Sonication-Assisted Hydrothermal Synthesis of B_4C Nanosheets for Fabrication of a Solar Steam Generator

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Introduction

Boron carbide (B_4C) is a ceramic material known for its incredible hardness. Liquid exfoliation of B_4C into nanosheets by bath sonication has been proven to work in making this material into a 2D material. This project was aimed at improving the method of synthesizing these nanosheets to get a better concentration of nanosheets and higher quality products. This project also applies the use of the nanosheets into an aerogel to be used to absorb light and heat water inside a steam generator.

Approach

Bath Sonication

- B_4C was dissolved into DI water and put into a vial that hangs inside of a water bath. Sound waves pass through the body of water inside of the bath and exfoliate the material. Liquid-phase exfoliation is normally used for layered materials. B_4C is not a layered material, this is the innovation of the project.

Gathering data

- The B_4C samples were characterized via Raman spectroscopy to gather optical images of the size of the samples, get an idea of the concentration of nanosheets, and to see if there were any defects in the nanosheets.

Methods

Liquid Exfoliation

- .4g of powdered bulk B_4C particles are put in a vial with 6 mil DI water as a solvent and suspended in a sonication bath. The bath exfoliates the particles into 2D nanosheets. This sonication process is repeated for several hours to get different samples to see how long the sonication process needs to take place to get the best quality nanosheets.

Characterization

- The B_4C vials that were sonicated were put into a centrifuge to then only collect the nanosheets in the vials and not the bulk particles that have gathered onto the bottom of the vials. These nanosheets were put onto a sapphire substrate by a spin coating method. These substrates were then used to transport the nanosheets to be characterized by Raman spectroscopy.

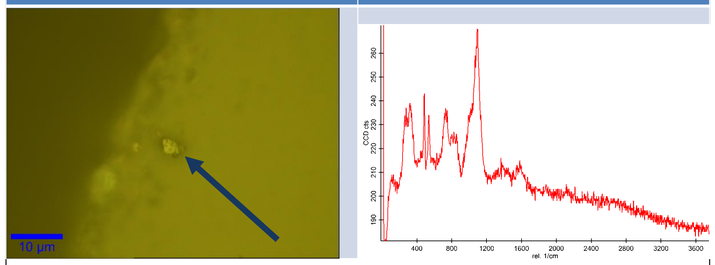
Hydrogel Synthesis

- The hydrogel recipe plus the nanosheets produced were baked together in a furnace to produce the gels. The hydrogels will later be freeze dried under vacuum to make aerogels with the nanosheets inside of them.

Results and Analysis

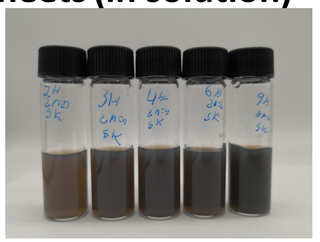
B_4C Nanosheets (3hr example)

Optical image	Raman Spectra



10µm scale bar (bottom left of optical image), nanosheet in center of image. Spectra x-axis is rel. 1/cm and y-axis is CCD cts.

B_4C Nanosheets (in solution)



2,3,4,6,9 hr sonication time B_4C Nanosheets in solution

B_4C Nanosheets (in hydrogel)

3 hr sonication time B_4C Nanosheets in hydrogels. Centrifuge process was done at 5000rpm for 2 minutes to gather nanosheets.

Obstacles

- Samples of B_4C nanosheets in their vials would degrade over a period of a month.
- The process of synthesizing the B_4C nanosheets is time consuming because of limitations of automation.
- Purity of samples is hard to control.

Next steps

- Do AFM analysis on nanosheets to determine thicknesses
- Use hydrothermal chamber to synthesize B_4C nanosheets
- Use aerogels to make steam generator
- Use new polymers to make the hydrogel

Reference

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