Natural Sciences and Engineering Research Council of Canada
Conseil de recherches en sciences naturelles et en génie du Canada

FORM 101
Application for a Grant
PART I

Institutional Identifier	
System-ID (for NSERC use only)	436404405
Date	2020/05/25

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Rezai	Pouya	P	**Valid** 400925

Department	Institution that will administer the grant
Mechanical Engineering	York

Language of application	What is the proposed cost-sharing ratio for this application?
[X] English [ ] French	100%

Type of grant applied for
Alliance Grants

Title of proposal
Point-of-Need Microfluidic Biosensor for Detecting Airborne Viruses using Molecularly Imprinted Polymers: Towards COVID 19 Virus Monitoring

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
Microfluidics, Sample Preparation, Point of Use Detection, Molecularly Imprinted Polymers, Virus Extraction, Virus Concentration, Sorting and Separation, Colorimetric Detection, MIP Microparticles and Nanoparticles, MIP-Virus Conjugation

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
1900	1901	1102	401

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.
Research involving : [ ] Humans [ ] Human pluripotent stem cells [ ] Animals [X] Biohazards

Indicate if any phase of the proposed research takes place outdoors and if you answered YES to a), b), c) or d), you must complete and attach Appendix A. See instructions for the Environmental Information Form. [X] NO [ ] YES

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
50,000	0	0	0	0

SIGNATURES (Refer to instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Head of department

Applicant's department, institution, tel. and fax nos., and e-mail

Mechanical Engineering
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Dean of faculty

President of institution (or representative)

Personal identification no. (PIN)	Family name of applicant
Valid 400925	Rezai

CO-APPLICANTS

I have read the statement "What do signatures on the application mean?" in the accompanying instructions and agree to it.

PIN, family name and initial(s)	Organization	Signature
284111, Brar, SKB	York	

PROTECTED B WHEN COMPLETED

Personal identification no. (PIN)	Family name of applicant
Valid 400925	Rezai

Before completing this section, read the instructions for the definition of collaborators in the Eligibility Criteria section of the Program Guide for Professors.

COLLABORATORS

PIN, family name and initial(s)	Organization / Department
Kraft, Dr.	Sixth Wave Innovation Inc.,
Kalivretenos, Dr.	Sixth Wave Innovation Inc.,
Gluckman, Dr.	Sixth Wave Innovation Inc.,
Magdouli, Dr.	Centre technologique des résidus industriels,

Personal identification no. (PIN)	Family name of applicant
Valid 400925	Rezai

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)
This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): 1 (416) 7362100 Ext. 44703
E-mail address (optional): prezai@yorku.ca

This project is a partnership between York University, Centre Technologique des Residus Industriels (CTRI), and Sixth Wave Innovation Inc. (SIXW). The goal of this partnership is to develop components of a portable and low-cost technology for rapid and on-site air sampling and detection of aerosol and droplet-encapsulated viruses in indoor and outdoor environments.
Virus capturing will be done by Molecularly Imprinted Polymers (MIPs) under the extensive expertise of the partner company, SIXW. MIPs are robust materials with pre-made nano-cavities that can capture target objects such as viruses in this project. For this, MIP-based microparticles for bulk conjugation and nanoparticles for electrode coating and surface immobilization of viruses will be designed and optimized. MIP microparticle-virus conjugates will be sorted and separated passively in portable microfluidic devices. Finally, on-chip virus capturing, tagging with detection labels. and quantitative detection will be performed calorimetrically using cellphone imaging and image processing.
This project will result in innovative scientific research, mobilization of research from conception to proof of concept stage, and lab-scale development and integration of sample preparation and virus detection devices. These integrated sample preparation and detection systems will be portable, easy to operate, and sensitive for future use by inspectors, businesses, hospitals, special care centers, and police force involved in decision-making to address various challenges associated with airborne pathogen outbreaks and pandemics. One postdoctoral fellow and two graduate students will be trained in this project and participate in scientific publications and generation of intellectual property in Canada.

Other Language Version of Summary (optional).

RELEVANCE AND EXPECTED OUTCOMES

- Outline the goals of the partnership and explain the potential outcomes and impacts.
- Outline efforts the partner organizations will invest following the project's completion to advance the results in Canada.

Goal: The goal of this partnership is to develop components of a portable and low-cost technology for rapid and on-site air sampling and detection of aerosol and droplet-encapsulated viruses in indoor and outdoor environments. Virus capturing will be done by *Molecularly Imprinted Polymers (MIPs)* under the extensive expertise of the partner company, Sixth Wave Innovation Inc. (SIXW). Virus capturing will be optimized by Dr. Brar and Dr. Magdouli with experience in microbial immobilization and development of micro- and nano-particles. MIP-virus conjugates will be manipulated in microfluidic devices to be developed by Dr. Rezai, an expert in Point-of-Use microfluidics for biodetection. Finally, quantitative virus detection will be performed calorimetrically using cellphone imaging and image processing under this NSERC project, while a parallel independent MITACS Accelerate project will be pursued for quantitative electrical detection of MIP-viruses. These integrated sample preparation and detection systems will be portable, easy to operate and sensitive for future use by inspectors involved in decision-making to address various challenges associated with pathogen outbreaks and pandemics.

Outcomes: This project will result in innovative scientific research, mobilization of research from conception to proof of concept stage, and lab-scale development of a portable sample preparation device for virus extraction from air and its integration with two detection units for colorimetric (under NSERC) and electrical (under MITACS) interrogation of airborne viruses. In addition to forming a collaboration between two academic researchers, one government scientist, and one nanotechnology company, this project will result in training of one postdoctoral fellow (PDF), one doctoral (PhD), and one Master of Science (MSc) student in areas such as polymer science, biochemistry, multiphase flows, microfluidics and biodetection. Each trainee is expected to publish one journal and one conference paper, and new intellectual properties will be generated by the end of this project. Expansion of partnerships with technology developers and end users will be pursued for continuation of this research.

Impact: The short-term impact of this technology is providing innovation and leadership in Canada to develop one of the first field-deployable air monitoring systems for detecting viruses such as SARS-CoV-2. The project should lead to the creation of advanced R&D jobs based in Canada. Shortly after this 1yr project, the team will be able to develop the first prototype and test it with a wide group of end users in government, police, private businesses, hospitals, special and elderly care centers, and many more to validate the technology and bring it to the market soon after. Empowering these groups will enhance the quality and outcome of surveillance and virus spread mapping in all places, help with making effective preventive decisions to manage outbreaks and save lives, lower the chance of infection and result in reduced pressure on the healthcare system, and give security and confidence to businesses to return to work faster and operate under safe conditions. Therefore, our technology will have both health and economic impacts on the Canadian system within the next 2 years and globally in 3-5 years.

Company Efforts Following Project Completion: SIXW is committed to bringing its MIP technology for the detection of SARS-CoV-2 to market. The company is currently in the process of securing several million dollars of capital investment and has made key manufacturing partnerships to accelerate the MIP development and manufacturing. The colorimetric and electrochemical detection technology is a part of SIXW core technology strategy for a family of products based on MIPs for virus detection in different applications. SIXW has identified multiple pathways to market, many of which would require the construction of manufacturing facilities and expanded R&D capabilities/facilities in Canada.

PARTNERSHIP

- List all partner organizations expected to play a key role in the activities.

- Describe the core activity of the partner organizations and how the topic is relevant and aligned with the partner organizations' activities.
- Explain how each partner organization will be actively involved. Describe the value added through in-kind contributions and how these are important to realizing the project's intended outcomes.

SIXW is a nanotechnology company focused on developing detection and extraction solutions that meet the highly specialized needs of its clients. The company specializes in advanced polymeric and non-polymeric chemistry, such as MIPs, to develop extraction and detection media that is powered by the specific molecular structure of the target substance. This is highly aligned with the proposed project aiming to use MIPs to capture viruses in air and detect them using colorimetric and electrical readouts.

This project is inline with SIXW recent patent filing with the United States Patent and Trademark Organization: *The Use of Molecularly Imprinted Polymers for the Rapid Detection of Emerging Viral Outbreaks,* Application Number: 63/010,244. SIXW will provide its core competencies in MIP synthesis and materials development to this project and leverage the contributing investigators expertise in bioengineering (Dr. Rezai) and biotechnology (Drs. Brar and Magdouli) to develop integrated sample preparation and sensing technologies for detecting viruses such as SARS-CoV-2 in air. SIXW has a proven track record in development and commercialization of similar technologies, including a rapid detection test (TRL 9) for improvised/homemade explosives, which has received >$5M in R&D funds.

In this project, SIXW will provide significant support towards development of the MIPs for selective binding of viruses (Obj. 1-2) and its colorimetric detection technology (Obj. 5), currently under development. Scientists from SIXW will meet weekly online with the academic team to help with the development of the proposed technologies. SIXW will also support their quarterly visits to York for in-person testing and project reviews. This is valued at over $65k of in-kind from SIXW, while the company will also contribute $11.25k cash towards the 1yr MITACS project (see above). SIXW's development of MIPs is a multimillion-dollar project that the co-investigators will be able to tap into for access to proprietary MIP materials and support. Furthermore, SIXW will play a significant role in coordinating with manufacturing partners for prototyping and bringing the technology to market.

PROPOSAL

- Outline the research objectives. Detail the resources and activities needed to achieve the anticipated results.
- Indicate approximate timelines for the activities to lead to milestones and deliverables using a Gantt chart, table or diagram.

The objectives to achieve our goal of portable and rapid detection of airborne viruses are:
Obj. 1: MIP synthesis and optimization of MIP affinity and specificity towards target viruses,
Obj. 2: Generation of functionalized MIP microparticles (NSERC) and electrode coatings (MITACS),
Obj. 3: Aerosolization of virus and inhibitor mock samples at controlled concentrations and optimization of virus conjugation to MIP microparticles/electrodes in detection-ready buffers.
Obj. 4: Separation of MIP-virus conjugates from inhibitors and preconcentration for enhanced detection,
Obj. 5: Colorimetric (NSERC) and electrical (MITACS) detection of viruses in portable microchips.

Major milestones, timelines and trainees are listed in the Table below. We will use non-pathogenic viruses like bacteriophages (e.g., MC2, T3 and T4) and heat-inactivated SARS-CoV-2 from ATCC Inc. Viruses will be grown in susceptible bacteria hosts, spiked in the experimental units, and sampled from different components of the system for concentration measurement by Real Time PCR and plague assay, as parallel tests for our portable biosensors. Our lab is already biosafety certified, fully equipped and well supported with standard operation procedures to work with these samples and methods.

Obj. 1: MIP materials will be synthesized and tested for virus affinity by SIXW staff and the academic team. MIP formulations will consist of monomers and crosslinkers. Selection of appropriate materials and polymerization methods are important for the fabrication of target-specific cavities and complementary functionalities for the template molecules. Different template molecules may have different types of interactions on polymer functionalization. Thus, the MIP-virus binding efficiency will be evaluated using different polymeric systems. Potential monomers that will be screened include acrylates, acrylamides, styrene, methylmethacrylate, methacrylic acid, and N-vinylpyrrolidone. N,N'-(1,2-dihydroxyethylene) bisacrylamide crosslinker will be used in DMSO or acetonitrile porogenic solvent to synthesize the MIPs. Bacteriophages and heat-inactivated SARS-CoV-2 will be used as templates. The monomers will self-assemble with the virus templates through non-covalent bonding during polymerization, providing a cavity with size, shape, and chemical functionality complementary to the virus. Initial generations of the MIP materials will be spin coated and imprinted with surface imprinting techniques onto a quartz crystal microbalance (QCM) electrode. Surface imprinting will be conducted by securing phages or inactivated SARS-CoV-2 virus to a glass slide through sedimentation and pressing it onto the prepolymer mixture spin coated on QCM electrode. The material will be polymerized (e.g. by UV) and the imprinting slide will be removed. The MIP will be washed with dilute HCl and ultrapure water to remove any remaining virus particles. SEM and AFM will be used to characterize the prepared MIPs which will be used for further studies of MIP-virus binding using QCM biosensor. Non-imprinted polymer will be used as a control for all the experiments. MIP affinity will be determined by exposing solutions of bacteriophages or inactivated SARS-CoV-2 using the QCM with a flow cell adapter and specificity and sensitivities will be determined and optimized.

Obj. 2: Once selective MIP formulations are determined in Obj. 1, the polymerization will be switched to emulsion polymerization techniques to produce particles in the size range of 1-50µm as needed in Obj. 3 and 4 for extraction and sorting of target viruses. MIP nanoparticles can also be synthesized with the same approach for coating the surfaces of microwire electrodes that are needed in part of Obj. 5 for electric detection of viruses. Emulsion polymerization works by dissolving the ideal MIP formulation in Obj.1 (including the virus template) in an organic phase and mixing it in an aqueous phase in the presence of surfactants. Mixing produces an oil-in-water emulsion with the MIP formulation as the organic dispersed phase inside the aqueous based continuous phase. Particle size will be controlled by the mixing speed during polymerization. In this research, the effects of polymerization conditions on particle size and morphology will be studied and optimized for yield and performance. Performance will be analyzed for selectivity, sensitivity, and capacity using adsorption experiments. Final materials will be characterized by SEM and AFM to determine particle sizes, monodispersity and surface structure. Moreover, the synthesized nanoparticles will be secured to the surface of gold wire electrodes using self-assembled monolayers to immobilize the MIPs using amine coupling chemistry. The capabilities of the

Milestone	**Deliverable**	**HQP**	**Month**											
			1	2	3	4	5	6	7	8	9	10	11	12
1-Synthesis & optimization of MIPs affinity and specificity (Obj. 1)	MIPs selective to phages & inactivated SARS-CoV-2	PDF	x	x	x	x	x			x		x		
2- Generate MIP microparticles & nanoparticle electrode coatings (Obj. 2)	Functionalized virus specific particles and wires	MSc	x	x	x	x	x			x		x		
3-Generate virus aerosols (Obj. 3)	Mock Air Chamber	PDF			x	x	x							
4- Extract aerosol viruses & capture them on MIP surfaces in media (Obj. 3)	Microfluidic bubble impinger	MSc			x	x	x	x	x	x				
5-Focus & concentrate MIP particle and MIP-virus conjugates (Obj. 4)	Microfluidic sorter & concentrator chip	PhD	x	x	x	x	x	x		x		x		
6-Capture/tag MIP-viruses on-chip (Obj. 5)	Filtration & tagging ad-on	PhD					x	x	x	x	x	x		
7-Detect viruses calorimetrically (NSERC) and electrically (MITACS) (Obj 5)	Sensitivity, detection limit, linearity & specificity	ALL 3						x	x	x	x	x	x	x

above MIP microparticles and wire coatings in capturing and extraction of target viruses from synthetic solutions will be investigated using SEM, AFM and RT-PCR.

Obj. 3: Bacteriophage and inactivated SARS-CoV-2 samples at 10^2-10^6 PFU/ml will be prepared in an *aerosolization media* (singleplex to multiplex) and sprayed into a Mock Air Chamber (MAC) using a nebulizer (BGI Inc.). These aerosolized viruses will be pumped from MAC into a 20-50mL *collection media* (Tryptic Soy Broth or Phosphate Buffered Saline) via an in-line microfluidic air bubble impinger. We have already developed a portable peristaltic pumping unit with rechargeable lithium battery that can be used at 0.1-1.5 L/min air flow rate. The microfluidic bubbler will include an array of 50-100 tree branch-like microchannel outlets arranged radially to impinge the sampled air from the MAC inlet into the *collection media*. Production of microscale air bubbles at the nozzle-shaped tips of the outlet microchannels will increase the surface-to-volume ratio of the bubbles, enhance the contact area between the air and media, decrease the time needed for aerosolized viruses to interface with the collection media, and subsequently increase the capturing efficiency of viruses. We have experience in modeling and experimental research on microfluidic droplet generation that will be instrumental in this part. We will investigate the effect of air sampling flowrate, virus type(s) and concentration in the MAC, and microfluidic channel design and dimensions on the sampling efficiency and viability of captured viruses. We will determine the optimal pumping and virus extraction conditions that maximizes virus capturing (>95%) and system portability (<2kg for microfluidic bubbler, pumps, collection media and packaging). The collection media will be spiked with MIP microparticles in Obj. 2 and virus conjugation efficiency and specificity will be studied and compared with the outcomes of Obj. 2.

Obj. 4: The collected samples in Obj. 3 will contain the target MIP-virus conjugates at low dose, and in real scenarios, other untargeted viruses, microorganisms, molecules, and particles. To enhance the concentration of MIP-virus conjugates for detection and separate them from other substances (detection inhibitors), we will use our microfluidic techniques to extract them based on the size and or inherent properties of the MIP microparticles. We have developed sorting devices that use inertial, elastic and magnetic forces to manipulate particles in microfluidic channels. With inertial forces, particles of specific size can be focused at the centerline of microchannel walls. By spiking Newtonian fluids with polymers such as polyethylene oxide (PEO), we and others have been able to develop viscoelastic fluids that can yield particle focusing at the center of the channel in square microchannels. We have also used low-cost permanent magnets to control the position of magnetic particles (inertially or elastically pre-focused) in the lateral direction in microchannels. If needed, MIP microparticles in Obj. 2 can be spiked with magnetic nanoparticles during polymerization to generate magnetic MIP microparticles for this objective. Our microfluidic particle sorting methods have been modeled and experimentally validated. We will use our numerical and experimental knowledge to design a passive microfluidic device that selectively focuses and separates MIP microparticle-virus conjugates from other non-target components in the collection media samples. For this, synthetic media will be generated with various concentrations of viruses, bacteria, inhibitor molecules like Humic acid, and other microparticles, and the effect of channel design and size, flow rate, and focusing stimuli like magnetic and elastic forces on separation of MIP microparticle-viruses and their concentration in the outlet of the device will be investigated.

Obj. 5: Current molecular detection methods like RT-PCR are hampered by intermittent shortage of reagents and their equipment-intensiveness. Canada and the world is in need of low-cost and portable air surveillance technologies. Here we propose adding a membrane filter in the outlet of the microfluidic sorter/concentrator device to trap MIP microparticle-virus conjugates for colorimetric detection. We will examine the normal and tangential orientation of the filter with respect to the flow and the effect of filter porosity and pore size on trapping MIP conjugates. For detection, antibody conjugated gold nanoparticles (AuNP) with specificity towards viruses will be injected onto the membranes using the same outlet of the sorter device. The effect of antibody and AuNP concentration and incubation time at room temperature will be investigated. In addition to readout using naked eyes (qualitative detection), filtered samples will be imaged with a cellphone camera and images will be analyzed by MATLAB to quantify the concentration of AuNP tags, and correlations with the concentration of spiked viruses will be examined. Results of our sensor will be compared with plague assay and RT-PCR results. Sensor's limit of detection, linear range, sensitivity and specificity will be determined and optimized. These outcomes will inform the team for the next stage of the project to perform technology integration, prototyping and validation with end users including the network of customers from SIXW.

TEAM

- List the applicant, any co-applicants and key staff of the partner organizations.
- Explain how the knowledge, experience and achievements of these individuals provide the expertise needed to accomplish the project objectives. Discuss the role of each individual and how their contributions, including those of staff from the partner organizations, will be integrated into the project.

Dr. Pouya Rezai's research program focuses on studying multiphase flows in microfluidic environments with applications in sample processing and biodetection as proposed in this grant. Dr. Rezai has developed multiple microfluidic devices for particle filtration and sorting in complex fluids and an electrochemical sensor for measuring the water salinity and temperature on-site. His research program has resulted in training of 10 graduate students (out of a total of 19), filing of 2 USA patents, and publication of 14 journal papers (out of 34) in the area of point-of-need detection since 2015. Dr. Rezai will oversee the research activities in Objectives 3-5, supervise all HQP, and provide background knowledge and technologies for development of microfluidic sample preparation and detection units.

Dr. Satinder Brar and her team have 20+ years of experience in development of analytical tools for emerging contaminants, at *ng-pg* concentrations, and green methods for wastewater and water treatment. Their research was awarded the American Academy of Environmental Engineers and Scientists (AAEES) University Research Grand Prize in 2017 for leadership and excellence in environmental engineering and science. She has been very successful in developing onsite sensors for detection of N_2O in agricultural installations, which is being tested at different sites across Quebec and Saskatchewan. Dr. Brar will co-supervise the HQP in this project and her role will be significant in Objectives 1-2 to synthesize MIP particles and coatings, and use them to extract viruses from liquid samples.

Dr. Sara Magdouli is a senior researcher at the *Centre Technologique des Residus Industriels* (CTRI) in the field of applied biotechnology and microbiology and an adjunct Professor in York University. She has experience in the development of biosensors for the detection of water contamination including *E. coli* and *Lactobacillus*. She has been working with SIXW on MIP technology for gold recovery in mine tailings in Quebec. In this project, she will assist Drs. Rezai and Brar on the biological aspects and student advising, to understand the interaction between virus particles and MIP in Objectives 1-2.

Dr. Garrett Kraft is an expert in polymer synthesis and MIP development and a project lead on SIXW development of MIP technology specific to SARS-CoV-2. Dr. Kraft is named as a principle inventor on two of SIXW patent applications involving MIP synthesis for virus detection. He will be coordinating SIXW efforts for this project. His role will be significant in all objectives, but he will be instrumental in advising the academic team on Objectives 1 and 2 that are focused on affinity of MIP to viruses and development of MIP-based microparticles and electrode coatings.

Dr. Aristotle Kalivretenos is an expert in organic chemistry at SIXW and has over 20 years of experience as an academic, industry consultant, industry scientist and a director. His expertise is in synthetic chemistry and he is listed as inventor on 5 US patents on detection of amine, glucose and other analytes using various techniques. Dr. Kalivretenos will provide guidance to the team and advice to all HQP particularly in Objectives 4 and 5 to conjugate viruses with gold nanoparticles and detect them calorimetrically and electrically.

	Personal identification no. (PIN)	Family name of applicant
	Valid 400925	Rezai

PROPOSED EXPENDITURES

	Cash				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1) Salaries and benefits					
a) Students	24,000	0	0	0	0
b) Postdoctoral fellows	10,000	0	0	0	0
c) Technical/professional assistants	0	0	0	0	0
d)	0	0	0	0	0
2) Equipment or facility					
a) Purchase or rental	0	0	0	0	0
b) Operation and maintenance costs	0	0	0	0	0
c) User fees	1,200	0	0	0	0
d)	0	0	0	0	0
3) Materials and supplies					
a) *Virus Growth & Detection*	10,500	0	0	0	0
b) *Fabrication Materials*	2,200	0	0	0	0
c) *Testing Material & Supply*	2,100	0	0	0	0
4) Travel					
a) Conferences	0	0	0	0	0
b) Field work	0	0	0	0	0
c) Project-related travel	0	0	0	0	0
d)	0	0	0	0	0
5) Dissemination					
a) Publication costs	0	0	0	0	0
b)	0	0	0	0	0
6) Technology transfer activities					
a)	0	0	0	0	0
b)	0	0	0	0	0
c)	0	0	0	0	0
Total Proposed Expenditures	50,000	0	0	0	0
Partner organization recognized for cost-sharing	0	0	0	0	0
Partner organization not recognized for cost-sharing					
Other funder (not involved in the research)					
Postsecondary institution					
Amount requested from NSERC	50,000	0	0	0	0

1. Salaries and Benefits: $34,000

Sixty-eight percent (68%) of the total budget is dedicated to the salaries of Highly Qualified Personnel (HQP). One part-time (20%) postdoctoral fellow (PDF), one fulltime Master of Science (MSc), and one fulltime doctoral (PhD) student will be recruited for this project to achieve the objectives in 1 year.

For milestones, please refer to the table provided in the proposal. **Milestone 1** to enhance the affinity and specificity of MIPs to target viruses will be done by the PDF. **Milestone 2** which focuses on synthesizing MIP microparticles and wire coatings will be done by the MSc. The PDF will develop the Mock Air Chamber (MAC) in **Milestone 3** while MSc will work on air sampling from MAC using the microfluidic bubble impinger and optimizing it for capturing viruses onto MIP in **Milestone 4**. The PhD will undertake **Milestone 5** to develop the microfluidic device for sorting and concentration of MIP-virus conjugates. He will also perform **Milestone 6** to filter conjugates on the sorter and tag viruses with gold nanoparticles (AuNPs). All HQP will collaborate to perform virus detection in **Milestone 7** with the PDF taking the lead.

Full-time salary of a PDF is estimated at $50k per year including benefits. PDF will allocate 20% of his/her time to the proposed NSERC project. **Therefore, a total of $10k is requested for PDF time**. Another 60% of PDF time ($30k) will be spent on the proposed MITACS Accelerate project which will run in parallel to this research and focus on detection of MIP conjugated viruses on electrodes using a microfluidic electric sensor in Dr. Rezai's lab. This project is independent from the proposed NSERC project in terms of finances and concept of detection. PDFs are usually assigned to 2-3 projects in our labs to help with widening their horizon of knowledge and developing skills in mentoring students. Accordingly, the remaining 20% of the PDF time may be allocated to a project being developed on using organism-on-a-chip devices to test the toxicity of antiviral products in collaboration with VivaVax Inc.

The annual funding package for an international MSc or PhD student at York University is $40k. It consists of $12k Research Assistantship (RA) from the supervisor (requested here for two students), and the rest is provided by fellowship and Teaching Assistantship (TA) from the Lassonde School of Engineering at York University. MSc and PhD students spend more than 80% of their time on research and 20% on TA. **The combined 12-month RA salary requested for the MSc and PhD students is $24k.**

2. Equipment or Facility: $1,200

User Fees - $1.2k: This is requested for access to SEM and AFM facilities at York University for an average of 4hrs a month at an hourly rate of $25 (mostly in Milestones 1, 2, 6 and 7).

3. Materials and Supplies: $14,800

Virus Growth and Detection - $10.5k: Bacteriophages T2, T3 and MC2 and heat-inactivated SARS-CoV-2 virus and their host bacteria strains will be acquired from ATCC Inc. (**$2k**). Materials like agar, Tryptic Soy Broth, Phosphate Buffered Saline, Bovine Serum Albumin, and other chemicals for culturing bacteria/ viruses and preparing aerosolization and collection media will be acquired from Sigma Aldrich (**$1.5k**). Chemicals and reagents for plague assay and PCR as parallel detection techniques to quantify virus concentrations in spiked samples and biosensors will be from Sigma Aldrich and Fisher Scientific (**$4k**). AuNP, antibodies and other chemicals/materials for functionalizing wires and particles will be procured from Sigma Aldrich, Fisher Scientific, Abcam, Sino, and or GeneTex (**$3k**).

Fabrication - $2.2k: The proposed microfluidic devices will be microfabricated in polydimethylsiloxane (PDMS) suing photolithography and soft lithography methods. For this, we will purchase silicon wafers from Wafer World (**$200** @ $25/wafer) to develop the master molds in our lab. PDMS will be purchased from Dow Corning Inc. (**$300** @ $100/kit). **$100** will be used for the cost of SU8 photoresist and other photolithography materials. Gold wires of different diameters (**$400**), quartz-crystal wafer (**$500**), gold plated electrodes (**$300**), and filters with different porosity and pore size (**$400**) will be procured from Milipore Sigma and Wafers World.

Testing - $2.1k: MIP materials will be mostly provided by SIXW. But materials like acrylamide, methylmethacrylate, methacrylic acid, and N-vinylpyrrolidone N,N'-(1,2-dihydroxyethylene) bisacrylamide may be procured for potential preparation of MIPs at York (**$700**). Microparticles of various sizes will be purchased from Spherotech Inc. for use as surrogates of MIP particles (for designing the sorter) when MIP particles are being developed (**$300** @ $100/package). For making viscoelastic buffers in the sorter device, poly(ethylene oxide) will be acquired from Sigma Aldrich at **$100** for 10gr.

Supplies will cost approximately **$1k** and include purchasing AFM/SEM supplies, petri dishes, pipette tips, glass dishes, measuring containers, media chambers, etc. for culture preparations and tubing, glue, interconnects and other consumables for interfacing with microfluidic devices.

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Valid 400925	Rezai

Organization Category

Partner organization recognized for cost-sharing

Partner organization

Sixth Wave Innovations Inc.

Partner department

Research and Development

Contact family name, contact given name

Garrett, Kraft

Contact email address

gkraft@6wic.com

CONTRIBUTIONS FROM PARTNER ORGANIZATION

	Year 1	Year 2	Year 3	Year 4	Year 5
Cash contributions to direct costs of research	0	0	0	0	0
In-kind contributions					
1) Salaries for scientific and technical staff	41,600	0	0	0	0
2) Donation of equipment, software	0	0	0	0	0
3) Donation of material	23,500	0	0	0	0
4) Field work logistics	0	0	0	0	0
5) Provision of services	0	0	0	0	0
6) Use of organization's facilities	0	0	0	0	0
7) Salaries of managerial and administrative staff	0	0	0	0	0
8)	0	0	0	0	0
Total In-kind contributions	65,100	0	0	0	0
Contribution to postsecondary institution overhead	0	0	0	0	0

Sixth Wave Innovation Inc. (SIXW) has over 100 years of R&D experience in Molecularly Imprinted Polymers (MIPs) synthesis and detection applications. SIXW will provide **a total in-kind of $65,100** towards the proposed project, consisting of $41,600 of salaries and $23,500 of materials and supplies as discussed below.

1. Salaries for Scientific and Technical Staff: $41,600

Dr. Jonathan P. Gluckman, Dr. Garrett M. Kraft and Dr. Aristotle Kalivretenos from SIXW will be involved in this project and work closely with the academic team. Dr. Gluckman is the Chairman and CEO of SIXW, Dr. Kraft is a Senior Scientist and Dr. Kalivretenos is the Director of Science with SIXW.

Dr. Gluckman holds a PhD from the University of Cincinnati and brings a 25-year track record of innovative, technology-driven achievements to his role as Chairman of SIXW. As founder and CEO of Integrated Dynamics, a government engineering services company since 1996, Dr. Gluckman focused on the development and subsequent transition of advanced technologies into commercial applications. As the leader of SIXW since 2013, Dr. Gluckman has concentrated his efforts to complete IXOS®, in the metals processing industry. In this project, Dr. Gluckman will advise the academic team on technology design that is appropriate for future prototyping and commercialization purposes.

Dr. Kraft is an expert in polymer synthesis and development of MIPs. He is a project lead on SIXW development of MIP technology specific to SARS-CoV-2. Dr. Kraft is named as a principle inventor on two of SIXW patent applications involving MIP synthesis for virus detection and will be coordinating SIXW efforts for this project. His role will be significant in all milestones but he will be instrumental in advising the academic team on Milestones 1 and 2 that are focused on affinity of MIP to viruses and development of MIP-based microparticles and electrode coatings.

Dr. Kalivretenos is an expert in organic chemistry and has over 20 years of experience as an academic (adjunct professor at U of Maryland Baltimore County), industry consultant, industry scientist and a director. His expertise is in synthetic chemistry and he is listed as inventor on 5 US patents on detection of amine, glucose and other analytes using various techniques. Dr. Kalivretenos will provide guidance to the team and advice to all HQP particularly in Milestones 6 and 7 to conjugate viruses with gold nanoparticles and detect them calorimetrically and electrically.

The company scientists will meet with the team for an average of 4 hours per week mostly using online tools like Zoom and Skype. In the initial meetings, the technology needs, milestones and device design and performance specifications will be discussed and agreed upon. In the following meetings, the academic team will present its research progress to the company and perform demonstrations and co-testing with the technical staff in their quarterly visits to the lab. On these meetings and visits, future plans will be developed, and the deliverables will be reviewed and revised. At an averaged rate of $66.67/hr, the total contributed in-kind service to the project will be 3 scientists × 52 weeks × 4 hr/week × $66.67/hr = **$41,600**.

2. Donation of Material: $23,500

Along with procurement and synthesis of materials for developing MIPs in this project, SIXW will also provide all of its proprietary MIP materials. A standardised R&D project with SIXW to produce prototype MIP materials starts at $750,000. SIXW is currently engaged in R&D developing materials that are highly aligned with the current proposal. As such SIXW is willing to donate the developed MIP materials with the internal cost of synthesis being $23,500. This value represents raw materials, overhead and two weeks of synthesis, processing, and characterization for small scale specialty synthesis. This donation represents the internal monetary value of producing specialty MIP materials at the 10g scale in SIXW's R&D labs. The 10g sample may come in the form of thin films, nanometer beads, micrometer beads, or a mixture thereof.

Reviewer Suggestions
(Form 101)

Date
2020/05/25

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Rezai	Pouya	P	**Valid** 400925

Title of proposal
Point-of-Need Microfluidic Biosensor for Detecting Airborne Viruses using Molecularly Imprinted Polymers: Towards COVID 19 Virus Monitoring

No.	Reviewer	Area(s) of expertise	PIN	Lang.
1	Ahmadi, Dr. (Ali) Engineering University of Prince Edward Island SSDE 330 550 University Ave Charlottetown, PE CANADA C1A4P3 1 (902) 5660521 aahmadi@upei.ca	Electro-hydrodynamics of micron-scale flows, Biomedical and bio-inspired systems		
2	Tsai, Dr. (Scott) Mechanical and Industrial Engineering Ryerson University 338B Eric Palin Hall (EPH) 350 Victoria Street Toronto, ON CANADA M5B2K3 1 (416) 9795000 ext 6424 scott.tsai@ryerson.ca	Microfluidics, Lab-on-a-chip, Biotechnology, Fluid mechanics		
3	Champagne, Dr. (Pascale) Civil Engineering Queen's University Ellis Hall, Room 241 Kingston, ON CANADA K7L3N6 1 (613) 5333053 pascale.champagne@queensu.ca	Bioresources Engineering		
4	Vuckovic, Dr. (Dajana) Chemistry and Biochemistry Concordia University L-SP 275-31 Richard J. Renaud Science 7141 Sherbrooke W. Montreal, QC CANADA H4B1R6 1 (514) 8482424 ext 3981 dajana.vuckovic@concordia.ca	Biochemistry, Analytical Methods, Sample Preparation		
5	Aarash, Dr. (Sofla) ufluidix Inc. 689 Warden Ave #17 Scarborough, ON CANADA M1L4R6 aarash@ufluidix.com	Microfluidics, Design and Manufacturing		

PROTECTED B WHEN COMPLETED

Reviewer Suggestions
(Form 101)

			Date
			2020/05/25
Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Rezai	Pouya	P	**Valid** 400925

Title of proposal

Point-of-Need Microfluidic Biosensor for Detecting Airborne Viruses using Molecularly Imprinted Polymers: Towards COVID 19 Virus Monitoring

		Area(s) of expertise		
6			PIN	Lang.
7			PIN	Lang.
8			PIN	Lang.
9			PIN	Lang.
10			PIN	Lang.

PROTECTED B WHEN COMPLETED

Personal identification no. (PIN)	Family name of applicant
Valid 400925	Rezai

REVIEWER EXCLUSIONS

SARA MAGDOULI

386 Rue Gagné, Rouyn-Noranda (Qc), J9X3P7, Phone: 819 279 0672 / 5819902131
Email: sara.magdouli@cegepat.qc.ca

RESEARCH EXPERTISE

Environmental microbiology, biotechnology, molecular biology, Bioprocess engineering, sustainable development, management of mine water and wastewater, mine waste management, mining, biotechnology, Biomining, (Bio)hydrometallurgy, land reclamation, solid and hazardous waste management, wastewater reuse and resource recovery, value added products from wastes, clean and green technologies, bioenergy and biofuel production, membrane technologies, tailings, soil and groundwater remediation.

RECENT WORK EXPERIENCE

2020-Present: Adjunct Professor, Department of Environment Engineering, Laurentian University, Sudbury
2019-Present: Adjunct Professor, Department of Civil Engineering Lassonde School of Engineering York University, Toronto
2019: Lecturer, Centre Technologique des Résidus Industriels (CTRI), College of Abitibi Temiscamingue, Quebec,
2018-Present: Environment Coordinator, Centre Technologique des Résidus Industriels (CTRI), College of Abitibi Temiscamingue, Quebec, Canada
2018-Present: Scientific Member of Excellence Centre Elements 08, Quebec, Canada
2017-Present: Adj. Professor, University of Quebec in Abitibi Temiscamingue (UQAT), Canada
2017-2018: Researcher, Project Manager, Centre Technologique des Résidus Industriels (CTRI), College of Abitibi Temiscamingue, Quebec, Canada
2013-2017: Research Ass., Institut National de la Recherche Scientifique (INRS), QC, Canada

EDUCATION

2013-2017: Doctorate Degree, PhD-Water Sciences, Bioprocess Engineering, Institut National de la Recherche Scientifique (INRS), Quebec, Canada
2010-2012: Master of Biotechnology and Sustainable Development M.A.Sc, Aix Provence Marseille, France
2008-2010*:* Master of Envirnmental Micrbiology-Applied Chemistry, M.A.Sc, Faculty of Sciences, Tunisia
2004-2008*:* Bachelor of Applied Science, Biotechnology B.A.Sc, Faculty of Sciences, Tunisia

CERTIFICATE AND TRAINING

November 2019: Lean and Industrie 4.0, GCM consulting
March 2019: Certified Measurement and Verification Professional in Training
September 2018: Quantification of GES emissions
September 2017: Project Management-ETS, Montreal

HIGHLY QUALIFIED PERSONNEL (HQP) TRAINING

I am the lead manager of a research team composed by 5 project managers and 3 technicians
Graduate Students and Postdoc Fellowship: Co-Supervisor of 3 PDF, 3PhD and 3 MSc students
Undergraduate Students: 2017- Present, Supervision of 15 Coop students of the College of Abitibi (Natural Sciences, Mineral technologies and Mineral Engineering)

COMMITTEES

March 2017- present: Member of the Canadian Institute of Mining, Metallurgy & petroleum (ICM)
March 2017-present: Reviewer for federal and provincial grants
May 2017 to present: Scientific Member, MISA group
October 2018 to present: Scientific member of Elements 08 Strategic Metals Excellence Centre (https://elements08.com/en/).
March 2017 to present: Scientific Committee of CTRI

AWARDS AND RECOGNITIONS

-Award offered by the University of Quebec, INRS-ETE, Qc
-Scholarship by University of Aix-Marseille, Mention Very Good
-First Rang in the University of Tunis

WRITTEN CONTRIBUTION (Citation: 270, H-Index: 8)

Books in preparation (Editor)

1) **Sara Magdouli**, Mehdi Zolfaghari, Satinder Kaur Brar, Carlos Ricardo Soccol, Rao. Y. Surampalli, Tian C. Zhang, Resource Recovery: Zero-waste Biomining, Elsevier (June 2020)
2) Mehdi Zolfaghari, **Sara Magdouli**, Satinder Kaur Brar, Carlos Ricardo Soccol, Rao. Y. Surampalli, Tian C. Zhang, Handbook of Environmental Practices in Mining Industry. Springer Nature (December 2021)

Research publications: 25 research publications in journals with impact factor from 2 to 8, H-index: 8

Conferences: Attended national and international conferences as keynote/plenary speaker

FUNDING

Lead Researcher of various grants related to environmental microbiology, biotechnology, molecular biology, bioprocess engineering, sustainable development, management of mine water and wastewater, mine waste management, biomining, ect. Among these grants, Dr. Magdouli is leading a project with Sixth Wave Inc. on the *Study of the Feasibility of Green Alternatives for Gold leaching and Recovery*

Funding Source: NSERC

Funding Program: ARD level II for 2 years (submitted 21 December 2019 and accepted 24-02-2020)

Main objectives/summary: The CTRI collaborates with 6th Wave-AEM to validate the potential of green alternatives and innovative IXOS® molecular imprinted technology to replace cyanide and activated carbon, respectively. The project is divided in two parts. Part 1 covers the trials for green alternatives (solvents, thiosulfate, aminoacids) for gold leaching. The tests and the validation of these alternatives will be a focus in this part. To attempt this goal, this phase will involve running tests in CTRI, collecting laboratory data for evaluating the performance of these products and their environmental risks. Thus, the study of the environmental toxicity of post-treatment waters and solids resulted as a second output of the whole process will be carried out. Further often, this phase will be used to analyse collected data and quantify key performance indicators (KPI) of these products compared to conventional process based on cyanidation (positive control). Part 2 of the project will be more focused on gold recovery with IXOS® technology at laboratory phase and pilot scale. The CTRI has seen the potential application of this technology for AEM. The economical study of IXOS® Molecularly imprinted polymer IXOS® resin for gold recovery will be carried out. This project builds for a long-term collaboration with 6th Wave Innovations Corp (6WIC) as they seek to establish highly effective technology into Abitibi marketplace.

ARISTOTLE G. KALIVRETENOS

EDUCATION

Ph.D. Organic Chemistry, Colorado State University (1990)
B.S. Chemistry, Clemson University, Chemistry, *summa cum laude* (1985)

WORK EXPERIENCE

Sicth Wave Innovations Corp, January 2020 to present, Director of Science
Aurora Analytics, LLC, 2004 to present, COO & Managing Member
Butler Manufacturing LLC**,** 2014 to present, Consultant
Notre Dame of Maryland University, 2005 to 2008, Adjunct Professor of Chemistry
Senseonics, Inc., 1999 to 2004, Scientist II. 1998-1999, Scientist
Paragon Bioservices, Inc**.,** 1998, Consultant
Univ of Maryland Baltimore County**,** 1998 to present, Adjunct Professor of Chemistry. 1992 to 1998, Assistant Professor of Chemistry
Unilever Research, U.S., 1991-1992, Synthetic Consultant
Columbia University, 1990 to 1992, Post-doctoral Research Fellow

SELECTED PUBLICATIONS

1) "Synthesis of Beta-Resorcylic Macrolides *via* Organopalladium Chemistry. Application to the Total Synthesis of (*S*)-Zearalenone" Kalivretenos, A. G.; Stille, J. K.; Hegedus, L. S. *J. Org. Chem.* **1991**, *56*, 2883-2894.
2) "Synthesis of Philanthotoxin Analogs with a Branched Polyamine Moiety" Kalivretenos, A.; Nakanishi, K. *J. Org. Chem.* **1993**, *58*, 6596.
3) "Labeling Studies of photolabile philanthotoxins with nicotinic acetylcholine receptors: mode of interaction between toxin and receptor" Choi, S.-K.; Kalivretenos, A.G.; Usherwood, P.N.R.; Nakanishi, K. *Chemistry & Biology* **1995**, *2*, 23.
4) "Tetrameric Peptide Bundles Via A Highly Convergent Synthesis" Hirsch, J.; Huang, W.; Kalivretenos, A.G. *Biopolymers* **1996**, *39*, 761-763.
5) “Synthesis and Separation of Hydrophobic Peptides for Use in Biomimetic Ion Channels” Kassim, S.Y.; Restrepo, I.M.; Kalivretenos, A.G., *J. Chromatogr. A*, **1998** *816*, 11-20.
6) “Synthesis of Amide Libraries with Immobilized HOBt” Vokkaliga, S.; Jeong, J.; LaCourse, W.; Kalivretenos, A. *Tetrahedron Lett.*, **2011**, *52*, 2722-2724.
7) “Engineering a Hyper-catalytic Enzyme by Photoactivated Conformation Modulation” Agarwal, P.K.; Schultz, C.; Kalivretenos, A.; Ghosh, B.; Broedel, S.E. *J. Phys. Chem. Lett.* **2011**, *3*, 1142-1146.

PATENTS

1) “Butyryl-Tyrosinyl Spermine, Analogs thereof and Methods of Preparing and Using Same” Koji Nakanishi, Danwen Huang, Soek-Ki Choi, Aristotle Kalivretenos and Robert Goodnow, US Patent # 6,001,824, 1999.
2) “Detection of Analytes by Fluorescent Lanthanide Metal Chelate Complexes Containing Substituted Ligands” Arthur E. Colvin, George Y. Daniloff, Aristotle G. Kalivretenos, David Parker, Edwin E. Ullman and Alexandre V. Nikolaitchik, US Patent # 6,344,360, 2002.
3) “Detection of glucose in solutions also containing an alpha-hydroxy acid or a beta-diketone” George Y. Daniloff, Aristotle G. Kalivretenos, and Alexandre V. Nikolaitchik, US Patent #

7,078,554, 2006.

4) “Amine detection method and materials” Aristotle G. Kalivretenos, US Patent # 7,229,835, 2007.
5) “Amine detection method and materials” Aristotle G. Kalivretenos, US Patent # 7,592,183, 2009.

PROFESSIONAL SOCIETY MEMBERSHIPS

American Chemical Society (1986)

GARRETT M. KRAFT

EDUCATION

Ph.D. Polymer Science, University of Connecticut
B.S. Chemistry, Biology, University of Wisconsin-Stevens Point

WORK EXPERIENCE

Sixth Wave Innovations Corp, July 2017 to present. Senior Scientist
University of Connecticut, August 2012 to July 2017, Graduate Researcher
Solidification Products International, 2015-2017, Product Development Intern
Oxford Performance Materials, 2016-2017, Graduate Researcher - Proxy UConn
ExxonMobile, 2014-2016, Graduate Researcher - Proxy UConn
Corenso, 2014, Consultant
CiDRA 2012-2014, Graduate Researcher – Proxy UConn
Wisconsin Institute for Sustainable Technology, 2008-2012, Research and Development Chemist

HONORS

GAANN Fellowship – 2016, 2017
SPE Connecticut Section Scholarship – 2014, 2015, 2016
ANTEC 2015 Graduate Poster Competition – 2nd Place
Outstanding Student Chapter 2015 – 5th Place Nationally
Doctoral Dissertation Fellowship – Fall 2015
Predoctoral Fellowship – Fall 2012
SRF Grant 2011

PUBLICATIONS AND PRESENTATIONS

1) Kraft, G.M, Hire, C.C., Santiago, A. Adamson, D.H., "Electrospun biomimetic catalytic polymer template for the sol-gel formation of multidimensional ceramic structures", Materials Letters, 240:242-245 (2019).
2) Kraft, G. M.; Mohammadi, R.; Adamson, D. H. Controlled synthesis of amphiphilic polymer bottlebrushes. GAANN Fellowship Research Report, U.S. Department of Education, January 20, 2017.
3) Kraft, G. M. Controlled polymer synthesis and 2D sheet based materials**.** University of Connecticut Institute of Materials Science Advisory Board Meeting, Storrs, CT, October 26, 2016.
4) Kraft, G. M. Biomimetic materials: brushes, foams, and fibers. University of Connecticut GAANN Fellowship Research Seminars, U.S. Department of Education, Storrs, CT, October 17, 2016.
5) Kraft, G. M.; Bento, J. L.; Madugula, D.; Marinez, A.; Adamson, D. H. Synthesis of complex amphiphilic polymers by azeotropic distillation techniques. Proceedings of the 250th American Chemical Society National Meeting, Boston, MA, August 16-20, 2015.
6) Kraft, G. M.; Weinstein, S. D.; Woltornist, S. J.; Adamson, D. H. Infusion of catalytically active polymers for templated condensation of metal oxides in foam composites. Proceedings of the 250th American Chemical Society National Meeting, Boston, MA, August 16-20, 2015.

7) Kraft, G. M.; Woltornist, S. J.; Oyer, A. J.; Carrillo, J. Y.; Xu, T. O.; Adamson, D. H. Graphene: from interfacial trapping to strong, electrically conductive foams. Proceedings of the ANTEC 2015 Technical Conference and Exhibition, Orlando, FL, March 23-25, 2015.
8) Kraft, G.M., Hui, T., Bento, J.L., Hire, C.C., Adamson, D.H. Living anionic polymerization: Controlling molecular weight, composition and architecture. . Proceedings of the ANTEC 2015 Technical Conference and Exhibition, Orlando, FL, March 23-25, 2015
9) Kraft, G. M.; Santiago, A.; Hire, C. C.; Adamson, D. H. Electrospun biomimetic synthetic polymer for templated ceramic condensation. Proceedings of the 248th American Chemical Society National Meeting, San Francisco, CA, August 10-14, 2014.
10) Droske, J. P.; Juetten, M; Kraft, G. M.; Huberty, W.; Pieper, R. “Green” thermosets: solventless synthesis and reversible crosslinking of poly(alkylene mercaptosuccinates). Polymer Preprints, ACS Division of Polymer Chemistry 2012, 53 (2), 339.
11) Kraft, G. M. Degradation rates of poly(alkylene succinate) analogs under compost conditions. (Grant submitted to) The Student Research Fund, University of Wisconsin-Stevens Point, October 28, 2011.
12) Kraft, G. M.; Sternhagen, G. L.; Droske, J. P. “Green” crosslinkable polymers for sustainable applications. Fourth Annual Wisconsin Science and Technology Symposium, University of Wisconsin-Whitewater, July 28-29, 2011.
13) Kraft, G. M. A “green” step-growth synthesis of crosslinkable polyesters. University of Wisconsin-Stevens Point College of Letters and Science 12th Annual Undergraduate Research Symposium, April 29, 2011.

PROFESSIONAL SOCIETY MEMBERSHIPS

American Chemical Society
Society of Plastic Engineers
Society of Mineralogical Engineering

JONATHAN P. GLUCKMAN

EDUCATION

Ph.D. Human Factors/Experimental Psychology, University of Cincinnati (1990)
M.A. Human Factors/Experimental Psychology, University of Cincinnati (1988)
B.S. Psychology, Bradley University (1985)

WORK EXPERIENCE

Sixth Wave Innovations Corp, July 2013 to present. Chairman & CEO
Raptor Detection Technologies, LLC, July 12, 2010 to June 26, 2013. General Manager & EVP
Raptor Detection, Inc. April 2007 to 2010. President & CEO
Link Plus Corporation. December 2004 to April 2007. President & Chief Operating Officer. January 2004 to December 2004. Executive Vice- President & Chief Operating Officer.
Integrated Dynamics Inc.1996 to 2003. Chief Executive Officer & Co-founder.
JS Technologies, Corp. a subsidiary of Integrated Dynamics, Inc.2001 to 2003. Vice President Technology/Chief Technical Officer & Co-founder.
JJM Systems, Inc. Intelligent Control Technologies Division, 1993 to 1996. Division Manager.
US Naval Air Warfare Center, Aircraft Division. 1991 to 1994. Block Manager / Staff Engineering Psychologist.

MAJOR PUBLICATIONS

1) 1)Molecularly Imprinted Polymer Applications for the Gold Mining Industry, G. Southard, J. Gluckman, B. Maull Proceedings of Heap Leach Solutions, 2015 September 14-16, 2015, Reno, Nevada, USA.
2) Gluckman, J.G., Warm, J.S., Dember, W.N., & Rosa, R.R. "Demand Transitions and Sustained Attention". Journal of General Psychology. (1993)
3) Harris, S.D., Ballard, L., Girard, R. Gluckman, J.P."Sensor Fusion and Situation Assessment: Future F/A-18 Capabilities."In A. Levis and I. Levis (Eds.), Science of Command and Control: Part III Coping with Change, AFCEA International Press,(1994).
4) Harris, S.D. and Gluckman, J.P. (1994) "A Conceptual Framework for Advanced Tactical Information Management Systems." In A. Levis and I. Levis (Eds.), Science of Command and Control: Part III Coping with Change.
5) Gluckman, J.G. & Becker, D. (1993). "Knowledgeable Observation Analysis-Linked Advisory System (KOALAS) and Multi-sensor Integration." (Technical Report No. N1808-TR-93-00151) Naval Air Warfare Center (1993).

HONORS

Outstanding Service to the Shuttle Cockpit Upgrade Team, 1998, Air Vehicle and Crew Systems Department Scientific Award, 1993.

PATENTS

Southard, G. E.; Gluckman, J. P. Molecularly Imprinted Polymer Beads for Extraction of Metals and Uses Thereof. U. S. Patent 9,504,988, 2016.

Macklin, J.D., Bonneau Jr., W.C., Gluckman, J.P., Dorovskoy, I, Security Polymer Threat Detection Distribution System, 2013.

PROFESSIONAL SOCIETY MEMBERSHIPS

American Chemical Society (2014)
Society of Mineralogical Engineering (2014)