The Uses of Laser-Induced Fluorescence to Distinguish between Dental Caries and Sound Tooth

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Abstract: *In this paper nitrogen laser (N_2) was used to induce emission to distinguish between dental caries and sound teeth.*

Three samples of dental caries and one sample of sound teeth have been used to determine the absorbance of dental caries and sound teeth using UV-Vis spectrophotometer then it irradiated by nitrogen laser (N_2) with wavelength 337.8 nm, pulse energy 0.04 mJ and pulse time 100 msec. The interaction between ultraviolet laser photons and the teeth was induced visible spectrum recorded by a USB spectrophotometer.

The result showed an emission of broadband from (363 to 627nm) and another sharp peak at the visible region (673nm) and third sharp peak at the infrared region (1013nm) in all samples, the intensity of these bands and peaks are low in dental caries spectra while they were high in the sound tooth spectrum.

Keywords: *Dental Caries; Diagnostic; Fluorescence; Laser-matter interactions.*

1. INTRODUCTION

Laser-induced fluorescence (LIF) is the optical emission from molecules that have been excited to higher energy levels by absorption of photons. One of the most frequently used applications of LIF is measuring a biological preparation with a dye. A fluorescing dye is chosen which binds to specific structures inside a cell so that when the preparation is lit by a laser, an image of the structures can be made. Sometimes not even a dye is needed but already part of an organism, for example, photosynthesis.

Dental caries is a disease in which enamel and dentin are gradually eroded, due to the elimination of minerals by acid excreted from bacteria in tooth surface plaque. Dental caries is a chronic disease that occurs frequently.

Dental caries is a disease, which leads to the destruction of the tooth structure and eventually to infection of the dental pulp and even surrounding tissues. Factors contributing to the progression of the disease include diet (mainly fermentable carbohydrates), microbes, and the host (amount and constituents of the saliva, habits). The progression of dental caries lesions needs time. Fluoride protects the teeth from dental caries by influencing the tooth structure

Dental caries is usually performed using a tool called explorer that catches as it moves across a tooth with a cavity. This method of detection has many limitations, including the instrumentation.

Laura E .Tam, DDS, et al in (2001), reviewed current knowledge concerning conventional and new diagnostic methods for occlusal caries. These methods have several limitations, particularly in their ability to diagnose early carious lesions. Part II examines new and emerging technologies that are being developed for the diagnosis of occlusal decay. Electrical conductance measurements and quantitative laser- or light-induced fluorescence represent significant improvements over conventional diagnostic methods, especially for in vitro applications and particularly with regard to sensitivity and reproducibility.

Iain A. Pretty, BDS, M Sc, PhD and Gerardo Maupomé, in (2004) PhD examined some of the diagnostic tools supporting a philosophical shift in mainstream dental practice from concern with extensively decayed teeth to a focus on detecting incipient dematerialized tissues.

Ana Maria COSTA, Lillian Marley de PAULA, Ana Cristina Barreto BEZER in (2007), Evaluated the use of a laser fluorescence device for detection of occlusal caries in permanent, was found that the laser detection method produced high values of sensitivity (0.93) and specificity (0.75) and a moderate positive predictive value (0.63).The laser device showed the lowest value of likelihood ratio (3.68). Kappa coefficient showed good repeatability for all methods. Although the laser device had an acceptable performance, this equipment should be used as an adjunct method to visual inspection to avoid false positive results.

Anttonen , Vuokko in (2007), used Laser fluorescence in detecting and monitoring the progression of occlusal dental caries lesions and for screening persons with unfavourable dieter habits This study focused on the clinical use of laser fluorescence compared to visual inspection (VI) for detecting and monitoring the progress of caries lesions during a one-year follow-up period and for screening subjects with unfavourable dietary habits causing demineralization of teeth.

Roxana Ranga1et al in (2007), has attempted to emphasize the efficiency of laser-fluorescence (LF) and fibre optic trans-illumination (FOTI) as complementary methods for diagnosing the early caries lesion.It has also demonstrated the interactive and didactic role of the Diagno dent pen.

Bennett T. Amaechia in (2009), described the various technologies available to aid the dental practitioners in detecting dental caries at the earliest stage of its formation, assessing the activities of the detected carious lesion, and quantitatively or qualitatively monitoring of the lesion over time. The need and the importance of these technologies were also discussed. The data discussed are primarily based on published scientific studies and reviews from case reports, clinical trials, and in vitro and in vivo studies.

Zangooei Booshehry et al, in (2010), evaluated different caries diagnostic methods, Clinical Visual Inspection, Fiber Optic Transillumination, Caries Indicter Dyes, Fluorescent Methods.

Fardad Shakibaie, Roy George, L.J.Walsh, in (2011), proposed the principle of the fluorescent phenomenon, then explore the scientific background of fluorescent studies on the dental tissue. The laser-induced fluorescence can be used to detect and diagnose dental caries, calculus and bacterial biofilms in dental applications. Pini et al. Used laser fluorescence to detect residual pulp tissue within the root canal, using a 308 nm wavelength ultraviolet laser, while Sarkissian and Le used 366, 405, and 440 nm wavelengths to distinguish remaining pulp tissue and bacteria from normal hard tissue in root canals. Most work using fluorescence in dentistry has employed visible light as the excitation source.

Yao-Sheng Hsieh 1,2, and et al in (2013) described the applications of dental optical coherence tomography (OCT) in oral tissue images, caries, periodontal disease and oral cancer. The background of OCT, including basic theory, system setup, light sources, spatial resolution and system provided. The comparisons between OCT and other clinical oral diagnostic methods are also discussed.

The use of laser-induced emission to determine the absorbance of dental caries and to distinguish between emission from dental caries and sound tooth.

The basic goal of this research is to use laser-induced emission to distinguish dental caries compared with sound teeth.

2. EXPERIMENTAL PART

2.1. Materials

2.1.1. Dental Caries and Sound Teeth

Dental caries is a disease in which enamel and dentin are gradually eroded, due to the elimination of minerals by acid excreted from bacteria in tooth surface plaque.

Fig1. *The Dental Caries*

Fig2. *The Sound Teeth*

2.1.2. Solvent

Used water because the sample is in the solid state.

2.2. Devices

2.3.1. The Nitrogen (N_2) Laser

Nitrogen laser is an example of the molecular laser, using transitions between vibrionic state. This laser oscillates at a wavelength of 337 nm, in the ultraviolet region.

2.3.2. The Vibratory Disc Mill RS 200

The Vibratory Disc Mill RS 200 is suitable for the extremely quick, loss-free and reproducible grinding of medium-hard, brittle and fibrous materials to analytical fineness. The instrument runs steadily and smoothly, even with heavy grinding sets, at maximum speed thanks to the new Stabilized-Plane-Drive.

With its robust design, the RS 200 has proven to be ideal for use in the building materials sector (cement), in geology, mineralogy, metallurgy and in power plants. Due to the high-end fineness and speed, the RS 200 is the perfect mill when it comes to preparing samples for spectral analysis.

2.3.3. UV- Vis Spectrophotometer

UV- Vis mini 1240 spectrophotometer was used in the study to measures absorption spectrum of dental caries and sound.

The UVmini comes standard with a Spectrum mode that allows for full spectral data acquisition over the wavelength range of 190nm to 1100nm The UVmini provides flexible print options with the use of either a thermal screen copy printer or a variety of PC printers. The screen copy printer enables instant printing of tabulated data as well as copied information directly from the screen. The PC printers can be utilized for and for finer print resolution of spectral data.

2.3. The Method of Experiment

To distinguish between dental caries and sound tooth:

These teeth were ground to fine powder using the Vibratory Disc Mill RS 200, shown in fig 3.4

The powder samples were dispersed in distilled water. The absorption spectrum of these samples was carried out using UV-Vis mini 1240 spectrophotometer, shown in fig 3.5

PL properties were determined using nitrogen (N_2) laser with a wavelength of 337.8 nm, power 0.04 mW, and repetition rate 100 msec, shown in fig 3.6
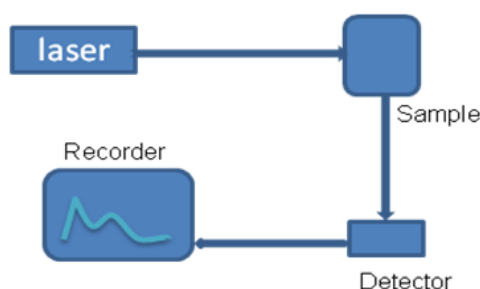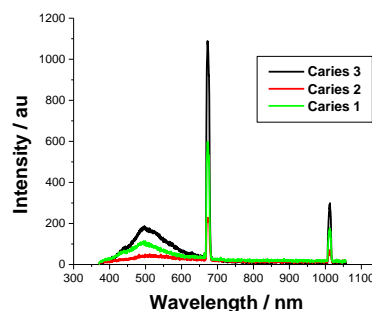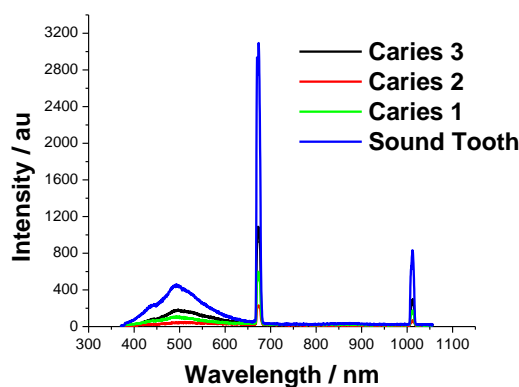

Fig3. *PL system*

3. RESULTS AND DISCUSSION
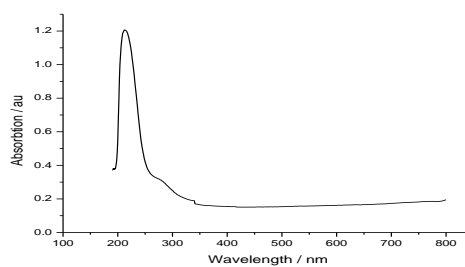
Fig4. *Absorbance spectra of dental caries*

Fig5. *The Spectra of the Dental Caries (Excitation at 337.8 nm)*

Fig6. *The spectra of dental caries and sound tooth (Excitation at 337.8 nm)*

Spectra in fig 5 show that the spectrum of the three samples of dental caries, in second and third spectra were sharp peaks (673,1013) nm and in the first spectrum was broad peak(500) nm

The intensities of the sharp peak of dental caries at 1013nm of the sample caries $_2$ is 190 au, the sample caries$_3$ is 425.4 au and sample caries$_1$ is 290 au.

The intensities of the sharp peak of dental caries at (673) nm of the sample caries $_3$ is 1215 au , the sample of caries $_2$ is 345.8 au and sample caries$_1$ is 713au.

Spectra in fig 6 there are three samples of dental caries and one is sound tooth, this spectrum shows that when dental caries and sound tooth irradiated to laser, the intensity of the sharp peak of sound tooth at 1013 nm is 969 au, at the sharp peak 673 nm the intensity is 3227 au and the intensity at the broad peak is around 597 au.

The intensity of the broad peak at (500) nm of the caries$_3$ is 312.4au, the caries$_1$ is 230.5au, and the intensity of the caries$_2$ is 166au This spectrum shows that the intensity in sound tooth is very high (364.42) au while in dental caries$_3$ the intensity is low (144.62) au in caries$_1$the intensity is lower (69.6) au than caries$_3$ and in caries$_2$ the intensity is the lowest (52.47) au.

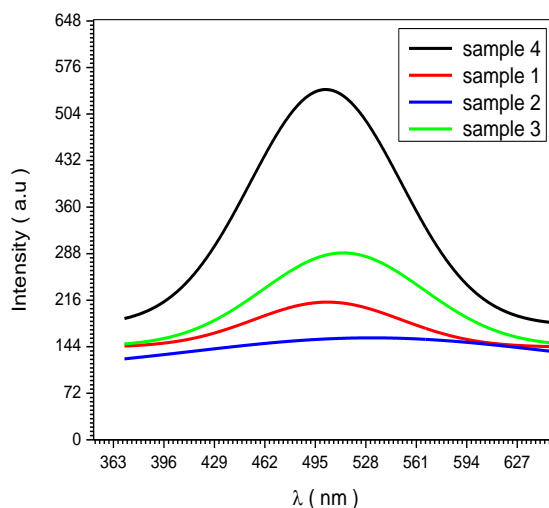The caries proportional inverse to the intensity of induced emission.

Fig7. *The broad band of dental caries and sound tooth (Excitation at 337.8 nm)*

Table1. *Comparative of dental caries and sound tooth*

No of sample	λ (nm)	A	Fw.HM	I (a.u.)
Sample1	502.9	8460.86	114.24	69.6
Sample2	531.79	15295.38	273.81	52.47
Sample3	513.28	11917.71	124.19	144.62
Sample4	501.78	44938.24	115.58	364.42

The results show that there is a difference in the intensities of the emission peaks from the Luminescence of dental caries and sound tooth.

4. CONCLUSIONS

PE (photoemission) spectra of dental caries and the sound tooth have been obtained and investigated.

All samples produce abroad band and sharp peak in the visible region and sharp peak in the infrared region

The obtained results show different PE spectra from all samples. Comparing the PL spectra from the sound tooth with dental caries, we found that the intensity is decreased in the caries tooth which indicates that the intensity is depending on the amount of decay.

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