IoT based AI Application for Posture Recognition to Reduce Workplace Injuries

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Motivation

- Lifting heavy items is one of the leading causes of injury in the workplace. As per U.S. Bureau of Labor Statistics report:
  - In 2001, over 36 percent of injuries involving missed workdays resulted due to **shoulder and back injuries** in workers.
  - In 2017, **97,990 workers** taking a day away from work involving overexertion in lifting or lowering.
- Some of the common reasons for workplace injuries:
  - Short term pains in due to accidental events such as worker getting struck by some object.
  - Overexertion during manual heavy object transportation.
- The weight lifting pains can result in:
  - Inflammation and trauma to the tissue in and around the joints.
  - Wear and tear of the joints and cartilage.
  - Degeneration of the tendons.
  - Early-onset of arthritis.
- Posture detection and monitoring can loop to serve as an early warning system for the workers to enhance their work efficiency and physical health.
- **The motivation behind the proposed study is to address the problem of detecting and monitoring body postures in the work place where heavy object lifting is a part of the worker routine**.

Background

- Real-time pose estimation for a person is a key component in enabling machines to have an understanding of people in images and videos.
- Papandreou et al. (2017), Cao et al.(2017), Cao et al. (2018) have proposed various approaches for human pose recognition using deep learning.
- We intend to develop a human pose monitoring system on top of these approaches.
- We also intend to further predict the behavioral intent of the person using temporal data and recurrent models of neural network in our system.
- Being aware of good posture is the first step to breaking old poor postural habits and reducing stress and strain on your spine.

Objectives and Task Description

- The main objective of this project is **detecting and monitoring body postures** in the work place where heavy object lifting is a routine.
- Specific tasks involved in this project are as follows:
  - Design and development of an Edge Computing based camera feed processing unit to enable real-time posture detection on factory floors.
  - Develop user interface to allow multi-device accessibility and data visualization.
  - System design to allow prediction of workers' behaviors using computer vision and deep learning.

Experimental Design

- We are using the postural cuttoffs defined in REBA (Rapid Entire Body Assessment) standards as a reference for our development.

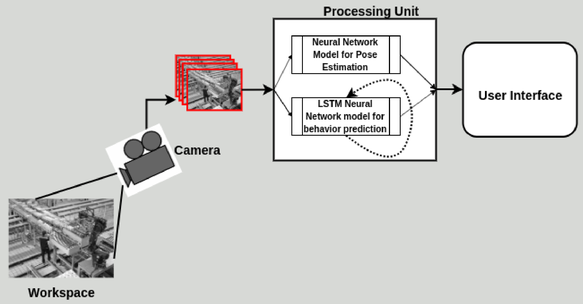

Figure: Schematic of the proposed setup

- The data-sets of human activity understanding presented by Caba Heilbron et al. (2015) and human pose dataset presented by Andriluka et al. (2014) will be used for this project. No human subjects will be involved in the current phase.

Expected Results

- An IoT device using **NVIDIA Jetson TX2 board** as the processing unit.
- The setup will be able to suggest corrective measures based on the detected postures of people.
- Body posture monitoring will be valuable to formulate requirements for a healthy working environment.
- Optimization of the manual handling of heavy objects on the factory floor is the primary focus of this research.

(a) Input (b) Output-Keypoints (c) Output-Skeleton

Figure: Detection of People: (a) Worker handling heavy load, (b) Key points on human body and (c) Posture skeleton of the worker.
Image Source of (a): https://flic.kr/p/9QTZJN.
The above result was generated by using the work presented by Cao et al. (2018) available at https://github.com/CMU-Perceptual-Computing-Lab/openpose.git

Limitations and Future Direction

- Limitations of this system include:
  - This approach being non-invasive, it can't give the physical information about the environment.
  - Including some wearable devices in addition to video feed for posture monitoring has a potential to improve the accuracy of the system.
  - For wide area coverage at workplace, multiple cameras will be required.
- Future work towards improvement of this system may include:
  - Incorporating the developed application on cloud platform for accessibility on mobile devices.
  - Data collection and data analytic platform development for the human pose recording and intent analysis.
  - Incorporation of developed pose recognition system in robots may result in:
    - Development of robust human robot interaction systems allowing robots to take decisions based on predicted human behavior.
    - This can further ensure safety in case of factory workers working along side manufacturing robots.
    - This module can also help in ensuring safety of pedestrians if used in self-driving cars.

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Acknowledgement

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Characterizing Fine and Ultrafine Particle Exposure Among Home Healthcare Workers

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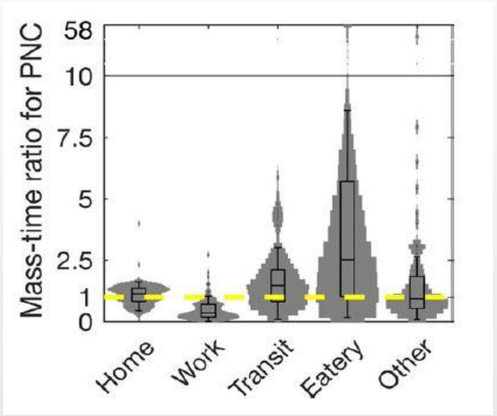
Background

The Bureau of Labor and Statistics identified home healthcare (HHC) as one of the fastest growing careers and is expected to grow over 60% by 2024 (1). HHC workers experience many exposures (sharps, violence, SHS, blood-borne pathogen, ergonomic risks).



HHC workers spend a significant amount of time in vehicles driving to and from patients, increasing their risk of air pollution exposure. Studies have identified higher exposures to air pollutants occur during transit times over other microenvironments (2).

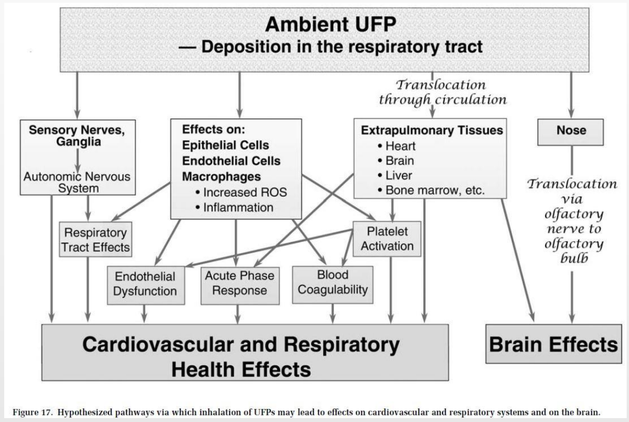
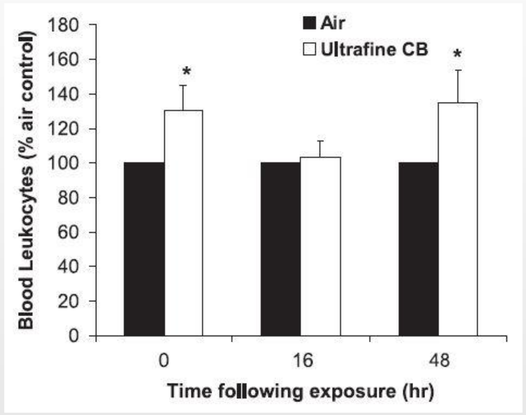


Figure 17. Hypothesized pathways via which inhalation of UFPs may lead to effects on cardiovascular and respiratory systems and on the brain.



Toxicology studies report that ultrafine particles (UFP) are more toxic than larger particles and subsequently promote greater health risks. Their ability to create reactive oxygen species, deposit into the alveolar region, and translocate to the blood supports these theories, but epidemiological results are conflicting (3, 4).

Specific Aims

Simultaneous monitoring of UFPs and other pollutants is limited. We intend to combat these limitations using 3 validated, real-time, personal air pollution monitors. This will address research gaps in UFP exposure pattern differences over PM2.5. This proposal is novel, stemming from the amount of time HHC workers spend within vehicles. This, along with their projected job outlook create a significant research need.

Specific Aim 1: Characterize home health care workers' personal exposures to PM2.5 and UFP at their homes, during transit, and during patient visits.
Specific Aim 2: Compare varying UFP exposure metrics, including particle number concentration, mass concentration, and lung-deposited surface area (LDSA) and determine their association with respiratory symptoms.

Research Design

Sampling Session		
Initial Study Visit	Sampling Days	Final Study Visit
1-2 days prior to sampling session	*Days 1-5*	*1-2 days after sampling session*
60 minutes	*~9 hours/day*	*30 minutes*

• consent
• instruction on study equipment
  ○ MicroPEM
  ○ Partector2
  ○ Low-cost sensor
  ○ Smartphone
• sensor fitting
	• UFP measurement
	• PM2.5 measurement
	• EMA app survey (1 survey per night)
	• CO_2
	• Humidity
	• Temperature
		• collect study equipment
		• payment

Participants will wear 3 personal PM sensors to collect real-time exposure data (LDSA, PNC, MC) across 5 consecutive workdays. Subjects will turn on sensors 1/2 hour before work for continuous monitoring until 1 hour after they return home, capturing multiple microenvironments.

Subjects will complete a survey at the end of each sampling day via a mobile app about their surroundings, sleep, respiratory health symptoms, and abnormal exposures experienced during daily work activities. GPS coordinates will also be recorded via an app to identify time-series PM concentrations.

Analysis: Pearson correlations of time-series data across microenvironments will be calculated to examine differences in exposure patterns. A mixed effects model will be used to examine associations between UFPs or PM2.5 and the microenvironments. Poisson regression models will determine associations between respiratory counts and UFP particle count, LDSA, and PM2.5 mass concentration to determine which metric contribute the most to health outcomes.

Study Population

A sample target population of 30 HHC workers will be recruited from various home healthcare agencies within Ohio. Subjects will be recruited on the following inclusion criteria: current full-time home healthcare nurse, aid, or therapist, between the ages of 18 and 50, and in good health standing. Potential subjects will be excluded if they are a smoker, live with a smoker, or are pregnant.

Expected Results

We expect data to provide preliminary insight into air pollution exposure and occupational risk among HHC workers. Because these workers spend a significant amount of time in cars, we expect to find higher concentrations of PM during transit times. We believe UFP concentrations will show significantly unique exposure patterns than that of PM2.5. Because UFPs are known to have larger surface areas compared to other pollutants, we expect the LDSA metric to be most indicative of adverse health responses.

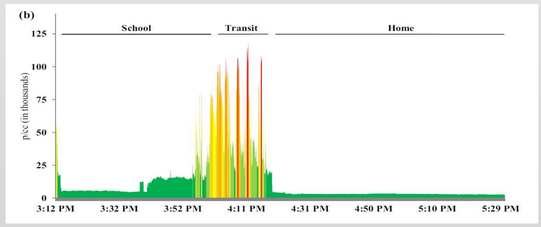


Figure: Preliminary field test showing UFP measurements among school age children (5).

Future Direction

As a pilot project, I plan to expand upon the results outlined in this proposal to correlate personal UFP data to adverse cardiovascular outcomes. I hope to continue my focus on UFPs in the HHC population through future dissertation efforts.

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Role of firefighting-associated chronic stress factors in immune dysfunction in mouse model

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Background

- Firefighters, like many other occupational groups, perform long work shifts involving nightshift and thus remain sleep deprived [1.]
- Increasing evidences suggest that sleep deprivation (SD) induces stress or injury[2], in multiple organs and thus may predispose individuals to development of different diseases.
- Indeed, SD has been associated with many disease like type 2 diabetes mellitus [3], obesity [4], cancers [5], cardiovascular disease[6], infections [7] , among others.
- Firefighters undergo stress due to sleep deprivation and exposure to hazardous chemicals such as in the firefighting foams (e.g perfluorooctanoic acid/PFOA).
- Independent human studies have shown that SD leads to alteration in immune function in multiple ways, such as inducing IFN-γ secretion, decreasing phagocytosis in peripheral blood cells[8], decreasing lymphocyte proliferation, decreasing NK cell count and target cell killing activity[9],[10] and decreasing antibody production from plasma B cell[11]
- PFOA is widely used in fire extinguishing foams and a number of industrial and consumer products and has been frequently detected in food-chain and drinking water[12] and bioaccumulates in kidneys, liver and blood[13] .
- Animal studies have suggested that PFOA has immune suppressive effects[14] and causes different type of cancer in rodents[13]. In mice, PFOA causes decreased T cell-dependent antibody production[14]. Serum PFOA levels were negatively associated with response to diphtheria and tetanus vaccination in children[14].

- **Hypothesis:** Collectively, these facts coupled with the reports of sleep deprivation associated stresses in high risk jobs lead us to hypothesize **that occupational SD-induced chronic stress modulates immune homeostasis and function, which may be further exacerbated by co-exposure to** perfluorooctanoic acid **(PFOA**). This alteration in immune parameters, may at least in part, can serve as a tool for finding novel biomarkers and help understand the mechanism of different disease conditions as a result of firefighting- related exposures.

Objectives

Aim 1: To assess sleep deprivation (SD)-associated chronic stress in an SD mouse model based on biomarkers.

Aim 1a: We will use the established multiple platform method to induce sleep deprivation and chronic stress mice model.

Aim 1b: To analyze sleep deprivation induced chronic stress associated bio-markers (cortisol and C-reactive protein) by ELISA in serum.

Aim 2: To examine the effects of co-exposure (SD + PFOA) on stress and immune function in the SD mouse model.

Aim 2a. Immune cell phenotyping and immune mediator profile will be measured based on qRT-PCR analysis. (Gene- T-bet, Fox-p3, IL-10, TNF-α, IL-1β, IL-6, IFN-γ, Cxcl5, NK1.1, Cxcl11)

Study plan

A mouse model of sleep deprivation based on the reported modified multiple platform method will be set up by using 6-8 week old C57BL/6 mice (n=8 mice/ group). Briefly, in this method, the mice will be placed in a water cage (e.g. 42 cm×28 cm×18 cm high), containing six platforms (3 cm in diameter), surrounded by water up to 1 cm beneath the platform surface for 24 h. Ad libitum food and sterile water will be given to mice during the sleep deprivation period. Chronic stress will be induced by following the sleep deprivation scheme outlined in **Figure-1** without or with weekly co-exposure to PFOA (@ 1ug/kg mice body weight, which is equivalent to the range of reported PFOA level in firefighters) by oral gavaging on day 7, 14 and 21.

Modified multiple platform techniques

Image.1 Modified multiple platform: Six round platforms of 3-cm-diameter each, in water tanks of (42 cm×28 cm×18 cm high) size.

Experimental design

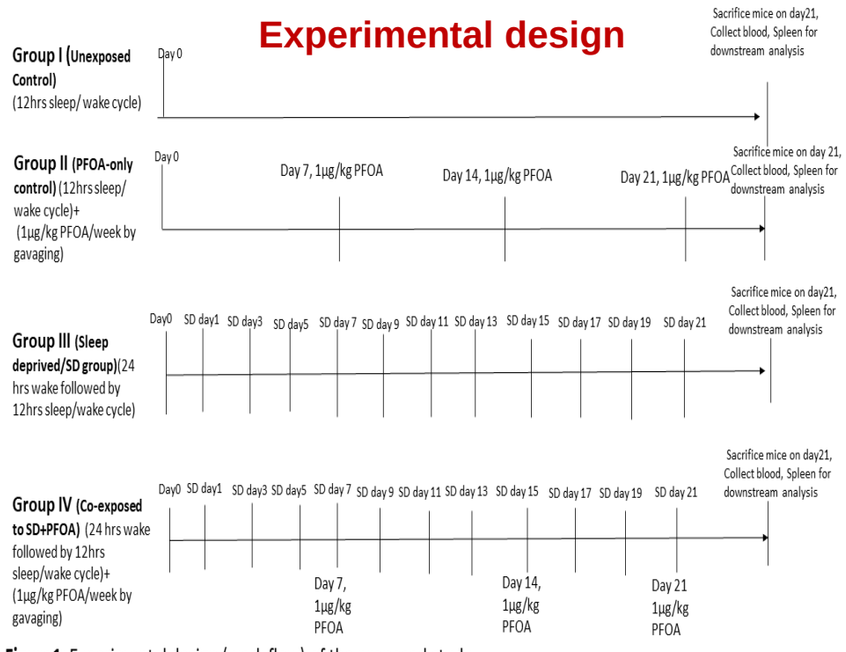

Figure1: Experimental design (work flow) of the proposed study.

Limitations

We anticipate no specific technical problems in inducing SD and performing PFOA exposure given our prior experience in mouse studies in mentor's laboratory. We expect no obvious problems in sampling and immunological analysis considering the PI's specialization in immunology and mentor laboratory's track record in environmental immunology and established routine lab techniques. However, it is possible that some mice may die due to SD induced stress in the middle of the experiment. In that case, we will continuously monitor the mice and shorten the duration of the SD cycle to a level enough to induce measurable stress indicators.

Expected results

1. We expect to identify alterations in immune cells profile in mice with the SD-induced stress without and with PFOA exposure, in a differential manner. This information is expected to provide insights into the interplay between the SD induced stress and PFOA exposure
2. we expect to identify novel specific immune biomarker candidates associated with SD-induced stress and/or PFOA exposure

Future directions

1. This study will unravel the risks as result of chronic stress due to occupational risk factors sleep deprivation and PFOA exposure.
2. This work will reveal specific deployable biomarkers in different body fluids as a result of altered immune status.
3. Preliminary data obtained through this pilot study will be used to submit a larger grant to NIOSH to pursue future expanded studies on role of firefighting-associated chronic stress factors in immune dysfunction of occupational workers and associated health disorders and diseases in firefighters.

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A LEAD-FREE CARBON-BASED SHIELDING MATERIAL TO PROTECT HEALTHCARE WORKERS

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University of CINCINNATI

1. Background

- The safe use of x-ray generating machines in industry and medical facilities requires that users be shielded from unnecessary radiation exposure.
- In addition to structural shielding, workers are required to wear a protective vest, skirt, or apron that likely contains lead, a toxic heavy metal.
- However, these garments are heavy, bulky, and uncomfortable to wear, especially for long periods of time that could lead to musculoskeletal pain or other orthopedic condition.(1)
- A recent hospital study found measurable quantities of lead dust on the surface of these garments representing an increased risk of lead exposure for both healthcare workers and patients.(2)
- Lead-free, polymer-based x-ray shielding aprons with metal particles suspended in the polymer matrix are available but are prone to damage similar to the conventional aprons.

Cracked lead shield; Diagn. Interv. Radiol. 2012; 18:147–152

- The lighter carbon nanotubes is proposed as a low-density matrix for this research in which metal particles can be integrated to produce a garment for x-ray shielding.

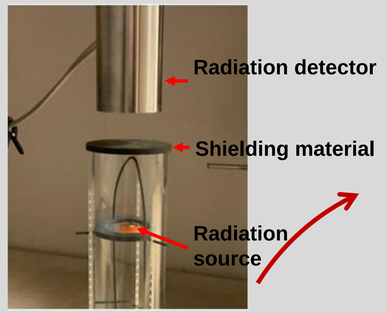
2. Objectives

- **Develop a lead-free, durable, flexible, lightweight, carbon nanotube-metal (CNT-Metal) composite material that attenuates low energy photons (x-rays).**
- **Incorporate the CNT-Metal material in a fabric that can be used to produce personal protective garment to shield x-rays.**
- **Compare the radiological shielding properties of the CNT-Metal composite material to commercially available lead and lead-free garments.**

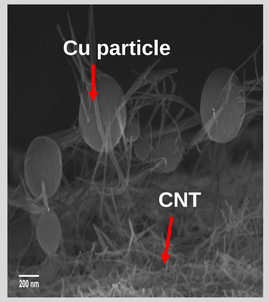
3. Methodology

Measure the transmission of low energy photons through different lead-based x-ray shields to verify the attenuation coefficient for lead.

Simulate the expected attenuation coefficient for various CNT-metal materials using the NIST Xcom software.



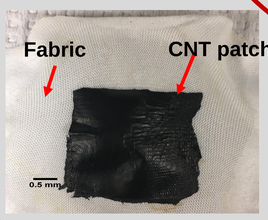
Metal integration in the CNT material.



Material characterization.

Measured attenuation coefficient of lead

Testing of the material for X-ray shielding.



Integration of the CNT-metal material in the fabric.

SEM

XRD

4. Timeline

Report submission 8/21/2020

Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug

- **Verification of attenuation coefficient fro lead**
- **Material simulation using NIST Xcom software**
- **Metal integration in the CNT material**
- **Material characterization**
- **CNT material integration in the fabric**
- **X-ray shielding testing of CNT fabric system**
- **Report preparation**

5. Perceived Challenges

- Non-homogeneity of the material
- Thick CNT sheet for the target SE

Solution

- Laminating multiple CNT sheets in angle

6. Potential Research Opportunity

The result of this research work can be expanded to develop radiation shields for aircraft crew members, as they are exposed to largest annual effective dose of all the US radiation exposed workers.(3)

7. Acknowledgement

This research study is supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant **#T42OH008432**

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Assessing volunteer workers' exposure to dust, metals, and bioaerosol during equine assisted activities/therapies

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Background

Equestrian facilities represent microenvironments with multiple sources of air contaminants. Horse and human movement creates particulate matter suspensions from soil-based surfaces, bedding, and horse feed.[1] Volunteer workers assist in equine assisted activities/therapies delivery. No safe level of air pollution exists.[2] Recommendations to reduce daily exposures must be weighed against benefits of engaging in activities that may increase exposures.

Preliminary Data

	Metals (ppm)		
Footing Type	Mn	Fe	Pb
Sand (n=15)	309	12,388	8
Sand w/Fiber (n=12)	356	1684	4
Rubber Composite (n=2)	50	841	18

Metals vary with footing type (p=0.0172, 0.0002, and 0.0004, respectively by metal) and means are within normal values.

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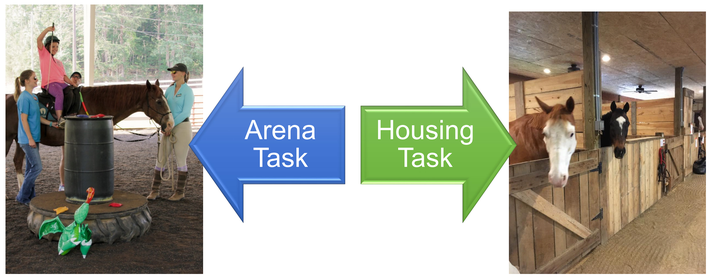
Experimental Design

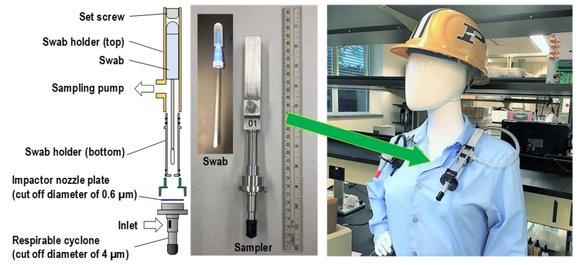
Aim 1: Qualify work practices that impact volunteer workers' exposure to airborne contaminants in EAA/T environments

Collaborate with PATH Intl.	Survey	Choose 3 sites with similar • Work practice • Facility (covered/enclosed) • Footing Type

Aims 2 & 3: Quantify volunteer workers' personal exposure

12 Volunteers per site (n=36)	Arena Task (n=18) Housing Task (n=18)	Devices: SKC 25 mm cyclone Bioaerosol sampler	Gravimetric analysis ICP-MS Total airborne bacteria





Future Directions

Establish links between exposures and biomarkers among EAA/T volunteer workers. Characterize chronic exposures and bioaccumulation of metals. Develop best practice recommendations for therapeutic interventions to ensure health and safety.

Acknowledgements

The authors acknowledge the contributions of HALTER and Healing Strides of VA, the volunteer communities associated with these facilities, and the contributions of Staci McGill and Tim Hilbert for footing samples analyses. This research study is supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432.

Heavy metal sensor for construction workers based on 3D graphene

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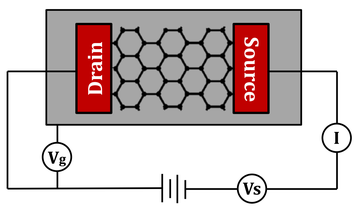
Background

Among all environmental contaminants, heavy metals and in particular Pb^{2+} are classified as one of the most hazardous materials for human's health. Even small amount of lead in the body could be harmful and since its elimination rate is slow, prolonged exposer to small quantities can lead to accumulation of detrimental levels of lead in tissues. High concentration of this element in the body can result in permanent damage in nervous system or death. Exposure to lead in human could be related to impaired cognitive functions, hearing problems, behavioral abnormalities and neuromuscular weakness [1- 3]. Therefore, it is of high importance to design high sensitivity sensors for detection of lead.

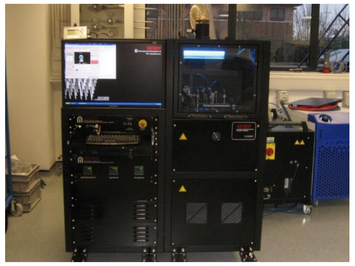
Objective

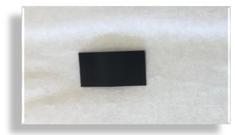
This project seeks to create a highly sensitive sensor that can be used in the work environment of the construction workers. The aim of this 1-year project is to create a ***lead*** sensor by investigating the sensitivity of novel 3D graphene-CNT and 3D graphene-vertically aligned 3D graphene hybrid structure.



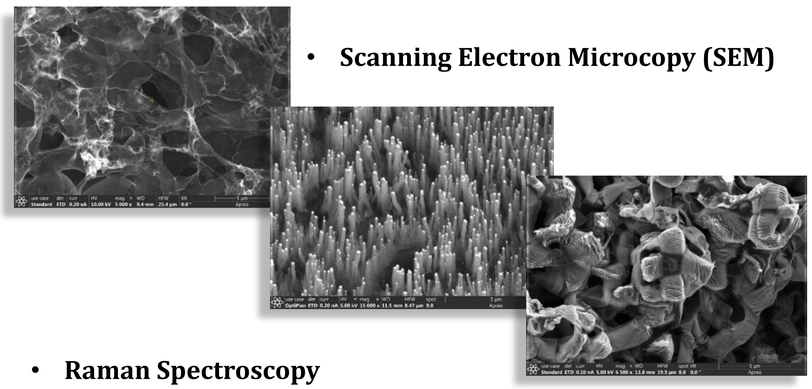
Methodology

- **Synthesis and characterization of hybrid nanostructure:** Low Pressure Chemical Vapor Deposition (LPCVD), Plasma Enhanced Chemical Vapor Deposition (PECVD).
- **Doping of nitrogen in hybrid nanostructure:** Ammonia plasma.
- **Electrical sensing:** Field Effect Transistor (FET).

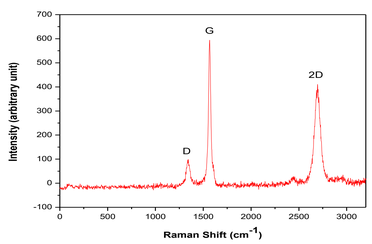




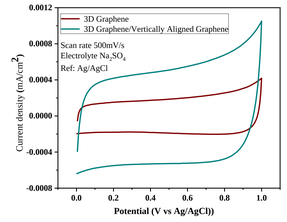
Initial results



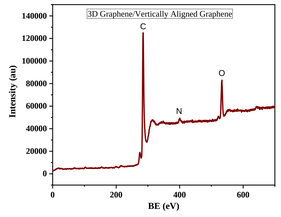
- **Scanning Electron Microcopy (SEM)**
- **Raman Spectroscopy**



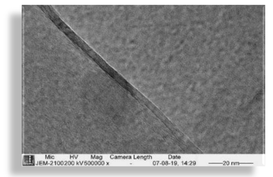
- **Cyclic Voltammetry**

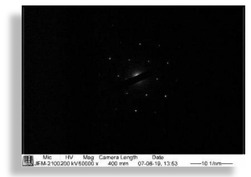


- **X-ray photoelectron spectroscopy (XPS)**



- **Transmission Electron Microscopy (TEM)**





Future Direction

- Optimizing the process parameters to obtain the suitable hybrid structure to maximize the sensitivity.
- Preparing the FET sensor and measuring the sensitivity.

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Acknowledgment

This research study is supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432

Neurotoxicity of Perfluoroalkyl Substances (PFAS) Mixtures in Firefighting Materials

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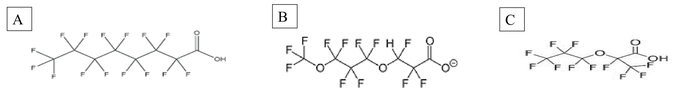
INTRODUCTION

- Perfluoroalkyl substances (PFAS) are synthetic compounds that are composed of fluorinated carbon chains.
- These compounds are used in wide range of applications due to oil, water, stain resistant properties such as clothing, carpets, fabrics for furniture, adhesives, paper packaging for food, and heat-resistant/non-stick cookware.
- The carbon-fluoride bond is very stable, thus PFAS are bioaccumulative in organisms and persistent in the environment.
- PFAS exposure is linked with many adverse health effects such as liver diseases, thyroid hormone disruption, decrease immune response and increase cholesterol levels[1,2].
- PFAS is detected in the blood of the general population but firefighters and first responders are at higher risk of exposure to PFAS[3,4].
- Aqueous Film Firefighting Foam (AFFF) contains PFAS mixtures due to their effectiveness in extinguishing fires especially fuel fire. Also, the turnout gear contains PFAS as a water repellent agent[5].
- Firefighters can be exposed to PFAS through inhaling combustion products of PFAS-containing consumer products such as carpets and furniture during firefighting or drinking PFAS-contaminated water.
- The concerns of PFAS toxicity led to voluntarily phasing out of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) by their manufacturer.
- New AFFF formulation contain shorter chain PFAS such as GenX (6 carbon) and ADONA (7 carbon). These chemicals have very limited toxicological data.
- Many animal studies support potential neurological effects associated with PFAS exposure, focusing on PFOS and PFOA [6,7].

OBJECTIVES

- Assessing the developmental neurotoxicity (DNT) of GenX or ADONA using zebrafish (*Danio rerio*) as an animal model.
- Assessing effect of GenX and ADONA on the development of dopaminergic pathway.
- Assessing DNT of GenX /PFOA mixture and ADONA/PFOA mixture.



Chemical Structure of (A) PFOA, (B) ADONA, (C) GenX

RELEVANCE To NORA

This study will identify potential adverse effects of GenX, ADONA and PFOA exposures. This aim is in line with the goals of the national occupational research agenda (NORA) public safety sector. This sector aims to reduce public safety workers' hazardous exposure and to set standards for their protective clothing and equipment standard.

ZEBRAFISH AS AN ANIMAL MODEL

Why use Zebrafish:

- Epidemiological studies weren't conclusive in terms of linking PFAS exposure to neurobehavior and neurological diseases[1].
- The concern about GenX and ADONA is relatively recent, so there is a big need to characterize the risk of those chemicals using animal models.

Advantages of Zebrafish:

- The zebrafish has a sequenced genome and 80% homology of genes associated with human disease[8].
- The zebrafish is a well-established model to study DNT and neurobehavior[9].

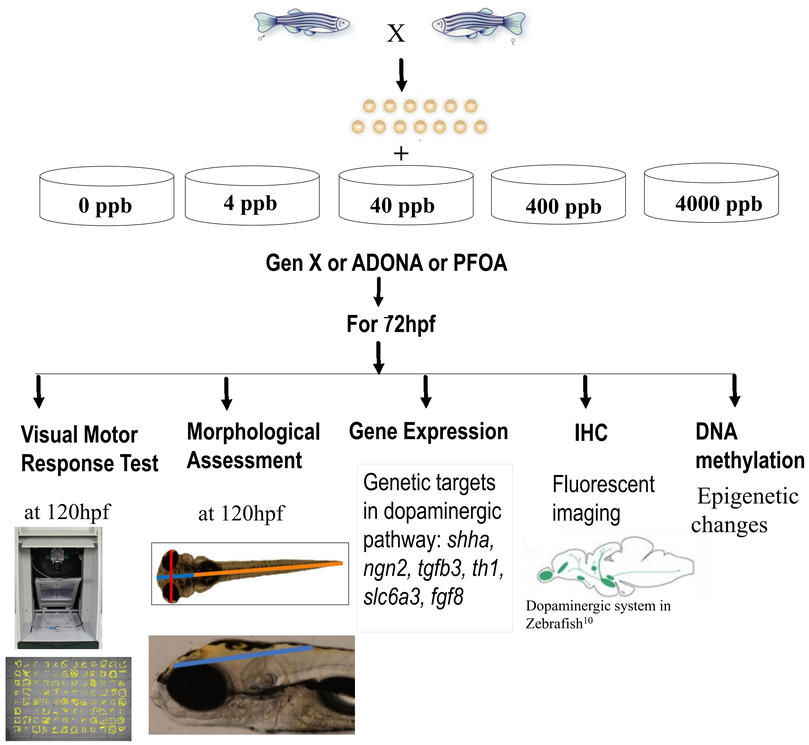
EXPERIMENTAL DESIGN

Breeding:

- Adult fish are bred in spawning tanks
- Embryos will be collected immediately after fertilization
- 50 embryos/ petri dish

DNT assessment of single chemical exposures:

1- Locomotor Activity Assessment
2- Morphological Assessment
3- Gene Expression
4- Immunohistochemistry (IHC)
5- loci-specific DNA methylation analysis



EXPERIMENTAL DESIGN (CONTINUED)

DNT assessment of binary chemical exposures:

Same set of experiments using GenX and PFOA or ADONA and PFOA mixtures. Concentrations of each chemical will be determined based on the results of single chemical exposures.

EXPECTED RESULTS

We are expecting that:

- GenX or ADONA exposure will result in a decrease in locomotor activity compared to PFOA.
- Gene expression of genes in the dopaminergic pathway will be affected by GenX and ADONA.
- Gene expression alterations are associated with changes in DNA methylation.
- Number of dopaminergic neurons will decrease in GenX and ADONA exposures.
- GenX/PFOA or ADONA/PFOA exposures will results in synergistic effect compared to single chemical exposure.
- **Research to practice potential :** results of this study will emphasize importance of cleaning turnout gear, and proper handling of AFFF waste. It also may influence changes of the AFFF formulation and standards for turnout gear.

FUTURE DIRECTIONS

- Long term effect of GenX and ADONA exposure as well as GenX/PFOA and ADONA/PFOA will be assessed by assessing the same endpoints on adult fish.
- The findings of this project will be used as preliminary data for a future R01 proposal (targeting Oct. 2020 submission).

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ACKNOWLEDGEMENTS

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Dual-Functionality Heatable Carbon Nanotube Air Filters for Healthcare Providers

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b. Department of Chemical Engineering, University of Cincinnati, Cincinnati, OH 45221, USA

University of CINCINNATI

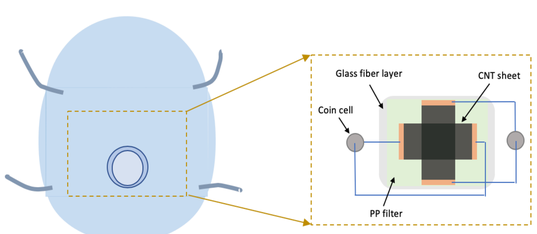
Background

- Healthcare workers recognized by WHO as "the most valuable resource for health", work in one of the most hazardous environments[1].
- One of the critical hazards in healthcare industry is biological exposure[2]. The conventional masks with single filtration function is powerless to the complex environment.

- Carbon nanotube (CNT) due to small diameters and high specific surface area, has been incorporated with conventional polymeric fibers to improve filtration efficiency[3].
- CNT heaters exhibit ultrafast thermal response, low operation voltage, long life times and hundred times lighter than copper[4].
- Our team recently have successfully applied CNT heater to water purification industry for highly effective separation and in-situ inactivation of bacteria[5], proving its ability to be incorporated into air filtration.

Objective

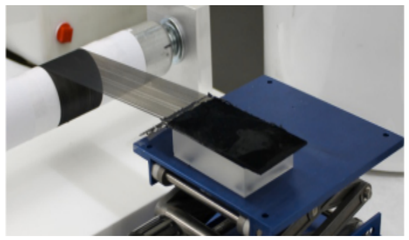
This project seeks to synthesize CNTs that are ideal for air purification through heating. The integration of CNT heater into a fabric filter enables dual functionality. The primary goal of this 1-year project is to design, fabricate and test a heatable CNT air filter incorporated into a face mask that can protect healthcare workers from hazardous microbes.

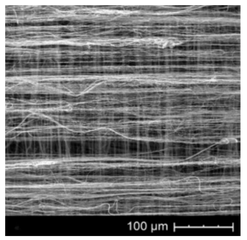


Experimental

- **Synthesis and characterization of CNT.**
  -- Chemical vapor deposition (CVD), Raman spectroscopy, scanning electron microscope (SEM).

- **Fabrication of CNT sheet heater filter.**
  -- CNT sheet accumulation, transfer to air filters.

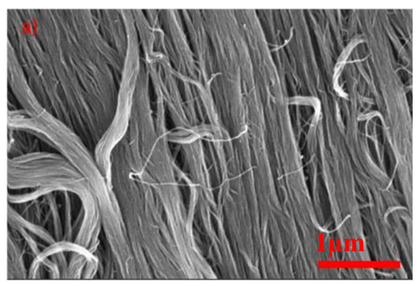




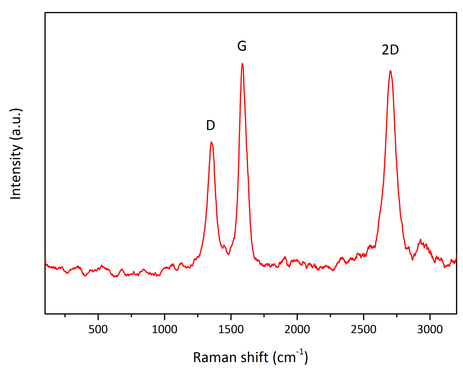
- **Incorporation into mask and heating performance test.**

Preliminary Results

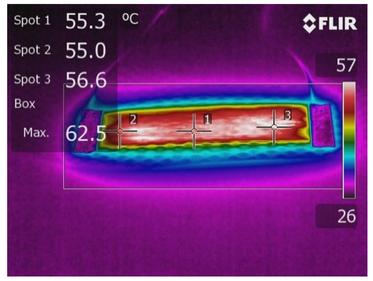
- SEM



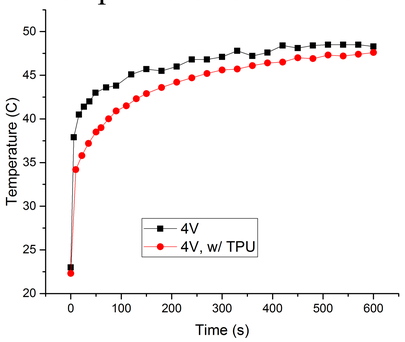
- Raman spectroscopy



- Infrared images



- Temperature vs Time curve



Future Direction

- Fabricate and assemble CNT sheet into cross-ply structure. And test the heating performance.
- Test the heating effect on biological hazards such as bacteria. Find an optimized temperature based on the results of biological test.
- Transfer CNT sheet on polymeric air filter and incorporate into mask. Then verify the pre-optimized temperature and adjust the device based on the results.

Acknowledgement

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Home Healthcare Workers' Occupational Exposure to Bioaerosols and Associated Respiratory Symptoms: A Pilot Study

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Background

- US population is aging, people living longer, and health care cost is soaring
- Receiving health care in the comfort one's own home is now the preferred choice
- As a consequence, the home health care industry is booming
- In 2008, 13.3 million people were employed in private-sector health care
- Through 2026, healthcare settings job growth is projected to be 18%
- The number of home health care workers (HHCWs) will then increase by 41% meaning more than 4 million additional jobs [1,2]
- Unlike other healthcare settings, private homes in which health care is provided are not considered workplaces and therefore no occupational standards or regulations exist
- HHCWs face many challenges in their duties including exposure to airborne microbial agents
- Such microbial agents could be associated with adverse respiratory health issues
- Example: Healthcare professionals have a higher prevalence of asthma attacks than non-healthcare workers [3,4]
- No study has assessed HHHCWs' occupational exposure to bioaerosols
- Research is needed to assess the exposure of HHCWs to bioaerosols and to investigate the association between such exposure and the prevalence of respiratory symptoms.

Objective

This study aims to assess the HHCWs' exposure to bioaerosols in visited patients' private homes, and the association between such exposure and respiratory symptoms

Overall hypothesis: HHCWs working in private homes are exposed to diverse microbial agents and therefore, elevated bioaerosol exposure in quantity, diversity and abundance will be associated with increased respiratory health symptoms

Specific aim 1: Assess HHCWs' exposure to bioaerosols by DNA quantification with qPCR and by the determination of the diversity and the abundance through metagenomic with NGS in the air and surface samples collected in the visited homes to be compared to other occupational studies

Specific aim 2: Investigate the association between the HHCWs' exposure, as ascertained by the quantity, the diversity and the relative abundance of the airborne microbial agents, and the increase in the prevalence of respiratory symptoms.

Significance

- Filling the knowledge gap on HHCWs' exposure to bioaerosols and associated respiratory symptoms
- To our knowledge, this study is the first to investigate bioaerosol exposure in HHCWs
- The study objectives align with NIOSH National Occupational Research Agenda
- Results will contribute to establish standards and regulations to protect HHCWs

Study population

Subjects are home healthcare workers:

- Adults employed as HHCW in the Kentucky-Indiana-Ohio tristate area
- in HHC for at least one year and HHC is their only job at the time of data collection
- Age between 18-60 years old
- Of all races, ethnicities and genders
- In overall good physical health
- With no respiratory disease prior to the current job

Methods and activities

Study design

This is a cross-sectional observational study

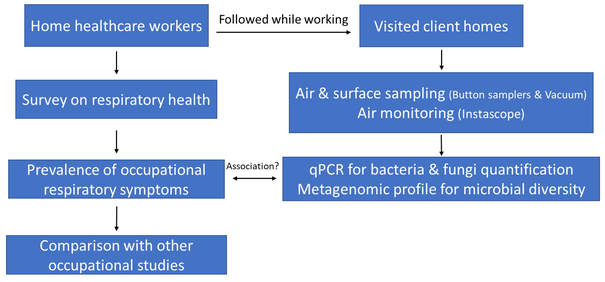

Figure1: Study design of the exposure to bioaerosols among HHCWs

Recruitment

- Obtain the Institutional Review Board (IRB) approval
- Advertise the study to targeted home healthcare agencies in the area
- Contact, screen, recruit, and enroll volunteer participants
- Schedule a one shift-long sampling session with each participant for data collection

Sampling and data collection

- Sample indoor surfaces and air using vacuum and Button aerosol samplers
- Monitor fungal spore concentration and distribution using Instascope
- Administer self-reported respiratory health survey to HHWCs

Figure 2: Devices and instruments to be used for data collection

Sample analysis

- Real-time polymerase chain reaction (qPCR) with universal primer to quantify DNA copy of microbial agents.
- Instascope generates data reports automatically.
- Metagenomics with next generation sequencing (NGS) using Illunima MiSeq with the internal transcribed spacer (ITS) and 16S rRNA amplicons to evaluate the diversity and the abundance of microbial agents

Metagenomic and statistical analysis

- R software, Mothur, Bioconductor and "vegan" package will be used for data analysis
- Wilcoxon test will be used to compare groups
- Alpha diversity values will be compared to the other study results
- Logistic regression will be used to model health outcome

Limitations

- Small sample size (maximum 30 subjects to be enrolled) will limit the generalization of our findings
- It will be difficult to distinguish the occupational exposure from other sources of exposure such as workers' home, traffic pollution, ambient air pollution, etc.

Expected results

We expect that home air and surface samples reveal exposure to bioaerosols higher than in optimal workplace conditions and that such exposure would be associated with respiratory symptoms in HHCWs

Future directions

This is a pilot study that will pave a way for a larger study and an epidemiological study to ascertain the association between exposure to bioaerosols and respiratory health effects among HHCWs

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University of Cincinnati Education and Research Center

Designing Next-Generation Solid State Electrolyte via a Multiscale Computational Scheme

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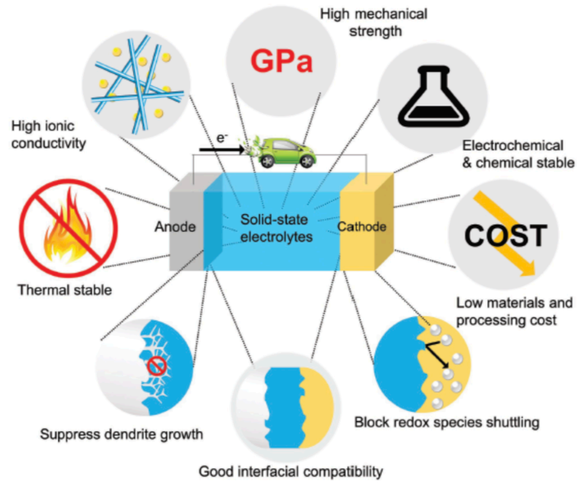
University of CINCINNATI

Background

- Lithium-ion battery is widely used in electric vehicle, electronic devices due to its light weight, and high- energy density (theoretical 350–400 W h kg^{-1}).
- Lithium batteries are criticized because of the potential safety concerns that they pose.
- The most significant drawback of lithium batteries is their battery short circuits and thermal runaway.
- Solid-state battery technology recently became a promising approach to improve the safety concern of Li-ion battery by using solid-state electrolyte (SSE).
- SSE requires the material to have both a fast ion transport speed and decent mechanical rigidity.

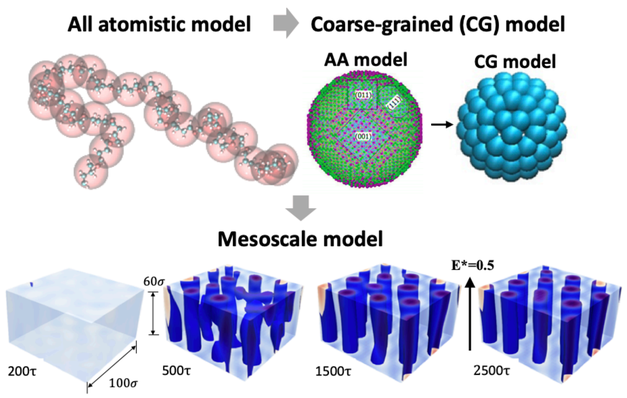


- Polymer based SSE are one of major candidate, however the mechanism of the ion transport and mechanical behavior remains elusive.

Objective

Demonstrate the viability of a versatile approach to bridge the all atomistic (AA) and coarse grained (CG) model for a representative group of ionic polymers-nanoparticle to pave the way for design the SSE for the next generation Li-ion battery.

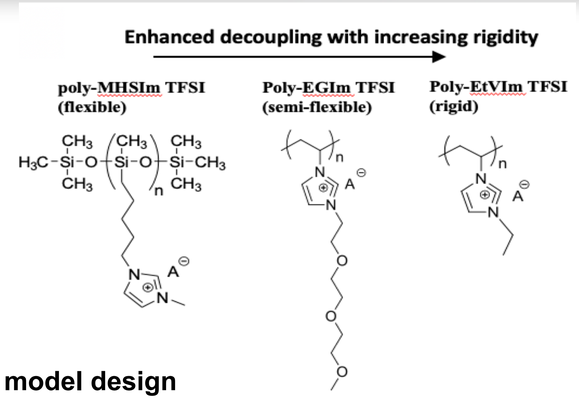
Research Design

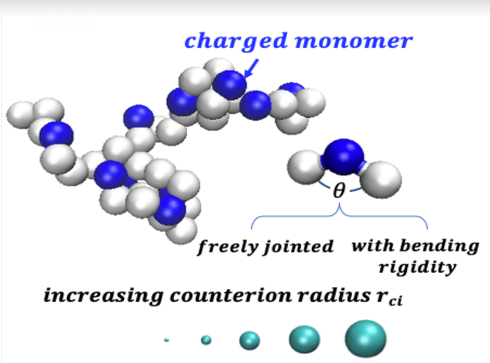


- A multiscale model seamlessly linking AA and CG models is thus needed to enable high fidelity prediction of ionic polymers efficiently

Features of all atomistic (AA) and coarse-grained (CG) models

- The coarse-grained molecular dynamics (CGMD) simulation is a powerful tool to predict the ion transport of ionic homopolymers and mechanical properties in ionic block copolymers.
- However, a direct comparison between CGMD and experimental results is challenging due to the loss of atomistic detail.
- AA MD is accurate in capturing nanoscale features and convenient to compare with realistic material systems used in experiment.
- Spatiotemporal limitation makes it challenging to emerge as a rapid design tool of bottom-up characterization and prediction.





AA model design

A small number of polymer chains will be considered, which will be chosen from a representative group that has variety in chemical structure and backbone/side chain rigidity.

CG model design

- Different types of beads can be used to represent different atom group mapping from the AA model.
- The number of parameters can be minimized and CG model parameters are more transferable across different types of monomers.

Chain rigidity and nanoparticles (NPs)

- The varying rigidity can be reflected by the angular potential.
- NPs will be introducing to the AA and CG model, where the realistic shape and mass of the particle will be considered.

Task Description

Task 1. Establish the all-atoms (AA) models of different ionic polymers including homopolymers and block copolymers.

Task 2. Develop a versatile systematic CG modeling strategy for simulating the ionic polymers with varying backbone or side chain rigidity.

Task 3. Employ the Inverse Boltzmann Method (IBM) method[4] to insert atomistic details into the CG model for bonded and non-bonded interaction optimization.

Task 4. Extend the CG approach to block copolymers and to incorporate NPs if time permits.

Expected Results

- A full atomistic description of the potential ionic polymers for solid state electrolyte is established to characterize their mechanical and ionic and mechanical properties.
- A coarse-grained description of the ionic polymers is established to extend the spatiotemporal scale of the full atomistic model.
- Understand the effect of nanoparticles to the structural, ion transport and mechanical properties of ionic polymers.
- Elucidate the effect of increasing polymer chain rigidity to the ion transport mechanism.

References

[1] Nature Materials, 2013. 12: p. 452.
[2] Polymer, 2004. 45(11) 3869-3876.