Purification of Boron Nitride Nanotubes

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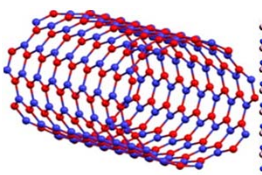
Abstract

With the discovery of carbon nanotubes, CNTs, and the many properties of these tubes; from a unique combination of stiffness, strength, and tenacity compared to other fiber materials that more often than not lack one or more of these properties and thermal and electrical conductivity, a lot of interest has been placed on carbon's periodic neighbors, boron and nitrogen. Boron nitride has been under the academic and industry spotlight for being capable of producing the same kind of tubes, boron nitride nanotubes (BNNTS), that carbon can but with some differences in characteristics. Some of the differences include a higher weight to strength ratio, wide band gap semi conductivity, and more thermally and chemically stable. BNNTs are also much more difficult to synthesize and until recently, could not be produced on a large scale. Purification is a critical post-production step following any synthesis and is the focus of the efforts presented here.

Introduction

Boron Nitride Nanotubes are 1 dimensional nanostructures composed of boron and nitrogen atoms in a hexagonal lattice rolled up to form a tube.



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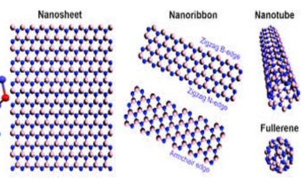


Pakdel et al. Nano boron nitride flatland 2013

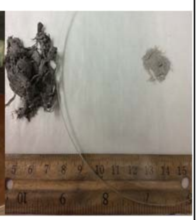
- Insulating independent of chirality
- High oxidation resistance
- High axial Young's modulus
- High thermal conductivity

Method

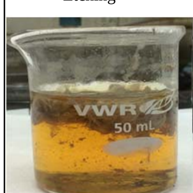
Chemical Treatment

BNNTs were poured into nitric acid, heated to 100° C, for variable amounts of time.

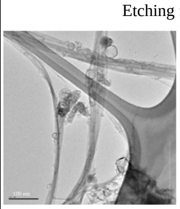
During Chemical Etching

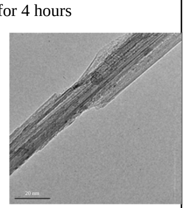


Before and After



Etching for 4 hours



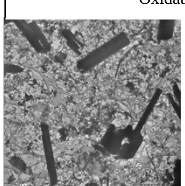


TEM Image Analysis

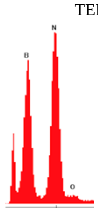
Thermal Treatment

BNNTs were partially oxidized at 800° C for 1 hour and then bathed in 90° C deionized water for 1 hour.
Sample was then sonicated and filtered using 0.4 micron filter paper.

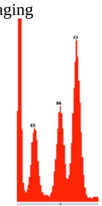
Oxidation Treatment



TEM Imaging



Before oxidation

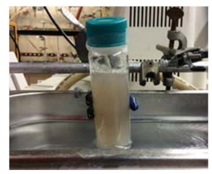


After oxidation

Sample Content Analysis using SEM EDAX

Kinetic Purification

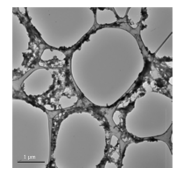
- Consists with 3 steps
  1. Dispersion and Suspension
     Different Solvents were tested by sonicating



BNNTs in Sodium Dodecyl Sulfate (SDS)

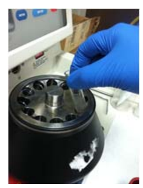
At 0 min

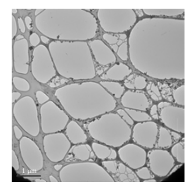
At 1 hour



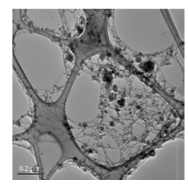
Dichlorobenzene suspended

  1. Centrifuging and Supernatant Collection



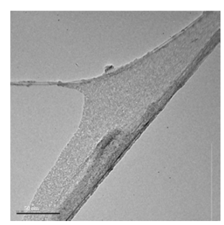


Dichloroenthane at 20000 rpm

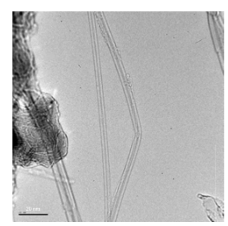


Dichlorobenzene at 3000 rpm

  1. Filtering and Washing



SDS before filtering



SDS after filtering

Conclusion

- Nitric acid treatment and thermal oxidation:
  - Remove significant amounts of amorphous and crystalline boron as well as any metallic precursor.
  - Some tubes damaged during the process.
  - Demonstrates evidence that centrifuging and filtering must precede any of above treatments in order to remove nanocages.
- Out of the tested solvents, SDS seems to be the better candidate for suspension and isolation.
  - SDS leaves residue that seems to be capable of being washed away.
- Centrifuging at 3000 rpm is not sufficient to separate the nanotubes from other non-tubular nanostructures.

Future Work

- Continue centrifuge tests at various rpm speeds to determine at which acceleration a significant amount of non-tubular BN nanostructures separate from BNNTs.
- Combine different techniques to improve purification.
- Test whether nitric acid treatment makes BNNTs hydrophilic.
  - Current results demonstrate the surface chemistry of the tubes might have been modified during the nitric acid treatment.

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