**Instruments**

The SEM images were acquired from the Zeiss SUPRATM 55 SAPPHIRE field-emission scanning electron microscope. The AFM images were acquired from the Bruker Icon atomic force microscope. FTIR spectra were collected in wavenumber range of 4000-400 $cm^{-1}$ on a Thermo Nicolet IS5 instrument. Raman scattering was conducted on a Horiba Jobin-Yvon Lab Ram HR VIS high-resolution confocal Raman microscope equipped with a 633 nm laser. $^1H$ NMR spectroscopy was performed on the Bruker Advance DRX-300

spectrometer (Bruker, Germany) at 25 °C. The XPS spectra were obtained from a Thermo Escalab 250Xi spectrometer equipped with an X-ray source producing Al K$\alpha$ radiation (1486.6 eV). The friction tests were completed by a MS-T3001 ball disc friction tester. Water contact angle tests were carried out by a SDP 260 contact angle/surface tension analyzer at room temperature.

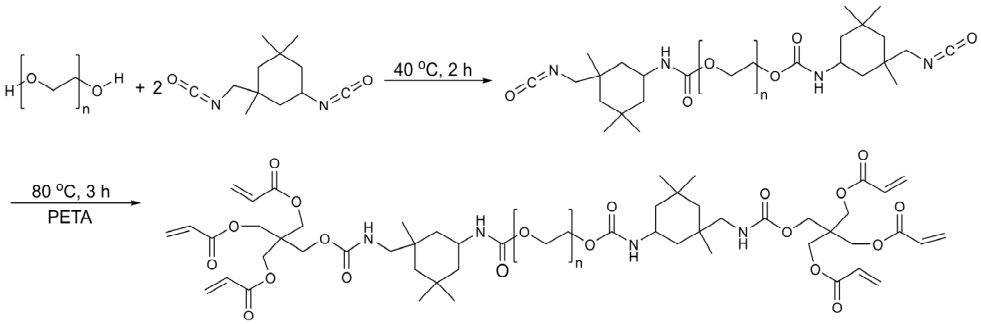


**Figure S1.** Schematic diagram of synthesis of polyurethane acrylate (PUA).

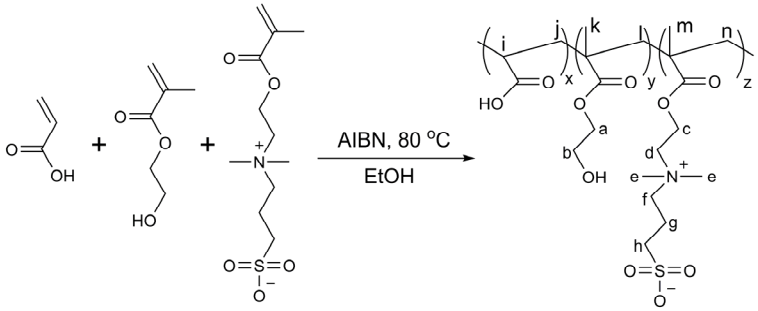


**Figure S2.** Schematic diagram of synthesis of P(AA-HEMA-SBMA) acrylic resin (PAHS).

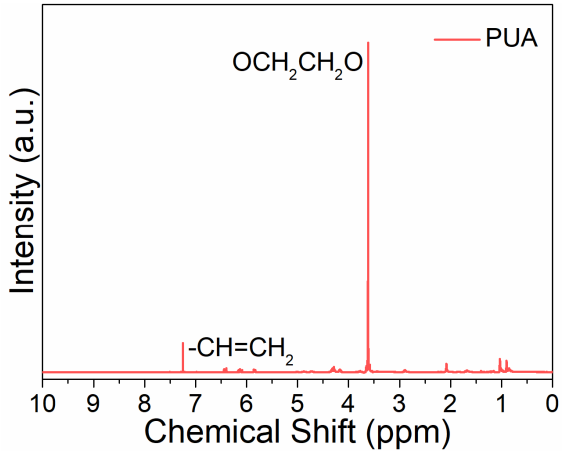

**Figure S3.** $^1$H NMR spectrum of polyurethane acrylate (PUA): $^1$H NMR (400 MHz, $CDCl_3$) $\delta_H$ 5.84-6.45 (-CH=$CH_2$), 4.27 (-$COOCH_2$-), 3.61 (-$OCH_2CH_2O$-), 0.90–2.08 (-$CH_3$, -$CH_2$-).

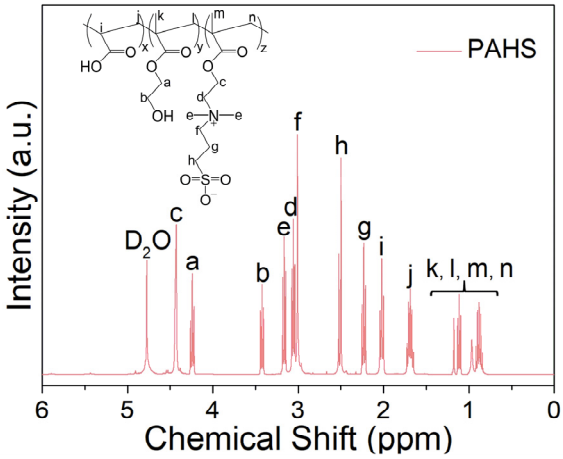


**Figure S4.** $^1$H NMR spectrum of P(AA-HEMA-SBMA) acrylic resin (PAHS): $^1$H NMR (400 MHz, $D_2O$) $\delta_H$ 4.48 (c), 4.24 (a), 3.42 (b), 3.21 (e), 3.05 (d), 3.02 (f), 2.51 (h), 2.23 (g), 2.02 (i), 1.68 (j) 0.88-1.17 (k, l, m, n).

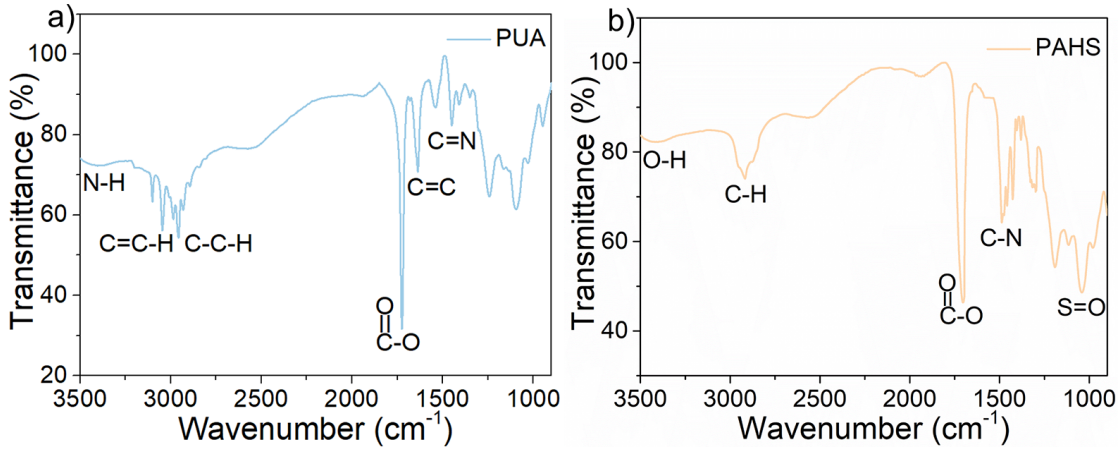


**Figure S5.** a) FTIR spectrum of polyurethane acrylate (PUA). b) FTIR spectrum of P (AA-HEMA-SBMA) acrylic resin (PAHS).

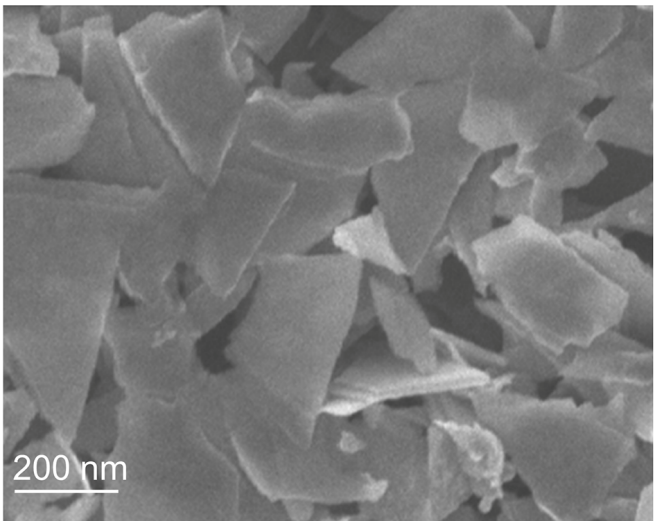


**Figure S6.** SEM image of black phosphorus nanosheets (BPs).

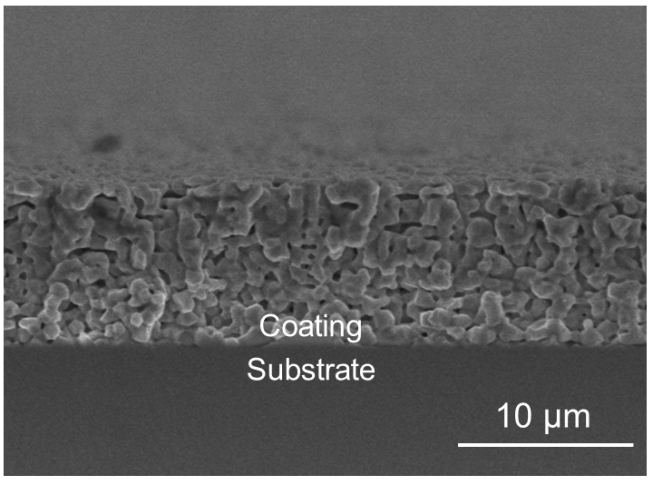


**Figure S7.** The cross-section SEM image of PUA/PAHS/BPs HN.

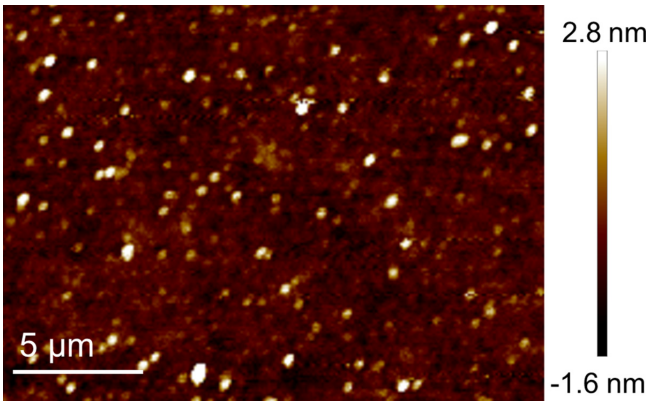


**Figure S8.** AFM image of PUA/PAHS/BPs HN.

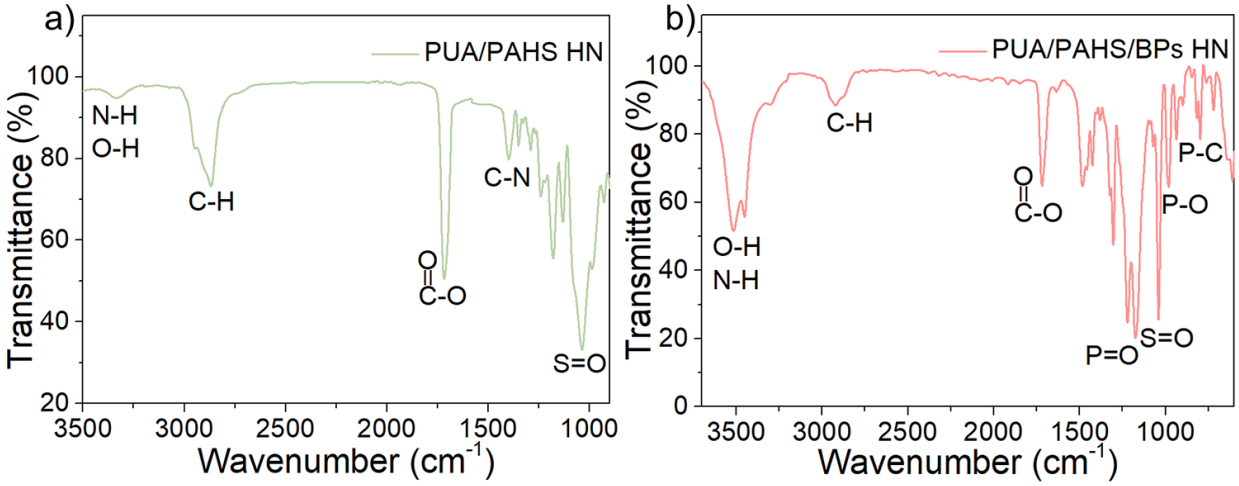


**Figure S9.** a) FTIR spectrum of PUA/PAHS HN. b) FTIR spectrum of PUA/PAHS/BPs HN.

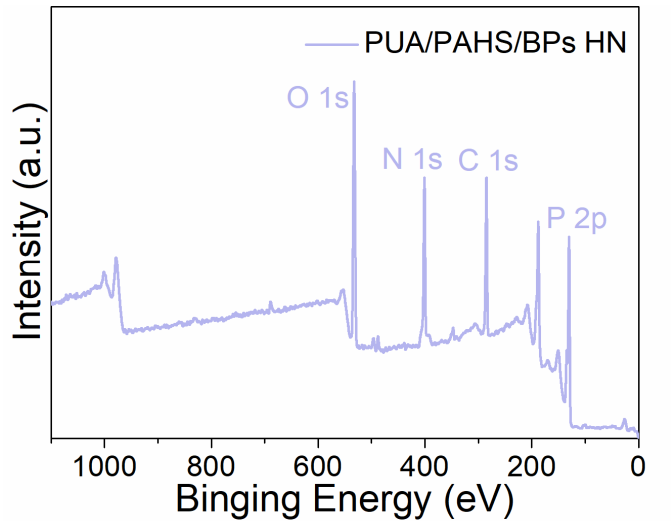


**Figure S10.** XPS spectrum of PUA/PAHS/BPs HN.

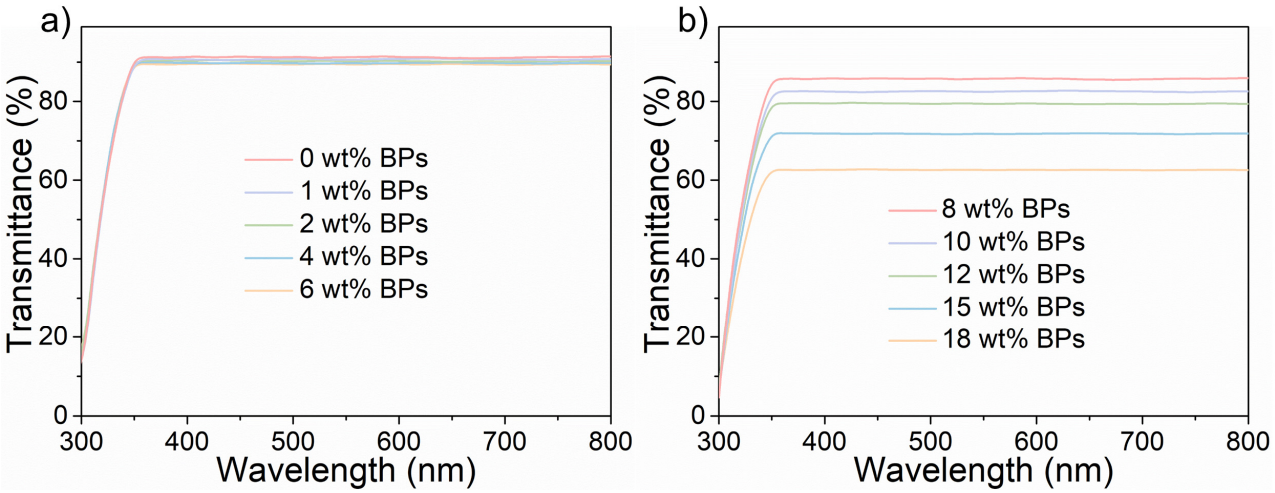


**Figure S11.** a) Transmission spectra of PUA/PAHS/BPs HN with 0 wt%, 1 wt%, 2 wt%, 4 wt% and 6 wt% BPs respectively. b) Transmission spectra of PUA/PAHS HN with 8 wt%, 10 wt%, 12 wt%, 15 wt%、18 wt% BPs respectively.

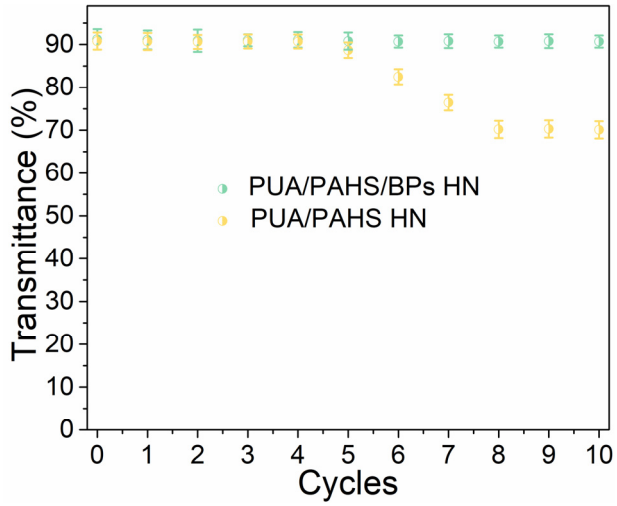


**Figure S12.** The average transmittance of a PMMA slide coated with PUA/PAHS/BPs HN during antifogging tests after high and low temperature cycles.