NC-1031: Nanotechnology and Biosensors

ANNUAL MEETING

MARCH 9-10, 2008
CHAPEL HILL, NC

CHAIR
MILFORD HANNA
University of Nebraska

VICE CHAIR
SURANJAN PANIGRAHI
North Dakota State University

SECRETARY
KAUSTUBH BHALERAO
University of Illinois

ADMINISTRATIVE ADVISOR
VINCE BRALTS
Purdue University

IN ATTENDANCE
Advisor: Vince Bralts
Arkansas: Yanbin Li
Arizona: Jeong-Yeol Yoon
Hawaii: Daniel Jenkins
Illinois: Kaustubh Bhalerao & Graciela Padua
Indiana: Marshall Porterfield & Jenna Rickus
Iowa: David Grewell
New Jersey: Paul Takhistov
North Dakota: Suranjan Panigrahi
Utah: Anhong Zhou

Meeting minutes

March 9th 2008

1:00 Opening remarks by Vince Bralts Recap of meeting last year. A Sharepoint website has been put up to upload NC-1031 related documents. The presentations and report will need to uploaded to the website. Bralts also delivered a presentation on behalf of Hongda Chen. The presentation included an update on nanoscale science and technology. A copy of the presentation is placed on the website.

1:30 PM Arizona: Jeong-Yeol Yoon reported on technologies, to bind antibodies on a nanofabricated surface

1:50 PM Hawaii: Daniel Jenkins reported on sensors based on isothermal DNA amplification.

2:00 PM Iowa: David Grewell presented Lab on a chip devices for biochemical analyses.

2:17 PM Illinois: Kaustubh Bhalerao presented data on nanoscale protein aggregation and whole cell biosensors.

3:17 PM Arkansas: Yanbin Li presented a large selection of biosensor / nanotechnology applications in disease detection

4:00 PM Indiana: Jenna Rickus presented projects within the physiological sensing facility.

4:30 PM Break for the day

March 10th 2008

8:40 AM Location of 2009 meeting to be decided between Hawaii or Washington DC, after talking to Hongda Chen. The meeting will convene tentatively in mid-April. 2010 location is New Jersey. Dr. Panigrahi will draft a proposal with justification for the time and place of the 2009 conference. Suggestion was made to ask Hongda Chen about inviting ARS people to increase group membership.

8:53 AM North Dakota: Suranjan Panigrahi presented e-nose sensors for packaged meats.

9:28 AM New Jersey: Paul Takhistov presented impedance sensors based on aluminum nanopore films.

10:09 AM Vince Bralts presents additional information on how to operate the team website.

10:36 AM Discussion on issues and opportunities for collaboration within the group. Excerpts of the discussion and some issues raised are presented on the next page.

11:48 AM Paul Takhistov was unanimously elected Secretary to coincide his being Chair with the location of the meeting.

12:01 PM Meeting adjourned.

DISCUSSION DIRECTIONS FOR COLLABORATION

Several possibilities for collaboration were discussed. These included, Collaborating on a book focused on applications of biosensors and nanotechnology in food and agriculture, developing NC-1031 as a resource for nanotechnology awareness in USDA, and creating a NanoHub branch to showcase applications in agriculture and food.

It was also suggested that a matrix of critical needs in the industry can be developed, which would warrant the development of nanotechnology based solutions. This matrix could also include an estimation for the urgency of each need as well. A white paper could be developed along these lines. Example subtopics could answer the following questions: What is synergy between nanotechnology and biosensors? What is the role of industry in furthering this technology? What can basic research achieve? What are the basic science activities? What are the translational opportunities? What is the time scale / urgency behind every need?

Issues related to collaboration were also discussed. One of the major issues discussed was that any meaningful collaboration would require a large amount of resources. Copyright issues relative to disseminating materials were also discussed.

Station reports

Arizona, University of Arizona

Jeong-Yeol Yoon

Through self-assembling antibody-conjugated submicro- or nanoparticles on the desired nanometer wells (through size-matching), we can construct a protein nanoarray capable of single molecule detection. 300-, 160- and 70-nm fluorescent particles are self-assembled to the respective e-beam nanoarray patterns. Size-dependency is confirmed by a fluorescent microscope (with a 100x oil immersion objective) and a SEM. This system will eventually be applied for detecting the differentiation factors (e.g. Oct4) in the human embryonic stem cell (hESC) cultures, which requires single molecule detection. Antigen-antibody binding is monitored by using the fluorescent particles or NOM (nano-on-micro) configuration. Fluorescent or quantum dot emission is attenuated when antigen-antibody binding occurs. Preliminary data for detecting Oct4 is demonstrated in 2007.

We also investigate the use of latex immunoagglutination assays in both microchannel and microdrop lab-on-a-chip platforms, towards automated, reagent-saving and high-throughput pathogen detections. The use of optical light scattering detection should make the detection limit extremely low, close to the single molecule/cell level. We detect Escherichia coli (10 CFU/mL), Salmonella typhimurium (5 CFU/mL), bovine viral diarrhea virus (BVDV; 0.5 TCID50/mL) and porcine reproductive and respiratory syndrome virus (PRRSV; 10-4 TCID50/mL) with our method. The detection limits of RT-PCR assays are typically 102 TCID50/mL for viruses. The detection limits of other immunoassay attempts in lab-on-a-chip are typically 100 CFU/mL for bacteria. Our goal is to make the lab-on-a-chip platform portable, affordable, yet adaptable, through eliminating expensive components and make actuation as simple as possible.

Publications

Lucas, L,J., and Yoon, J.-Y. 2008. On-Chip Detection Using Optical Fibers. In D. Li (ed.), Encyclopedia of Micro- and Nanofluidics, Springer, Berlin Heidelberg (in press).

Yoon, J.-Y., and Garrell, R.L. 2008. Biomolecular Adsorption in Microfluidics. In D. Li (ed.), Encyclopedia of Micro- and Nanofluidics, Springer, Berlin Heidelberg (in press).

Kim, K., Yoon, J.-Y., Kwon, H.-J., Han, J.-H., Son, J.E., Nam, S.-W., Giacomelli, G.A., and Lee, I.-B. (2008) 3-D CFD Analysis of Relative Humidity Distribution in Greenhouse with Fog Cooling System and Refrigerative Dehumidifiers. Biosystems Engineering doi:10.1016/j.biosystemseng.2008.03.006 (in press).

Yoon, J.-Y. (2008). Open-Surface Digital Microfluidics. The Open Biotechnology Journal 2: 94-100.

Yoon, J.-Y. (2008). Latex Immunoagglutination Assay in Lab-on-a-Chip. Biological Engineering 1: 79-94.

Heinze, B.C., Song, J.-Y., Han, J.-H., and Yoon, J.-Y. (2008). Latex Immunoagglutination Assay for Bovine Viral Diarrhea Utilizing Forward Light Scattering in Microfluidic Device. Proceedings of SPIE 6886: 688605.

Han, J.-H., Heinze, B.C., and Yoon, J.-Y. (2008). Single Cell Level Detection of Escherichia coli in Microfluidic Device. Biosensors and Bioelectronics 23: 1303-1306.

Lucas, L.J., Chesler, J.N., and Yoon, J.-Y. (2007). Lab-on-a-Chip Immunoassay for Multiple Antibodies Using Microsphere Light Scattering and Quantum Dot Emission. Biosensors and Bioelectronics 23: 675-681.

Kim, K., Giacomelli, G.A., Yoon, J.-Y., Sase, S., Son, J.E., Nam, S.-W., and Lee, I.-B. (2007). CFD Modeling to Improve the Design of a Fog System for Cooling Greenhouses. JARQ 41: 283-290.

Yoon, J.-Y., Han, J.-H., Heinze, B., and Lucas, L.J. (2007). Microfluidic Device Detection of Waterborne Pathogens through Static Light Scattering of Latex Immunoagglutination Using Proximity Optical Fibers. Proceedings of SPIE 6556: 65560M.

Lucas, L.J., Han, J.-H., Chesler, J., and Yoon, J.-Y. (2007). Latex Immunoagglutination for a Vasculitis Marker in a Microfluidic Device Using Static Light Scattering Detection. Biosensors and Bioelectronics 22: 2216-2222.

Han, J.-H., Kim, K.-S., and Yoon, J.-Y. (2007). The Enhanced Diffusional Mixing for Latex Immunoagglutination Assay in a Microfluidic Device. Analytica Chimica Acta 584: 252-259.

Participants:

Individuals: Jeong-Yeol Yoon (PI); Keesung Kim (postdoctoral fellow); Lonnie J. Lucas, Tremaine B. Powell, Jin-Hee Han, Brian C. Heinze, Phat L. Tran (graduate students); Jennine N. Chesler, Anbar Najam (undergraduate students).

Partner organizations: National Veterinary Research and Quarantine Service, Republic of Korea.

Collaborators: Christopher Y. Choi (University of Arizona, Tucson, Arizona); Barun K. De (University Medical Center, Tucson, Arizona), Jae-Young Song (National Veterinary Research and Quarantine Service, Anyang, South Korea), Kye-Seong Kim (Hanyang University, Seoul, South Korea) and Gene A. Giacomelli (University of Arizona, Tucson, Arizona).

Target Audiences:

Academic research, veterinary diagnostics, medical diagnostics, emerging biotech industry.

Idaho, University of Idaho

Josh R. Branen & A. Larry Branen

Enzyme-linked immunomagnetic electrochemical biosensor

A comprehensive evaluation of immunomagnetic particles has been undertaken to determine parameters, conditions and approaches that will provide the most efficient capture of target analytes. Experimental variables include volume of samples, sample matrices (buffers, food products, and wastewater samples), time, temperature, size of immunomagnetic particles, functionalization of magnetic particles and amount of magnetic particles. Preliminary results have shown that magnetic particle size and surface chemistry can be selected to provide highly efficient and rapid capture of live organisms or toxins from particular food products. Capture variables can also be tuned to allow for larger samples (>10 milliliters). This optimization has been integrated with an electrochemical detection approach to allow rapid (less than 3 hours) and sensitive detection of Escherichia coli O157:H7 (<50 cfu/ ml) and Staphylococcal enterotoxin B (<1 pg/ ml). Initial experiments are underway to determine the potential improvement of target capture using immunomagnetic nanoparticles. A combined capture and culture protocol has shown promise for the differentiation of live and dead organisms.

Silica nanospring biosensors

The integration of silica nanosprings with biosensor platforms is currently under study. Silica nanosprings have an extremely large surface to volume ratio, surface characteristics that can be tuned with proven physical and chemical methods, and are amenable to use with standard photolithographic techniques. Two nanospring mat electronic biosensor devices have been designed and fabricated and are being tested for sequence specific detection of DNA in collaboration with University of Idaho scientists in the Departments of Physics, Chemical Engineering and Biological Sciences. General methods are also being developed for the biological functionalization and characterization of

nanospring surfaces with the potential application of these surfaces to other biological approaches relevant to food safety.

Diagnostic applications of Locked Nucleic Acid

In collaboration with the University of Idaho's Department of Chemistry, we have recently begun the exploration of Locked Nucleic Acids (LNA) as a novel nanomaterial for biosensor applications. Specific sequences have been designed to determine improvements to nucleic acid detection. The designed sequences will allow integration with the current detection systems. Synthesis of the LNA oligonucleotides is in progress in the Department of Chemistry and heterogeneous assay development and biosensor design has begun. Hybridization efficiency experiments will commence in the near future with the synthesis of the first LNA sequences.

Collaborators

D. Eric Aston, Department of Chemical Engineering, University of Idaho

Patrick Hrdlicka, Department of Chemistry, University of Idaho

David McIlroy, Department of Physics, University of Idaho

James Nagler, Department of Biological Sciences, University of Idaho

Publications and presentations

Corti, G., Lidong Wang, David Major, Josh Branen, Jamie Jabal, Larry Branen, James Nagler, Eric Aston, Grant Norton, David McIlroy. 2007. In Functional Materials for Chemical and Biochemical Sensors, edited by E. Comini, P-I. Gouma, V. Guidi, X-D. Zhang (Mater. Res. Soc. Symp. Proc. Volume 1010E, Warrendale, PA, 2007), 1010-V05-03.

Branen, J.R., Jamie M. Jabal, Giancarlo Corti, M. Grant Norton, D. Eric Aston, A. Larry Branen, James J. Nagler, and David N. McIlroy. 2007. Nanospring-based Electronic Biosensors for DNA Detection. Invited presentation. June 19, 2007. AAAS, Pacific Division. Boise, ID.

Illnois, University of Illinois

Kaustubh Bhalerao

Nanoscale structure and aggregation behavior of zein

Zein is an insoluble, undigestible byproduct of the corn ethanol industry. As a biological material, zein represents the realities of working with and trying to understand the complex, polydisperse nature of biomaterials. Using dynamic light scattering, to investigate the aggregation behavior of zein in ethanol-water cosolvents, we were able to demonstrate that while zein shows a polynomial dependence on the solvent composition, its diffusion coefficient shows an Arrhenius type relationship with respect to solvent temperature. Together, these phenomena account for 40% of the variability seen in zein diffusion coefficients over a wide range of solvent conditions. This provides sound engineering information relevant to the extraction, purification and processing of a potentially valuable biological material.

Whole cell biosensors

Whole cell biosensors are unicellular living organisms designed to detect and report various analytes of interest in their immediate surroundings. Whole cell biosensors could have a significant impact in environmental monitoring, as sentinel organisms in microbial colonies, as detectors of other pathogens and contaminants and in life sciences research. A major drawback with these systems is their unpredictable sensitivity to the analytes of interest. We have been using principles of synthetic biology to develop "signal amplifiers" within whole cell biosensors that can amplify small, transient, biochemical signals produced in response to environmental analytes. In addition to amplification, the synthetic circuits also show "memory-like" behavior: the whole cell biosensor continues to respond to the stimulus long after the stimulus is removed.

Publications:

K.D. Bhalerao and G. Nistala (2007) Nanoscale Biology: Engineering Applications. Encyclopedia of Agricultural, Food and Environmental Engineering. Editor: Dennis R. Heldman. Commissioned by Taylor & Francis Group. Accepted as of January 2008.

G.J. Nistala, K. Wu, C.V. Rao and K.D. Bhalerao (2007) A novel synthetic plasmid network to monitor and control gene expression. Annual meeting, Institute of Biological Engineering, March 29-April 1, 2007, St. Louis, MO.

G.J. Nistala, K. Bansal and K.D. Bhalerao (2008) Couple applications of the positive feedback motif: Biosensing and protein production. Annual meeting, Institute of Biological Engineering, March 6-8, 2008, Chapel Hill, NC.

Iowa, Iowa State University
David Grewell

Output:

The activities of this during this period included process characterization of zero flash embossing as well as biosensor characterization in terms of resolution and fidelity. Experiments included evaluating the effect of independent parameters such as embossing time, amplitude and clamp force on dependent parameters such as embossing depth and feature quality. Optical and scanning electron microscopy were used to characterize the quality of embossed features. In addition, experiments were conducted to determine the effect of glucose concentration and sample size on assay resolution. The products from this period included; fundamental understandings on enzymatic oxidation of glucose in the presence of glucose oxidase (GOx). In additions, two ways of estimating glucose concentration: 1) by the analysis of the reaction products and 2) by measuring the PL intensity (I) or the PL decay time of an oxygen sensitive dye, co-embedded with GOx in a thin film or dissolved in solution were developed and characterized. These findings were presented in Agricultural Engineering 590 (High Powered Ultrasonics) as well as a peer reviewed conference.

Outcome/Impacts:

Impacts included the development of a novel technique for the detection of glucose concentration. The technique is based on a lab-on-CD based biosensing platform is its simplicity in terms of usage, versatility in terms of multi-analyte detection feasibility, and compact size. These devices are envisioned to be low-cost and disposable, allowing high frequency testing without the risk of cross contamination, a characteristic that is critical for many applications such as testing for pathogens in food processing. In addition, because of the laws of scaling, these devices will function rapidly and allow nearly immediate diagnosis, which can be critical in detecting possible pathogen-based terrorist threats. An expected result of the characterization of glucose concentration and assay fidelity was that the strongest signal occurs with the highest glucose concentration of 33 mM. However a faint signal was measured in case of the control experiments where no glucose was present. This possible experimental error was attributed to electroluminescence (EL). This impacted the measurement technique and reaction chamber design on new and future lab on a CD designs. It is important to note that a provisional patent detailing this technology has been allowed.

Publications:

Harmon G., Grewell D., 2007, Elimination of Flash – A Novel Micro-Embossing Technique, 65th Annual Technical Conference for the Society of Plastic Engineers Proceedings, Society of Plastic Engineers, Brookfield, CT

Vengasandra S.,Grewell D., 2007 Microfabrication Of Polymer Substrates For Lab-On-A-Cd Applications, 65th Annual Technical Conference for the Society of Plastic Engineers Proceedings, Society of Plastic Engineers, Brookfield, CT

Participants

David Grewell, Assistant Professor, Iowa State University, Department of Agricultural and Biosystems Engineering

Srikanth Vengasandra, Graduate Student, Iowa State University, Department of Agricultural and Biosystems Engineering

Yuankun Cai, Graduate Student, Iowa State University, Department of Physics

Ruth Shinar, Professor, Iowa State University, Department of Physics

Joseph Shinar, Professor, Iowa State University, Department of Physics

Target Audience:

This work was presented in Agricultural Engineering 590 (High Powered Ultrasonics) as well as a peer reviewed conference (x2). The audience includes engineers and scientist developing novel microfabrication techniques and application designs. Because several studies have suggested that females have an affinity for making global impacts in the future and this work has the potential to save lives worldwide, females include a targeted audience.

Project Modification:

Because of new insights gain from collaborative efforts with interdisciplinary groups from the Department of Physics department, assays have been expanded from anthrax to include glucose. This expands the potential impact and outcomes of future work.

Michigan, University of Michigan
Evangelyn C. Alocilja

Outputs:

Polyaniline (Pani) nanowires were synthesized using five protonating acids, namely: 4-sulfobenzoic acid, phenylphosphonic acid, 4-hydroxybenzenesulfonic acid, perchloric acid, and hydrochloride acid. Conductivities of the resulting solid polymers ranged from 10^2 to 10^3 S/cm. Their conductivities in liquid ranged from 0.4 to 1.2 S/cm.

Electrically-active immunomagnetic (EIM) nanoparticles were developed and synthesized. EIM were used to pre-concentrate the target bacteria from the sample just like the immuno-magnetic beads and directly used in the biosensor platform for direct detection.

Experiments were conducted to study the effect of carbon nanotube-polyaniline nanocomposites on the Bacillus cereus biosensor. Single-walled and multi-walled carbon nanotubes were evaluated in the experiments. Different methods were being evaluated to conjugate the polyaniline nanowires, carbon nanotubes, and antibodies in the development of nanotransducers for the biosensor.

Various nanoporous silicon (NPS) chips were also fabricated using electrochemical anodization in a Teflon electrochemical cell. Experiments were conducted to identify the best anodizing conditions considering variation in silicon wafer characteristics. The NPS chips showed photoluminescence property under UV light. The nanopores were characterized using a scanning electron microscopy (SEM). Silanization was utilized to functionalize the NPS chips. The specific DNA probe (5'- [Amino link] AATATGCTGCCTACTGCCCTACGCTT -3' (positions 690 to 716 of target, 26 bases)) for Salmonella enteritidis insertion element (Iel) gene was immobilized on the porous silicon after silanization. Pathogen culture and extraction of the double stranded DNA from Salmonella enteritidis (strain S-64) were performed using conventional protocol. The sample DNA was amplified through polymerase chain reaction (PCR). The PCR result was evaluated by gel electrophoresis and its concentration was determined by spectrophotometer.

Outcomes/Impact

In 2007, we were able to train 3 high school students, 8 undergraduate professorial assistants, 1 engineering research intern, 9 graduate students from the Biosensors Lab and 3 graduate students from other labs, and 2 research associates. These students and research associates are going to be the new generation of scientists who will contribute to the field of biosensors in the future.

We have also developed the first draft of eight lesson plans on "Nanotechnology and Biosensors" for the middle school and high school science curriculum through our science teacher collaborator.

Publications:

Yang, L., Chakrabartty, S., and Alocilja, E.C. 2007. Fundamental building blocks for molecular bio-wire based forward-error correcting biosensors, Nanotechnology Journal 18, 6pp.

Kindschy, L. and Alocilja, E.C. 2007. Development of a Molecularly Imprinted Biomimetic Electrode. Sensors Journal 7:1630-1642.

Muhammad-Tahir, Z. Alocilja, E.C., and Grooms, D.L. 2007. Indium Tin Oxide-Polyaniline Biosensor: Fabrication and Characterization, Sensors Journal 7:1123-1140.

Pal, S., Alocilja,E.C., Downes, F.P. 2007. Nanowire Labeled Direct-Charge Transfer Biosensor for Detecting Bacillus species, Biosensors & Bioelectronics Journal 22:2329-2336.

Nebraska, University of Nebraska
Milford Hanna

Electrospray encapsulation:

Previously, bovine serum albumin-loaded polylactic acid and chitosan capsules were prepared with small particle size and near monodisperse size distribution.using a single-nozzle electrospray technique. This was followed by the preparation of bovine serum albumin-loaded polylactic acid capsules using a two-phase coaxial jet electrospray technique in which no emulsification process was involved, resulting in a maximum retention for bioactivity of the sensitive core materials. We plan to use the two-phase coaxial jet electrospray technique for encapsulation of bioactive food ingredients and define optimal conditions to generate highly functional micro/nano capsules.

Tapioca starch-poly(lactic acid) nanocomposite foams

Tapioca starch-poly(lactic acid) nanocomposite packaging foams were produced by melt-intercalation using a twin screw extruder. Tapioca starch and 10% PLA were blended with a small quantity of nanoclay (3 wt%) and

preconditioned at 17-20% moisture content over-night. A 150-rev/min screw speed was used for the extrusions. The temperature at the feeding section was maintained at 50°C, the second barrel section at 100°C, the third barrel section at 150°C and die section at 150°C. A 3 mm diameter die nozzle was used to produce a continuous cylindrical rope-like extrudates which were cut by a rotary cutter. Incorporation of a small quantity of nanometric-sized clay particles into these foams improved the functional properties. Improvements included improved physical properties (higher expansion ratio, lower density), improved mechanical properties (lower bulk compressibility, higher spring index, higher Young's modulus), improved structural properties (compact and smaller cell size and higher cell population), improved thermal properties (higher onset thermal degradation temperature) and improved physico-chemical properties (higher WAI and lower WSI).

Publications:

LEE, S.Y., Xu, Y., and Hanna, M.A. (2007). Tapioca starch-polylactic acid-based nanocomposite foams as affected by type of organoclay. J. Intern. Polymer Processing XXII(5); p. 429-435.

LEE, S.Y., and Hanna, M.A. (2007). Tapioca starch-polylactic acid-Cloisite 30B nanoclay foams. Accepted by J. Polymer Composites.

LEE, S.Y., and Hanna, M.A. (2007). Preparation and characterization of tapioca starch-poly(lactic acid)-Cloisite NA+ nanocomposite foams. Accepted by J. Appl. Polym. Sci.

LEE, S.Y., and Hanna, M.A. (2007). Preparation and characterization of tapioca starch-poly(lactic acid) nanocomposite foams by melt-intercalation based on clay type. Accepted by J. Ind. Crops and Products.

LEE, S.Y., Hanna, M.A. and Jones, D.D. (2007). Modeling mechanical properties of tapioca starch-poly(lactic acid) nanoclay foams with an adaptive neuro-fuzzy inference system. Accepted by Starke.

Xu, Yixiang and Hanna, Milford A. 2007. Synthesis and characterization of tripolyphosphate (TPP) cross-linked chitosan capsules using electrospraying technique. Journal of Microencapsulation, 24(2):143-151.

Xu, Yixiang and Hanna, Milford A. 2008. Morphological and structural properties of two-phase coaxial jet electrosprayed BSA-PLA capsules. Journal of Microencapsulation, accepted

New York, Cornell University

Antje Baeumner

Lateral flow assays (LFA) with liposome signal amplification and microfluidic biosensors with fluorescence and with electrochemical detection are being developed. In the LFA format, the use of liposomes over colloidal gold and latex beads, as well as alkaline phosphates for visual detection was investigated, determining a decrease in the limit of detection with liposomes by at least a factor of 10.

Microfluidic systems are being developed on a modular basis using hot embossing nanofabrication techniques. Modules for RNA isolation, amplification and detection are designed and tested. Specifically, the hardware for signal recording of an electrochemical microfluidic system was designed and tested. The minipotentiostat system is coupled with interdigitated ultramicroelectrode arrays and is applied to the detection of nucleic acid molecules. A small portable handheld device is thus available which will be used in the future in the development of robust and inexpensive, sensitive and specific pathogen microfluidic sensors.

Publications:

Connelly, J.T., Nugen, S.R., Borejsza-Wysocki, W., Durst, R.A., Montagna, R.A., Baeumner, A.J. "Human Pathogenic Cryptosporidium species bioanalytical detection method with single oocyst detection capability", Analytical and Bioanalytical Chemistry (available on-line 2008)

Edwards, K.A., Curtis, K.L., Sailor, J., Baeumner, A.J. "Universal liposomes: Preparation and usage for the detection of mRNA" Analytical and Bioanalytical Chemistry (accepted,

Kwakye, S.B. and Baeumner, A.J. "An Embedded System for Portable Electrochemical Detection" Sensors and Actuators B, vol. 123, pp. 336 – 343 (2007)