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Analysis of silver compounds in reaction products of silver diamine fluoride, an anti-caries agent, with bovine tooth

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1 Introduction

Silver compounds have a long history of use because of their potent antimicrobial properties. In dentistry, silver diamine fluoride (SDF) is a topical fluoride solution that has been used for caries prevention and treatment. The 38% SDF solution was developed in Japan and approved for use as a therapeutic agent in the 1960s. More recently, the US Food and Drug Administration (FDA) admitted its safety and effectiveness to meet FDA's requirements for marketing approval. The application of SDF is indicated to arrest caries of the primary teeth in children and prevent root caries in elderly people. However, the main disadvantage of SDF is discoloration of teeth surface.

A number of clinical studies have demonstrated that SDF is effective in reducing carious lesions [1]. In vitro studies reported that SDF increases the mineral density of the carious lesion and that SDF hardens teeth surface due to formation of highly mineralized zone [2]. The antibacterial effect was sufficient enough to inhibit cariogenic biofilm formation [3]. However, only a limited number of publications have reported on the mode of action of SDF on mineralized tissue and on silver compounds that cause teeth-discoloration. When SDF reacted with hydroxyapatite in teeth, it is believed that CaF_2 and Ag_3PO_4 are readily formed, which was confirmed by means of energy-dispersive X-ray analysis and X-ray diffraction. In this study, we investigated on silver salts formation when SDF reacts with teeth component (enamel, dentin and collagen type I) by XAFS measurements

2 Experiment

Bovine enamel and dentin were pulverized under liquid nitrogen in a cryogenic mill into fine particles with diameters less than 75 μm. Collagen Type I from bovine achilles tendon was also used as substrate. The 0.05 g of bovine enamel, dentin and collagen powder was treated with the 0.1 ml of 38% SDF solution (55000 ppm fluoride herein). After 3 min reaction time, the powder samples were washed with DW three times and centrifuged. The deposit of sample powder was kept at 37°C for 7 days with ambient light exposure. The XAFS measurements were carried out on these powder samples with He filled sample chamber at BL-9A beamline. The Ag L_3-edge XANES spectra were measured by the fluorescence yield method using a Lytle detector and scanned for the spectral range of 3.32 keV - 4.42 keV. The spectra of metallic silver and silver compounds such as Ag_3PO_4, Ag_2O, AgO, Ag_2S, AgF, AgI and $AgNO_3$ were measured to compare those of SDF-reacted samples.

3 Results and Discussion

Figure shows XANES spectra of (a) SDF-treated enamel, (b) SDF Figure -treated dentin, (c) SDF-treated collagen type I and (d) SDF without substrate. When compared with references (metallic silver and other silver compounds), these spectra are differed from those of references (references spectra not shown). This indicates that SDF does not give a positive reaction with enamel, dentin or collagen Type I.

In this study, we did not use artificial saliva during SDF reaction. Since SDF is alkaline, minerals in teeth are not dissolved or not release Ca^{2+}, PO_4^{3-} and HPO_4^{2-}. Therefore, SDF is unlikely to react teeth components. For a further study, we should use artificial saliva that includes Ca^{2+} and HPO_4^{2-}. The high concentration of Ca^{2+} and HPO_4^{2-} in saliva should be responsible to form SDF-salts.

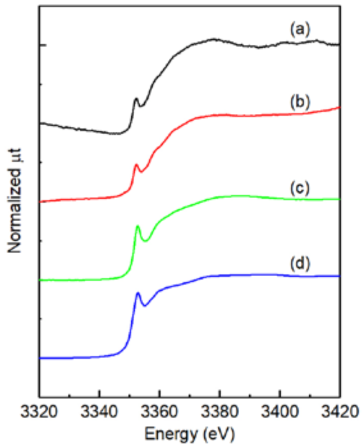

Figure Ag L_3-edge XANES spectra of (a)SDF-treated enamel, (b) SDF-treated dentin, (c) SDF-treated collagen type I, and (d) SDF without substrate.

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