THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

UAB Superfund Research Center
Impact of Airborne Heavy Metals on Lung Disease and the Environment

Advanced Materials & Manufacturing in Response to Community & Covid19

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P42 Super Fund Lead Project 5 with Dr. Veena Antony (UAB Team)

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THE COMPOSITES iacmi INSTITUTE

OAK RIDGE National Laboratory

Team Leverage – Collaboration on P42

Manufacturing USA Institute – 160 member companies

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Leading university in materials & manufacturing R&D

OAK RIDGE National Laboratory

DOE's Largest Materials & Manufacturing Lab in the US

UAB NIEHS Superfund program

Nano-Micro Hybrid Fibrous Materials for Contaminant Removal and Site Remediation; Lead – Uday Vaidya, UT-ORNL, Knoxville

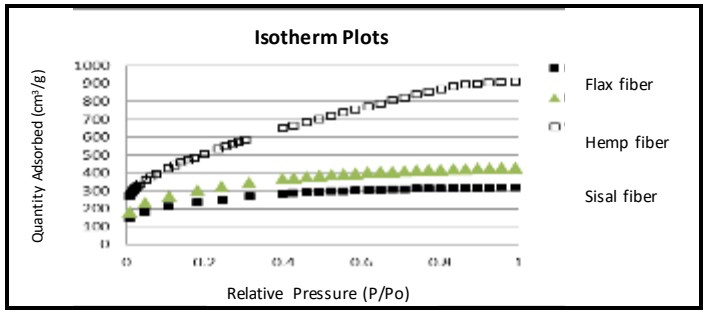
Hypothesis: Can innovative composite *Materials by Design* result in reliable capture and adsorption of Cd, Mn, As

- **Aim I:** Multiscale tailored fiber mats for adsorption/ removal/capture of Cd, Mn and As enabled from carbon fiber derived from precursors -
  - Textile grade carbon fiber precursors
  - Recycled carbon fiber
  - Natural fiber materials (e.g. sisal, flax, bamboo)
- **Aim II:** Surface analyses such as porosity, surface area, pore width, micro-pore volume and pore size distribution
- **Aim III:** Scalable materials with: (a) adsorption and filtration of PMs; (c) filtration and capture of PAHs, and (b) chemical adsorption and removal of Cd, Mn and As from air, soil and water.

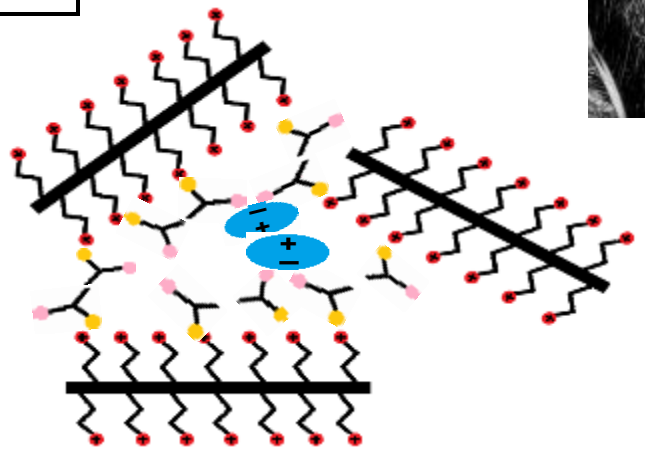
World's largest open access carbon fiber process development facility: *$35M facility investment*

The mats will be packaged into prototype for field evaluation- (a) cover test mounds of soil containing Cd, Mn and As; (b) packing as filters for interior spaces such as commercial buildings and homes; and (c) packaging into nets that can be placed at bottom of lakes/water bodies.

The team has expertise in fibers and composites manufacturing, characterization and products from nanoscale to macroscale

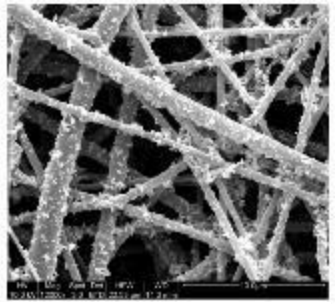


Chemically activated carbonized natural fibers: Demonstration of high adsorption based on pore size and morphology of flax, sisal and hemp fibers

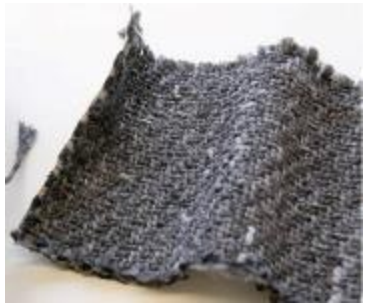


Tailored surface chemistry for porosity, adsorption and fiber and mat architectures

Field deployable prototypes can be readily produced



ACF nanofibers



ACF carbon fibers

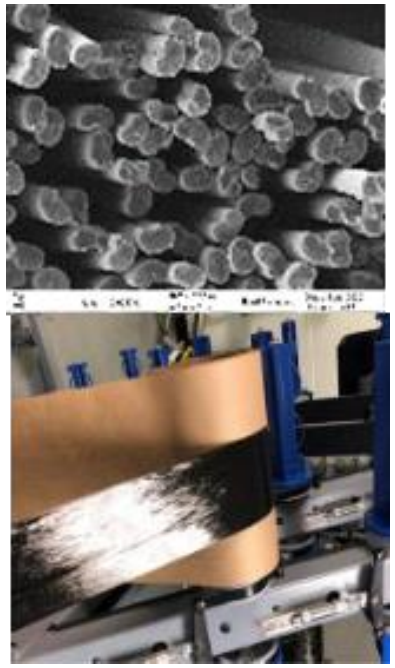
Product shaping from ACF carbon

Recycled & textile grade carbon fiber to wrapped rovings & mats

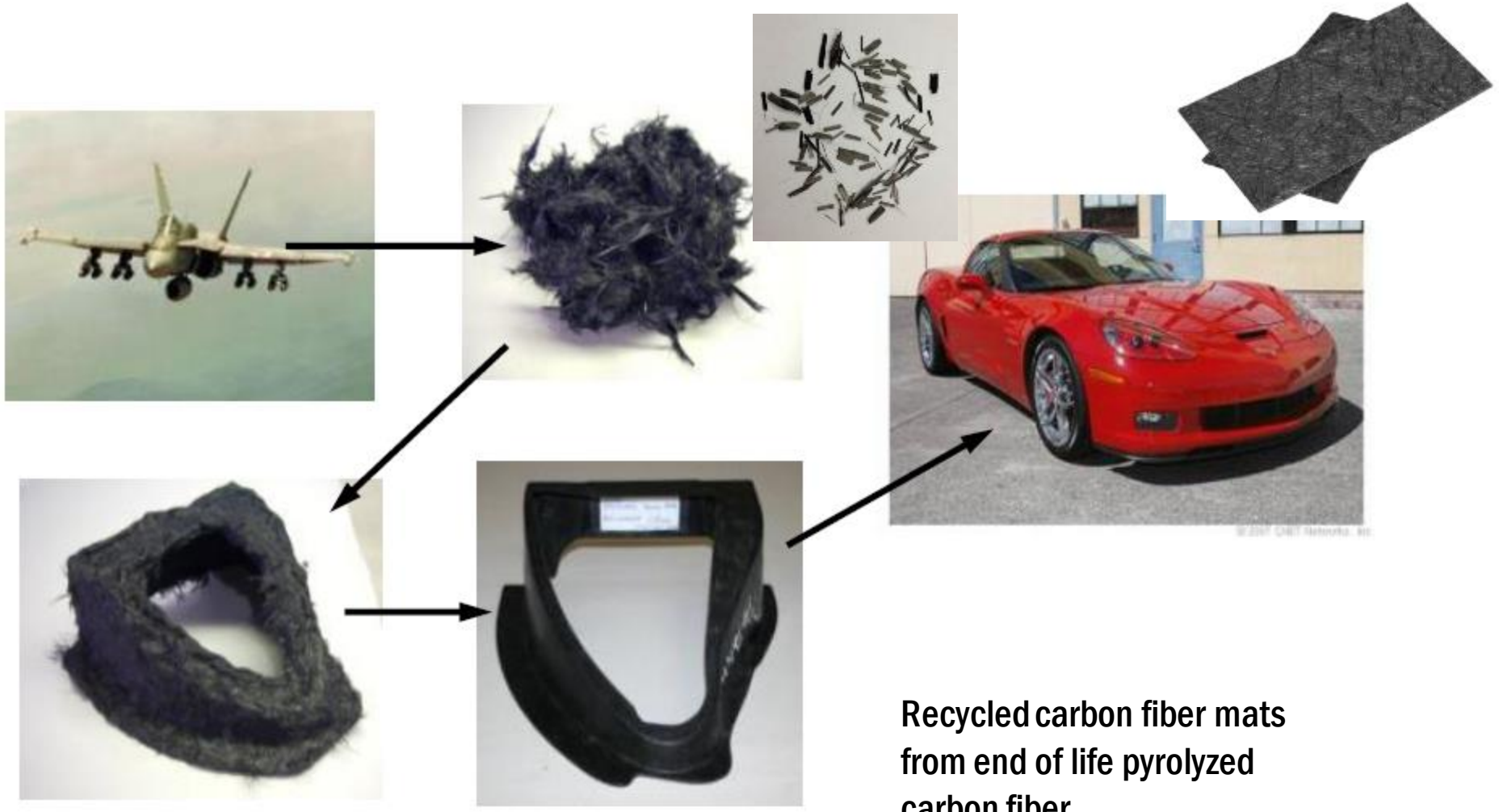
Natural fiber precursors

Examples of carbon and natural fiber precursor forms developed by the team

Value added carbon fibers end of life - Aerospace end of life – Pyrolysis fiber recovery and processing into tailored mats



Textile grade wide tow carbon fiber (low cost <$5/lb) ORNL CFTF

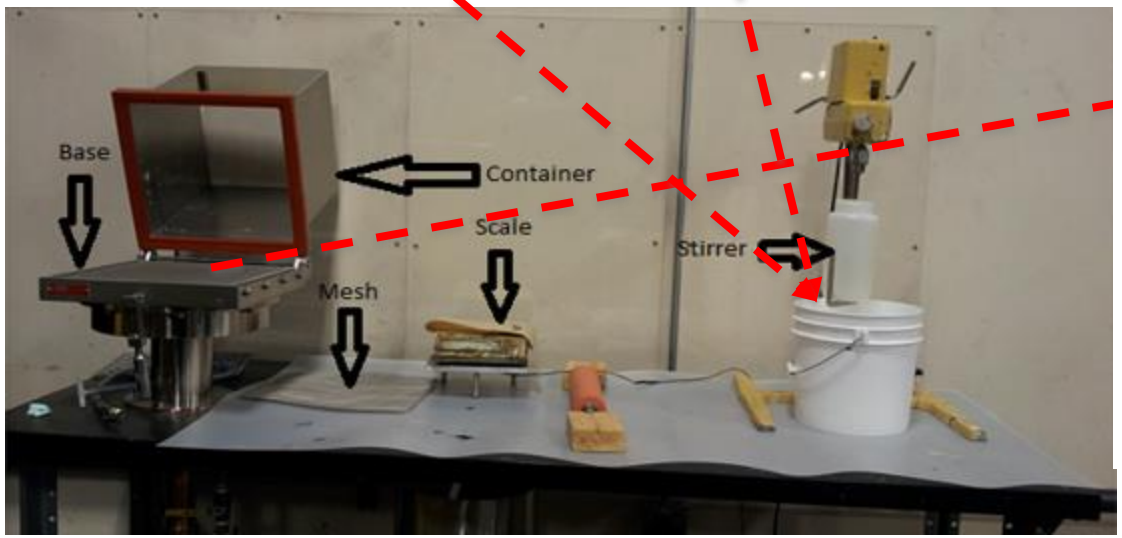


Recycled carbon fiber mats from end of life pyrolyzed carbon fiber

Preliminary work with Textile grade carbon fiber mats

PA6 fiber

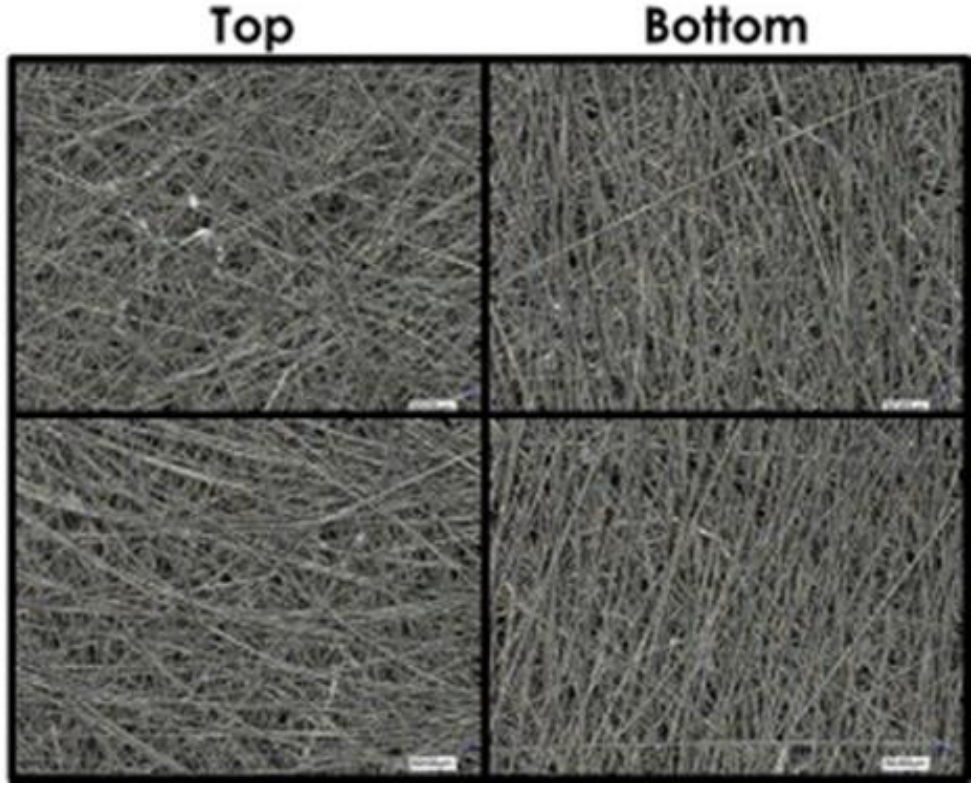
Textile grade tow carbon f



Wet laid set up

More "isotropic" mat

More "aligned" mat

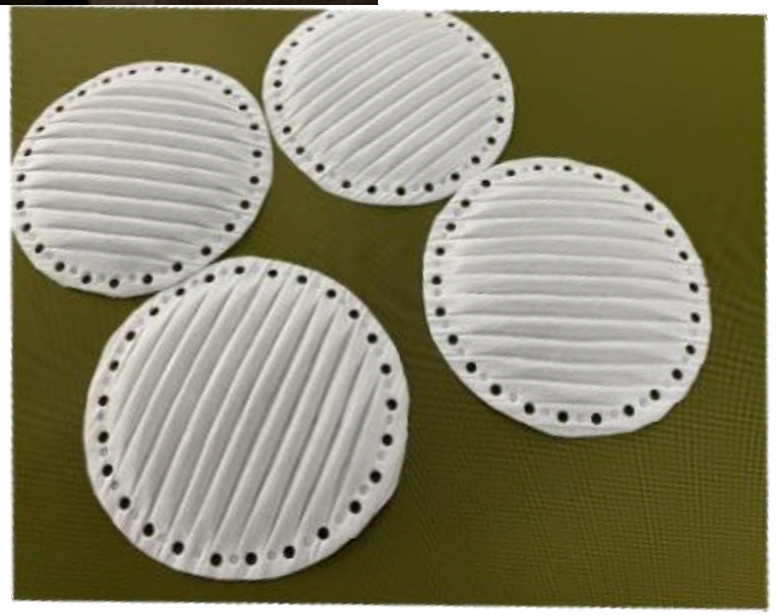


Covid Response

- Reusable masks and filter packaging
- Patient barrier
  - Soft
  - Rigid
- Faceshields (50,000 #)
- Testing tubes and caps (> 1 million)
- Biodegradable filter media

Reusable mask design with N95 filter

- Most components reusable for 1000s of uses
- Form-fit-function; will not come loose (like the nose wire)
- Practical in settings such as – hospitals, production areas, public gathering places, schools/universities/shop floors
- Reduces landfill & medical waste
- Can be readily disinfected
- Soap and Water | Alcohol-based Sanitizers | Bleach | VPHP | Heat | UV radiation
- Not limited to N95 – adaptable for other uses
- Fully recyclable



Advanced Manufacturing in Response to COVID-19
Production of N95 Mask Material – CF & Melt spun line at ORNL

Carbon Fiber Production Line (operates 2 shifts)

- 1 ft wide mat
- 18 ft/min rate,
- 450 ft^2/day
- Can produce 1 million mask worth filter material per week

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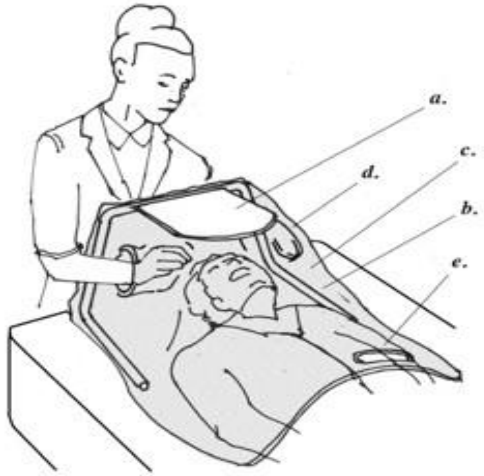
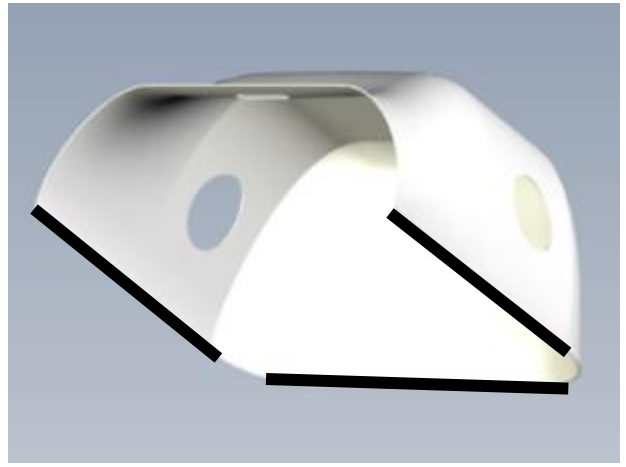
Patient Barrier for Intubation

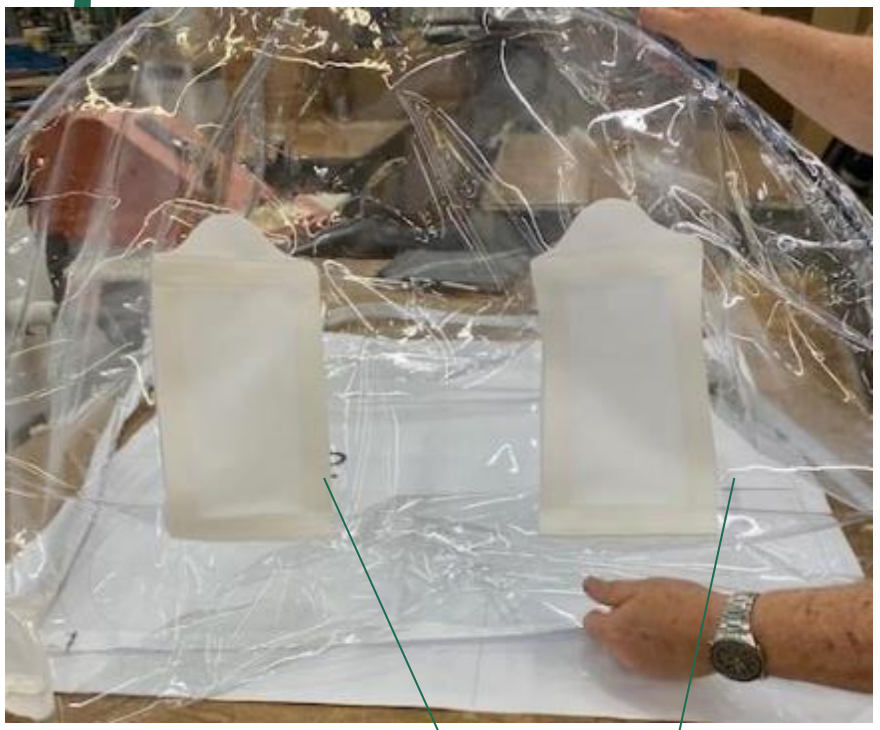
<u>Problem Statement</u>: Medical personnel
Even if wearing PPE (mask, gown) can be exposed to particles from the patient. The patient barrier will provide a safe environment for doctors and nurses to conduct procedures like incubation, medicine administration and interaction





Early prototype: Weight 4 lbs
Stackable | Modular | Sterilizable
Reusable

Collapsible version of patient barrier. Product ready for fielding and mass production



Custom filter materials

Motivation for P42 supplement - Medical PPE waste – millions of pounds

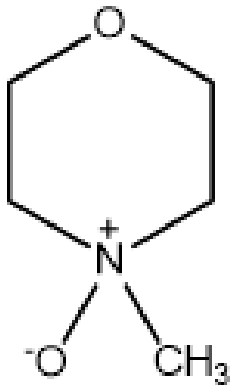
Most masks have limited use life

Sterilization not effective past few uses

Disposed as waste to landfill

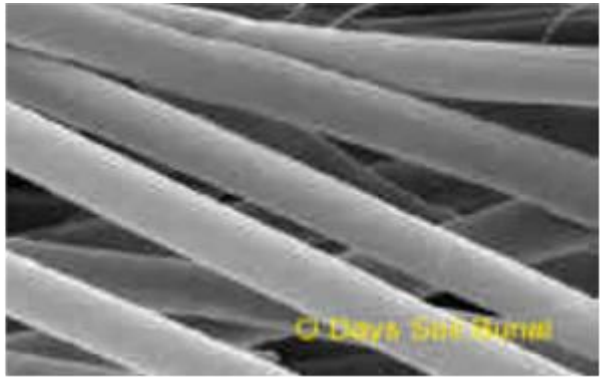
Reusable masks with biodegradable filters – environmentally friendly

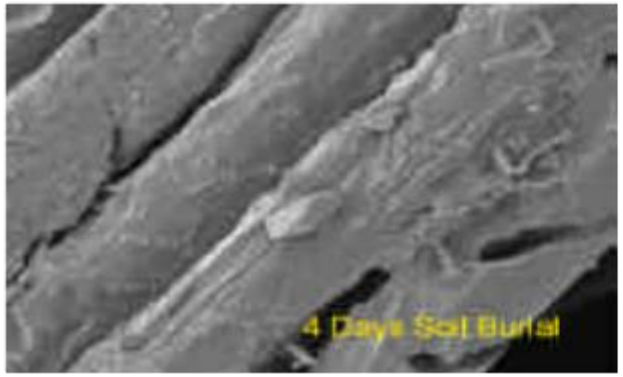
Regenerated Natural Cellulose Fibers

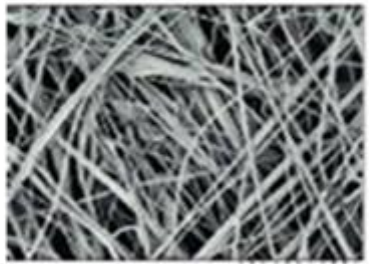


Regenerated natural cellulose fiber (RNCF). Made from wood pulp, which has cellulose in high purity with little hemicellulose and no lignin produces fibers with less than 1 µm size.

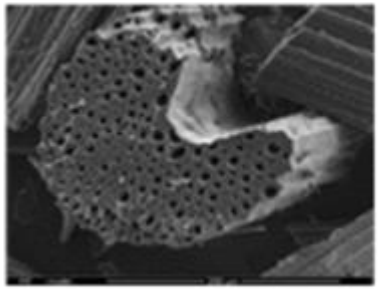
The RNCF structure has a high degree of cellulose crystallinity and crystalline orientation parallel to the fiber axis, which forms nanofibrils.



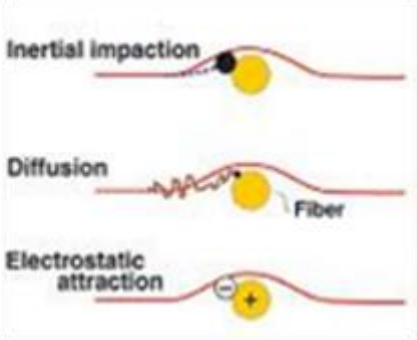


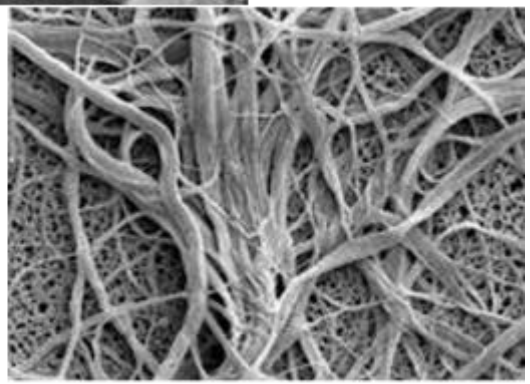


N95 melt blown polypropylene



Pore structure of natural fibers





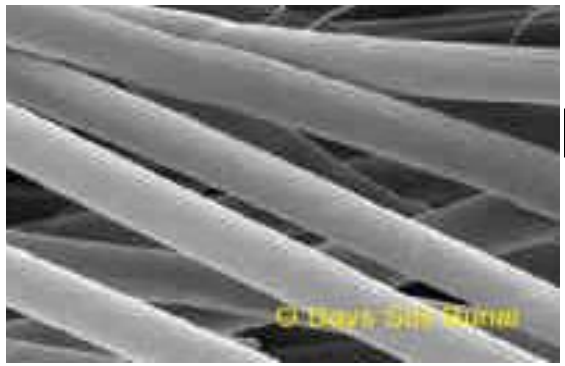
Filter efficiency mechanism

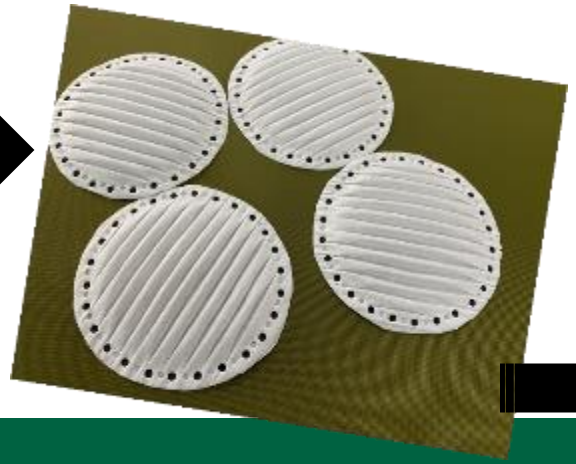
Aims (for supplement)

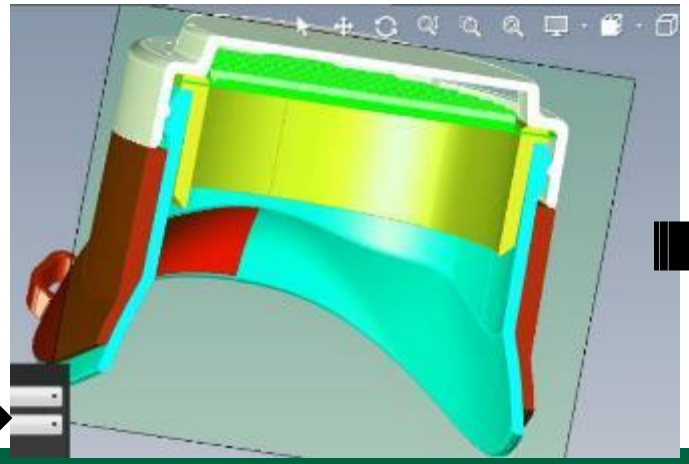
- **Aim I** *Material development*: Focus on regenerative natural cellulose fibers (RNCF) for evaluation as mask materials in N95 and related use in PPE. Hybridize other reinforcements (undeway)

- **Aim II** *Characterization*: The RNCF will be evaluated in detail for porosity, surface area, pore width, micro-pore volume and pore size distribution using BET and porosimeter methods. The surface morphology and surface chemistry will also be investigated using SEM, EDS, FTIR etc. The charge density and charge efficiency on the RNCF will be established. The RNCF will be tested side by side with the incumbent through NIOSH standards to confirm the filtration efficiency.

- **Aim III** *Product integration and evaluation*: After the full characterization of the RNCF they will be integrated in reusable masks under development. RNCF preforms will be prepared by die cutting to the opening of the filters providing the needed surface area for filtration and comfort. The RNCF based reusable masks will be distributed to the community and health care providers in the P42 ecosystem for evaluation, data collection and feedback.







User

Development of novel f-LIBS/LEAFS (Sergey Mirov)

- **Hypothesis:** Development of a novel f-LIBS/LEAFS (femto- laser induced breakdown spectroscopy/laser excited atomic fluorescence spectroscopy) and mid-IR frequency comb "Optical Nose" systems will enable ultrasensitive and rapid detection of Cd, Mn, As, and biomarkers associated with exposure to these metals.
- **Aim 1: To develop the f-LIBS/LEAFS platform to measure heavy metals.**
- **Aim 2: To develop the f-LIBS/LEAFS platform in conjunction with confocal microscopy to detect heavy metals.**
- **Aim 3: To develop a portable "Optical Nose" based on middle-infrared frequency combs.**

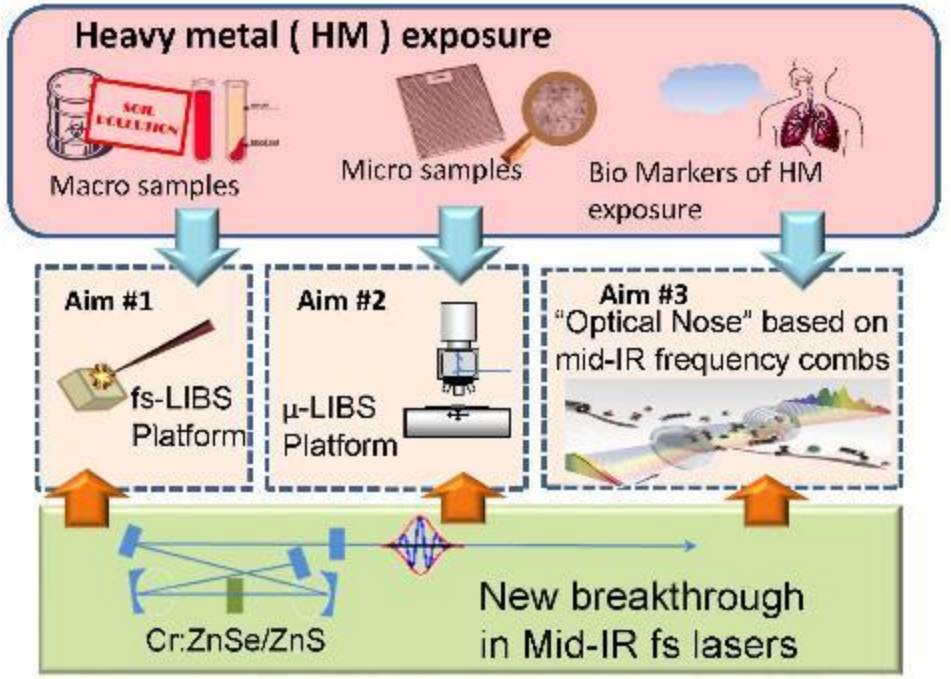


Diagram of proposed approaches to quantifying exposure to heavy metals

Meet the Team

Surbhi Kore

PhD Student

Mechanical-Materials Engineering; Focus on biofiber processing, fiber-matrix interface science

Ryan Ogle

MS Student

Biomedical engineering; Focus on product development and manufacturing, 3D printing, injection molding

Vinit Chaudhary

MS Student

Mechanical engineering; Focus on recycled and hybrid carbon fibers; wet laid processing & characterization

For information please contact

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