Repurposing of Landfill Fly Ash for Magneto-Rheological Cementitious Ink in 3D Concrete Printing ($50,000)

Konstantin Sobolev, Ph.D., Professor, Dept. Civil & Environmental Engineering

Dr. Sobolev's research focuses on high-performance cement-based composites, application of nanomaterials in construction, and waste utilization. He has brought all three of these elements together with this proposed technology. In this application, he plans to utilize the vast quantities of landfilled and ponded ash by further developing separation processes to produce a novel material, magneto-rheological cementitious ink (MRCI), for 3D printing. This new material has the potential for near-instant setting and improved green strength to concrete, along with reclaiming two other high value products: coal powder and fly-ash slurry for concrete manufacturing.

The need for suitable 3D printing concrete materials. The challenge of achieving the precise balance between a suitable concrete mixture that has workability yet is also able to set on-demand is an on-going need, especially for 3D printing applications. Stable layering of 3D printed concrete is also an issue. Dr. Sobolev's research team will show that landfilled Class F fly ash has a significantly higher iron content and physical characteristics that can be used to effectively replace portland cement. The implementation of 3D printing in the construction sector represents an opportunity for advancements in automation and rapid site development.

Current problems with concrete 3D printing. The proposed project seeks to beneficiate the high-iron landfilled ash that is currently a liability to utility companies and to develop high-end cement-based products and processes for the effective use of waste ash as a component in MRCI. It is envisioned that cement-based magneto-rheological fluids can be used in applications to act as a "set-on-demand" material, allowing the user greater control over the processing such as mixing, casting, and pumping of concrete.

Market for 3D printing in construction sectors. The demand for sustainable and eco-friendly materials based on industrial byproducts, such as off-spec fly ash, which are characterized by high contents of unburned carbon or various types of ferrous compounds, is increasing. The global market for green cement and fly ash markets is expected to reach $40B by 2025. The markets envisioned for this material include the construction industry for modern infrastructure and urban development projects. The implementation of 3D printing in the construction sector represents the opportunity for advancements in automation and rapid site development, as well as offering the ability to fabricate light-weight structures and members that would not be feasible in traditional placement constrained by the molds that concrete is poured directly into. In addition, the development of 3D printing technology for nano-engineered MRCI can boost efficiency, reliability, and productivity as compared to conventional concrete.

Nitrogen-enriched Covalent Organic Framework (COF) for Treatment of PFAS ($45,000)

Yin Wang, Ph.D., Assistant Professor, Civil and Environmental Engineering
Xiaoli Ma, Ph.D., Assistant Professor, Materials Science and Engineering

Dr. Wang's research focuses on the application of chemistry principles to design advanced techniques and strategies for sustainable protection and improvement of water quality. He has worked closely with companies involved in the UWM Water Equipment and Policy center to create technologies for water treatment and groundwater remediation.

Dr. Ma's research focuses on the design and development of advanced materials for use in separation, purification, and sensor technologies. His group currently aims to develop robust adsorbents and membranes with improved performances for water purification and gas separation.

The need for PFAS remediation. Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic organic chemicals that are widely used in a variety of applications, such as surface coatings (e.g. Teflon), production of fluoropolymers, surfactants, and firefighting foams. It is estimated that more than 3000 PFAS have been used in different formulations on the global market. Because of their diverse structure and large use, PFAS have been ubiquitously detected in aquatic systems such as surface water, groundwater, and wastewater. A recent survey reported the detection of PFAS in the public water supplies in 33 states in the United States. Many PFAS are very persistent in nature because they dissolve easily in water and take a long time (even years) to degrade. Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are the two most common PFAS, and the United States EPA has recently established the health advisory level at 70 ng/L for these two compounds in drinking water. However, different PFAS may exhibit distinct environmental behaviors due to their diverse structure and properties.

Problems with current PFAS remediation treatments. PFAS are highly resistant to biological treatment and conventional chemical destruction methods. Granular activated carbon (GAC) is the most widely used technology for PFAS removal from contaminated ground water. However, several limitations of GAC have be identified including: difficulty in removing commonly used short chain PFAS, a decrease in effectiveness in the presence of other natural organic substances in water, and difficulty in regenerating and reusing GAC. Although many other conventional methods such as ion exchange have been investigated for the PFAS removal, they have been found to exhibit slow removal and generate high levels of waste during the process.

Market for PFAS removal. Today's water utilities have limited options for removing PFAS. With urgency growing around PFAS, the proposed material may be used as an alternative to the commercial adsorbents for general purpose water purification or be easily incorporated into commercial products Milwaukee is a hub for many large international water corporations and potential industrial partners can utilize this technology either in their existing products or to develop novel devices for both home and water treatment system use. The proposed new materials have a great potential to help capture and remediate many persistent PFAS compounds that are plaguing our environment.

Project Objective. The goal of this proposal is to develop highly efficient, practical, and cost-effective adsorbent materials in powder form to remove a range PFAS from contaminated water. This team of PIs has the expertise to create an environmentally protective material that is very specific, adsorbent, tunable, and scalable.

Evaluation of a novel water treatment solution for Recirculating Aquaculture System ($40,000)

Osvaldo Sepulveda Villet, Ph.D., Assistant Professor, School of Freshwater Sciences

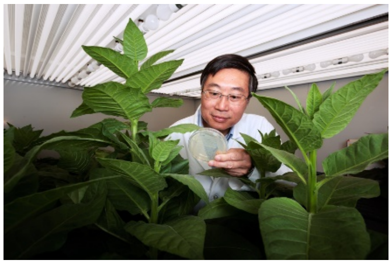
Dr. Sepulveda Villet's research focuses on urban and intensive aquaculture of Great Lakes fish species, population genetics of native species in the context of climate change, and the development of novel therapeutic and probiotic agents to reduce the incidence of early-life mortality and disease of cultured fishes. In this application, Dr. Villet plans to investigate a novel system for cleaning and treating RAS waste by combining his novel biological filter with Amglo's pulsing light disinfection system on a pilot scale.

Partnering with Amglo. By combining Amglo's High Intensity Pulsing Light (HIPL) technology for water disinfection with Dr. Sepulveda Villet's aquaculture biofilter, larger amounts of fish can be supported by production systems. The UWM technology is comprised of a chamber that contains a small volume of glass bubble microbeads, that act as a biological filter media substrate to support the growth of bacteria that aid in regulating nitrogen levels and in the breakdown of waste. Amglo will support the prototype development costs of the Blast-a-Path high intensity pulsed light system along with providing one of their team members during the testing phase. Blast-a-Path is a chemical-free solution that neutralizes biological agents and organic matter present in the waste stream. Pulsed light is superior to traditional mercury UV technology in that it causes instant cell death with no chance of recovery. This technology does not require a warmup period, the frequency can be adjusted to match the water flow, and the intensity of the pulse can be adjusted. These attributes make it an ideal candidate for the recycled water in an aquaculture setting. The Amglo company produces a variety of lamp types for the commercial business (airlines railways automotive etc.) and is repurposing its proven HIPL technology to expand into the disinfection area.

Current problems with domestic aquaculture. Seafood consumption in the US is at an all-time high, with 4.35 million metric tons produced for 2016 (National Marine Fisheries Services 2017). While the US is a net exporter of seafood products, the fact remains that most of this domestic production is fished rather than farmed. Domestic aquaculture production is low due to issues such as labor costs, regulatory impediments, and the upfront capital cost.

Market for RAS. This technology, if proven useful in the aquaculture space, will likely be extended for use in other water related areas like drinking water. Aquaculture currently produces more fish than those wild caught. A large and ever-increasing percentage of fish are now raised in land-based tanks with RAS. Currently 5% of aquaculture output comes from these RAS facilities and by 2030, 40% of aquaculture will come from these facilities. Two trends are evident, the need to conserve water by recycling and the need to optimize production by increasing fish density in the tanks. These two trends can only be satisfied with enhanced removal of toxic ammonia from the water by superior filtration and more effective removal of pathogens with superior disinfection technologies. This proposal provides an excellent example of industry and university research collaboration to advance aquaculture technology.

Novel biopesticide, RejulifeA, for controlling diseases of economically important agricultural crops ($35,000)



Ching-Hong Yang, Ph.D., Professor, Biological Sciences, Faculty

Dr. Yang's research focuses on the interaction of bacterial pathogens with a host, particularly agricultural crops. He has discovered many new antimicrobials including both compounds and helpful biological organisms. Many pathogens use the type III secretion system (T3SS) in which a pathogen uses a needle like protein system to inject harmful factors into a cell to infect it. Dr. Yang's work and his start-up company T3 Bioscience are finding new ways to keep crops from becoming infected without the use of antibiotics. The use of antibiotics in farming has contributed to antibiotic resistant bacteria which have made human infections more difficult to treat.

Novel approaches to develop antimicrobials. T3 Biosciences was formed in 2013 and initially used chemistry to mimic natural plant products to fight bacterial infections in crops. Next they pioneered a new method of screening soil samples to find helpful bacterial species able to fight harmful crop pathogens. They have collected soil samples throughout Wisconsin parks and across the country to find these organisms using microbial ecology and their proprietary harvesting and growth method named PROMISA. Their lead organism is named RejulifeA after Yang's own father who passed away due to an antibiotic resistant infection. This biopesticide shows promise against fire blight disease in apple/pear, as well as citris infections, and tens of other crop infections, and could be use both by organic and non-organic farms.

Market and customer discovery. In the US, apple farmers spend near $14M a year fighting fire blight and still incur losses of $100M. T3 Biosciences has been in discussions with the Wisconsin Apple Growers Association, executives at Wilbur Ellis, and is exploring a distribution relationship with Agrosource. They have learned that farmers use multiple types of antibiotics and fungicides on apple crops, and pathogen resistance to these products can occur in as little as a few sprays. New effective products are needed, but it has been difficult to find formulations that rival antibiotics. Initial tests have shown that Rejulife A is 10-200 times more potent than the leading antibiotic used for fire blight. We have licensed two issued patents for the original chemical pesticides to T3 Biosciences, and one patent pending for the biopesticide in development which is jointly owned by UWMRF and T3 Biosciences.

Project Objective – Formulation and toxicology. Dr. Yang is requesting funding to conduct formulation testing and optimization for a greenhouse test of RejulifeA. A formulation must be easy to spray, environmentally stable, and must be able to enter into the flower blossum for effectiveness. This data will be crucial to collect for an EPA pre-submission meeting. In order to be approved by the EPA the biopesticide must also be tested in four crucial toxicology assays: oral, dermal toxicity, eye irritation, and skin sensitization. The T3 Biosciences team has successfully grown to a team of several scientists and has a strong CEO to lead the team to commercialization. They have raised $3.7M from private investors over the past 7 years and we wish to support the team to help push this revolutionary product closer to the market.

A smartphone system for intelligent diagnosis of wound healing ($30,000)

Zeyun Yu, Ph.D. Associate Professor, Computer Science and Biomedical Engineering

Sandeep Gopalakrishnan, Ph.D. Assistant Professor, College of Nursing

Dr. Yu's work is a futuristic mix of medicine and engineering. Using 3-D geometric modeling and image processing, he has been able to look at the microscopic mechanism of heart contraction which could ultimately lead to advances in treatment of heart disease. He is also developing new algorithms and software tools for other researchers and engineers to automate image processing and geometric modeling.

Dr. Gopalakrishnan's work focuses on developing novel non-contact 3D solutions on portable devices for analysis of wound healing. His research focuses on improving outcomes in chronic non-healing wounds by developing and translating therapeutic strategies. He is a Diplomate and the Secretary-Elect of American Professional Wound Care Association (DAPWCA) and an active member of Wound Healing Society and McPherson Eye Research Institute at University of Wisconsin-Madison.

The need for big data set and customer discovery. In Fall 2018, the team participated in the NSF I-Corp program at UWM to understand the market potential and the need for creating an online database that would help in chronic wound management. Various stakeholders including clinicians, industry executives, clinical trial managers, and legal experts in wound care domain were interviewed. The team found that the current technologies in the market could not address many key requirements such as automated and accurate wound measurements that include classification of wound type and tissue composition analysis that would help clinicians to diagnose and decide a treatment plan. They identified a need for a large data set to create an artificial intelligence (AI)-enabled wound analytic tool to automatically measure and classify wounds to document the healing progress. They want to create a wound imaging and analysis algorithm in a mobile platform that enables accurate measurements from the patient's home, allows consistent tracking and documentation, saves time, and integrates with electronic health records.

Project objective. The proposed smartphone app will capture wound images and provide AI enabled data analytics to precisely monitor the wound healing progress. Unique AI algorithms will be developed along with software tools for big data analytics including automated wound measurements and intelligent diagnosis. This app will be clinically tested for accuracy, precision and reproducibility and will be compared with the conventional digital techniques and other commercially available devices used in the wound clinics in collaboration with Dr. Niezgoda at AZH. This online database will provide a wealth of information to help clinicians in chronic wound management.