UNIVERSITY OF MANITOBA

CANADA FOUNDATION FOR INNOVATION 13-11
Innovation Fund

Notice of Intent

1. Completed NOIs must be submitted by the Associate Dean (Research)/Research Liaison Officer of the "Lead" Unit to the Office of Research Services to: Birtukan.Gebretsadik@umanitoba.ca by May 15, 2018.

Proposed name of project: Prairie Centre for Functional Nanomaterials Research Targeting Energy Capture, Conversion and Storage	**Estimated Total Project Costs:** $4M

Designated Project Leaders/Faculty/Dept: V. Nemykin/Science/Chemistry CV: [X]
J. van Lierop/Science/Physics CV: [X]

List Principal Users/Faculty/Dept:

1. R. Stamps/Science/Physics CV: [X]
2. G. Schrekenbach/Science/Chemistry CV: [X]
3. D. Herbert/Science/Chemistry CV: [X]
4. R. Davis/Science/Chemistry CV: [X]
5. S. Kuss/Science/Chemistry CV: [X]
6. C. Wiebe/Science/Chemistry U. Winnipeg CV: [X]

'Lead' Unit ADR/RLO:

Name: I. Oresnik

Briefly describe (max 2 pages, 12 pt. font size, 2 cm margins):

- The proposed research and how it is world-class, innovative and demonstrates clear benefits to Canada.
- The infrastructure and how it will enhance the University's existing research capacity.
- The excellence of the team, including expertise and existing collaborations necessary to conduct the proposed research.
- Plans to secure matching funds and the potential funding sources for the operation and maintenance of the infrastructure.

The proposed research and how it is world-class, innovative and demonstrates clear benefits to Canada: We propose to establish a research centre for **Functional Nanomaterials Research Targeting Energy Capture, Conversion and Storage.** The centre will focus on new methods and materials, and will generate an interdisciplinary training environment for the development of industry-transferable skills needed for meeting challenges in the sustainable energy sector.. There is clearly demand for interdisciplinary training in the Clean Energy production and storage and related sectors, as evidenced by team-based industrial responses in the competitive research and development environment (see, for example the industry/government white paper "National Collaboration Strategy for the Mining Industry: Driving Innovation in the Canadian Mining Industry"[1]; cross-industry collaborative bodies such as the 'Canada Oil Sands Innovation Alliance (COSIA)[2]; and 'Industry 2.0' examples, such as close-collaboration between companies such as BASF and 3M Canada[3]). Moreover, the tax on carbon emitting materials and processes included in the 2018 Federal and Manitoba Provincial Budgets highlights the growing importance of developing innovation capacity in the energy sector.

The Prairie region currently lacks infrastructure required for the cross-discipline components necessary for addressing Energy and Sustainability challenges in Canada. This proposed infrastructure will build a unique, World-class research and training centre in Manitoba that will serve the Prairie region and complements the Manitoba Institute for Materials. The proposed combination of the high-field magnetic, ultrafast optical, and theoretical infrastructure would allow the PIs and their HQP to conduct unique, necessary on-site and rapid feedback experimental and theoretical studies on magneto-optical nanomaterials with facilities not available with the necessary capabilities elsewhere in Canada. Together this team and the infrastructure will put the University in a position to compete successfully for larger team-based funding to enable research that crosses boundaries between experimental synthesis of functional materials, fundamental mechanisms in condensed matter physics, and computational modelling as used in quantum theory and molecular dynamics. While in academia, these areas are traditionally characterized by their own specific language, research culture and assumed background knowledge and training, in industry the focus is on how problem-solving that merges these disparate disciplines can often bear much more innovative fruit than a series of siloed approaches. This research team and the infrastructure is composed of a unique and powerful combination of synthetic chemists, characterization specialists, and computational chemists and physicists working together to design and make practical sustainable functional materials solutions for tomorrow's problems.

The twin focus on design/synthesis and analysis/characterization brings together researchers and student trainees in chemistry (synthesis, characterization, and theoretical modeling) and physics (characterization and theoretical modeling), and builds core strengths in both these areas while instilling the ability to communicate across disciplines. The overarching goal of this group is to develop new approaches and understanding at the quantum-level of the origins of the functional materials. New knowledge generated will address grand challenges associated with controlling materials processes at the level of electrons, and designing and perfecting new forms of matter with atom-level tailored properties. Projects will include construction and study of molecules and materials for green energy applications, including dissipationless electronics and quantum computing, solar energy harvesting, sustainable fuels production and green catalysis (heterogenous and homogeneous), and redox-flow battery technology for off-grid energy storage. Each project will incorporate both a wet-lab/bench-top component and a theory component, cementing the need for cross-talk between disciplines.

The infrastructure and how it will enhance the University's existing research capacity: The infrastructure that is needed to support the research program is i) a Quantum Design Physical Properties Measurement System 14 Tesla Cryogen-free system (Dynacool 14 T PPMS), ii) an Advanced Technology Liquefier (ATL) to provide the necessary liquid helium cryogen to support operations of a CFI-funded Quantum Design 5 Tesla Magnetic Properties Measurement System (Physics & Astronomy's 1980s helium liquefier is at the end of its useful life), iii) a Janis Research Corp. closed-cycle cryostat for atomic level characterization of materials from 10 to 800 K, iv) an in-situ high temperature x-ray diffraction furnace for a CFI-funded Bruker D8 Discover diffractometer, v) complete suite for ultrafast transient

absorption spectroscopy; vi) complete suite for ultra-fast photon-counting time-correlated spectroscopy; and vii) modern computational cluster for theoretical modeling. The research that this infrastructure will support exists at the exciting convergence of materials physics and chemistry. This infrastructure will enable and complement current cutting edge experimental techniques at the UofM to make, identify and understand the structure-composition-magnetism relationships in nanoscaled systems. This fundamental knowledge enables applications using i) nanocomposite magnets (e.g. traction motors and power applications such as inductors and transformers), ii) drug delivery and hyperthermia, iii) new materials for green catalysis, iv) new functional materials for solar cells, v) new materials for sustainable energy storage.

Materials research is one of the established areas of research excellence at the UofM. It is a core component of the materials science research and research training thrust of the University's Strategic Research Plan, and this proposal will form a significant addition (equipment and HQP) and contribution to the Manitoba Institute of Materials (MIM). This proposal feeds directly into the heart of the Materials Science research thrust of the University (and the Faculty of Science). While the University has supported and been successful in funding a highly sophisticated crystallography laboratory, a modern microbeam analytical facility and state-of-the-art structural materials testing and fabrication facilities, it currently lacks the required infrastructure to perform the synthesis and handling of samples, high temperature and field structure and characterization of nanoscale materials, and computational facilities for theory and model development to feed and direct materials discovery with state-of-the-art materials informatics driven research. This proposal addresses these weaknesses.

The excellence of the team, including expertise and existing collaborations necessary to conduct the proposed research: Example long standing collaborations at the UofM (several as grant co-PIs, and all are Manitoba Institute for Materials members) are Profs. V. Nemykin (Chemistry) and J. van Lierop (Physics & Astronomy) whom have collaborated for over 10 years, as have Profs. R. Stamps (P&A) and J. van Lierop; Profs. Nemykin and Herbert, Prof. Nemykin and Davis, Prof. C. Wiebe (Chemistry) and J. van Lierop have collaborated for the last 5 years. National and International collaborations that support this research program with van Lierop include the theory group at Memorial University lead by Profs. M. Plumer and J. Whitehead Drs. M. P. Rowe and C. A. Roberts (Toyota Motor Engineering & Manufacturing North America – materials synthesis and catalysis); x-ray synchrotron and neutron scattering work with Drs. J. W. Freeland and R. A. Rosenberg (Advanced Photon Source @ Argonne National Laboratory) and Drs. C. Dennis and J. Borchers (National Institute of Standards and Technology). International collaborations of prof. Nemykin include Prof. Belosludov (Japan), Prof. Blank, Ziegler, Zhdankin, Bruckner (USA), Prof. Galloni (Italy), Profs. Lukyanets and Voloshin (Russia), Prof. Gao (China), Prof. Kovtun (Ukraine). During the last few years, the profile and strength of the nanomaterials research conducted at the UofM with MIM has attracted Profs. Nemykin, Stamps, and Kuss. Through the combination of PIs and their HQP in this proposal, we now have a critical mass of researchers in the field of functional nanomaterials, whom with the requested infrastructure will propel the UofM into a materials science leadership position nationally and internationally by developing the Prairie region into a world-class area of research in nanomaterials.

Plans to secure matching funds and the potential funding sources for the operation and maintenance of the infrastructure: It is expected that a matching 40% of the funds for this proposal will be secured through the Province's Research Manitoba agency. In-kind contributions from Janis Research USA, Bruker Canada, and Quantum Design, USA have already been secured or are in discussions. Research contracts and tricouncil grant funds (e.g. NSERC, Engage, CRD, CIHR and CHRP; grants that the Principal Users have been awarded and will continue to apply for) will be supporting supplies, consumables and HQP costs for the requested infrastructure.

References:

[1] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/EMMC_Collaboration-Strategy-Mining_E_assessible.pdf; [2] http://www.cosia.ca; [3] https://www.basf.com/ca/en/company/news-and-media/news-releases-source/2016/05/P-CA-16-004.html; [4] http://www.sshrc-crsh.gc.ca/society-societe/community-communite/ifca-iac/02-natural_resources_report_naturelles_rapport-eng.aspx