drinks like cola, seven up, grape, pineapple, and citreous fruit juices, hence they will be in direct contact with dental ceramics. Figures (2-4) illustrates the effect of citric acid ($C_6H_8O_7$), tartaric acid ($C_2H_4O_6$), and benzoic acid ($C_7H_6O_2$) at (37)Co for (50-200) hours respectively on microstructure of FPL composite dental ceramic.

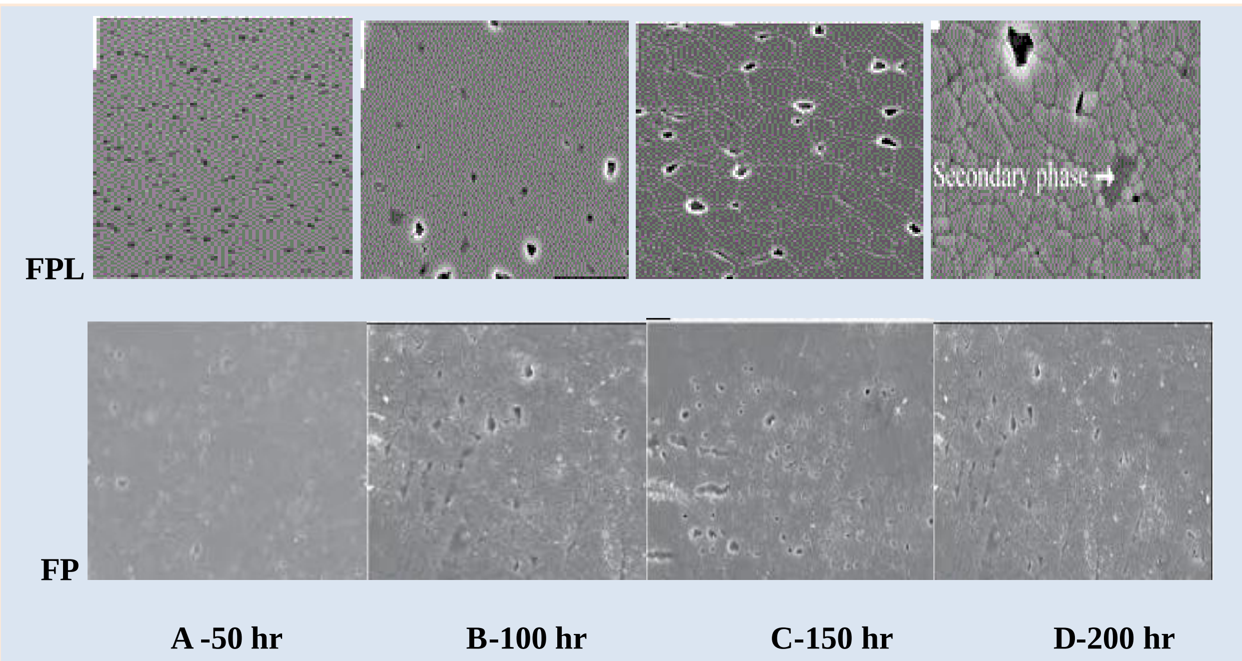

Figure (3) 50µm SEM Images of FPL, and FP dental ceramics after four immersing periods in benzoic acid

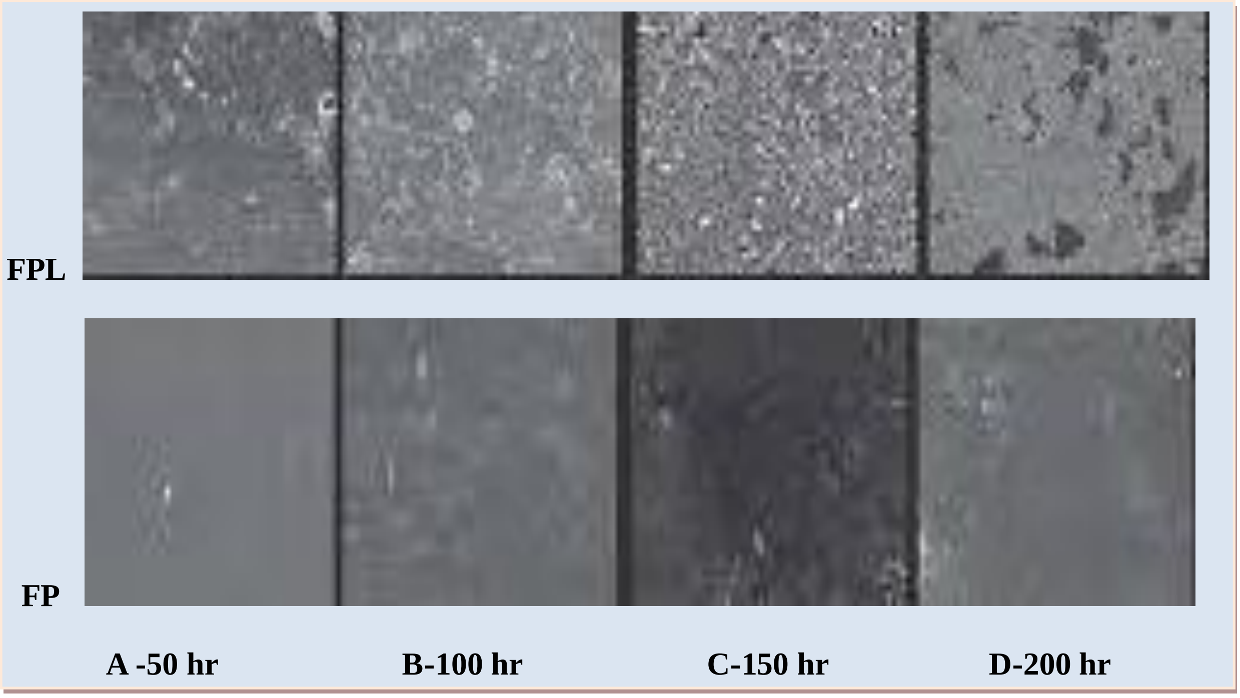

Figure (4) 50μm SEM Images of FPL, and FP dental ceramics after four immersing periods in tartaric acid

It is obvious from figures (2-4) that both FPL and FP dental ceramics have been affected by immersing in acids for prolong times, and in both cases changes on microstructure start when immersing time exceeds (50 hrs). Never the less when we compare between stability of FPL composite dental ceramic and FP dental glass ceramic we find that the last is the most stable with a very little changes on its microstructure [see figures (2-4) (A-D)] where we can see how FP dental glass ceramic preserved its microstructure while several defects appear and grow continuously in FPL microstructure. This behavior difference is due to the huge difference in the nature of FPL, FP dental ceramics microstructures, where FPL is a ceramic matrix material means it consists two phases (i) feldspathic (K2O.4SiO2) ceramic matrix, and (ii) Lucite (Al2O3) ceramic filler particles bonded together by physical means only. So it is a true fact that Lucite phase and grain boundaries between the two phases making FP composite dental ceramic is the weakest regions, and they are very candidate for the chemical attack by food acids in our research, this attack will form a special reaction paths concentrate on locations of Lucite particles such reactions increase with the decreasing in Lucite particle size because of the increasing in reaction surface area. This reaction is difficult to reach to saturation [17] means it will be continuous and so changes in FPL microstructure will be continuous too as can we see from SEM images shown in (upper part of figs (2-4)).

The lower part of the same figures represents microstructure of FP dental glass ceramic, where changes in its microstructure is much controlled all over the tests intervals and acids. This can be explain depending on the nature of reaction between FP glass ceramic and acid solutions [20]:-

$Ca10\ (PO4)6F2_{Fluorapatite}$ $F^{-} \longleftrightarrow H^{+}$ Acid solut

Means that this reaction can reach to saturation state when concentration of H+ (acid) and F-(FP dental glass ceramic) is equal and this will form a thin layer act as an energy barrier forbid any farther reaction between the acid solution and the FP dental ceramic. From the other hand glass ceramic in general is an ultra low to zero porous ceramic material [10] means it is very hard for any chemicals; including our investigated food acids; to penetrate it even after prolong immersing times. These combined two factors gave FP dental glass ceramic its microstructure stability over FPL composite dental ceramic.

Among the three investigated food acid citric acid (C6H8O7) has the biggest damaging effect on both types of dental ceramics, then benzoic acid (C7H6O2), and at last tartaric acid (C2H4O6) this may be related to the concentration of (H+) in each acid.

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