Enhanced Performance of Biobased Composite Films: The Role of Boron Nitride Nanoplatelets in tuning the Hydrophobicity, Chemical-Resistant, Thermal and Electrical Properties

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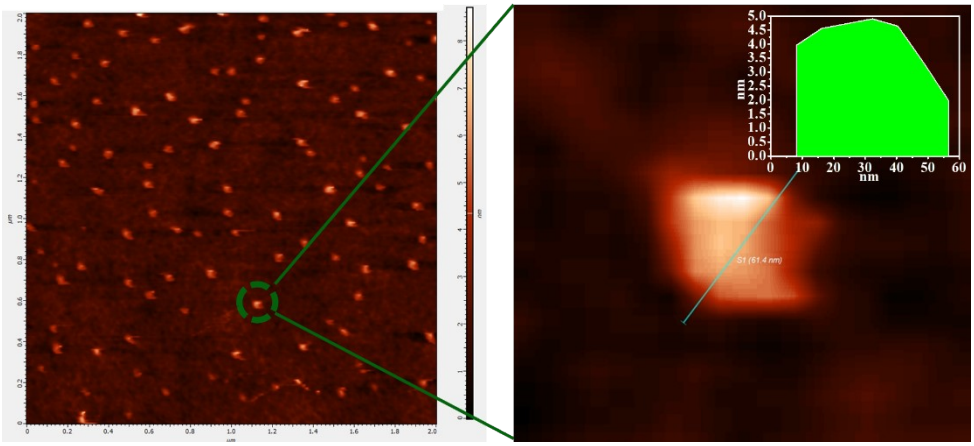


Fig. S1 Atomic force microscope (AFM) image of BNNP and the corresponding height distribution measured from AFM topographic data of BNNP.

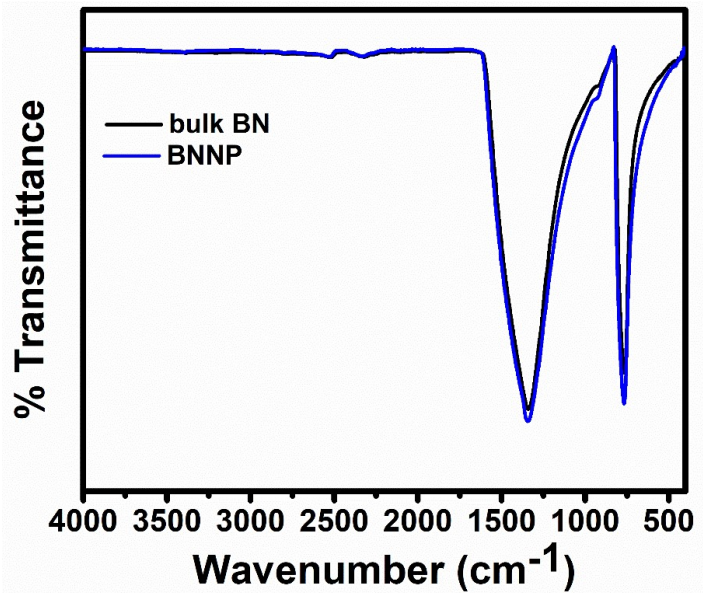


Fig. S2 FTIR spectra of bulk BN and as exfoliated BNNP.

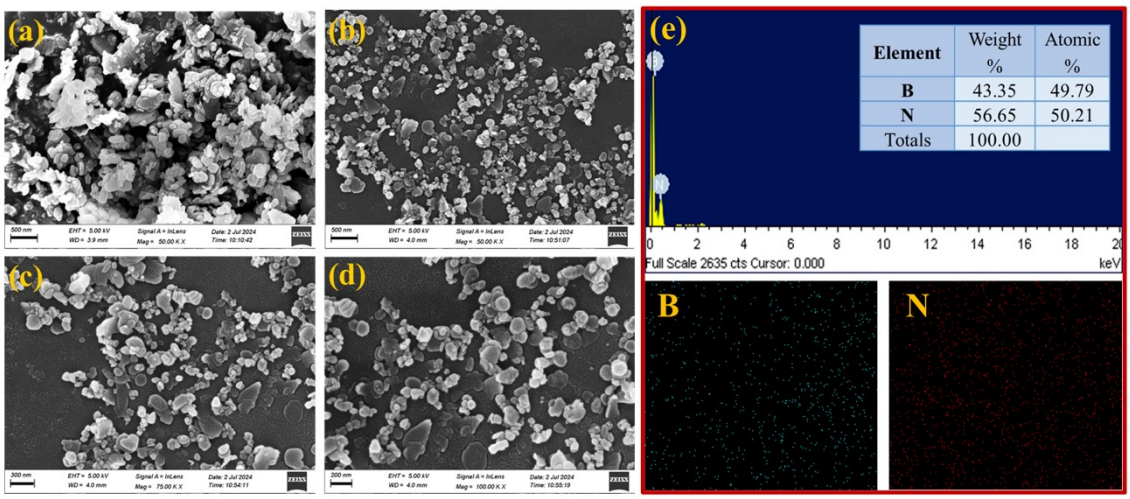


Fig. S3 Scanning electron microscopy image of (a) bulk *h*-BN and as exfoliated BNNP at different magnification scale (b) 500 nm, (c) 300 nm, (d) 200 nm, (e) SEM EDX elemental mapping of BNNP.

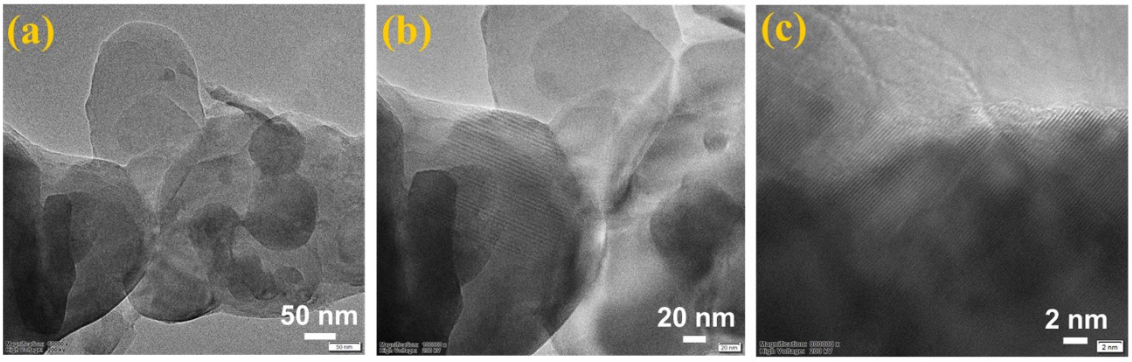
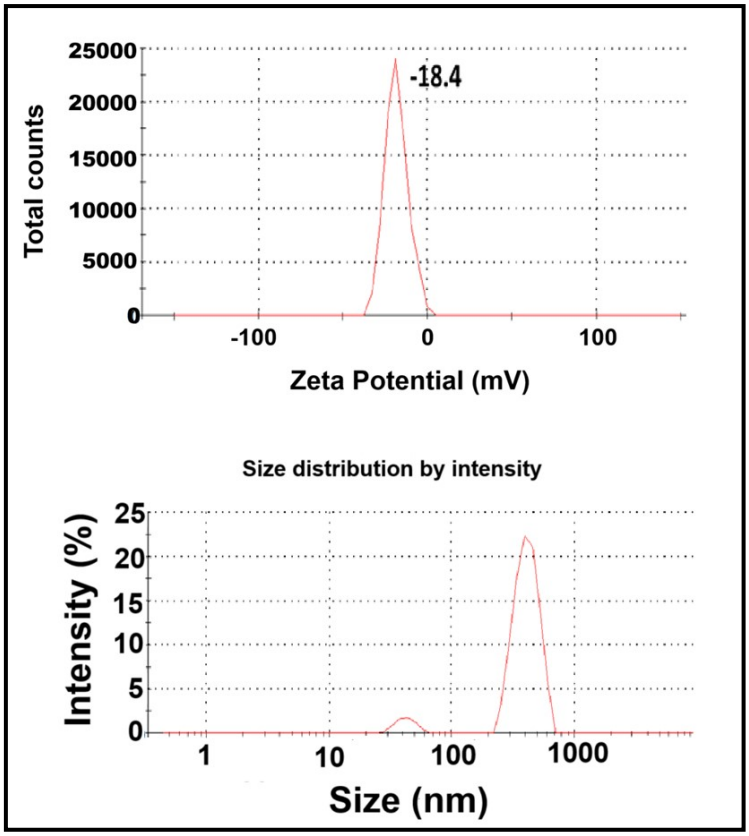


Fig. S4. (a-c) TEM images of exfoliated boron nitride nanoplatelets (BNNPs) at different magnifications.



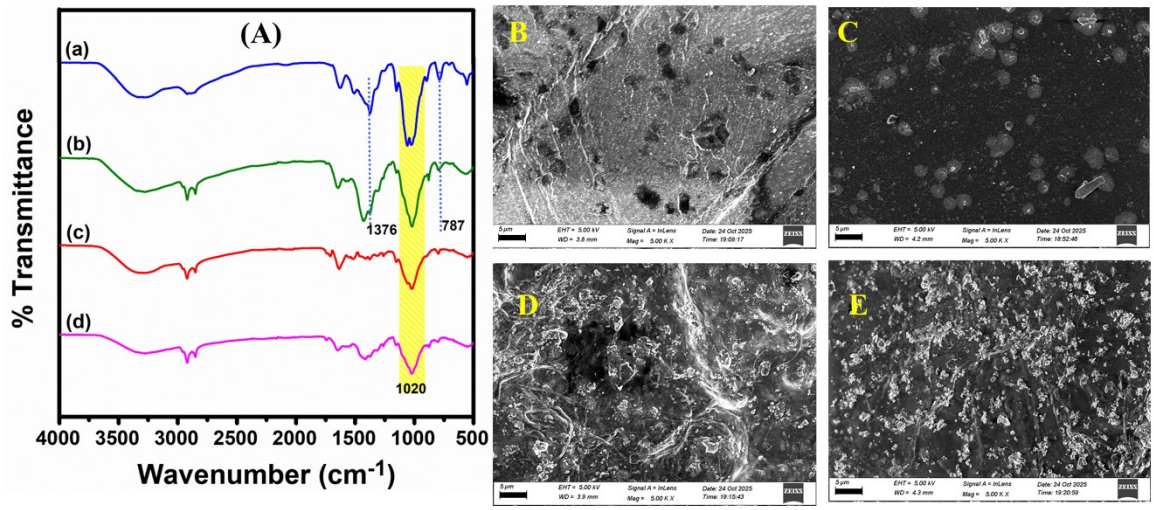


Fig S5. Zeta size and Zeta potential measurements of Cellulose nanofibers (CNF)

Fig S6. (A) FTIR spectra of (a) acid-treated BN2 film, (b) base-treated BN2 film, (c) acid-treated CH–CNF film, and (d) base treated CH-CNF films. (B, D) SEM micrographs of base-

treated CH–CNF and BN2composite films, respectively, and (C, E) SEM micrographs of acid-treated CH–CNF and BN2 composite films, respectively.

Measurements set-up for sensing

The study of dielectric properties of the composite film were thoroughly investigated using an LCR meter across a wide frequency range from 4 Hz to 8 MHz at a temperature of 300 K.[1] The film samples were cut into 1x1 cm^2 for the purpose of conducting precise and complete measurements. To ensure proper contact, both sides of each pellet were coated with silver paste. The Cole–Cole plot was utilized to further determine the sensing of the composite film (BN2) efficacy for ammonia. Solutions of 1, 3, 5% concentrations of ammonia (NH_3), Hydrogen peroxide (H_2O_2) were prepared. The dielectric value of the control sample was first measured. Then, 100 µl of different concentration of ammonia solution was dropped onto the pellet and dried at room temperature on a hot plate before taking another dielectric measurement. The same process was repeated with a 100 µl solution of H_2O_2 and the dielectric measurement was taken again.

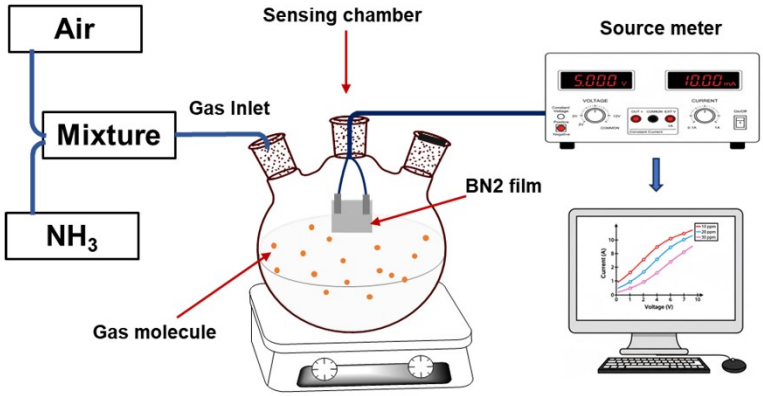
I-V Analysis Setup

The I-V measurements for the BN2 film under ammonia exposure were conducted using the custom flow setup shown in Fig. S7. The film was placed in the sensing chamber, maintained at 25 °C. Ammonia gas was generated by introducing known volumes (V_1) of a 1% w/w NH_3 ammonia solution. The resulting NH_3 gas concentrations (C) in the chamber were calculated using the following equation (S1)

$$C\ (ppm) = \frac{V_m \times \rho \times \varphi \times V_1 \times 1000}{M_2 \times V_2} \quad \text{.....S1}$$

where V_m is the molar volume at 25 °C (24.46 L/mol), ρ is the density of the ammonia solution φ is the mass fraction, M_2 is the molecular weight of ammonia (17.031 g/mol), and V_2 is the chamber volume (in L).

A Source Meter was connected to the film to apply a DC voltage sweep (0 V to 5 V) while simultaneously recording the current, yielding the I-V characteristics presented in Fig. S8(b).



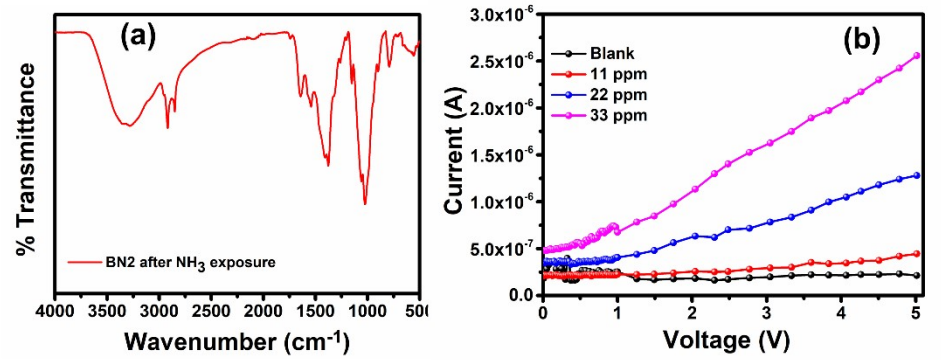


Fig S7. Custom ammonia sensing setup

Fig S8. (a) FTIR spectrum of BN2 film after NH_3 exposure showing characteristic changes in –OH and –NH vibrations, (b) I-V characteristics of BN2 film under varying NH_3 concentrations, indicating enhanced current response with increasing ammonia exposure.

References

1. R. Sonkar, M. P. Ghosh, S. Thakur, E. Saikia and D. Chowdhury, *Mater.Chem. Phy.*, 2025, 130578.