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### Carbon Fiber and Sustainability: Where we are today

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# Sustainability – What it is and what it is not

## Sustainability is Not: Just the ability to recycle some components at end of life

OR

Continuing the use of petroleum in any raw material or process for composites Sustainability is:

Use of plant or biomass based or recycled raw materials and precursors AND

Use of renewable energy sources for all composites processing

# Linear vs Circular Economy

- Current State of the Art is Linear
  - 1) Petroleum precursors
  - 2) Carbon fibers
  - 3) Carbon fiber composites
  - 4) Use until worn out
  - 5) Grind up and Landfill
- This has to change to achieve sustainability



# What is our Biggest Problem (Challenge?)

- Wind Turbine Blades at end of life - Spar is mostly carbon fiber
- Cut up and landfilled
- New Turbines in Europe using almost all carbon fiber
- Potential for 50 million tons of waste by 2050





## Some Other Challenges

### • Aircraft

- Boeing 787 and Airbus A350
- New eVTOLs mostly carbon fiber

### Automotive

- Carbon fiber composites in new cars, pickups, and large trucks
- Sporting Goods
  - Tennis rackets, golf clubs, helmets, paddleboards,.....







## Where are we Today?

- Beginning to reclaim some carbon fiber
  - Usually chopped up and pyrolyzed to remove resin
- Starting to reclaim some parts of wind turbine blades – spars are hard to remove
- Carbon fiber
  thermoplastics usually
  cut up and reprocessed





# The Future is Coming

### • Plant fiber based Carbon Fiber

- Flax, corn stalks, wood cellulose waste
- New Precursors for Carbon Fiber
  - Plant-based acrylonitrile
    - Southern Research to Trillium/Solvay
  - Lignin waste from paper processing
  - Nanocellulose fibrils



## A Little Detail – How We Get There









- Example 1 Carbon Fiber
  - Start with bio-based precursors like lignocellulose
  - Extract sugars using hydrolysis
  - Synthesize acrylonitrile from sugars to make PAN
- Example 2 Epoxy Resin
  - Plant oils, lignin, rosin as precursors
  - Biomass sugars converted into epoxy amines
  - Bisphenol from Magnolia trees that doesn't disrupt endocrine system

### 2/19/2024

# Bottom Line – Wrap Up

- We have a lot of work ahead
  of us
- Engineers are going to be key to meeting this challenge
- Good News the composites industry is engaged and working on it
- Everyone in this industry needs to get involved in meeting the challenge



## Thanks for Listening

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"If you are a student of materials you will love this book." —Mark Miodownik, director, Institute of Making, University College London

This is a book about composite materials, written from the perspective of someone who has been in the industry for more than four decades and had to learn about them the hard way. Aimed at the curious citizen scientist or maker, it is written in an accessible, entertaining, and jargon-free style, introducing and explaining the how and why of composite materials.

Following a history of composites, the book discusses the periodic table of elements and why getting to know this table is so important. It then introduces strings (fibers) and glues (matrices or resins) and explains how they're put together, how to design with them, and how to analyze what you've designed.

The work also describes the composites business and includes a list of good schools and their involvement with industry.

NED PATTON, Ph.D., P.E., has more than 40 years of experience in research and technology development, and has been involved with composites for 35+ of those years. He works at Northrop Grumman Marine Systems as a senior technical professional, and is actively developing composite material parts and structures for use undersea. He lives in Sunnyvale, California.



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