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TOPICAL UV LIGHT GENERATING CERAMICS FOR THE REMOVAL OF BIOFILMS AND FOULING

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Biofilms on medical implants, dental restoration as well as fouling in the maritime and real estate industry still pose a great challenge. Regarding the development of new counter-strategies, central concerns for antifouling are particularly the extrication of toxins and, hence, the environmental compatibility as well as for biofilm prevention their cytotoxicity in the adjacent tissue.

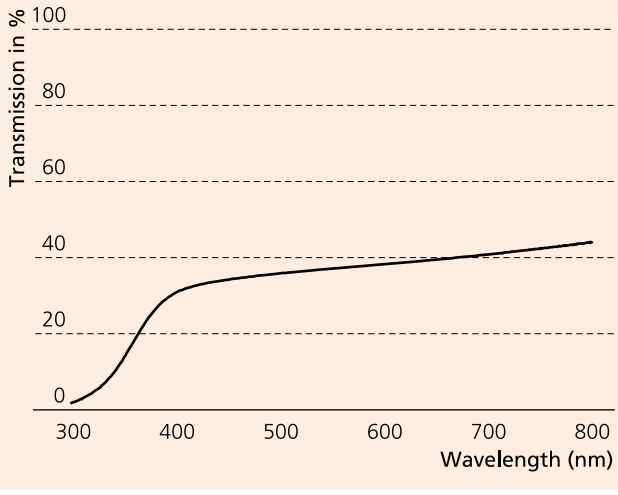
Normally, the removal of fouling and biofilm layers takes place mechanically. The effectiveness depends on the chemically toxic or biochemically cytotoxic pretreatment. The biochemically cytotoxic strategies for combating biofilm are confronted with tricky protection strategies of the biofilm itself, particularly at its surface. For eliminating the counterstrategies of the biofilm, the established traditional methods are inefficient and expansive. In contrast, the traditional mechanical prevention strategies often reach their limits because of the strong adhesion of the biofilm, especially in wet surroundings on surfaces, steps and fissures. As a result, the question of an alternative strategy in contrast to the traditional elimination arises.

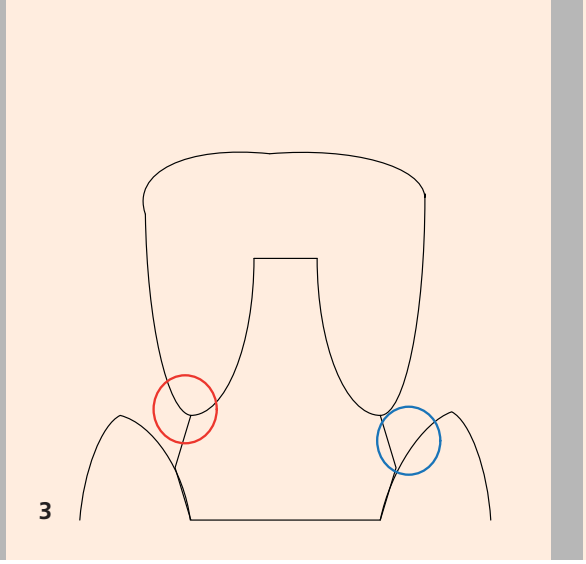
Research approach

As the biofilm adhesion is effective due to strong chemical bonds and at the same time changes or strengthens the bonds within the entire adhesive layer, the destruction of the adhesion of appositions and respectively biofilms on the surface is essential. When the biofilm's unprotected backside (adhesion side) is exposed to UV radiation, the new approach uses the effect of photodissociative decomposition of adhered biopolymers or biopolymer complexes at the biofilm adhesion-interface. For the application, the surface or the substrate needs to be transparent to UV radiation. However, the relevant dental ceramics, polymer composites, glasses, etc. are not transparent in the UV range. In order to generate a UV effect on the interface between biofilm and substrate, the UV radiation needs to occur locally and conditioned so that the healthy tissue is not simultaneously damaged. For attaining this effect, the property of translucency is used in the visible range (not UV!). After permeating the material, e.g. with blue light radiation, UV light is produced locally defined and topical at the adhesion side of the biofilm. This requires a light-converting layer (UV luminescent layer) on the substrate surface populated with biofilm, so that the unprotected backside of the biofilm can be irradiated. Luminescent materials, which can be equipped with a luminescent layer, are represented by the dental bio- and veneering ceramics of the IKTS with transmission rates of 20 to 60 % in the visible light spectrum (diagram below).

Irradiating this translucent ceramic with visible, non-cytotoxic blue laser light with a wavelength range from 450 up to 490 nm, a UVA/UVB radiation is emitted on the backside (adhesion layer) of the biofilm. The kind of luminescent material, its density and the exposure duration on the substrate surface allow a topical application of UV light. This topically applied UV light is only effective on the adhesion side of the biofilm without impairing the healthy tissue in the surrounding.

Translucency of IKTS bioceramics





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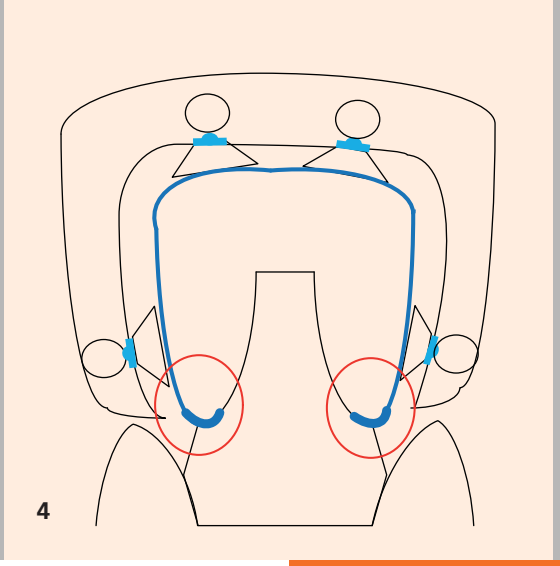

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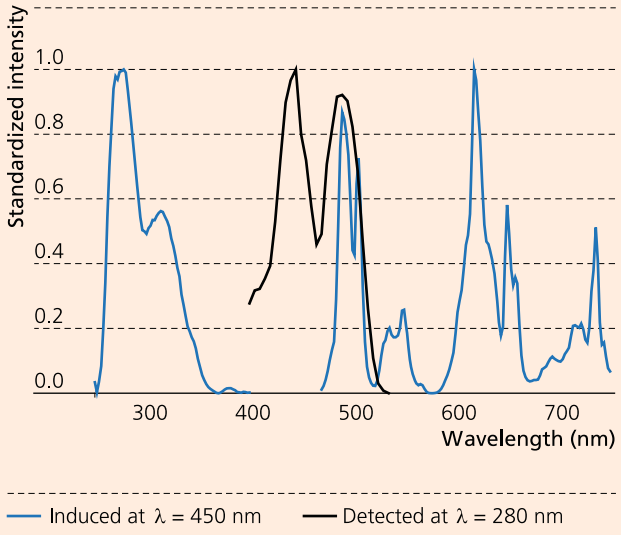
Application

One of the first applications can be seen in the protection of the preparation margin of dental restorations. At the lower final preparation margin, a more or less distinct cleavage range is formed between the dentin (dental neck) and the dental restorations (Figure 3).

Emission bands of the translucent material when irradiated with blue light (450 nm wavelength), excitation bands attested for UV radiation



There, biofilms, especially the periimplantitis (type of parodontitis) causing germs, find particularly attractive population areas. These areas are difficult to access with the current remedies and form biofilm islands, which seed biofilm germs again and again.

Due to their advantageous translucency (transmission rate) in the visible radiation range, the veneering, crown or bridge ceramics developed at IKTS offer particularly good requirements for the application of the above-mentioned UV effect, if they are equipped with a UV luminescent layer directly at the preparation margin and irradiated with intensive blue light, for example, with the aid of a luminescent jaw protection (Figure 4).

Services offered

- Customized, application-specific syntheses and developments of ceramic luminescent materials including characterization
- Development of application-specific laminations and corresponding surface structures
- Technical realization of application options

1 *Veneering ceramics with transmission in visible light.*
2 *Crown framework with biological design.*
3 *Preparation margin (red), dentin gingiva range (blue).*
4 *Schematic illustration of a jaw protection with blue lighting.*

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