The PDP 2006 Annual Progress Report

Infinite Quanta, Inc.

A Non-Profit 501(c)(3) Scientific Research Organization

2006 has been a year of progress in every respect with scientific and technical advancements, as well as corporate contributions. Highlights this year included $15,000 in equipment contributions which led to the development of the Dielectric Spectrometers 2 and 3 (DS2 and DS3). The year culminated to acceptance of our work in the prestigious American Institute of Physics journal *Review of Scientific Instruments*.

The year began with the development of the DS2. It is based on the Stanford Research SR830 DSP Dual-Phase Lock-In Amplifier. It has a frequency range of 1 mHz to 100 kHz and a current sensitivity of 2 fA ($2x10^{-15}$A). The spectrometer employs National Instruments LabView v8.2 to interface and control the lock-in amplifier. A custom parallel plate capacitive sample cell was created to interface with the amplifier. The custom LabView application controls the magnitude and frequency of the applied voltage across the sample cell while measuring and averaging the current through the sample. Incremental stepping of the frequency is performed to generate a dielectric spectrum.

Proton migration studies were performed on bovine hemoglobin. Hydration levels ranging between 30 to 250 water molecules per hemoglobin molecule were studied under the DS2. A linear relationship of hydration versus dielectric response was observed. However, it was realized that the response corresponded with the frequency roll-off of the current-to-voltage preamplifier built into the lock-in amplifier. It is clear that a replacement preamplifier is required for the DS2 to extend the roll-off to above 100 kHz. Also, a switching mechanism will be incorporated to automatically calibrate the spectrometer with known capacitors. These modifications will ensure that linearity and accuracy are enforced within the specified frequency range. The hydration studies will then be repeated and should lead to an understanding of proton migration due to the side R-group network of the hemoglobin protein.

The majority of the year was spent developing amplification and noise-rejection techniques for the DS3. The necessary hardware for its development was made possible by Fluke Corporation, Tektronix, and National Instruments. Essentially, commercially-available test and measurement (T&M) equipment were converted into a highly sensitive, stable, and multi-sample channel frequency-domain dielectric spectrometer using lock-in methodologies. This was performed using modern amplifiers and advanced software written in LabView. The work continues to progress, however, at this point, we have proven a frequency range of 100 mHz to 1 MHz and a dual-phase current sensitivity of 250 fA.

The developmental DS3 work was published in the *Review of Scientific Instruments* and entitiled, “Noise-Rejection Techniques for Impedance and Dielectric Spectrometers Using Ubiquitous Test and Measurement Equipment.” This work proves that modern developmental methods can produce more sensitive, more stable, and drastically less expensive spectrometers than those commercially-available, i.e., Agilent, Solartron Analytical, and NovoControl Technologies. An implication of this work is the commercial potential of these novel methods with minimum hardware interfacing and our custom software solution. A second work is in progress and should be submitted by April 2007.

We continue to submit proposals for commercial and federal funding. Our recent proposals are the best work to date. With the solid foundation of the past coupled with novel ideas and approaches for the future, we hope 2007will be a profound and rewarding year. You are invited to visit our news page at http://iquanta.org/news for up-to-date information and announcements.