TRIP REPORT

FOR THE VISIT ON JULY 12, 2001

WITH DESCRIPTION OF ON-GOING TASKS

W. LaVaughn Hales
9535 Hemlock Drive S. E.
Huntsville, AL 35803-1160
tel.: (256) 338-1530 fax: (561) 325-2493
email: wlhales@email.msn.com

Trip Report

Date of visit at the Biocontrol Technology, Inc. plant: July 11, 2001.

Principal contacts: T. J. Feola, David McMurry, Jeremy Grata, Jeff Thomas, Pat Cooper, Nancy Saxman

The visit consisted almost entirely of an extensive meeting and working session, during which several alternate approaches to the design of a compact spectrograph, and the entire optical data-acquisition system were discussed. The pros and cons of waveguide spectrographs were discussed at length.

The principal disadvantage of the waveguide designs is the attenuation of the signal due to the multiple reflections within the optical slab. It was generally agreed that with the planned light sources for future use, the throughput efficiency of the spectrograph is not a major problem. The efficiency is probably too low for use with the light source currently in use.

The present spectrograph performs admirably, but is quite large and heavy. The stray light is remarkably well controlled, considering the classical design of the spectrograph. Usually, if stray light is a major concern, and a Czerny-Turner design is preferred, a crossed Czerny-Turner will be used. The performance is the same, but it is easier to baffle the stray light effectively. Also, the crossed design may be a little more compact. The geometry of the input and output instrumentation is very different in the two designs, and may be a driving force in the choice of designs.

There was considerable interest in the possibility of using mid-infrared wavelengths for measuring blood glucose. This presents some very challenging problems. However, glucose has very prominent absorption bands in this region that can lead to very accurate measurements.

One approach that has been applied to mid-infrared measurement takes advantage of the fact that the human body is a very good emitter of black-body radiation in the very region in which the glucose absorption bands are found. Thus, the human body provides it's own illumination. The difficulty in this case is that since the blood is at the same temperature at the rest of the tissue, it is effectively transparent to the radiation, and no absorption spectrum will be observed. An approach that has been used with positive results[1] involved cooling the skin in the region of measurement to reduce the temperature of the blood relative to the background radiation behind it. This allows the blood to

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[1] D. C. Klonoff, J. Braig, et.al., "Mid-Infrared Spectroscopy for Noninvasive Blood Glucose Monitoring", Lasers and Electro-Optics Society, Newsletter, April 1998.

absorb more radiation than it emits. Although reasonable spectra can be obtained in this manner, humans have complex variations that reduce the reliability of this technique.

It was agreed that I will do an extensive technical literature search in an effort to identify possible techniques that will prove viable in mid-infrared measurements of blood glucose. The extensive resources of the Redstone Scientific Information Center will be utilized in this effort. Viable techniques utilizing an external light source will be of particular interest.

The control of the light from an external source offers particular problems, since the usual fiber materials are not transparent in this region. Non-fiber optical systems offer a possible solution, but may be cumbersome. Hollow fibers are in fairly common use in this spectral region also. Solid fibers transparent to mid-infrared frequencies will be sought if they exist at all. An in-depth literature search is in progress, and will be the subject of a report in the near future.

In noninvasive glucose measurements, there is the problem of small signal changes in the presence of noise that is much stronger than the data signal. This noise may also have some of the characteristics of the signal, making the separation of the signal and the noise even more difficult. The small signal - strong noise problem is also common in the field of astrophysics. Therefore, I shall examine the astrophysical techniques of data analysis in detail. These techniques are all too often ignored or unknown in other fields. This study is now on-going.

It was also agreed that I shall continue to investigate spectrograph designs that will minimize size and weight in near-infrared glucose measurement devices, and that will be compatible with planned light sources and detectors. Suitable instruments will also be sought for use in the mid-infrared, compatible with the more promising measurement techniques. Dr. Thomas has kindly supplied me with the design specifications of the Czerny-Turner spectrograph currently in use. This will be a benchmark against which future designs can be measured.

Summary

My current tasks are as follows:

1. Design of spectrographs of minimum size and weight for use in near infrared and mid-infrared wavelengths. Emphasis will be placed on compatibility with future light sources.

2. Investigate possible mid-infrared techniques for noninvasive measurement of blood glucose.

3. Search for fiber-optic materials and techniques for use in mid-infrared technology.

4. Research astrophysical and other techniques for the measurement of small signals in the presence of large, and possibly systematic noise levels.

Periodic reports will follow.