

Technologies:

Closed Loop:

1. Mechanical Sieves
 - Microfiltration used to simulate pore openings
 - Can be purchased in various sizes to account for ranges in ultrasound effectiveness
2. Personal Ultrasound Devices
 - Hand held devices that can be used to administer ultrasonic vibration
 - Operate at more effective frequencies than standard audio speakers
3. Dual Chamber Vacuum System
 - Would have an outer ring of constant vacuum. This would act to keep the device on the surface of the skin while Insulin is administered through pressure in the inner circle
4. Micro Needles
 - Create skin pores without causing any pain

Measurement:

1. Photo Acoustics
 - Measurement of glucose using light rays
2. Near Infra-red Spectroscopy
 - Glucose measurement using IR rays
3. Electro-Enzymatic Sensor
 - Glucose measurement from tears using contact lens

Patents:

Through our research we found patents of a similar nature to our problem. We used them to establish the current technologies so as not to impede on research currently being done and to use up to date ideas to build a basis for our own experimentation. Being conscious of the legal issues, we mainly focused on not crossing business and ethical lines.

Design Approach:

1. Design separate devices for the two main functions during extraction process:
 - Low frequency ultrasound device (for pore enlargement)
 - Vacuum pressure device (for extraction of interstitial fluid)
2. Verify previous group's result by testing the effect of vacuum pressure, with and without low frequency ultrasound, on pigskin during the extraction process.
3. Design a working prototype that incorporates both functions.
4. Test working Prototype on live rat.

Results:

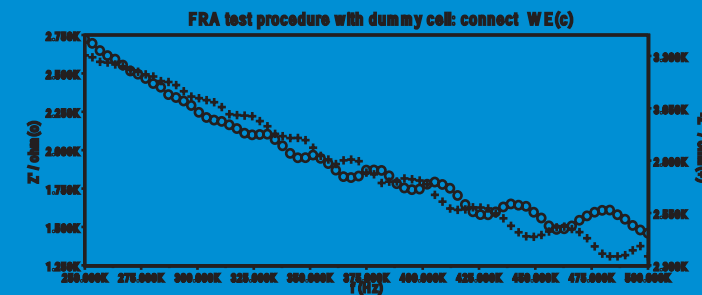
1. Early experiments showed promise: Green spots seen on the surface of the skin after application of ultrasound and vacuum. Increasing time of exposure to ultrasound and vacuum seemed to increase the amount of coloration seen on the surface of the skin.
2. Further investigation and testing proved our results to be inaccurate: Because the test tissue was no longer attached to its donor organism, the tissue became dry with increased exposure to atmospheric conditions. This caused the tissue to become translucent which gave the appearance that with increased testing time, greater amounts of fluid were being drawn to the surface. In fact fluid was being viewed through the surface of the tissue.
3. Variations in the test procedures also uncovered that results varied based on which vacuum prototype we used and were a direct result of ultrasound application.

Design Approach:

1. Impedance Spectroscopy:
 - Using the resonant frequency of glucose, measure the concentration of glucose from the magnitude of the dip in imaginary impedance at the resonant frequency.
 - Last semester's IPRO scanned from 1-100 KHz (the max output of the machine they used) and did not find a resonant frequency.
 - This semester we scanned from 100 KHz to 1MHz. Frequencies larger than 500 KHz produce inconsistent results probably due to changing internal inductance.

Results:

1. The results we have thus far do not indicate a relationship between concentration of glucose and any of the other variables tested including:
 - Real, imaginary, and total impedance
 - Phase shift
 - Locations/magnitudes of peaks



Background

Diabetes (Diabetes Mellitus or Diabetes Insipidus):

A disease in which the body is unable to produce or respond to insulin hormone in a normal way.

- **Type 1:** Deficient Insulin Production
- **Type 2:** Insulin Resistance
- **Gestational diabetes :** women who have high blood sugar (glucose) levels during pregnancy

21 million Americans are currently battling diabetes and 54 million adults and children in the U.S. are on the verge of being diagnosed with diabetes. The United States spend approximately 132 billion on diabetes related issues per year. Diabetes alone represents 11% of the U.S. health care expenditure Fasting Plasma Glucose Test (FPG) or an Oral Glucose Tolerance Test (OGTT) is used to determine diabetes. With the FPG test, a fasting blood glucose level between 100 and 125 mg/dl signals pre-diabetes. A person with a fasting blood glucose level of 126 mg/dl or higher has diabetes.

Current research in diabetes

(by American Diabetes Association):

- understanding the autoimmune process behind type 1 diabetes in children
- replacement of beta cells for the treatment of type1 diabetes
- the development of programmable implantable insulin pumps
- the discovery of a protein related to food intake and weight control
- understanding the incidence of ulcers, infections, peripheral vascular disease and amputations in diabetic patients

Mission Statement:

IPro 308 is dedicated to developing a closed-loop method of addressing type I diabetes involving a fully automated means of measuring glucose levels in the patient, determining the adequate insulin requirement and administering the dose, not only with minimal input and effort from the patient, but completely non-invasively and with no discomfort.

IPro 308:

Developing an Artificial Pancreas



IPro Team: (From Left To Right)

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