Carbon Hub Webinar - Call for Proposals Fall 2021

Carbon Hub

Topic #5: Demonstrate the value of CNT or other VACS, in structural applications, including non-critical ones.

Carbon Hub Webinar - Agenda

Carbon Hub

General	❑ Introduction Carbon Hub ❑ Mission and Vision	10 min
What are we trying to solve?	❑ Topic Introduction ❑ Expert deeper dive ❑ Key deliverables ❑ What is out of scope – What are we NOT looking for ❑ Budget and timeline	30 min
Q&A	❑ Please ask us questions	15 min
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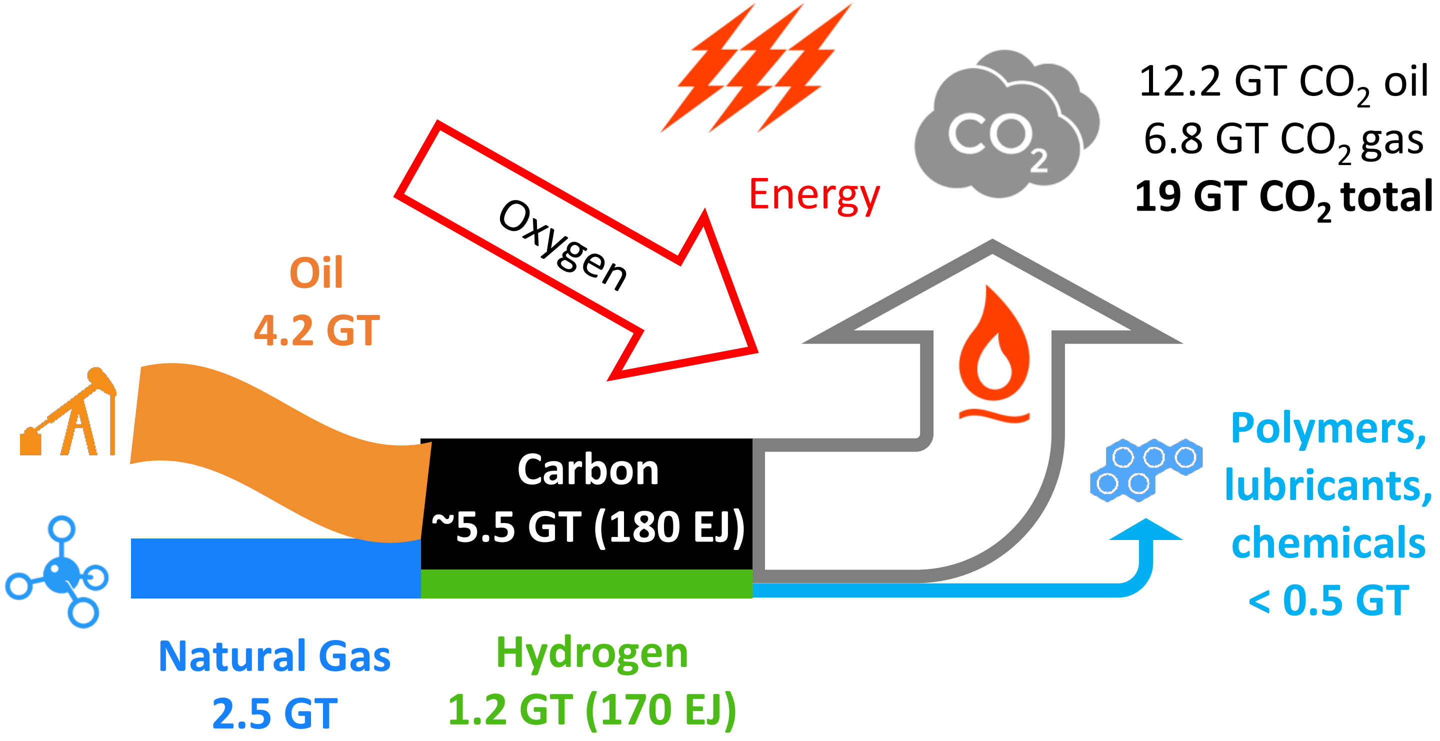
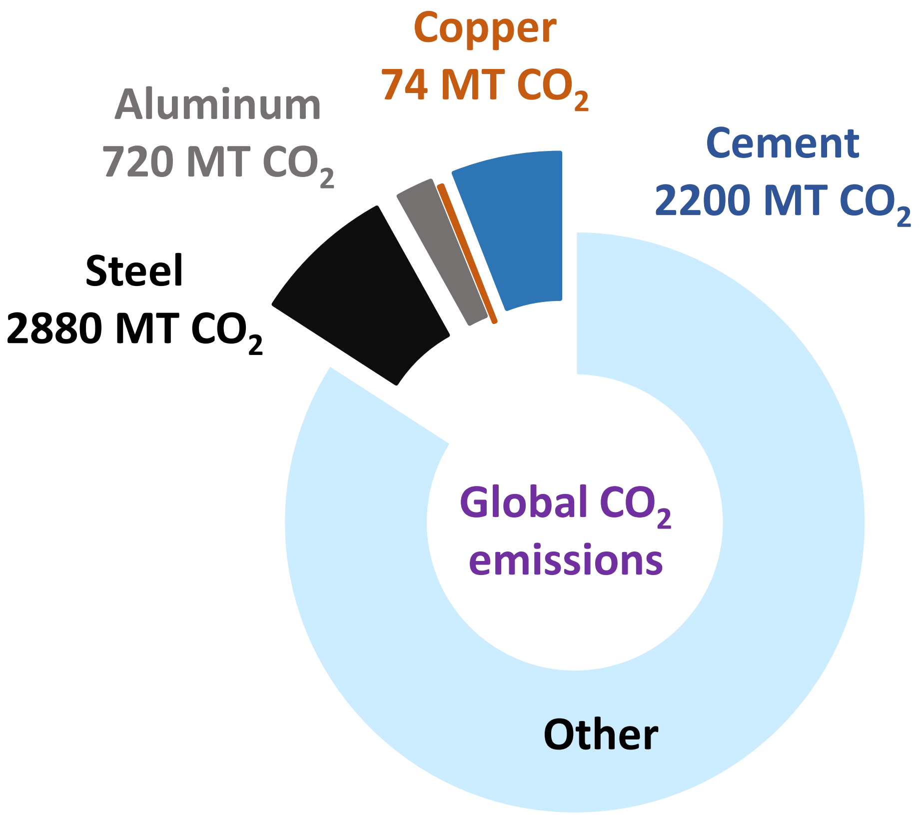
The Carbon and Material Challenge

Carbon Hub

85% of world energy comes from carbon combustion

12% of world energy is used for production of steel , aluminum and copper





19 GT CO_2 / yr

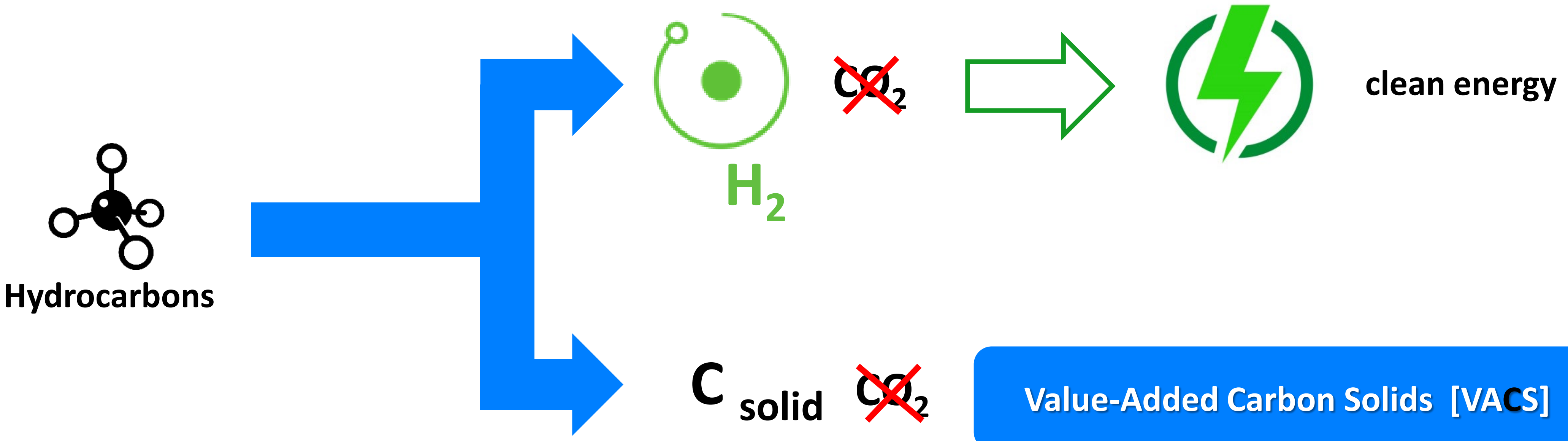
"indicative numbers" 2017 data

5.9 GT CO_2 / yr

"indicative numbers"

The Carbon Hub aims to alter the Energy – Materials Nexus

Carbon Hub



Value-Added Carbon Solids [VACS]

C solid
e.g. Soil amendment

GHG emission reduction
Enhance the soil microbial environment

Might reduce energy intensive fertilizer manufacturing

Improve soil drainage and water quality

Structured C solid
Displacing metals & building materials

CO_2 emission reduction
Lower need for metals, less metal oxide reduction

Energy & CO_2 reduction
Metal production is energy intensive

Avoid metal mining & processing

New materials

CO_2 emission reduction
New light weight materials for transportation in the distribution chain

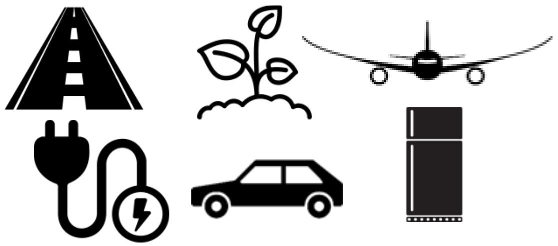
The carbon materials are recyclable

Value-Added Carbon Solids – Our definition

Carbon Hub

NG → H_2 ~~CO_2~~ **C solid** → **Application in end-products**

Natural Gas
Light HC



VACS

A solid carbon material produced by splitting efficiently (e.g., by pyrolysis) methane and light hydrocarbons with concurrent production of hydrogen and no carbon dioxide emissions.

Being used pervasively (>1 MM Tons/year)

Displacing metals, traditional construction ceramics, fertilizers and other materials with high CO_2 footprints.

excluded

- Carbon black, amorphous carbons, graphite
- Polymers
- Solid carbon whose only value is a CO_2 emission avoidance or that will be oxidized in other processes (e.g., metallurgical coke)

included

- Carbon materials that have macroscale structural integrity and properties that overlap with widespread materials
- Carbon powders that have potential use as additives in very large-scale systems, e.g., in soil or concrete

Examples of Value-Added Carbon Solids – Carbon Nanotubes (CNTs)

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Opportunities

- ❑ CNTs can be synthesized in one process step from methane or light hydrocarbons
- ❑ CNTs can be converted into macroscopic materials;
- ❑ based on properties, a subclass of CNT macro-materials could replace metals or other construction material

Challenges

- ❑ CNT synthesis is still an early-stage, **low-volume** endeavor;
- ❑ synthesis **efficiency is low** and must be increased by orders of magnitude to attain competitiveness with incumbent materials;
- ❑ the **knowledge base** for increasing the efficiency and scale of CNT synthesis must be developed

VACS

Application in end-products

scale   value

Examples of Value-Added Carbon Solids – Soil Amendment

Opportunities

- forms of carbon (e.g., biochar) may improve the fertility and viability of soils while simultaneously reducing fertilizer usage and the agricultural carbon footprint.

Challenges

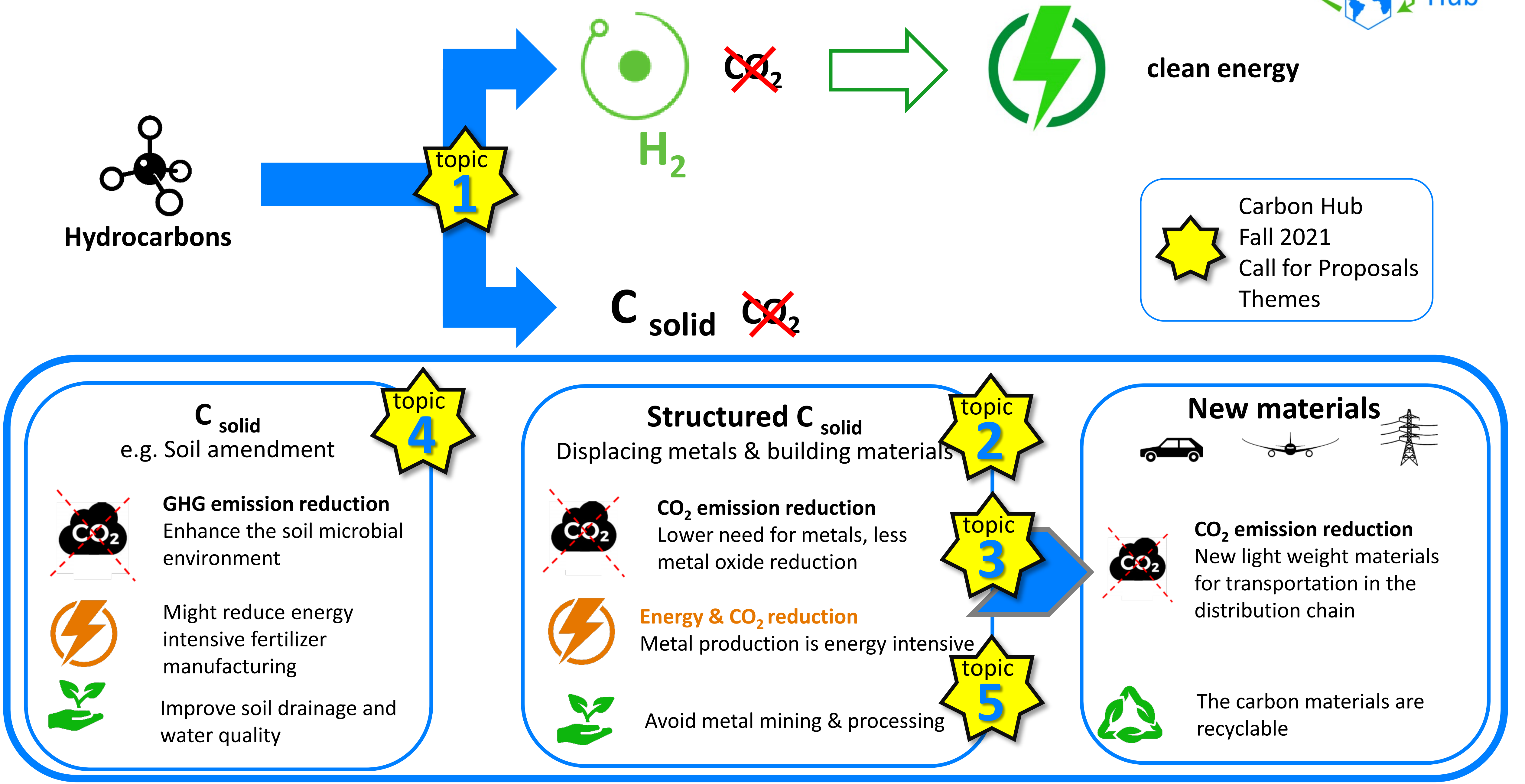
- current carbon soil additives are **too expensive** for large-scale deployment
- and are **not made from methane** and light hydrocarbons;
- the **knowledge base** for efficiently synthesizing soil additives from methane and light hydrocarbons must be developed

VACS

Application in end-products

scale value

The Carbon Hub aims to alter the Energy – Materials Nexus



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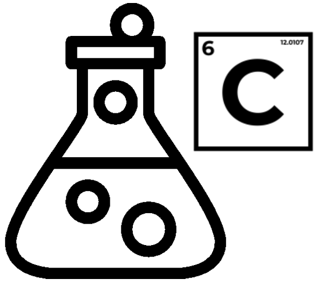
Overview Fall 2021 - Call for Proposal Topics

Carbon Hub

1

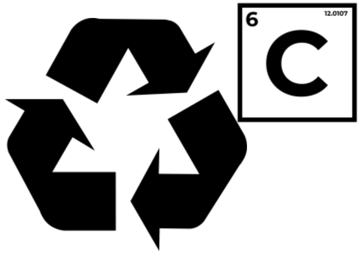
Improve understanding of the catalysis and reaction mechanism in (thermocatalytic) pyrolysis to efficiently convert methane to VACS.



2

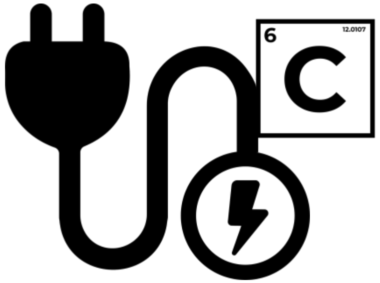
Improve Carbon nanotube [CNT] and VACS standardization and environmental impact understanding.

- CNT material standardization (terminology, testing)
- LCA and End-of-Life use mapped for CNT or other VACS



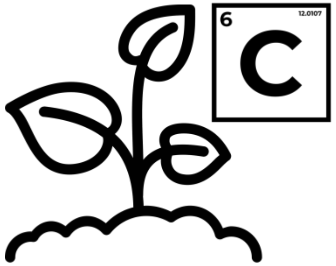
3

Demonstrate the value of a Carbon nanotube [CNT] fiber-based power cable prototype.



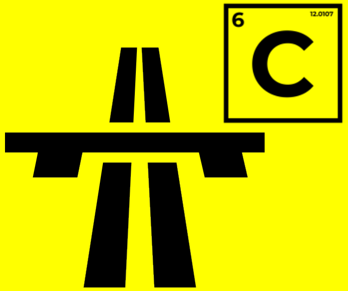
4

Demonstrate and explain efficacy of a VACS as a soil amendment.



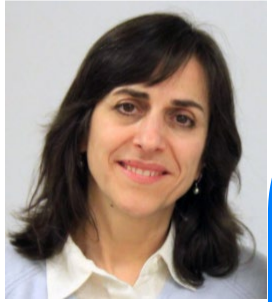
5

Demonstrate the value of CNT or other VACS, in structural applications, including non-critical ones.



2020 Topic #5 Projects Awardees

Carbon Hub



PROFESSOR OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Topic #5 CNT or other VACS in structural applications

Berkeley UNIVERSITY OF CALIFORNIA — Optimization of novel carbon fiber reinforced cement-based materials using multi-scale experimental and computational techniques

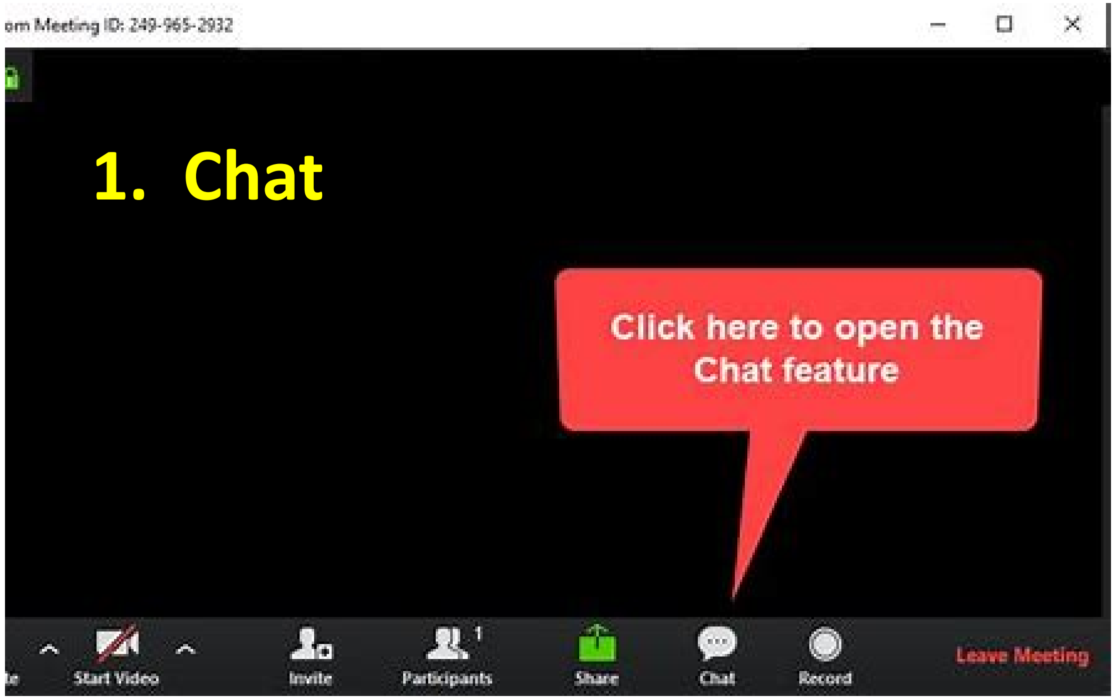
imdea instituto madrileño de estudios avanzados — CNT fibers for displacement of metallic current collectors in the next generation LIBs- NANOCARBAT

Massachusetts Institute of Technology — CarbonHouse structural analysis and testing

Associate Professor, Architecture, MIT

Q&A – Please ask us any questions you might have

Carbon Hub



Why are we targeting VACS in structural applications?

- **Carbon sequestration**: the solid carbon is locked in a semi-permanent form and is not converted into CO_2, as in metallurgical applications
- **Carbon Intensity**: added benefits from potential displacement of existing materials manufactured with higher Green House Gases (GHG) footprint
- **Potential market:** the size of the market for building and construction materials (e.g. concrete + metals) could match the size needed for deploying methane pyrolysis at scale

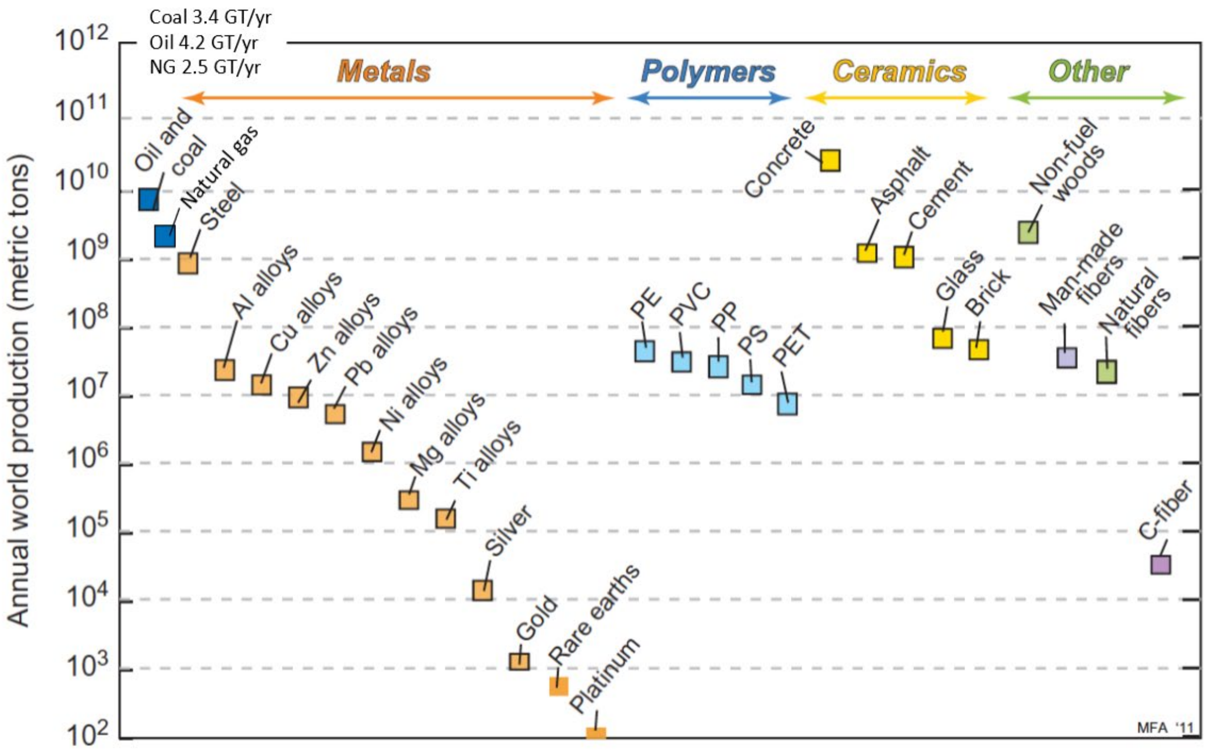
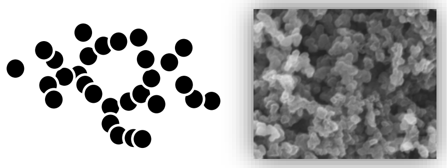


FIGURE 2.3 *The annual world production of 27 materials on which industrialized society depends. The scale is logarithmic. The log scale conceals the great differences; the production of steel, for instance, is one billion (10^9) times larger than that of platinum.*

VACS = value added carbon

C-products sold for their functionalities in structural applications

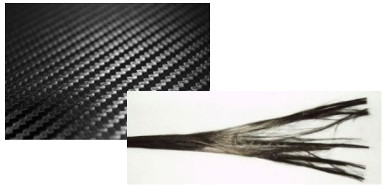
Carbon Black



- 12 Mt/year
- Rubber Reinforcement
- Derived from oil residuals
- Established markets
- Well defined products standards and specification

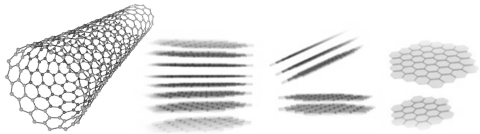
OUT of SCOPE

Carbon Fibers



- ~100'000 t/year
- Aerospace, cars, wind
- PAN-based
- Younger markets
- Emerging new applications and evolving standards

Nanomaterials-based additives



- <10'000 t/year
- Aerospace, cars
- Multiple feedstocks
- Emerging markets with several niche applications
- Products standards and specifications yet to be defined

Current markets sizes for carbon in structural applications does not match today's and future hydrogen markets

Known obstacles to a widespread adoption of carbon in structural applications: Nanomaterials Additives Focus

- Properties at the nanoscale are hard to translate into macroscale products
- Use as additives in composites remains limited due to multiple aspects:

  Lower Percolation threshold (compared to Carbon Black)

  →reduce the market potential

  Less than ideal Dispersion

  Less than optimal Load Transfer due to interface issues

  Matrix-Carbon interaction

  Products quality & lack of standards

Some of deliverables we are looking for

Can we understand what carbon morphologies and macroscopic architectures could be important in example, cement that;

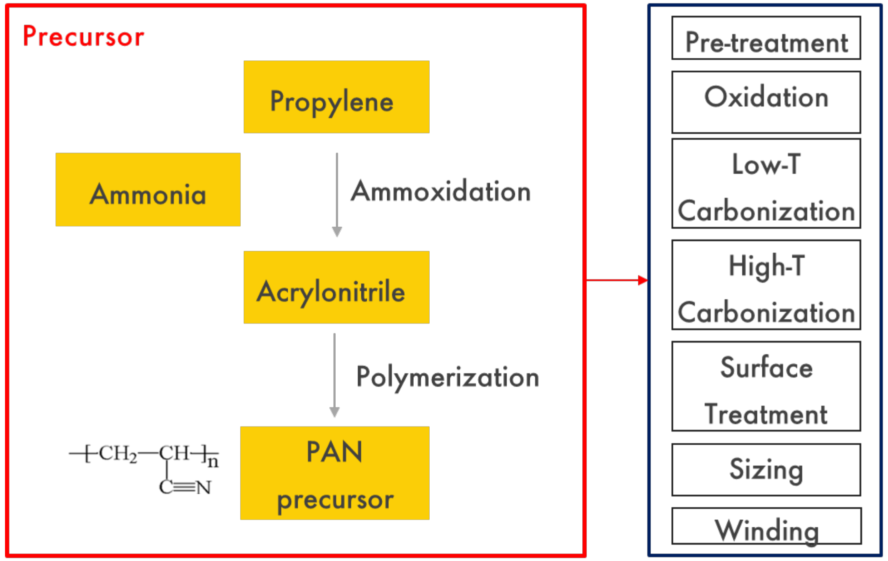
- Adds functionality/performance
- Safely used with available, mostly low-tech equipment?

We encourage prototypes and fundamental science proposals that could resolve or mitigate current hurdle for deployment of carbon products at scale

Known obstacles to a widespread use of carbon in structural applications: C-Fibers Focus

Current challenges of existing PAN-based carbon fibers technology

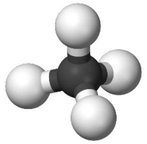
- Cost
- Green House Gas Footprint
- Recyclability
- Performance in final composites
- End Products Manufacturing



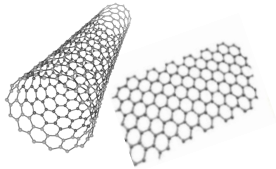
We encourage prototypes that could show potential benefits of a VACS-based or modified fibers (GO, CNTs) compared to PAN-fibers and enable a broader applications and/or superior performances in the final composites

GO = graphene oxide
CNT = carbon nano-tubes

A different paradigm: assembling methane-derived materials into macroscopic products

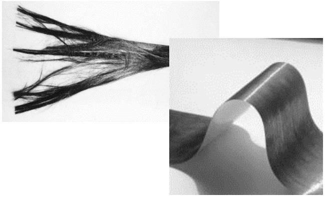


Carbon Morphologies from pyrolysis

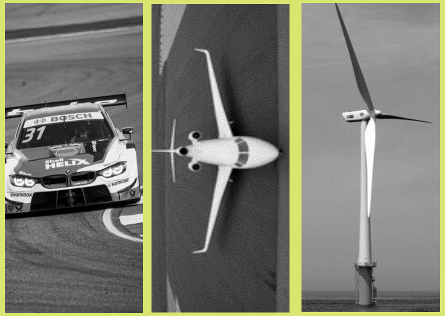


- Functionalization
- Chemical "disentangling"
- Spinning
- Reassembling

1-Dim or 2-Dim structures



Structural applications



What novel forms of surface functionalization could be used to improve load transfer in polymer applications?

Can we control surface properties during synthesis to possibly minimize/reduce the need of surface functionalization?

Select a prototype system to demonstrate performance using VACS properties to improve product design, manufacturing processes, installation ease, or total cost of ownership over the life of the structure?

What deliverables are we looking for

Areas of Interest Include:

- Demonstrate and explain the science underlying viable, structural applications for a VACS
- Select a prototype system to demonstrate performance using VACS properties to improve product design, manufacturing processes, installation ease, or total cost of ownership over the life of the structure
- Demonstrate proof of concept for novel applications such as concrete additives
- Investigate how a CNT fiber surface modifications scheme influences load transfer, and mechanical properties under application conditions
- Novel CNT/thermoplastic composites for automotive/structural applications

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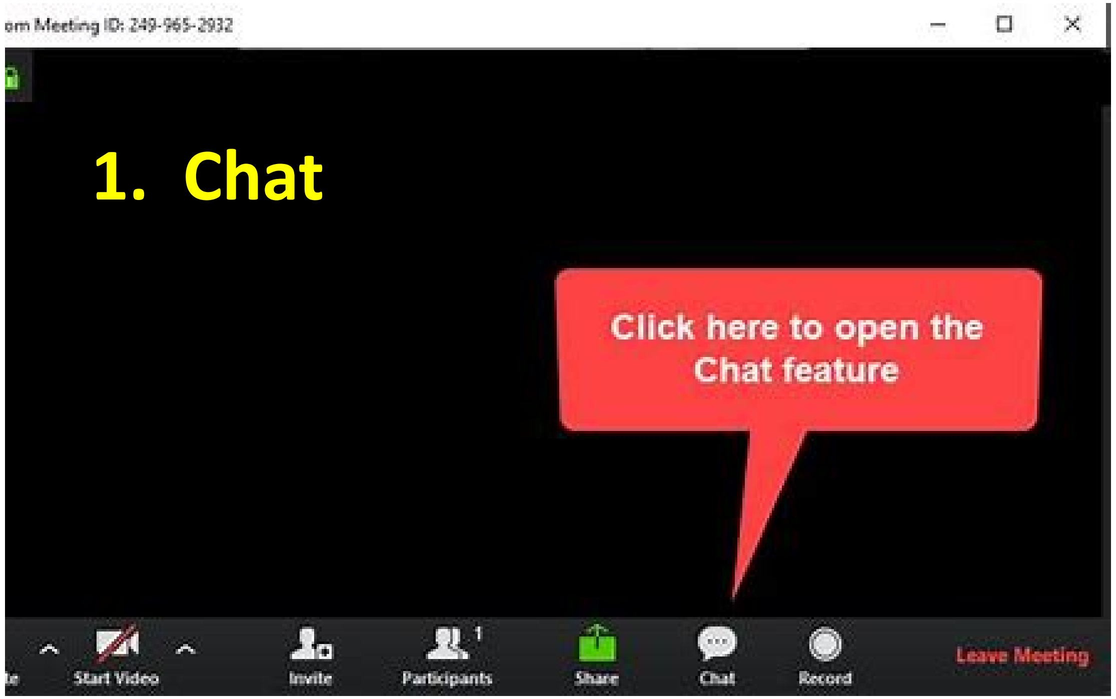

1. Chat

2. Raise your hand and we will invite you to speak

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Next Steps – How to submit

Carbon Hub

carbonhub.rice.edu/CFPCollaborators

RICE UNIVERSITY
Carbon Hub
Accelerating the Energy Transition Through Green Hydrocarbons

Menu

Carbon Hub - Call For Proposals 2021

On this page, you will find the Call for Proposals details that are restricted to our Collaborators only.

You may download the full Call for Proposals guidelines and instructions document in PDF form here.

**UPDATE: The Budget guidelines are attached here and the referenced spreadsheet can also be found here.

Please note, all Rice Collaborators should contact us directly at carbonhub@rice.edu to obtain the internal Budget template. That template cannot be shared with external Collaborators.

Oct 29 – 11.59 pm CT deadline

Call for Proposal Timeline

Carbon Hub

Release CfP — 13 (Sept)

CfP webinars — 27 – 1, 6

7 weeks to submit

Deadline CfP submission — 29 (Oct)

Awards Announced — 14 (Dec)

Sept | Oct | Dec

Oct 29 – 11.59 pm CT deadline

A Summary of the aspects we'd like you to address in your proposal (1/2)

Carbon Hub

CURRENT PROPOSAL SECTION	SECTION CONTENTS	PAGE LIMITATIONS
Executive Summary	Research Team a) Name of Principal Investigator(s) b) Affiliation – institute c) Address, city, country Contact details: email and phone Topic # and Proposal Title Abstract	1
Innovation, Impact, and Linkage to Carbon Hub Vision	How are you addressing the Topic Challenge? Provide a concise description of why the proposed research will further the Carbon Hub Vision.	1
Proposed Work	What techniques & knowledge will you use? Provide a concise description of the equipment, technology and knowledge you will be using. Why is this an effective way to address the challenge? Provide a concise description why your approach is an effective and innovative way to create new insights and value. What are the key deliverables?	4

A Summary of the aspects we'd like you to address in your proposal (2/2)

Carbon Hub

CURRENT PROPOSAL SECTION	SECTION CONTENTS	PAGE LIMITATIONS
Team Organization and Capabilities	What is the team to address this challenge? Concise description of research team actively working on proposed effort: names, project roles. Why should we fund your team? What is the team's expertise and capabilities? Concise description of key expertise and capabilities as related to the project approach.	1
Budget	Breakdown by categories, including any cost share. (budget template will be provided by September 30, 2020)	1
References cited	Includes both literature references and references to earlier work by the proposing team.	2
Personnel Qualifications Summaries	NSF-style preferred	2 pages per person
Risks and Other Insights	What are the key risks in your approach? How are you managing the risks? What else might be important?	1

Some of the Terms & Conditions

- **The primary Principal Investigator (PI) must be a Carbon Hub Academic Collaborator** (https://carbonhub.rice.edu/collaborators) to be eligible to submit a proposal
- If you are not currently a Collaborator, please inquire at **carbonhub@rice.edu**

- **Fall 2021 : $1.5+ million budgeted for new and continuing awards**
- Anticipates granting 4 - 7 awards across the 5 Topic areas
- **Individual awards may vary between $50,000 and $250,000**
- For PIs who are not at Rice University, funding will start upon successful negotiation of a subcontract between Rice University and their home institution
- Funding agreements are expected to launch in Feb 2022, or once negotiations are complete

Results can be published – THEY ARE NOT CONFIDENTIAL
Results will be shared with Carbon Hub members

Further details on the Carbon Hub website and in the Call for Proposal documents

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