Photocatalytic Activity of Low Temperature Oxidized Ti-6Al-4V

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INTRODUCTION: Photocatalysis on TiO₂ surfaces by UV illumination has been studied and applied in a range of fields, including biomaterials for its known bactericidal effects [1]. TiO₂ irradiated with UV light generates an electron-hole pair, which reduces O₂ and oxidizes H₂O to superoxide ions (O₂^{•−}) and hydroxyl radicals (•OH), respectively [2]. These can then decompose nearby organic material, such as adherent bacteria. The current study is a preliminary investigation on photocatalytic activity of TiO₂ surfaces obtained by a quick, low temperature surface modification technique, using H₂O₂ and H₂O as oxidizing agents. The aim is to optimize the oxidation process and apply the active surface on dental Ti-6Al-4V crowns and bridges produced via electron beam melting (EBM). This would add an on demand, *in situ* antibacterial feature to the device, reducing bacterial pressure and avoiding the onset of peri-implantitis.

MATERIALS AND METHODS: Discs of Ti-6Al-4V were manufactured from EBM rods (Arcam AB, Mölndal, Sweden). H₂O₂ treatment at 80°C for 30, 75 or 120 minutes was followed by hot water (80°C) aging for 90, 225 or 360 minutes. The effect of long-term oxidation (18h in H₂O₂, 54h in H₂O) was also investigated. Photocatalytic activity after oxidation was determined using a UV-1800 spectrophotometer (Shimadzu, Kyoto, Japan). Discs were placed in a flat-bottomed cuvette filled with 5µM of the colored, organic solution rhodamine B (rB). A small well drilled in the bottom of the cuvette allowed magnetic stirring of the dye during tests. Pulsing (100 Hz) UV light at 365 ± 10 nm was irradiated from 2 cm above sample surfaces. Degradation of rB due to photocatalysis on TiO₂ was monitored by stepwise absorbance measurements at 5-minute intervals for up to 8 hours. Oxidized surfaces were imaged using a LEO 1550 SEM (Zeiss, Oberkochen, Germany).

RESULTS: A clear trend between oxidation time and photocatalytic activity can be seen in Figure 1, where absorbance (related to rB concentration) is plotted as a function of time under UV irradiation. Approximating the degradation rate of rB as a first order reaction, a rate constant can be derived from each curve. Preliminary results show a near linear

behaviour between oxidation time and photocatalytic activity when comparing rate constants from short- and long-term oxidations.

Fig. 1: Degradation of rhodamine B over time. Legend indicates sample oxidation time in H₂O₂ and H₂O, respectively.

Figure 2 shows a clearly distinguishable TiO₂ surface layer only after long-term oxidation, which further explains its higher photocatalytic activity.

Fig. 2: SEM images of samples oxidized for a) 2+6h and b) 18+54h in H₂O₂ and H₂O, respectively.

DISCUSSION & CONCLUSIONS: The presented surface modification technique of Ti-6Al-4V is a cheap and straightforward way of obtaining photocatalytically active surfaces with on demand antibacterial properties. TiO₂ growth and photocatalytic activity shows strong dependency on oxidation time, and results suggest a linear relationship. Long-term oxidation is necessary to achieve desired antibacterial effect, and further studies will reveal optimal oxidation parameters.

REFERENCES: ¹ Sunada K et al., Env. Sci. & Tech. 1998;32:726-8. ² Welch K et al., Dent. Mater. 2010;26:491-9.

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