

## GLOSSARY:

**Autoclave:** A strong, sealed, heavy vessel for sterilizing equipment and conducting chemical reactions under high pressure.

**Carbon fiber:** A strong, thin fiber, consisting of long, chainlike molecules of pure carbon that are made by heating synthetic fibers such as rayon in the absence of oxygen. Carbon fibers are used in composite materials in aircraft, automobiles, architecture, and in other applications where light materials capable of withstanding high stress are required.

**Composites:** Materials consisting of separate parts or elements; compound.

**Oxidizing:** Chemical reactions in which an atom or ion loses electrons, and undergoes an increase in valence. Removing an electron from an iron atom having a valence of +2 changes the valence to +3.

**Phosphor:** Any of a number of substances that exhibit luminescence when struck by light of certain wavelengths, as by ultraviolet.

**Quantum tunneling:** A quantum mechanical effect in which particles have a finite probability of crossing an energy barrier, such as the energy needed to break a bond with another particle, even though the particle's energy is less than the energy barrier. Quantum tunneling has no counterpart in classical mechanics, in which a particle can never cross an energy barrier with a higher energy level than the particle has. The emission of alpha rays in radioactive decay is a case of quantum tunneling; though the alpha particles are strongly bound to the nucleus and don't have as much energy as the bond does, they still have a finite probability of escaping the nucleus. The design of transistors and many diodes makes use of this effect.

**Resin:** Any of a class of nonvolatile, solid or semisolid organic substances, as copal or mastic, that consist of amorphous mixtures of carboxylic acids and are obtained directly from certain plants as exudations or prepared by polymerization of simple molecules: used in medicine and in the making of varnishes and plastics.

**Ultrasound:** The use of ultrasonic waves for diagnostic or therapeutic purposes.



### TMW MEDIA GROUP

2321 Abbot Kinney Blvd., Venice, CA 90291

(310) 577-8581 Fax: (310) 574-0886

Email: [sale@tmwmedia.com](mailto:sale@tmwmedia.com) Web: [www.tmwmedia.com](http://www.tmwmedia.com)

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# Show Me Science Advanced

## Textiles

## Carbon Fibers

K4611DVD

**Advanced Teachers Guide**

## SYNOPSIS:

Engineers are constantly developing new lightweight, durable textiles to be used in many facets of our daily lives. Airplanes, and not simply the carpets and seat covers, have integrated more textiles such as carbon fiber into the main structures.

This issue demonstrates how carbon fiber is manufactured, tested and integrated into the airline and automobiles industry.

It also highlights some unusual textiles that are making their way into space suits, advertising, and clothing.

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## CURRICULUM UNITS:

- Chemistry
  - Engineering
  - Physical science
  - Physics
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## CAREER OPPORTUNITIES:

- Aviation engineer
- Chemical engineer
- Chemist
- Materials engineer
- Physicist

## PROGRAM OVERVIEW:

Manufacturers of airplanes and automobiles are increasingly turning to textiles, such as carbon fibers, to produce their new models. They rely on carbon fibers due to light weight and durable properties. For instance, the wing of an airplane might be metal, but many of the interior parts are made of carbon fiber. Aircraft engineers combine carbon fiber with other lightweight materials to create composites which are usually 20 to 30% lighter than metal alloys.

Carbon fiber threads are made up of between 1,000 and 48,000 tiny filaments. The filaments are created by oxidizing, or burning a synthetic polymer in a 2000 degree furnace, turning it into almost pure carbon.

Engineers are finding uses for new high tech materials, such as QTC – a polymer embedded with millions of tiny pointed metal particles. QTC acts like a resistor, but the metal particles are so close together, that if something in the environment changes, the charge between particles increases and electrons can jump from one to another in a process called quantum tunneling.

QTC is so sensitive that its resistance will alter if there are changes in sound, smell, temperature, or pressure. In future space missions, QTC might assist astronauts with fans, lights and other devices inside of their space-suits - controlled by so called soft switches – devices that make use of the fact that QTC becomes more conductive when pressure is applied.

## ISSUES & CRITICAL THINKING:

1. Have students brainstorm a list of materials they think are used in assembling an aircraft. Research the role of carbon fiber in the aviation industry.
2. Formula-1 race cars are built with materials that are durable yet lightweight. Have students research how these cars are built with a combination of materials to ensure a lightweight design, but strong enough to protect the drivers.
3. Ask students to think of potential areas where materials could evolve to make products more durable or better suited for a specific environment. For instance, cell phone screens seem to shatter. Are they being improved upon?
4. Are there any drawbacks to the widespread use of carbon fiber? Can it be recycled? Does it present a problem for waste disposal? What are its chemical properties?