Study of Dental Erosion using the PTR-LUM Technique

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Protocol

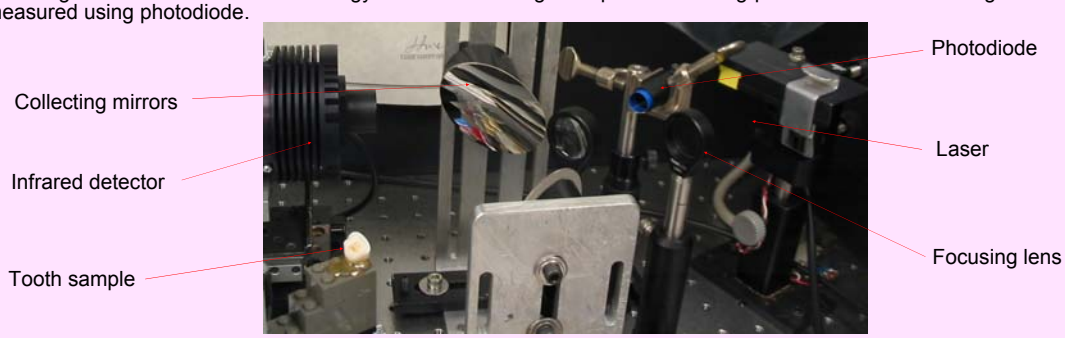
• 6 extracted caries-free human molars were mounted on LEGO blocks to facilitate scans.
•The samples were immersed in the freshly squeezed orange juice (pH4) for the following time periods: 20 minutes, 40 minutes, 1 hour, 2 hours, 6 hours, and 24 hours. The treatment of each sample was stopped at different time periods.
•The PTR-LUM scans were done before and after each treatment period. TMR analysis was performed for each sample after scans.

Experimental setup

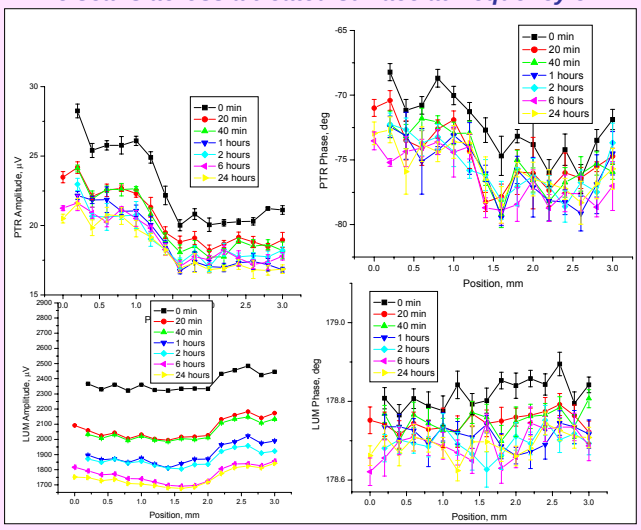
• A semiconductor laser emitting at 659 nm was the source of PTR signal and LUM.

•Modulated laser light generated infrared blackbody radiation from teeth. The modulated PTR signal from the sample was collected and focused onto a mercury cadmium telluride (MCT) detector.

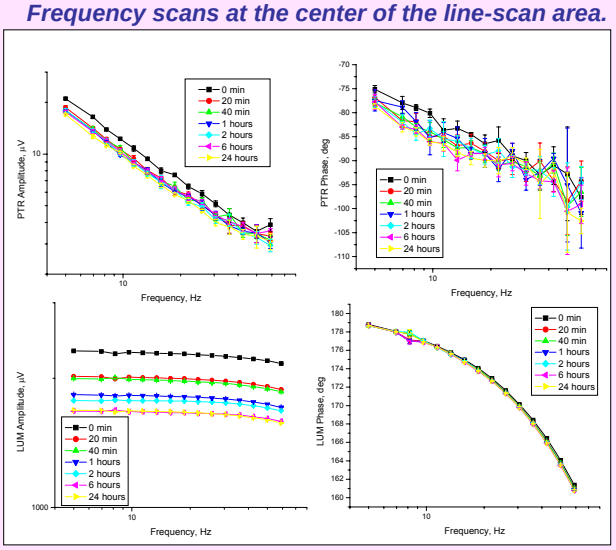
•The LUM signal is based on radiative energy conversion during the optical scattering process of the incident light inside the tooth. It was measured using photodiode.



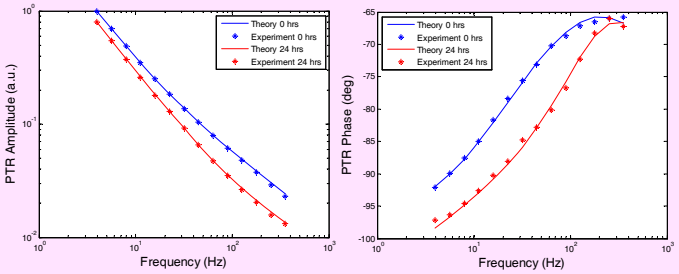
Line scans across a treated surface at frequency 5 Hz.



Frequency scans at the center of the line-scan area.



Theoretical model and results



Theoretical 3-Layer diffuse-photon-density-wave and thermal-wave model describes the frequency dependence of the PTR signal (A. Hellen *at al*, Applied Optics 49, 2010).

Fitted parameters of tooth enamel after (and before) the 24-hrs erosion treatment:
α_1 = 4.76x10^{-7} (4.38x10^{-7}) m^2/s – thermal diffusivity,
κ_1 = 0.13 (0.83) W/mK – thermal conductivity,
μ_{a1} = 90.7 (83.6) 1/m – absorption coefficient,
μ_{s1} = 158 (4509) 1/m – scattering coefficient.
Thickness of the eroded layer L_1 = 18.1 μm (TMR result).
The change in parameters reflects the increase in porosity.

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