Optimization of Vertically Aligned Boron Nitride Nanotube Membranes via Magnetic Arrangement in a Lyotropic Precursor for Water Transport Applications

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Boron nitride nanotubes (BNNTs) possess significant potential in water transport applications, demonstrating greater water flux over that of carbon nanotubes and contemporary reverse osmosis membranes. Larger-diameter BNNTs can also harvest osmotic power up to 1000x more efficiently than current methods. However, practical application of BNNTs is limited by lacking research and the overall difficulty with performing scalable characterization of nanomaterials. This research designed and optimized a facile, scalable method for fabricating vertically aligned BNNT membranes using noncovalent functionalization with ionic surfactants, a lyotropic liquid crystalline (LLC) precursor to aid alignment, and molecular dynamics (MD) simulations to determine the ideal BNNT chirality for desalination. The cylindrical micelles in a LLC mesophase self-assemble parallel to an applied magnetic field, templating the alignment of sequestered BNNTs. 4.25 g/L of raw grown BNNTs were purified and dispersed in an ammonium oleate aqueous solution, which was used to prepare a LLC mesophase in thin (<1 mm) film geometries. The films were aligned by being subjected to sample annealing in a 1.4 T magnetic field for 3 hours, and then polymerized with 365 nm UV light. Polarized Raman spectroscopy of the films at 0°/90°/180° orientations demonstrated an additional Raman mode at 90°, indicating successful alignment and optimized density of BNNTs by expressing increased intensities when polarization is parallel to the nanotube. MD simulations of pressurized water traveling through (9, 0) zigzag, (6, 4) chiral, and (5, 5) armchair BNNTs demonstrated that water passes through (9, 0) zigzag BNNTs faster than the other tested BNNT chiralities.

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