Diverse medical technologies: How Compact Spectrometers are being used to develop health-related methods and devices

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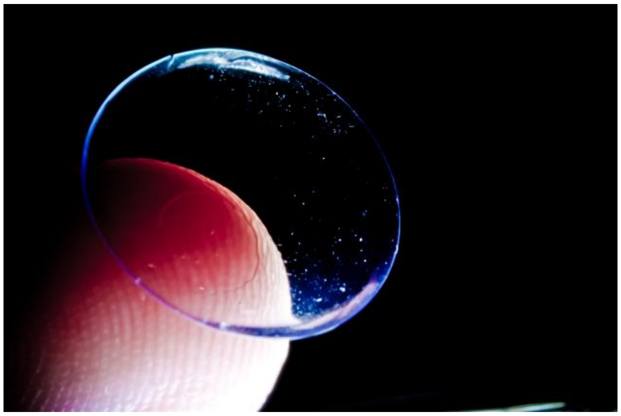
Earlier, I wrote a piece about how StellarNet customers are using compact spectrometers to tackle the multi-headed beast that is cancer. While cancer is a large problem, it is but one of many in the healthcare industry. Diseases need to be understood, treatments need to be developed, and more fundamentally, methods and devices need to be created to perform measurements at all steps. Here's a sampling of the diverse ways that StellarNet customers are creating health-related methods and devices.

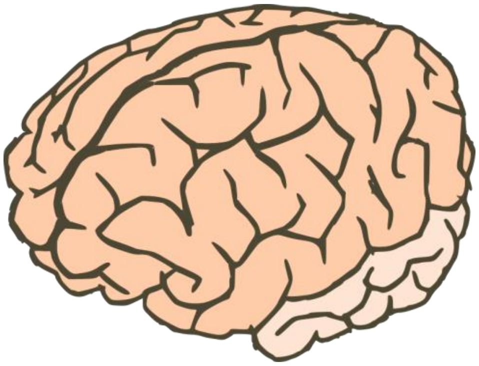
Methods



Contact Lens 2, by n4i via Flickr, licensed under CC-BY.

The Matija group at the University of Belgrade has developed a technique called Aquaphotomics to study how water interacts with materials. The researchers used a StellarNet DWARF-Star spectrometer and a transmission fixture to measure the first overtone of water (1300-1600 nm) in hydrogels, used for contact lenses. They performed two interesting experiments: one comparing a low water content hydrogel to a medium water content hydrogel [1], and one looking at worn versus new lenses [2]. In both experiments, performing principle component analysis on the spectra allowed for classification of the materials. It also revealed properties of the materials. For the water content, the low and medium content hydrogels had similar amounts of bound waters, waters hydrogen bonded to the hydrogel molecules. The medium content hydrogel had increased free water content, meaning waters that were not strongly bound to anything. For the worn lenses, wear decreased the number of bound waters, which increased the waters free to bond with the proteins that accompany wear, such as proteins found in tears.

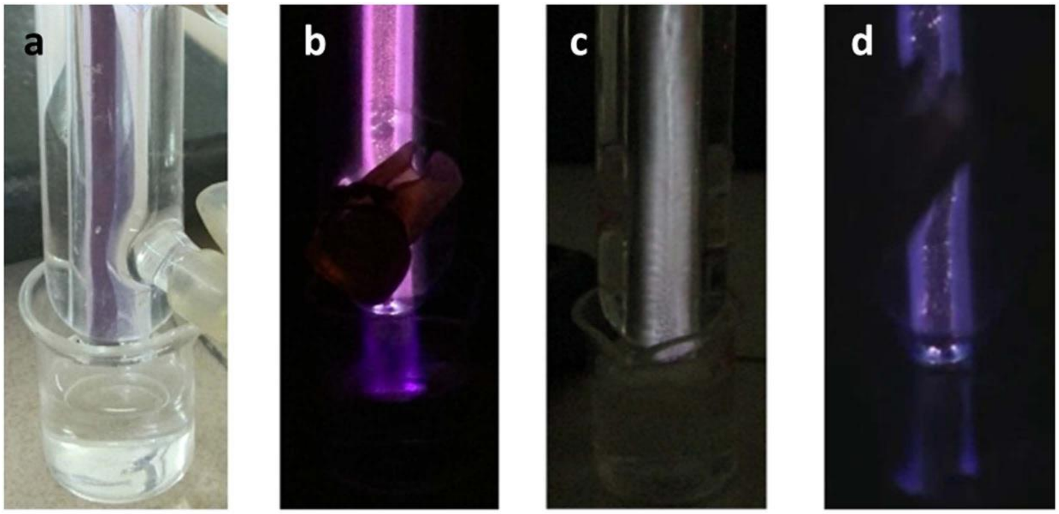
The near IR region can also be used for detecting oxygen in the brain. Rackebrandt and Gehring created a method to measure the oxygen content of arteries in the brain [3]. Notably, the method is accurate and fast, which current methods have never achieved simultaneously. They created a phantom model that matches the optical properties of the scalp, skull, blood, and brain and collected signal at varying distances from the light source. They used a StellarNet white light source and BLUE-Wave spectrometer to measure a



reference spectrum. The spectra from the phantom model matched the reference at several distances from the light source as well as for several skull thicknesses, proving the technique's suitability for measuring oxygen content.

Devices

As we saw for cancer, plasma devices are useful for selective targeting. Instead of targeting cancer cells, Wang *et. al.* targeted *Schistosoma japonicum*, a parasite that causes schistosomiasis [4]. They found that using oxygen-rich gases to generate plasma could produce a 20% survival rate of the parasite in water after treating for 10 minutes. They used a BLUE-Wave spectrometer to measure the discharge of the plasma, which included oxygen and nitrogen radicals. Taking pH measurements of the treated water over time confirmed that these species were reacting. The image below shows the plasma device discharging into the sample.



Partial figure from Ref [4], licensed under CC-BY.

Devices don't always have to be so "sciency;" they can also be made of more commonplace devices. Petryayéva and Algar made a bioassay imager and FRET apparatus out of an iPhone [5]. The flashlight provided a light source (characterized by a GREEN-Wave spectrometer) and the camera provided a detector. Using a 3D printed sample holder, they showed that the phone could detect proteins bound to quantum dots. They also demonstrated a FRET experiment. When Alexa fluor 680 dye was used as a ligand, the quantum dot signal was quenched. When thrombin was added to the solution to cleave the dye, the signal returned in real time. While the phone was not as good as laboratory instruments, it provides a cheaper and portable alternative.

Finally, Orlova *et. al.* sought to make a UV transparent thin film with provitamin D embedded in it [6]. They used a BLACK-Comet to measure the irradiance of the UV light source, allowing the conversion from irradiation time to UV dose. Plotting the film's absorbance at 282 nm versus dose showed that a polyvinyl butyral film gave good sensitivity at low doses. Because of this, the authors suggested that the film would be useful as a UV dosimeter to help limit a person's UV exposure.

From measuring water in contact lenses to characterizing the iPhone's flashlight, StellarNet products are an integral part of medicine and healthcare. Next time you receive treatment for an illness or injury, remember to thank your doctors, of course. But, save a thank you for a spectroscopist, too.

References

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