LASER AND INSTRUMENTATION IN LIFE SCIENCES

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The aim of this activity is to develop new processes, methods and instrumentation using high and low-power lasers, which can be useful as a diagnostic or a therapeutic tool in Medicine and Dentistry. Morphological changes in laser-treated enamel and dentin and the ablation threshold were determined for several wavelengths (diode at 960 ?m, Er:YAG at 2,94 ?m, Er, Cr: YSGG at 2,79 ?m, Ho:YLF at 2,065 ?m, Nd:YAG at 1,06 ?m, TEA CO_2 at 10,6 ?m, TEA CO_2 at 9,6 ?m), with different pulse widths (free-running, Q-switch and mode-locked) and irradiation parameters. A home made Er:Tm:Ho:YLF laser emitting at ?=2,065 ?m was used to irradiate bovine enamels. As a result, it was verified increased calcium and phosphorus concentrations at different depths of the tissue, indicating an increased enamel resistance to acids. It was also observed (by X-ray fluorescence) an increased concentration of Ca atoms related to P ones, indicating a new biphasic structure, identified by X-ray diffraction as tetracalcium phosphate [$Ca_4(PO_4)_2O$] and hydroxyapatite. The temperature raise measured in the pulp chamber region was verified to be lower than the pulpal damage threshold temperature.

The use of an Er, Cr:YSGG laser in hard dental tissue, with lower energies than its ablation threshold, is under investigation in both health and carious tissues, by chemical and spectroscopic techniques. The hardness of melted enamel and dentin surfaces and changes in chemical composition from irradiated samples will determine the optimal laser irradiation condition for caries prevention. An increased enamel and dentine radiation absorption in the UV and blue region was observed when the tissues were thermally treated. Loss of water and changes in the structure of its organic matrix were observed by FT-IR. The infrared and electron spin resonance (ESR) were used to study thermally treated enamel and dentin, identifying the chemical radical that produced ambiguous ESR signals. The results showed ESR signals in dentin (100^{o}C-1000^{o}C) and enamel (250^{o}C-1000^{o}C). The signal formed after heat treatment below 400^{o}C was assigned to degradation products of the organic material and the signal that predominated in tissues heated between 500^{o}C and 900^{o}C was assigned to the cyanate ion (NCO^-).

Studies were carried out to investigate the influence of low-intensity laser therapy on skin wound healing, bone integration, and temporomandibular disorders at different wavelengths (red and near infrared). Significant differences were observed between irradiated and control groups. It was verified that the penetration depth of linearly polarized light is longer in the wounded skin than in the health skin. The state of the blood supply in biological tissues is of fundamental importance for the study of several pathologies, as well as for the research of physiologic phenomena. The investigation of the microcirculation has been accomplished by Laser Doppler Flowmeters (LDF). The technique is non-invasive, and does not offer risks to the patient. The measured blood flow is, however, affected by factors hardly controllable in practice, such as the position of the sensor, calibration of the instrument, hindering the routine use of the technique.

This research area seeks to develop Doppler signal processing methods intended to extract information about hemodynamic parameters of the microcirculation, whose measurable values via LDF are less sensitive to the factors that limit the conventional technique. Practical applications are also of interest, such as in the pulpal vitality test, the study of alterations of the flow in the pulp due to orthodontic movements and the study the microcirculation alterations due to laser therapeutic processes in hard and soft tissues. The evaluation of the pulp blood flow during orthodontic movements has been accomplished by using indirect and destructive techniques. It was observed that during orthodontic movements, the pulp blood flow can decrease, initially by the arteries strangulation, and latter by a pulp inflammation induced by a periodental inflammation process. Spectroscopic analysis of dental fluorescence excited with a blue laser diode was performed. The spectra obtained from different degrees of caries lesions were significantly different from sound tooth structure.

This method demonstrated potential application to evaluate these lesions. Another study has been carried out to evaluate the use of a portable spectrometer to detect caries when tooth is excited with red light. Promising results were obtained from initial readings. Projects supported by: FAPESP (Process 00/14817-9; 98/06784-1 and 00/14817-9); CAPES (PROCAD 0156/01-9).