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Human Teeth With and Without Dental Caries Studied by Visible Luminescent Spectroscopy

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The visible emission spectra and fluorescent lifetimes from decayed and nondecayed regions of teeth were measured and compared. The spectrum from carious lesions is different from that of noncarious tooth regions. This may offer a non-X-ray method for diagnosing dental caries in humans.

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Introduction.

Optical spectroscopy offers a way to detect and characterize physical and chemical changes which occur in materials. Over the years scientists have derived fundamental information about the structure of materials and the energy transfer processes which occur in materials by studying emission-absorption spectra and relaxation kinetics.[1,2] There are, however, limited data on the spectroscopy of teeth.[3-6] In this paper we report measurements of the visible luminescent spectra and relaxation lifetimes from human teeth with and without caries. The purpose of our research was to determine if a difference exists between the visible luminescent spectra and lifetimes from decayed and nondecayed regions of teeth. The spectrum from carious lesions was found to be different from that of noncarious regions. This may offer the basis for a supplementary method for diagnosing the presence of dental caries.[7]

Materials and methods.

To measure the visible emission spectrum from teeth, quasi monochromatic light from a tungsten source dispersed with a grating monochromator was focussed on the teeth. The wavelengths used to excite the luminescence from the teeth were 350 ± 5nm, 410 ± 5nm, and 530 ± 5nm. The luminescence from the front surface of a tooth was collected into a Spex ¼-meter scanning spectrometer blazed at 1000 nm. For the 410 nm and 530 nm excitation, a Corning 3-73 or a 3-67 filter was placed at the entrance slit of the spectrometer. A photomultiplier tube (PMT) RCA 7265 (S-20) located at the exit slit of the spectrometer measured the intensity at the different wavelengths. The output of the PMT was connected to a Princeton Applied Research lock-in-recorder combination to display the spectrum. The fluorescent lifetimes from the teeth were measured using a single 530 nm picosecond excitation laser pulse, a fast Hadron 105 S20 photodiode and Tektronix 519 oscilloscope.[8] Three Corning 3-67 filters were placed on the face of the photodiode to eliminate any scattered 530 nm excitation light. With the filters in place luminescence at wavelengths only greater than 560 nm was detected by the photodiode. The uncertainty in measuring lifetimes from the oscilloscope photograph traces is ± ½ nsec. The visible emission lifetimes and spectra were measured on decayed (carious) and nondecayed coronal regions of six different extracted teeth from different adults. The lesions studied were medium-sized, ~1-3 mm. The extracted teeth were cleaned using Alconox. The surface of the tooth was cleaned with methanol prior to excitation. The emissions from the dentin and enamel surfaces were also measured.

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Results.

Typical emission spectra measured from carious and healthy normal regions on the same tooth excited by 410 nm light are displayed in Fig. 1. The spectra were constructed taking into account the spectral response of the detection system (filters, PMT, and spectrometer), normalizing to unity at the intensity maximum. The emission spectra from the decayed surface con-

tain no more than a 25% contribution from the surrounding nondecayed regions. The beam size on the tooth was a rectangular area about 1 mm x 3 mm. The slit of the spectrometer was masked. In Fig. 2 the difference in spectra between the carious and normal regions is shown. The emission intensities from carious lesions of various teeth were within an order of magnitude of the intensities from the same size of noncarious regions. The yield of the visible emission from a tooth is about 27 times weaker than the total fluorescent emission from Rhodamine 6G at 10^{-4}M dissolved in water.

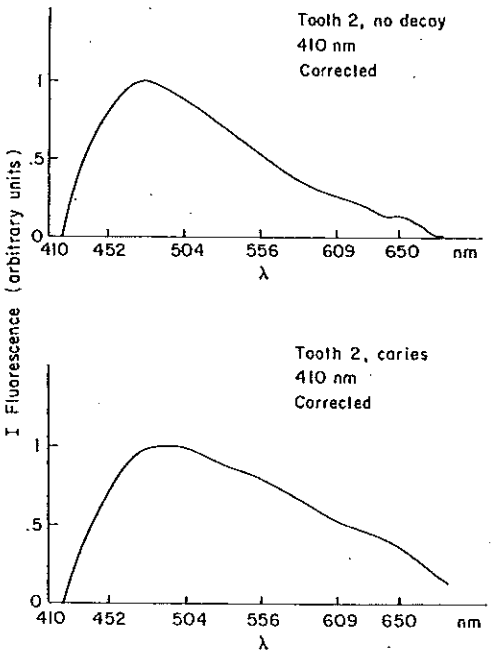

Fig. 1 – Luminescent spectrum from noncarious and carious regions of a tooth excited by 410 nm light.

Figs. 1 and 2 indicate that the spectra of carious lesions are shifted to the red portion. In addition, the caries spectra have more relative intensity in the longer wavelength region > 540 nm (red portion) than the spectra obtained from the nondecayed teeth. The size of the spectral content and shift depends on the contribution from the excited normal region surrounding the carious lesion. The largest difference between the spectra from carious and non-

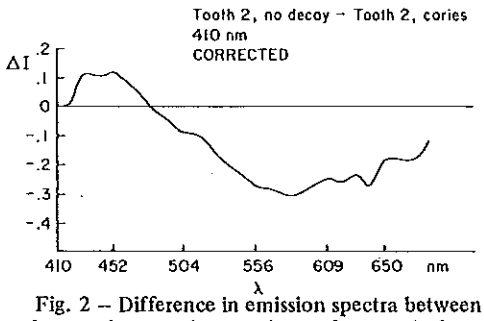

Fig. 2 – Difference in emission spectra between carious and noncarious regions of a tooth from Fig. 1.

carious teeth occurs at about 600 nm. Similar differences were consistently observed on samples from six teeth. The spectra measured from normal enamel and dentin are essentially the same. The peaks in the luminescent spectrum excited by 350 nm and 530 nm light are located at about 427 nm and 580 nm, respectively. For these exciting wavelengths, the relative intensity in the red portion of the spectrum is greater for a carious region than for a noncarious tooth region.

Within the limits of the time measurement accuracy, the emission lifetimes from decayed and normal teeth were about the same, $\approx$ 2.3 nsec. Using different Corning-colored filters in front of the photodiode, the intensity of the signals observed by the oscilloscope seems to be correlated with the measured emission spectra excited by 530 nm light. Because the measured lifetimes are extremely fast, the observed visible emission spectrum most likely arises from fluorescence.

Conclusions.

The causes for the differences in the spectra from decayed and nondecayed regions of a tooth are unknown at present. The difference between the visible emission spectra from carious and noncarious teeth may offer a non-radiographic clinical method to detect dental caries in humans.[7]

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