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# Enhancement Corrosion Resistance of FP Dental Ceramic Restorative by Desk Sputtered Nano $TiO_2$

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**Abstract:** Ceramic disk specimens with (10 mm height *8 mm thickness) were made from Flouropatite ceramic ($Ca_{10}P_6O_{24}F_2$) and coated with (280 nm) of nano Titania ($TiO_2$) by desk sputtering process. Morphology of both uncoated and coated specimen were detected by SEM before and after a prolong immersing intervals in citric ($C_6H_8O_7$), tartaric ($C_2H_4O_6$) and benzoic ($C_7H_6O_2$) food acids at 37°C for 50, 100 or 150 h.

**Key words:** Dental ceramic, nano coatings, desk sputter coatings, sputtering, Flouropatite, citric

## INTRODUCTION

Dental ceramic is a nonmetallic and inorganic structure primarily containing oxygen with one or more metallic (Al) or semi-metallic elements (K, Ca, P) and Si (Denry, 1996; Kelly, 1997; Giordano, 2000). Two concepts must be regarded about dental ceramics highly aesthetic dental ceramics are predominantly glassy and higher strength substructure ceramics are generally crystalline and the history of development of substructure ceramics involves an increase in crystalline content to fully crystalline (McLean, 1965; Grossman, 1985; Andersson and Oden, 1993). The change from glassy crystalline dental ceramic can be achieved either by addition of ceramic filler particles to form a composite material (Raigrodski, 2003) or by termed ‘‘ceraming’’ which is a special heat treatment that turns the glass component into ceramic to form a “glass ceramic” material (Heffernan *et al*., 2002a, b; Hornberger and Marquis, 1995; Kelly, 1995; 1999; Kelly *et al*., 1995). Dicor or Fluoroapatite (FP) ($Ca_{10}$ $P6O_{24}$ $F_2$) is the first commercial glass ceramic available for fixed prostheses, contained filler particles of a type of crystalline mica (at -55 vol. %) (Kelly *et al*., 1989, 1995). More recently, a glass-ceramic containing (70 vol. %) of crystalline lithium disilicate filler has been commercialized for dental use (Denry, 1996; Kelly *et al*., 1990) main disadvantage of dental glass ceramic is the basic ion exchange capacity (Thompson *et al*., 1994), especially when they contact with acids for a prolonged times (Kawai and Urano, 2001) even though, the potential erosive effect of acidic food additives on all dental ceramic has not been clearly documented (Hahn *et al*., 1993). Thin coatings applied by physical or chemical means is one of the solutions for this problem (21). The main aim of this study was to enhance corrosion resistance of Flourapatite (FP) through applying a thin layer of nano Titania (n $TiO_2$) which is a highly corrosive resistance, un-toxi ceramic material that can be used for this purpose. The effect of Citric ($C_6H_8O_7$), tartaric ($C_2H_4O_6$) and benzoic ($C_7H_6O_2$) food acids which are the mostly used in soft drink like different kind of juices, seven up and cola drinks the effect of such food acids on morphology and changes due to corrosion of Flourapatite (FP) dental glass ceramic were investigated with in this study.

## MATERIALS AND METHODS

Flouropatite ceramic ($Ca_{10}P_6O_{24}F_2$) from (IPS Empress Esthetic) company, ultra-pure nano Titania (n $TiO_2$) from (TAVANA Nano Lab. Products) were used. Citric ($C_6H_8O_7$), tartaric ($C_2H_4O_6$) and benzoic ($C_7H_6O_2$) food acids were delivered from (MERIK Chemicals).

**Specimen preparation and testing:** Ceramic disk specimens with (10 mm) height and (8 mm) thickness were made from Flouropatite ceramic ($Ca_{10}P_6O_{24}F_2$), then a desk sputter coating system type (DSR1) was used to apply a (4 nm) layer of nano $TiO_2$ over the specimen by the presence of (99.99%) Argon gas and at a (170 L/m) rotary vane pump. After that the coated and uncoated specimen were immersed in 4, 5, 6% concentration of citric acid ($C_6H_8O_7$), tartaric acid ($C_2H_4O_6$) and benzoic acid ($C_7H_6O_2$) at 37°C for 50, 100, 150 h. Morphology of the specimens was detected using SEM before and after the immersion.

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## 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. 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 (Hornberger and Marquis, 1995), this effect can be reduced using different types of impermeable coatings (Kelly *et al*., 1990) in this research a (280 nm) desk sputtered coating of nano Titania (n $TiO_2$) was applied over FP dental glass ceramic to eliminate the contact between corrosive media and restorative. Microstructure was detected with SEM before and after immersing in Citric acid ($C_6H_8O_7$), tartaric acid ($C_2H_4O_6$) and benzoic acid ($C_7H_6O_2$) at 37 °C for 50-150 h. Figure 1 illustrates SEM images of the uncoated and n $TiO_2$ coated FP dental ceramics. While Fig. 2 show the difference in surface morphology of the two types of FP restorative.

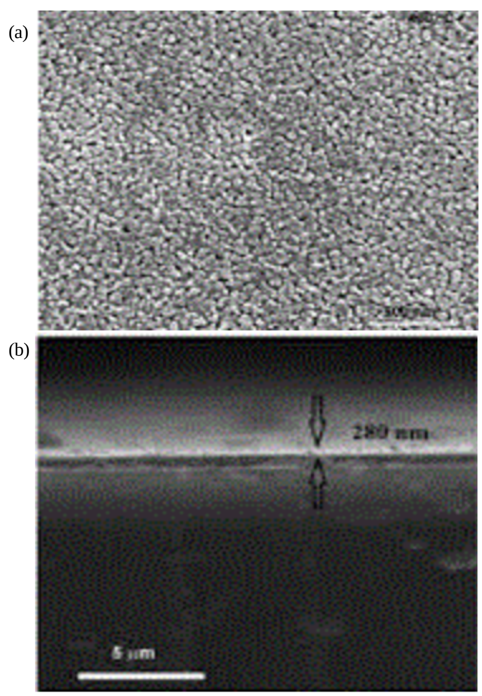


Fig. 1: SEM images of the; a) Uncoated where the secondary ceramic phase dispersed through the glassy matrix and the grain boundaries between the two phases are shown and b) Desk sputtered (280 nm) $nTiO_2$ coated FP dental ceramics

From Fig. 1, we can see that microstructure of FP dental ceramic (the left image) contains a very fine ceramic crystalline phase dispersed through the glassy matrix, grain boundaries between the two phases are obvious too, these areas are very candidate locations for the attack of corrosive media. The right image from Fig. 1 shows the (280 nm) $nTiO_2$ desk sputtered FP dental ceramic, the surface here becomes smoother no grain boundaries can be seen and a very homogeneous surface is produced, we may presume a very low penetration for the corrosive media and hence a high corrosion resistance, beside this fact Titania $TiO_2$ is one of the most chemical resistance ceramic oxide in both acidic and alkaline media. In Fig. 2 the difference in surface morphology of the both uncoated and coated FP dental ceramic is shown, it is obvious that desk sputtering process gives us a highly uniform and even disperse $nTiO_2$ layer with much lower roughness surface, hence, a lower interaction spots between the corrosive acids and the coated surface. A food acids are materials added to make flavors sharper and also acts as preservatives and antioxidants. Common food acid include citric, tartaric and benzoic acids among several other acids (Hornberger and Marquis, 1995). These three acids are a common ingredients in drinks like cola, seven up, grape, pineapple and citreous fruit juices,

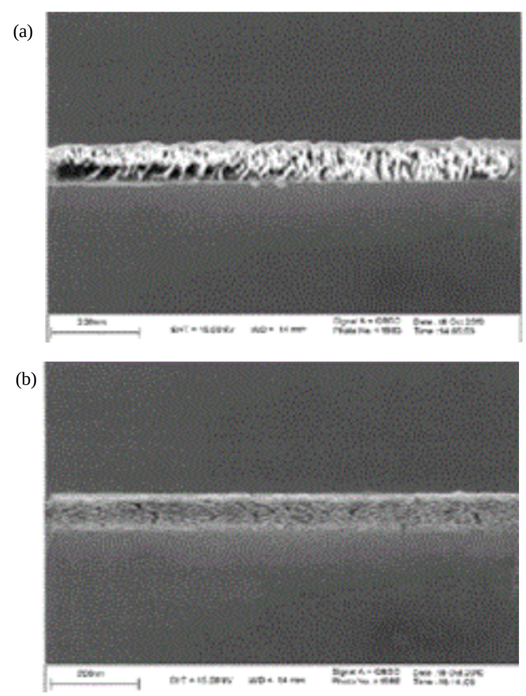


Fig. 2: Surface morphology of uncoated FP dental ceramic and n $TiO_2$ coated FP dental ceramic

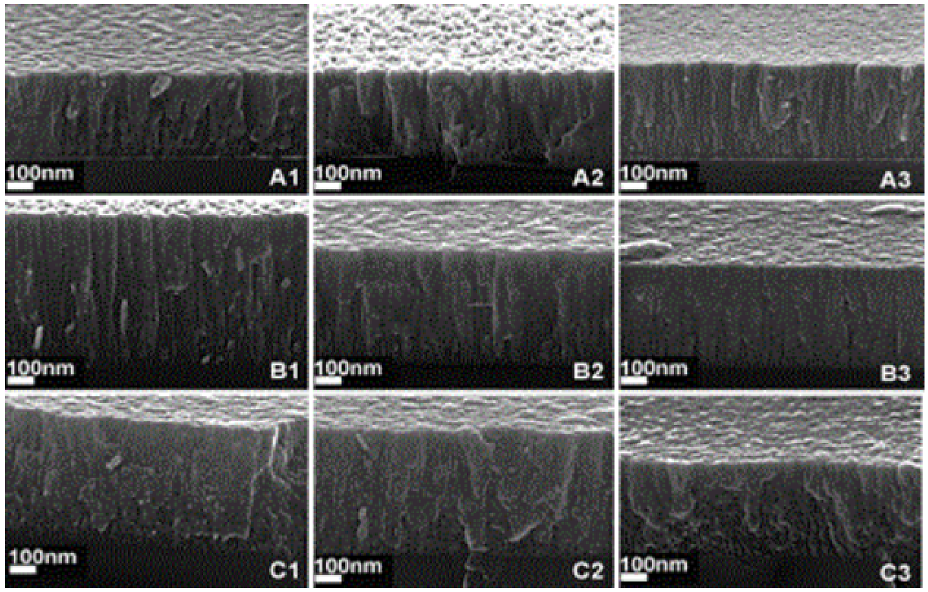


Fig. 3: SEM of (A1 50, A2 100 and A3 150 h) citric ($C_6H_8O_7$), (B1 50, B2 100 and B3 150) tartaric ($C_2H_4O_6$) and (C1 50, C2 100, C3 150) benzoic ($C_7H_6O_2$) food acids on morphology of (280 nm) layer thick coated FP dental glass ceramic after (50-150) immersing hours at 37°C

hence, they will be in direct contact with dental ceramics. Figure 3 shows the effect of Citric ($C_6H_8O$ ), tartaric ($C_2H_4O_6$) and benzoic ($C_7H_6O_2$) food acids on morphology of (280 nm) layer thick coated FP dental glass ceramic after (50-150) immersing hours at 37 °C.

From the Fig. 3, we can see that n $TiO_2$ coating was not affected by any of the investigated food acidic media even after a very long immersing time (150 h), hence, it provides a very high protection for the under beneath FP substrate which means a long life for the restorative even if it was used with a soft drink aholic person. Figure 4 detects changes within the morphology of uncoated FP dental glass ceramic after the exposure to (A 50, B 100 and 150 h) to citric, tartaric and benzoic food acids. In all acids corrosion rate and changes in morphology increase with immersing time, this changes starts as a low penetration when immersing time was (50 h) this penetration alters to be a numerous and large cavities widely dispersed with in the FP dental glass ceramic and especially located at the grain boundaries between the glassy matrix phase and dispersed crystalline ceramic phase. Figure 4 also detect that unlike the coated $nTiO_2$ FP dental glass ceramic, corrosion rate and morphology a change within the uncoated FP dental glass ceramic depends on the type of acidic media where the highest effect was for citric acid, then tartaric acid while benzoic acid has the lowest effect on the morphology.

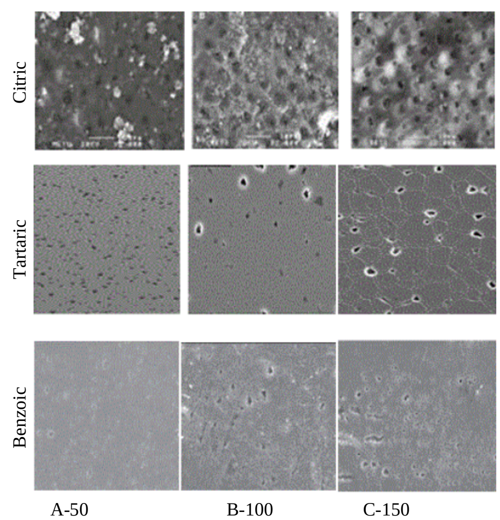


Fig. 4: SEM morphology of uncoated FP dental glass ceramic after (A 50, B 100 and C 150 h) immersing time at 37C° in Citric ($C_6H_8O_7$), tartaric ($C_2H_4O_6$) and benzoic ($C_7H_6O_2$) food acids

## CONCLUSION

Nano coating with 280 nm thick over FP dental glass ceramic largely enhance the morphology and corrosion resistance of such restorative material.

Corrosion resistance of coated FP dental glass ceramic depends on type of acidic food and immersing time, unlike the coated one.

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