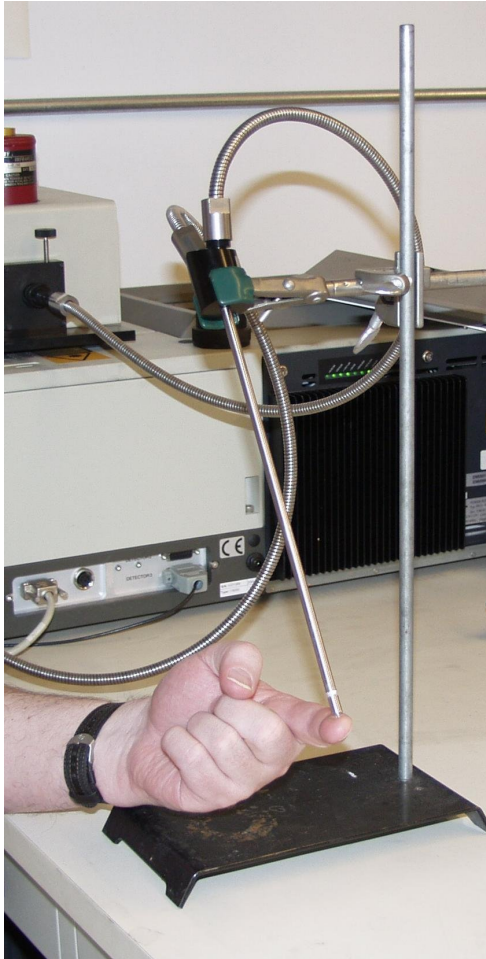


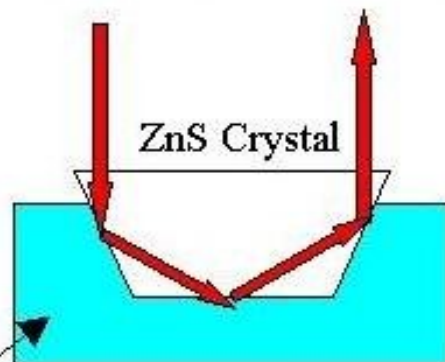
## **In-Vivo Spectroscopy of Human Tissue: Skin and Cartilage**



*Figure 1: Collecting data from human skin using TissueView*



*Figure 2: The TissueView ATR crystal is made of zinc sulfide and has a 1 mm diameter flat tip*



**Tissue**

*Figure 3: The flat ATR crystal is nominally a 3-bounce design*

Mid-IR spectroscopy is a very useful technique for characterizing biological tissue. The combination of a sensitive ATR crystal with a flexible fiber-optic cable turns it into a truly non-invasive, *in-situ* method. The specially designed ATR crystal, shown above, has a flat tip to minimize discomfort to the patient and maximize the contact area between the crystal and the tissue.

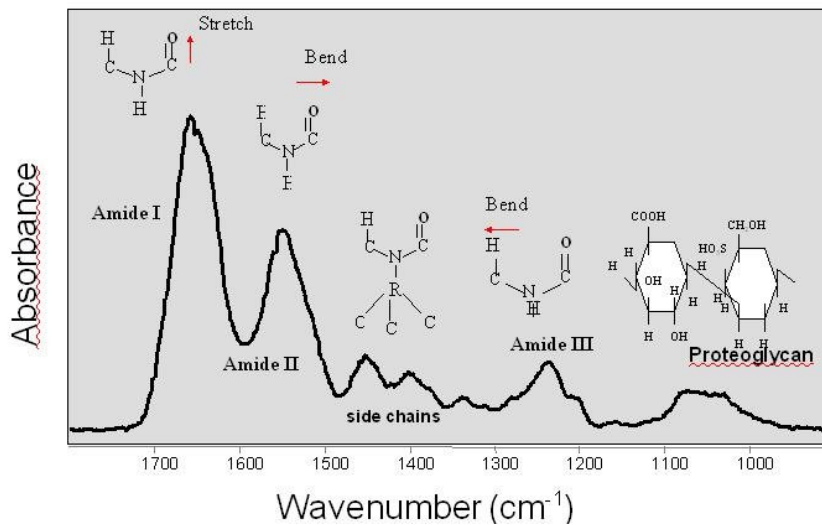
Two applications of TissueView™ are discussed here: evaluation of human cartilage to estimate the degree of degradation<sup>1</sup>, and examination of human skin<sup>2</sup>.

1 Bostrom, Camacho et al., *Applied Spectroscopy*, 59(12):1527-1533 (2005)  
2 Kollias et al., *J. Investigative Dermatology*, 116(3), 380-386 (2001)

## Experimental

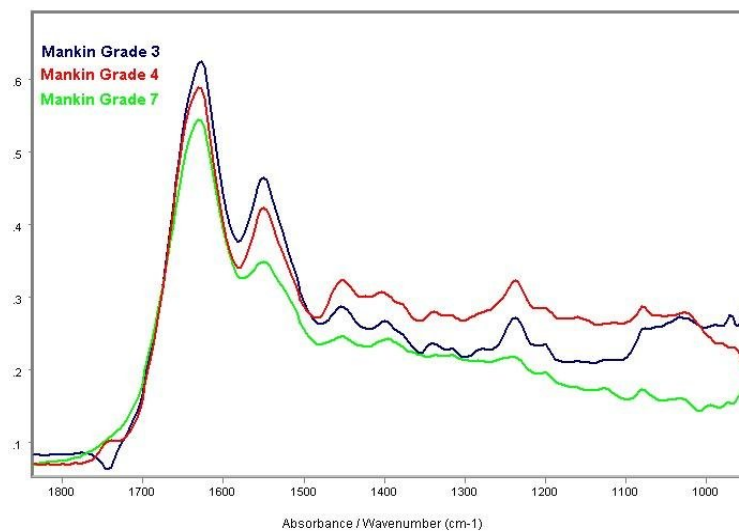
In a typical test, the tip of the ATR crystal is pressed against the test tissue for 10 to 30 seconds while data are collected; the force applied to the sample can be controlled (for example, to 0.7lb in the cartilage study) using a specially adapted probe including a load control mechanism. The background spectrum is collected in air, and data are collected at a resolution of either 4 or 8  $\text{cm}^{-1}$  depending on the exact experiment.

## Results: Cartilage Studies

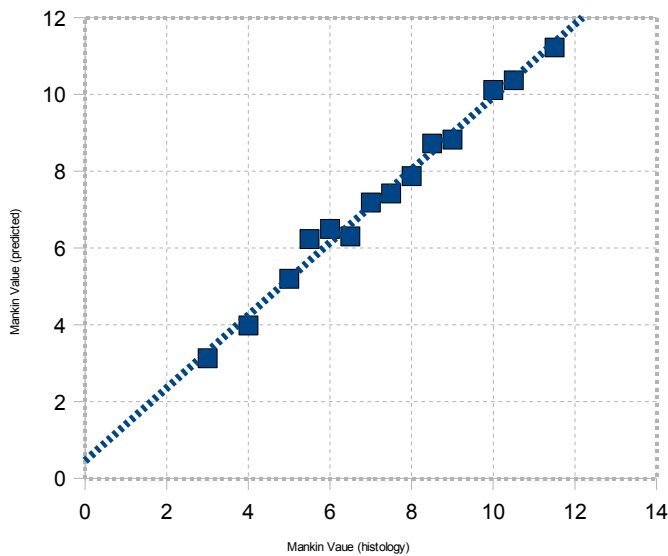


A typical mid-IR spectrum of human cartilage is shown here with band assignments for the various functional groups present in the complex structure of the material.

When the TissueView spectrum obtained from a set of cartilage samples is compared with the histological Mankin<sup>3</sup> score assigned to each sample. When the average spectra for several samples at three different scores are compared, there are clearly changes in the spectrum.



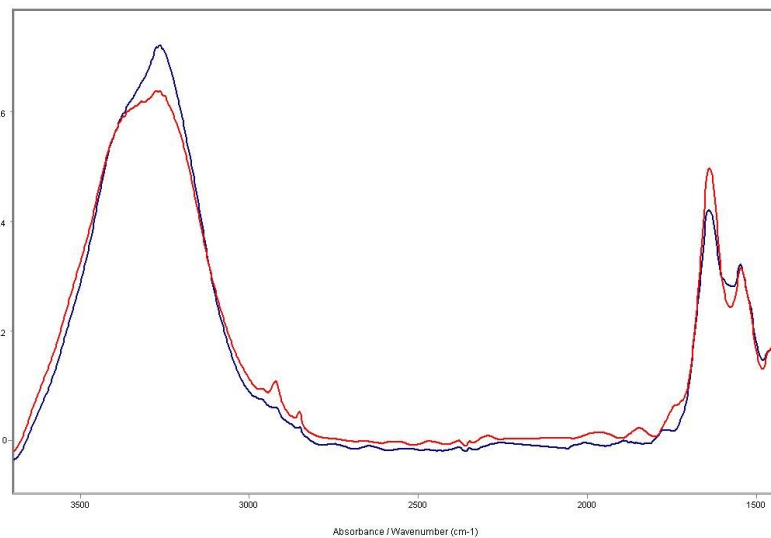
3 The Mankin score correlates with the level of cartilage damage from 0 (normal) to 14 (severely degraded). See Oegema et al., Handbook of Histology Methods for Bone and Cartilage, Chapter 31 (Humana Press)



When a PLS1 statistical model is built from the cartilage spectra, and used to predict Mankin scores from spectra left out of the model, the average predicted values show a good linear relationship with the true histological values.

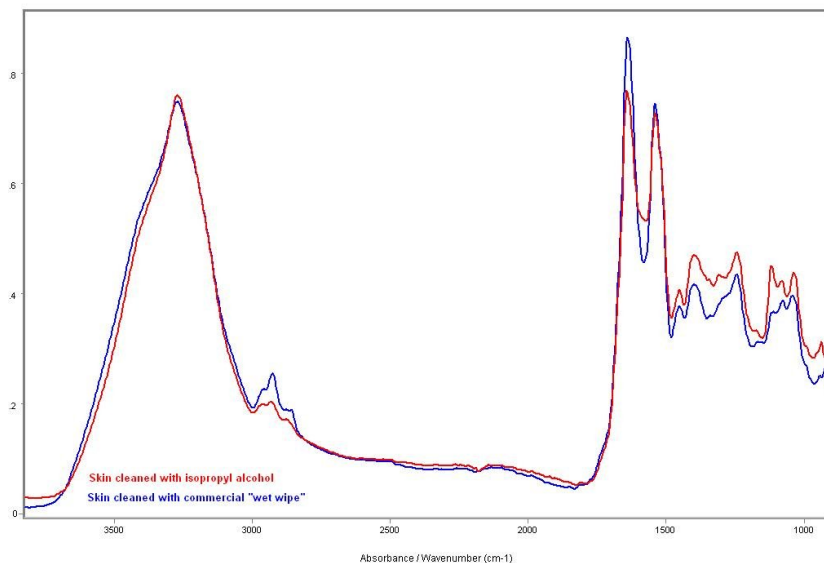
### *Results: Skin Studies*

TissueView spectra of human skin can be used to study a number of different skin properties. The spectra shown here illustrate different levels of skin hydration. A human subject cleaned the skin of one hand with isopropyl alcohol, then placed it in a vinyl glove containing 10 ml water. The red trace shows the TissueView spectrum obtained after 10 minutes hydration; the navy trace shows the result of 30 minutes' hydration.



Changes are observed<sup>4</sup> in the broad O-H stretch feature between 3685 and 3000  $\text{cm}^{-1}$ ; in the lipid C-H stretches between 3000 and 2800  $\text{cm}^{-1}$ ; and in the amide I and amide II bands at 1640 and 1540  $\text{cm}^{-1}$  (a region that also includes a water band).

<sup>4</sup> For a detailed discussion of the mid-IR spectra of hydrated skin, see Shah et al., *Methods Find Exp Clin Pharmacol.*, 30(7), 499-512 (2008)



The effect of skin treatments on the skin can also be investigated using TissueView. The traces shown here compare skin cleaned with isopropyl alcohol and skin cleaned using a commercial “wet wipe” in which the principal ingredients are water, hexylene glycol, and glycerin. Besides the changes

in the water and amide I and II bands that may be mainly associated with hydration, there are changes in the region between 1220 and 1000 cm-1 that may indicate the presence on the skin of glycol and glycerin species.

### Discussion

Mid-IR spectroscopy is a well established method for characterizing biological tissue, including human tissue, to evaluate its condition, state of hydration, etc. and to study the effect of treatments such as lotions and ointments. Remspec's TissueView system turns a useful lab technique into a powerful non-invasive, *in-situ* method for carrying out this type of study, turning FTIR from a research tool into a practical diagnostic method. Interchangeable, sterilizable ATR heads are available for TissueView, making it practical to use the method in clinical settings.



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