KANSAS CITY NSC National Security Campus

CARBONIZED ASPHALTENE-BASED CARBON-CARBON FIBER COMPOSITES

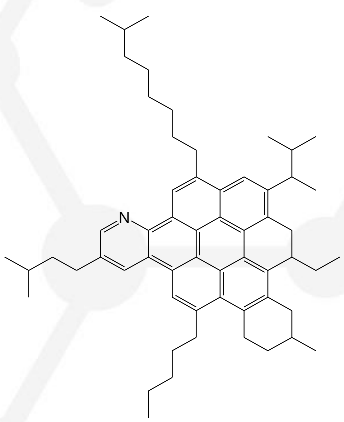
The carbon replaces the conventional polymeric binder used in a carbon fiber reinforced composite matrix.

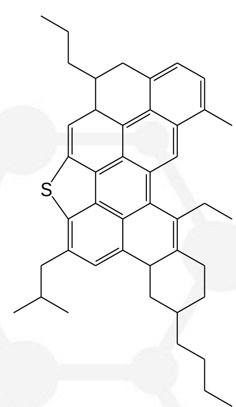
Background

Conventional carbon fiber reinforced composites consist of a polymeric binder and carbon fiber. The carbon fiber provides the primary reinforcement for the composite and represents the largest mass fraction of the matrix. The polymeric binder, about one third of the composite mass, holds the composite together. In addition to holding the composite together, the binder sets the upper temperature capability of the carbon reinforced composite. More advanced carbon fiber composites use phenolic or pitch binders, which later are carbonized producing a higher strength, higher temperature composite. Typical carbon fiber tensile strength and modulus are two orders of magnitude higher than their polymeric binder counterparts. Overall, composite properties improve with improved binder strength and stiffness. Upper temperature capability improves as the binder temperature capability approaches the carbon fiber temperature limits. This technology uses carbonized asphaltenes to produce carbon-carbon fiber reinforced composites.

Description

Asphaltenes are a poorly understood, graphene-like component of crude oil that are generally considered to be a nuisance in heavy oil production and refining, and are currently being stockpiled in large quantities. Asphaltenes give crude oil its black color, are responsible for its viscus nature, and can make up to 15% by volume of some heavy oils. Their basic structure is cyclic, containing about 90% carbon and 6% hydrogen with the remainder being, sulfur and nitrogen. Typical asphaltene structures are shown below.





Asphaltenes

Honeywell

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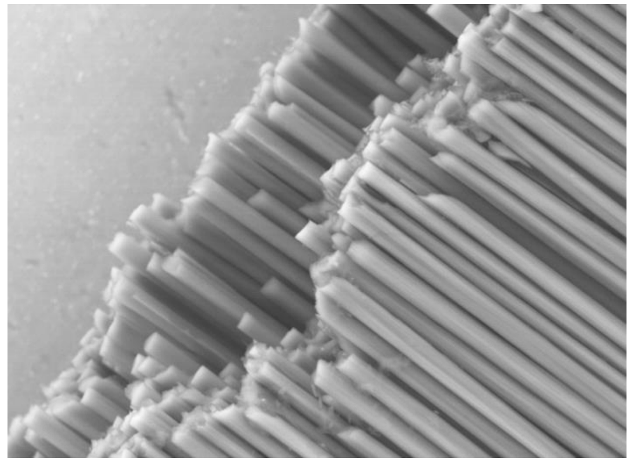
In this technology, carbon replaces the conventional polymeric binder used in a carbon fiber reinforced composite matrix. The carbon is derived from the carbonization of pentane insoluble asphaltenes. The carbon-carbon fiber composite is made by 1) applying a solution of asphaltenes to the carbon fiber, 2) consolidation of the wetted carbon fibers, 3) removing the carrier solvent, and 4) carbonization of the asphaltenes in an inert atmosphere. During carbonization, hydrogen is driven from the asphaltene yielding essentially a carbon bound carbon fiber composite. As carbon-carbon bonds form between the asphaltenes structure and carbon fiber, a homogeneous high strength monolith develops. The ultimate goal is to have binder strength and stiffness similar to carbon fiber reinforcement making up the composite.

An example of a carbon-carbon fiber composite from asphaltenes is shown below:



SEM image of carbon-carbon fiber composite

Advantages

Asphaltene based binders have advantages over conventional resin composite carbon-carbon fiber matrix and phenolic /pitch binder systems. Asphaltenes are lower cost compared to phenolic and resin system binders and contain higher carbon concentrations compared to pitch binders as they do not contain naphthenic acids. Although not tested, asphaltene based carbon-carbon fiber composites are expected to have high electrical conductivity due to the formation of a carbon-carbon monolith structure.

Applications

Applications requiring high strength, stiffness and extreme temperature resistance would benefit from this technology. Demanding aerospace and defense applications such as rocket nozzles, guide vanes, composite brakes are examples.

- Commercial and military aircraft disc brakes
- Re-entry heat shields
- Missile nose cones and guide vanes
- Automotive powertrain components

Intellectual Property Status

This technology is protected under US Patent numbers 9,527,746 and 9,580,839.

Keyword List

Low cost high temperature binders, carbon-carbon fiber composites, asphaltenes

Contact

Andrew Myers
816-488-4432
amyers@kcp.com