Caries Research
Editor-in-Chief: J.M. ten Cate, Amsterdam

Reprint
Publisher: S. Karger AG, Basel
Printed in Switzerland

Caries Res 1988;22:230–231

0008–6568/88/0224–0230 $ 2.75/0

Antibacterial Action of Powdered Semiconductor on a Serotype g *Streptococcus mutans*

(Short Communication)

T. Morioka[a], *T. Saito*[a], *Y. Nara*[a], *K. Onoda*[b]

[a] Department of Preventive Dentistry, School of Dentistry, Kyushu University, Fukuoka;
[b] Research Section of Shiken Corporation, Osaka, Japan

Key Words. Antibacterial effects · Semiconductor, powdered · *Streptococcus mutans* · Titanium dioxide

Recent studies have shown that powdered semiconductors irradiated with visible light possess the ability to decompose organic substances including lactic acid [Freund and Gomes, 1969; Sakata and Kawai, 1981; Harada et al., 1985] and that it has a bactericidal effect against several species of microorganisms such as *Escherichia coli* [Matsunaga, 1985]. It has been postulated that the bactericidal effect depends on a redox reaction between semiconductor and coenzyme A in which the latter is oxidized intracellularly in the microbial cells [Matsunaga, 1985]. However no similar experiment has been carried out with oral bacteria. In this study experiments were carried out to determine the effect of a powdered semiconductor, TiO_2, on cariogenic *Streptococcus mutans*. The powdered TiO_2 used in this experiment was the rutile type with a purity of 99.98%, and a particle size of 1.48 μm (Fujichitan Co., Osaka, Japan). *S. mutans* strain AHT (serotype g) which was incubated at 37 °C in brain heart infusion (BHI) broth (BBL, Cockeysville, USA) was employed as the test organism. The bacteria were preincubated for 14 h. The cultures were diluted to contain approximately 1×10^4 cells/ml, and aliquoted into two sterilized capped vials. Then powdered TiO_2 was added to one vial at the concentration of 0.1% (w/v), and the other vial was used as the control without TiO_2. Both vials were placed on magnetic stirrers in a desiccator and the reaction mixtures in the vials were stirred to prevent settling down of the powdered TiO_2. Incubation was carried out anaerobically at 37 °C. Then the reaction mixtures were irradiated with a 100-Watt mercury lamp [Neosuper HRF 100X/T(L), Toshiba, Tokyo, Japan] from a distance of 18 cm in an incubator. The incubator (MIR 151, Sanyo, Osaka, Japan) had a cooling system to prevent any rise in temperature due to lighting and generated heat from magnetic stirrers which were placed in the incubator. The light from the mercury lamp was passed through a water-filled acrylic tank with a light path of 5 cm to eliminate any heating effect on the microorganisms in the vials. Thus the temperature of the reaction mixture was regulated at 37 ± 2 °C during the experiments. Aliquots were removed from each vial at 20-min intervals and inoculated onto BHI agar plates; and the colony population was estimated by an ordinary procedure. All assays were repeated at least three times to confirm reproducibility of the experimental results.

Figure 1 shows the effect of powdered TiO_2 on *S. mutans* strain AHT. In the control mixture no decrease in the number of viable cells could be seen during the experiment. On the contrary, in the mixture containing TiO_2 the viable cells were markedly decreased at 40 min and more than 99% of the cells were killed by 80 min. No colonies were observed on BHI plates after 100 min. Furthermore, when the TiO_2 was highly dispersed by means of ultrasonic oscillation prior to use, the rate of reduction in the number of viable cells was significantly enhanced, as shown in figure 1. This phenomenon is easily attributable to the increment in surface area of the particulate TiO_2 due to its greater dispersion.

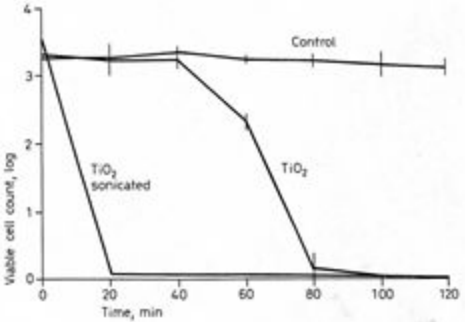

Fig. 1. Antibacterial effect of powdered TiO_2 on *S. mutans* AHT.

Photo semiconductors are excited and carry out photo-catalytic reaction when irradiated with light of shorter wave-length than the band gap energy of semiconductors. Therefore, in the case of TiO_2 light under 415 nm including ultraviolet rays which corresponds to the band gap energy (3.0 eV) would be quite effective [Matsunaga, 1985]. The light derived from a mercury lamp contains a wide range of wavelengths from ultraviolet to infrared. Since the glass of the desiccator and vials absorbed a large part of the ultraviolet rays, the direct bactericidal effect of these rays was eliminated. This is verified from the fact that cell viability in the control mixture did not decrease during 120 min of incubation. Further studies should be done using other species of oral microorganisms.

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Toshio Morioka, DMSc, DDS
Department of Preventive Dentistry
School of Dentistry
Kyushu University 61
3, 1-1 Maidashi, Higashi-ku
Fukuoka (Japan)