Fabrication of Boron Nitride Nanotube/Polymer Composites for Neutron Shielding

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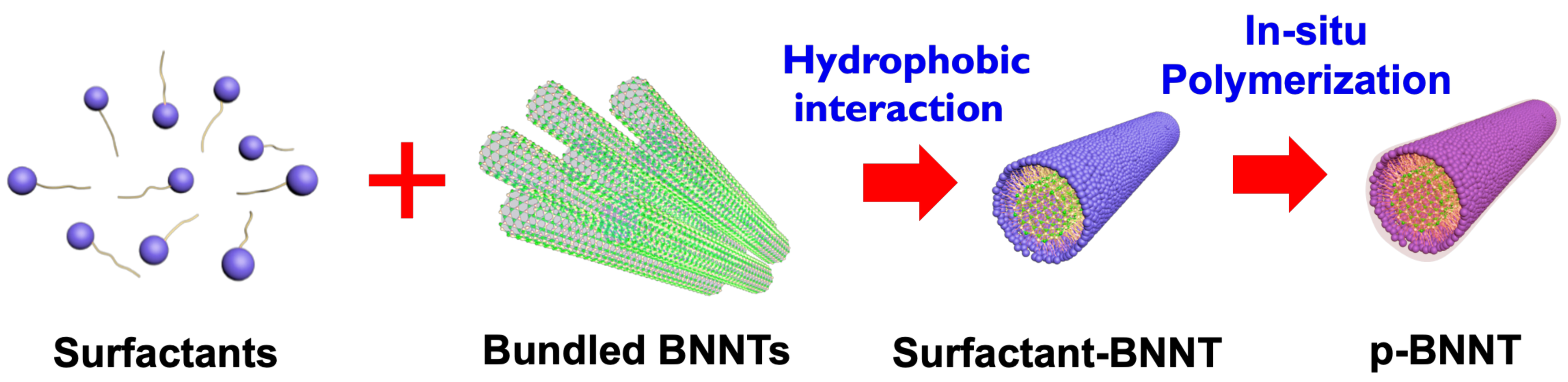
❑ Introduction

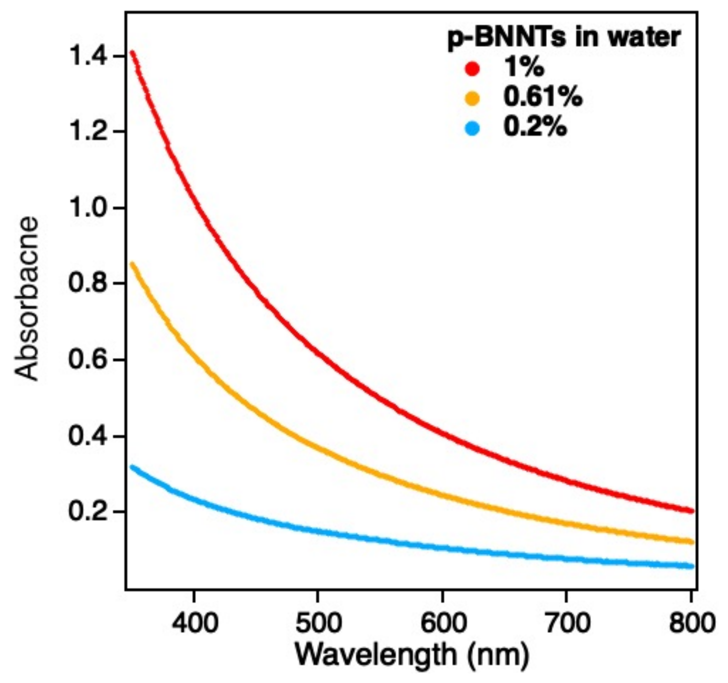
Since the first synthesis of boron nitride nanotubes (BNNTs), there has been significant interest in their potential applications as piezoelectric materials, electro-thermal insulators, and neutron shielding materials, due to their excellent mechanical, electrical, thermal, and neutron shielding properties. The boron atom in BNNTs has a thermal neutron cross-section of over 3000 barns, making them suitable for neutron shielding. However, in order to apply BNNTs as lightweight and easy-to-use neutron shielding materials, it is necessary to prepare composites of BNNTs with polymers capable of forming various shapes by the sol-gel process in aqueous solution. To manufacture the neutron shielding composite material, hydrophilic BNNTs were dispersed in a solution with Agarose polymer, and the mixture was heated and cooled to fabricate the Aga/p-BNNT hydrogel. The hydrogel was then dried to form the Aga/p-BNNT film, and its structural information and neutron shielding capability were confirmed through small-angle X-ray scattering (SAXS), optical microscopy (OM), and neutron transmission.

❑ Hydrophilic Functionalization of BNNTs

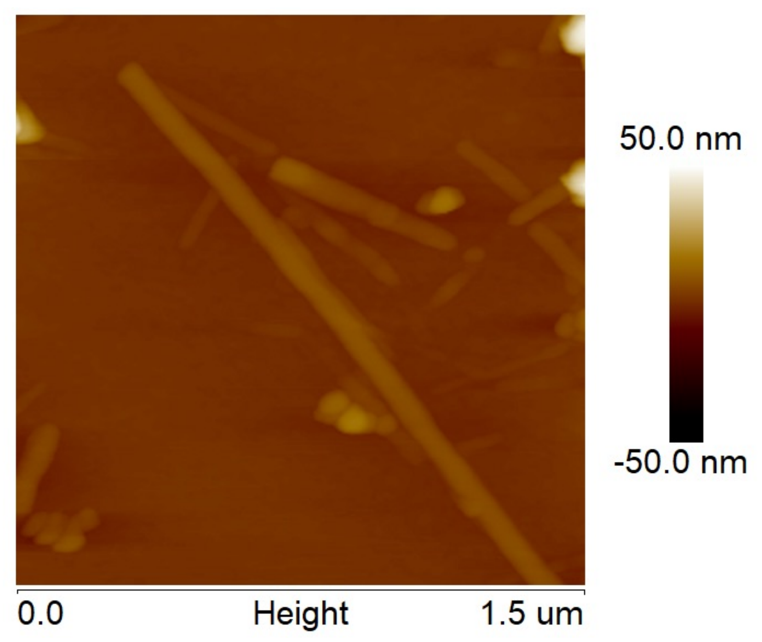
▶ Schematic diagram of p-BNNT Fabrication



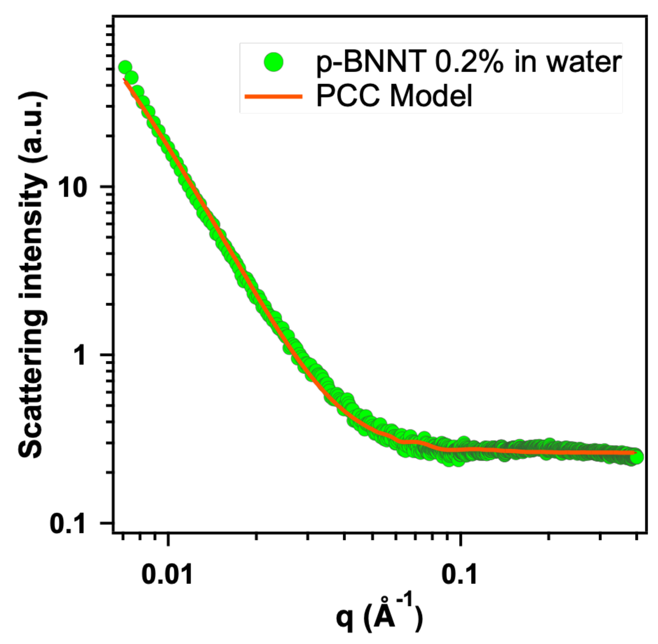
▶ UV-vis spectrum of p-BNNT

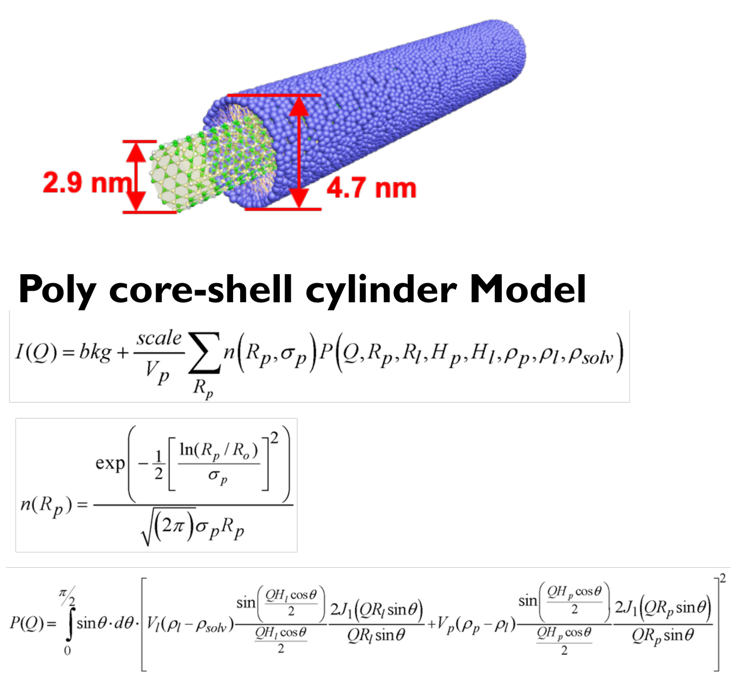


▶ AFM image of p-BNNT



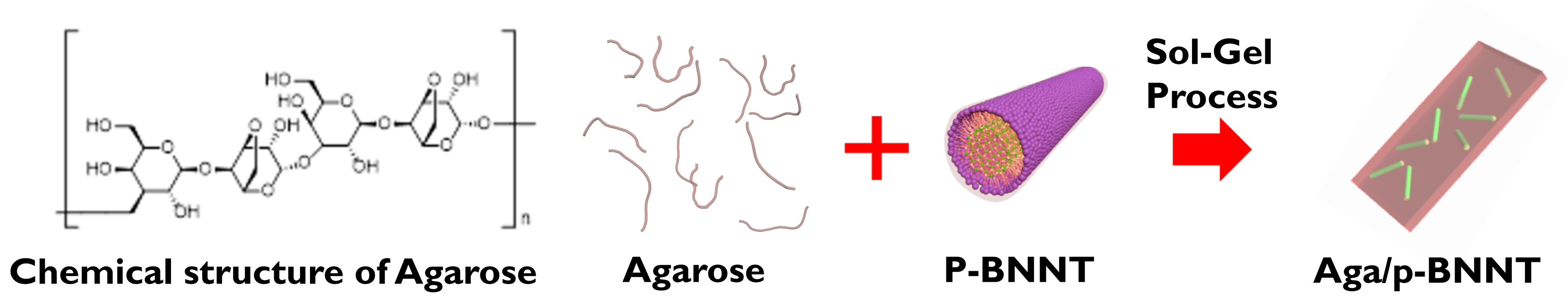
▶ SAXS intensities of p-BNNT





❑ Fabrication of Aga/p-BNNT Composites

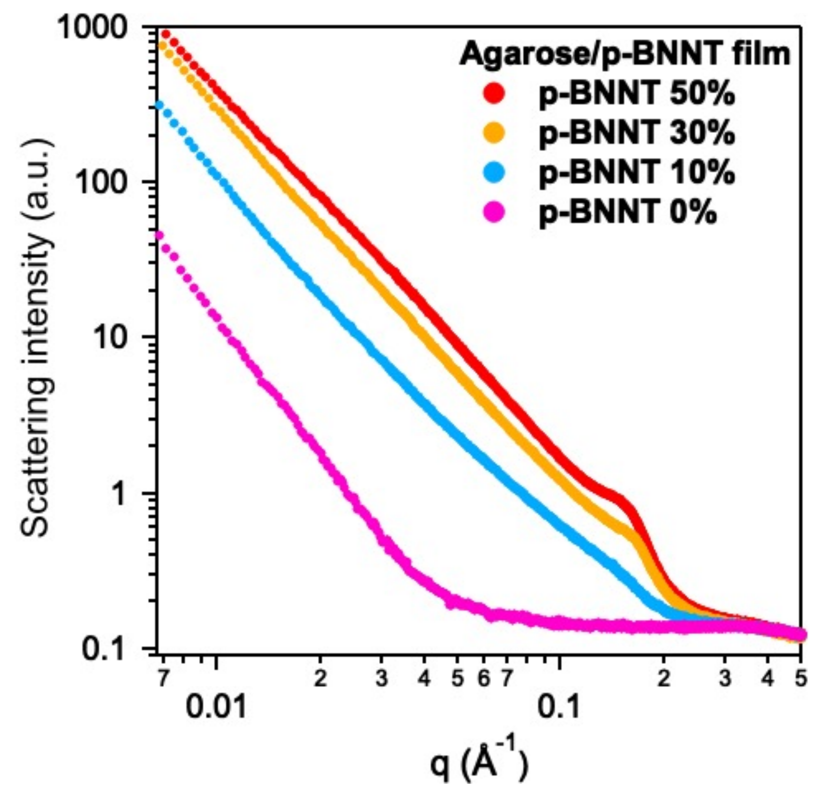
▶ Schematic diagram of Aga/p-BNNT Fabrication



▶ Photographs of Aga/p-BNNT films

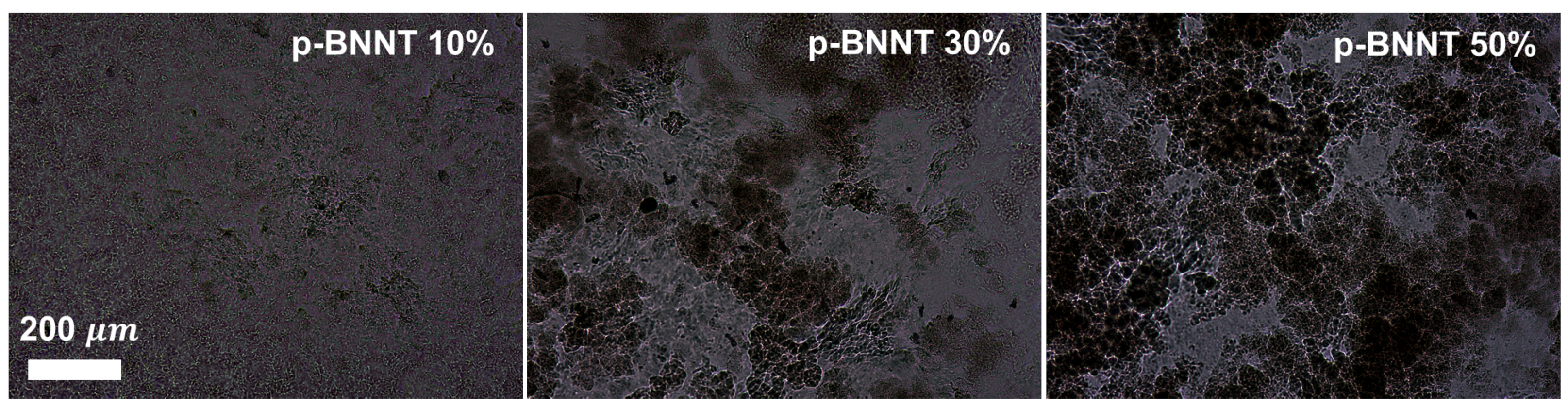
❑ Neutron Shielding Capability of Aga/p-BNNT film

▶ SAXS intensities of Aga/p-BNNT films



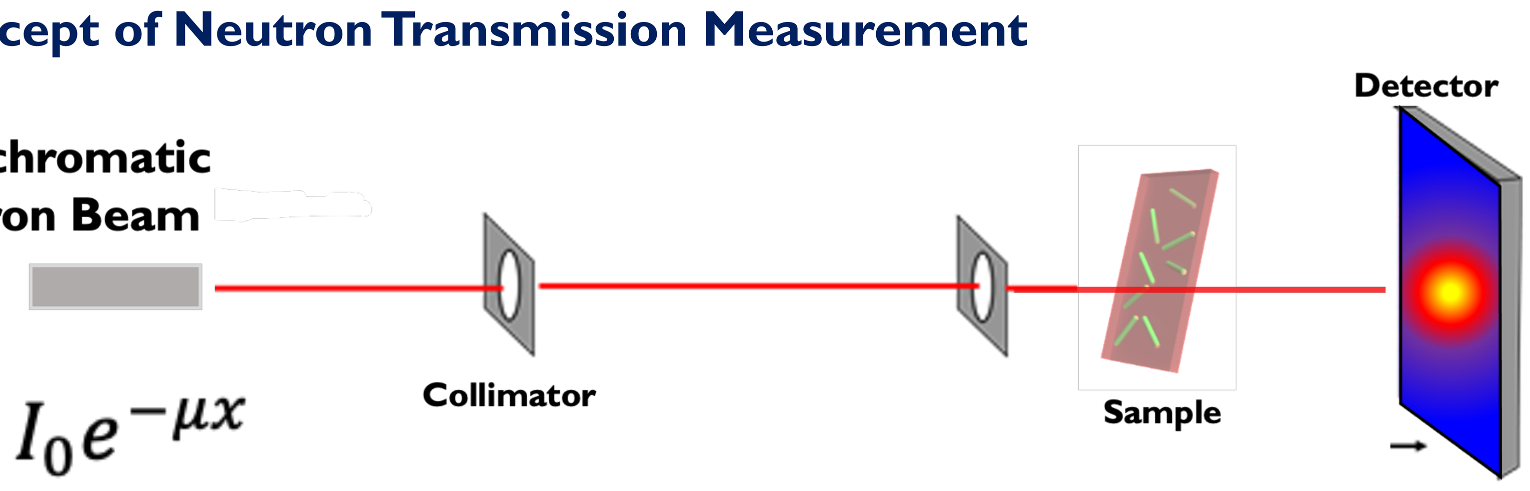
To investigate the structural changes of the Agarose/p-BNNT composite thin film according to the p-BNNT content, a SAXS measurements were conducted. As a result, SAXS measurements confirmed the presence of interaction peaks due to aggregation of particles when the p-BNNT content was 30 wt % and 50 wt % in the Aga/p-BNNT film.

▶ OM images of Aga/p-BNNT films



In the OM images, aggregation, hundreds of micrometers in size, were observed over 30 wt % of p-BNNTs in composites.

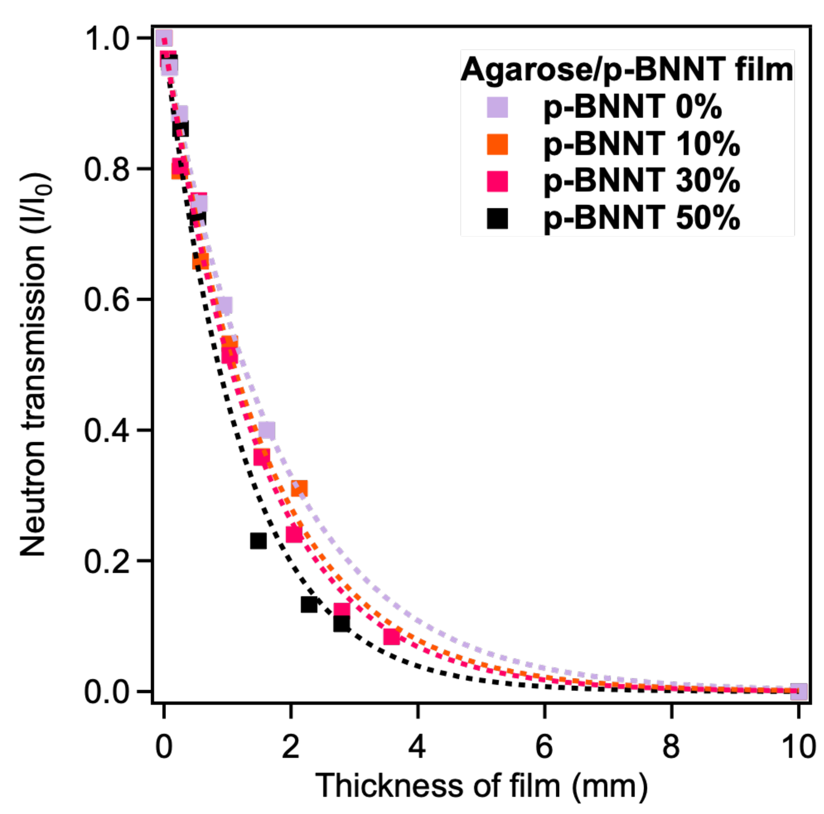
▶ Concept of Neutron Transmission Measurement

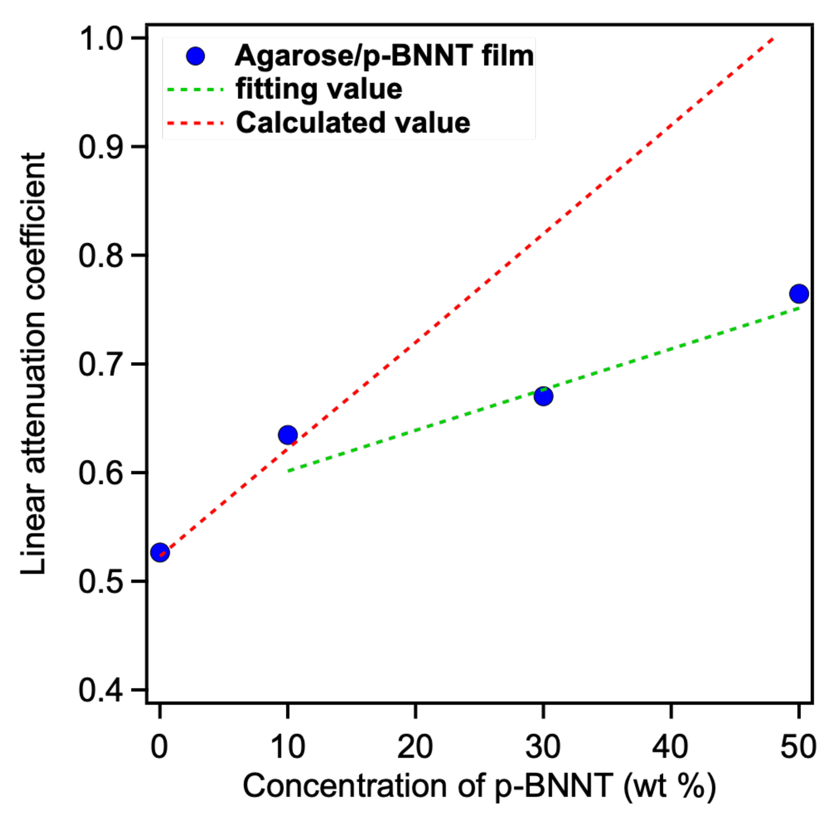


$$I = I_0 e^{-\mu x}$$

μ : Linear attenuation coefficient I : Intensity after attenuation
I_0 : Incident intensity x : Physical thickness of sample

▶ Neutron shielding capability of Aga/p-BNNT films





The linear attenuation coefficients of the Aga/p-BNNT composite films ranged from 0.533 ± 0.04 mm^{-1} to 0.765 ± 0.062 mm^{-1} from 0 wt % to 50 wt % p-BNNT content. However, when the p-BNNT content was higher than 10 wt %, it was confirmed that the linear attenuation coefficient was lower than the calculated value. Therefore, it was confirmed that the linear attenuation coefficient value decreased when the p-BNNT content increased from 10 wt % to 50 wt % by the effect of aggregation in composites.

❑ Summary

In summary, this study exhibits the potential of Agarose/p-BNNT composites for neutron shielding applications. As a result of SAXS and OM measurements, it was confirmed that the Aga/p-BNNT thin film was formed without aggregation up to 10 wt% p-BNNT content. As the concentration of p-BNNT increased, the neutron transmittance decreased, confirming that p-BNNT is effective as a neutron shielding material.