

Electronic Supplementary Information

Plastic Reusable pH Indicator Strips: Preparation via Anion-Exchange of Poly(Ionic Liquids) with Anionic Dyes

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1. Chemicals

Acrylonitrile, 1-vinylimidazolium, divinyl-benzene (DVB), 1-bromobutane, cresol red, methyl orange, thymol blue, bromocresol green, benzoin ethyl ether (BEE), ethyl alcohol, diethyl ether and ethyl acetate were purchased from Shanghai Chemical Reagents Co. (Shanghai, China) and used as received. All of the vinyl monomers were made inhibitor-free by passing the liquid through a column filled with basic alumina to remove the inhibitor and then stored at $-5\text{ }^{\circ}\text{C}$ before use. Deionized water was used for all experiments.

2. Synthesis of 1-Butyl-3-vinylimidazolium Bromide

1-Butyl-3-vinylimidazolium bromide ([Bvim][Br]) was synthesized as described.¹ The mixture containing 1-vinylimidazole (3.000 g, 0.032 mol) and equivalent molar amount of 1-bromobutane (4.37 g, 0.032 mol) was stirred in ice bath for 20 min, and then continuously reacted at room temperature for 48 h. The product was washed three times with diethyl ether and ethyl acetate and then dried in vacuum at room temperature. Colourless viscous liquid (yield: 93 %) ¹HNMR (400 MHz, D₂O) δ (ppm): 7.63 (s, 1H), 7.44 (s, 1H), 7.01 (t, 1H), 5.66 (d, 1H), 5.27 (d, 1H), 4.11 (t, 2H), 1.76 (m, 2H), 1.21 (m, 2H), 0.80 (m, 3H).

3. Preparation of plastic pH-sensitive strips

A typical experimental procedure for the preparation of the plastic pH-sensitive strips was as follows.² A mixture of [Bvim][Br]/acrylonitrile (1:1 weight ratio), divinylbenzene (8 wt % to the formulation based on the weight of monomer), and 1 wt % of photoinitiator benzoin isobutyl ether was stirred and ultrasonicated to obtain a homogeneous solution, which was then cast into a glass mold and photo-crosslinked by irradiation with UV light of 250 nm wavelength at room temperature. The thickness of the membranes was controlled at around 50 μm by using standard spacer bars. The resultant membranes were immersed into a N_2 -saturated dye aqueous (or ethanol) solution for anion-exchange reaction. The resultant membrane samples were washed with ethanol or distilled deionized water to remove the excess dyes absorbed on the surface of the polymeric membranes, and then vacuum dried at room temperature before the characterization.

4. Characterization

¹HNMR spectra were recorded on a UNITY INOVA 400 MHz nuclear magnetic resonance instrument using D_2O as the solvent and tetramethylsilane (TMS) as an internal standard. Fourier transform infrared (FT-IR) spectra of the polymers were recorded on a Varian CP3800 spectrometer at a resolution of 4 cm^{-1} in the range of 4000-400 cm^{-1} . UV-vis absorption spectra were recorded at room temperature using a TU-1800 SPC spectrophotometer. Energy-dispersive X-ray (EDX) spectroscopy measurements were performed with the spectrometer attached on the Hitachi Model S-4700 field-emission SEM system.

2. FT-IR spectra, indicating pictures and UV-vis spectra

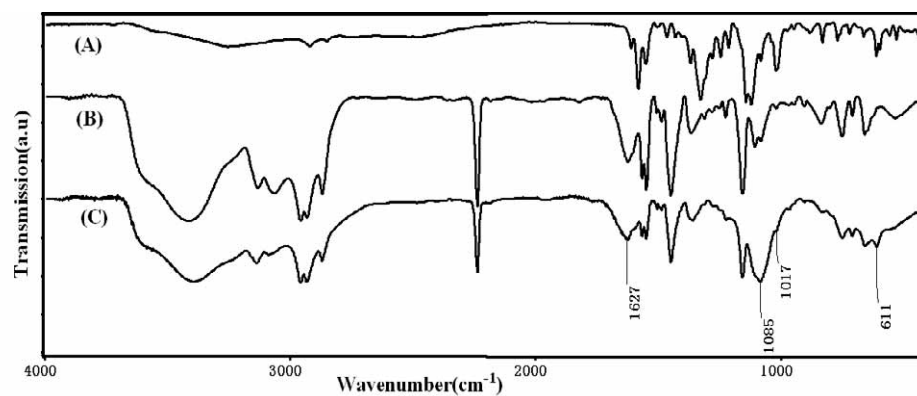


Fig. S1 FT-IR spectra of (A) Dye CR; (B) PIL membrane and (C) PIL-CR membrane.

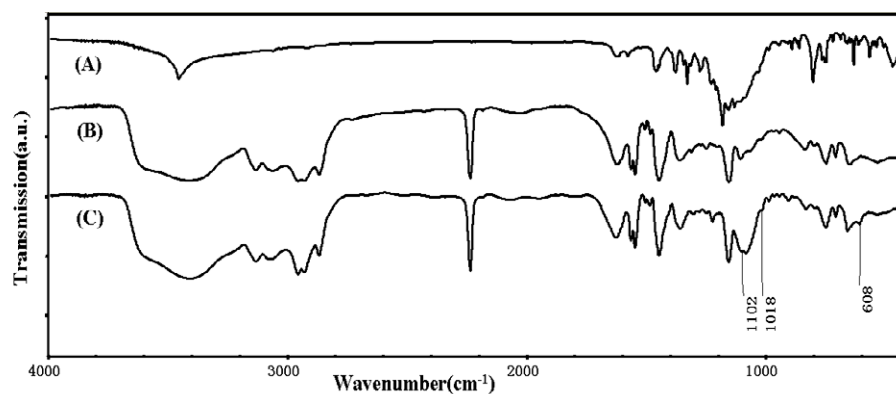


Fig. S2 Fourier transform infrared (FT-IR) spectra of (A) Dye BG; (B) PIL membrane and (C) PIL-BG membrane.

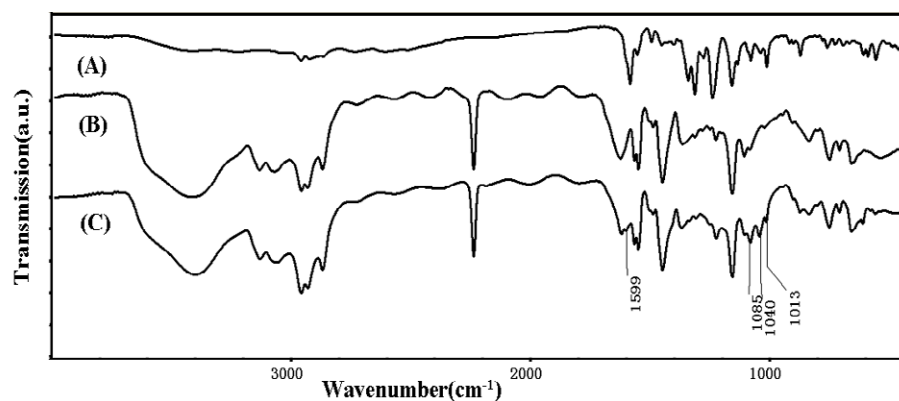


Fig. S3 Fourier transform infrared (FT-IR) spectra of (A) Dye TB; (B) PIL membrane; and (C) PIL-TB membrane

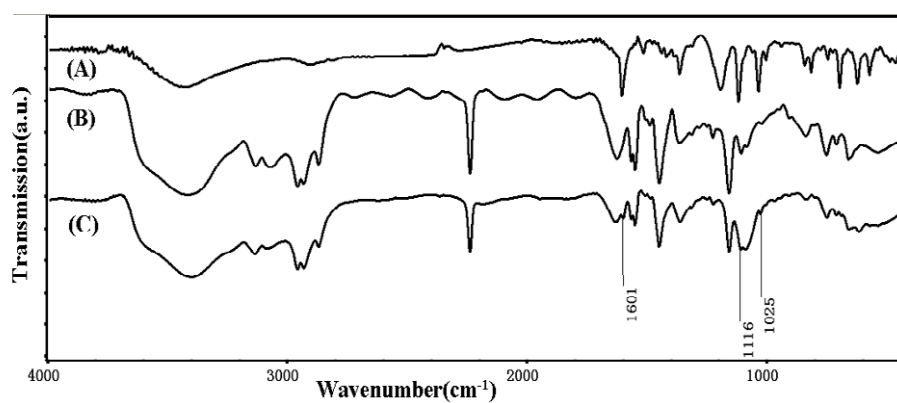


Fig. S4 Fourier transform infrared (FT-IR) spectra of (A) Dye MO; (B) PIL membrane; and (C) PIL-MO membrane.

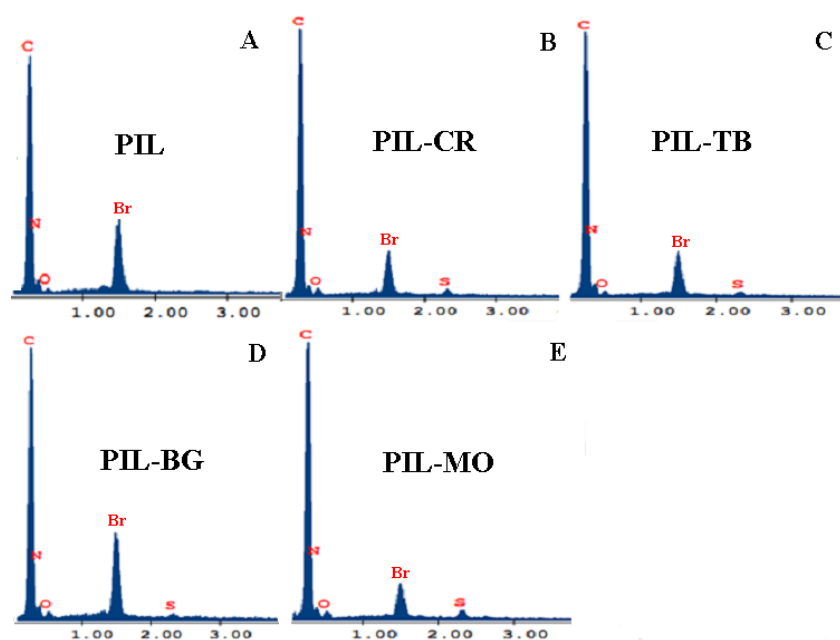


Fig. S5 Energy-dispersive X-ray (EDX) spectra of (A) PIL (B) PIL-CR (C) PIL-TB (D) PIL-BG and (E) PIL-MO.

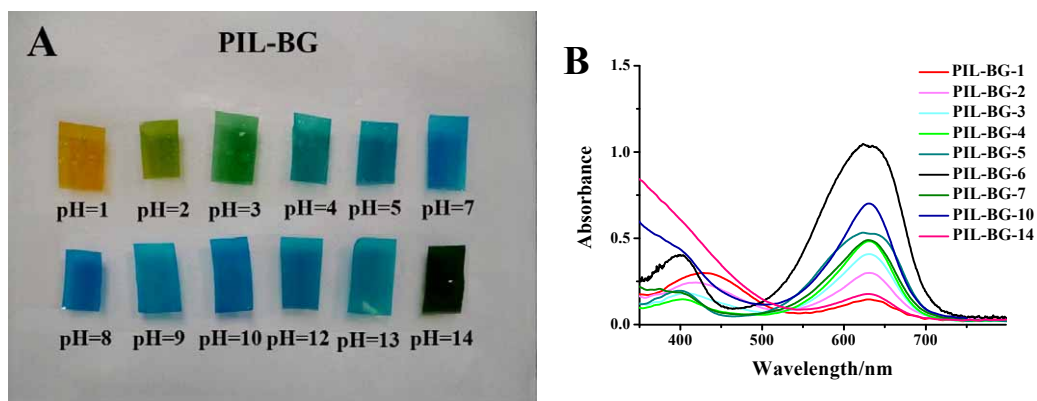


Fig. S6 (A) Indicating pictures of PIL-BG; and (B) UV-vis spectra of PIL-BG membrane at various pH values.

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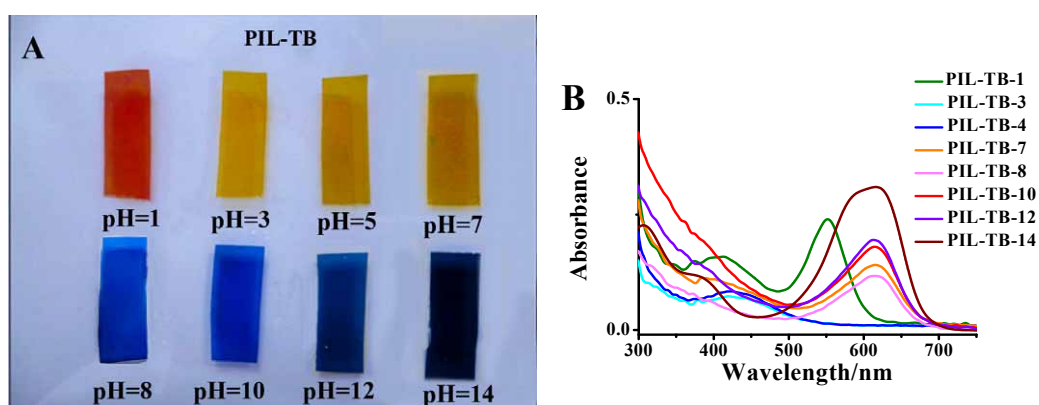


Fig. S7 (A) Indicating pictures of PIL-TB; and (B) UV-vis spectra of PIL-TB membrane at various pH values.

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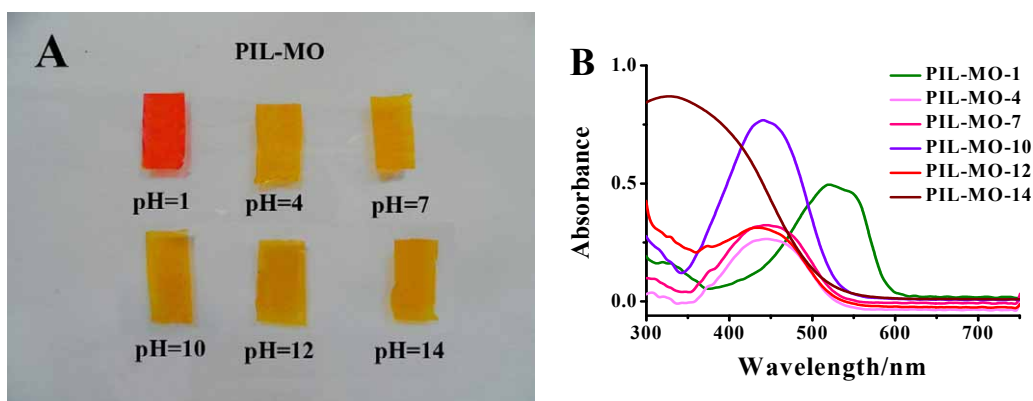


Fig. S8 (A) Indicating pictures of PIL-MO; and (B) UV-vis spectra of PIL-MO membrane at various pH values.

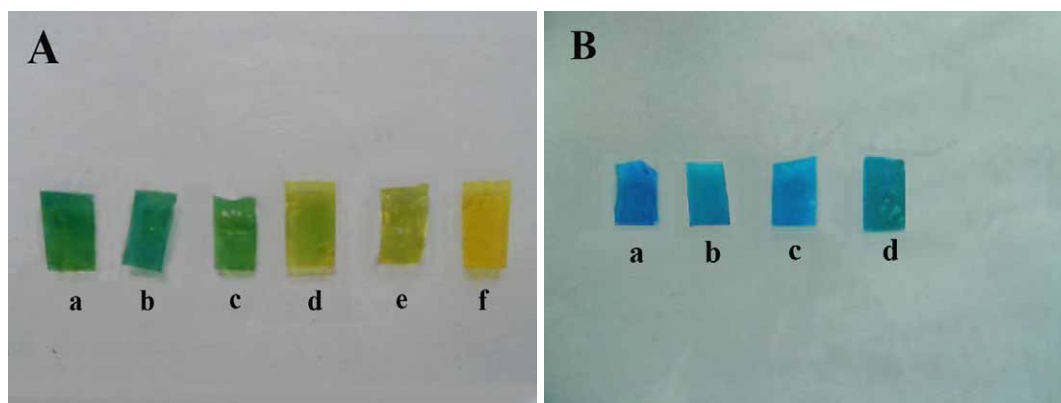


Fig. S9 (A) Indicating pictures of PIL-BG in acetone with AcOH as acid sources with varied AcOH concentrations (a) 0.7 mol/L (b) 0.9 mol/L (c) 1.1 mol/L (d) 1.3 mol/L (e) 1.5 mol/L (f) AcOH; (B) Indicating picture of PIL-BG in ethyl alcohol with ethylenediamine as basic sources, varied ethylenediamine concentrations (a) 0.1 mol/L; (b) 0.4 mol/L; (c) 0.7 mol/L and (d) ethylenediamine.

Reference:

- S1. J. Yang, L. Qiu, B. Liu, Y. Peng, F. Yan and S. Shang, *J. Polym. Sci. Part A: Polym. Chem.* 2011, **49**, 4531-4538.
- S2. B. Lin, L. Qiu, B. Qiu, Y. Peng and F. Yan, *Macromolecules* 2011, **44**, 9642-9649.