Supporting Information

Triple non-covalent dynamic interactions enabled tough and rapid room temperature self-healing elastomer for next generation soft antenna

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Fig S1. (a) Chemical structures of the compounds for synthesizing PU-PEI elastomer. (b) Schematic illustration of the fabrication of PU-PEI elastomer (i. PU colloid; ii. PU-PEI colloidal complex; iii. PU-PEI elastomer).
The FTIR spectra of PU, PEI and PU-PEI are shown in Fig S2. The PU has typical peaks of N-H stretching at 3323 cm$^{-1}$, C-H stretching at 2937 cm$^{-1}$ and 2860 cm$^{-1}$, C=O stretching at 1709 cm$^{-1}$, N-H bending at 1535 cm$^{-1}$, C-H bending at 1458 cm$^{-1}$ and 1365 cm$^{-1}$, and no absorption peak of the N=C=O group (2270 cm$^{-1}$), indicating the formation of urethane (H-N-COO-) group from N=C=O (IPDI) and O-H (PPG-2000). The PEI has typical peaks of N-H stretching at 3276 cm$^{-1}$, C-H stretching at 2940 cm$^{-1}$ and 2806 cm$^{-1}$ N-H bending at 1596 cm$^{-1}$, C-H bending at 1458 cm$^{-1}$ and 1342 cm$^{-1}$, and C-N stretching at 1350–1000 cm$^{-1}$. The similar FTIR spectra for both PU and PU-PEI elastomers indicate that no chemical reaction occurred after incorporating PEI into PU.
Fig S3. Average diameter and zeta potential of PU and PU-NH4OH colloid.
As the water evaporated, the polymer concentration of PU-PEI colloidal complex increased, resulting in phase change from fluid to gelation and then film. Initially, the samples contain the PU colloidal particles and the PEI polymers, which exist as a stable fluid. As the concentration increases, samples start to aggregate without losing their flowability. The aggregation is whitish and can be readily noticed with naked eyes. Then, with the continuous evaporation of water, samples become a gel that cannot flow. In the gelation state, samples only have weak mechanical properties that has not formed a film yet. Finally, as the color turns from white to transparent, the gel becomes to a continuous film that can be peeled off.
Fig S6. (a) AFM phase diagram of PU-PEI elastomer with (a) 0% PEI, (b) 2.3% PEI and (c) 6.6% PEI

Fig S7. Measured density of PU-PEI elastomers with different concentrations of PEI.
Fig S8. Transmittance of PU-PEI elastomers with different concentrations of PEI.

Fig S9. X-Ray diffraction of PU-PEI elastomers with different concentrations of PEI.
Fig S10. Stress-strain curve for PU-PEI elastomer (2.3% PEI) in wet and dry states. Inserted photo is PU-PEI elastomer (2.3% PEI) after soaking in water for 24 hours.

Fig S11. Self-healing efficiency of PU-PEI elastomers with different concentrations of PEI for 24 hours.
Fig S12. (a) Stress-strain curve of healed PU-PEI elastomer (2.3% PEI) at different healing conditions. (b) Self-healing efficiency of PU-PEI elastomers (2.3%PEI) at different healing conditions.
Fig S13. Ashby plot of “toughness”, “tensile strength” and “self-healing time” of the PU-PEI elastomer and other room temperature self-healing elastomers reported in literatures. \(^{18,20,22,24-27,32-53}\)
Fig S14. (a) Topology and (b) thickness of PU-PEI antenna.

Fig S15. a) Simulated 3d radiation pattern of original (left) and healed (right) PU-PEI antenna. (b-d) Simulated and measured 2d radiation pattern of PU-PEI antenna at phi 0, theta 90 and phi 90, respectively.
Fig S16. Measured impedance of original and healed PU-PEI antenna.

Fig S17. Efficiency of original and healed PU-PEI antenna.
Fig S18. Realized gain of original and healed PU-PEI antenna.

Table S1. Comparison of electrical conductivity, stretchability and stretching cycles of the PU-PEI-Ag composite with other printable silver-based soft electronic materials.

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<th>Conductive components</th>
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References


