

Electronic Supplementary Information (ESI)

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3. Confocal images of **PIP-TPE** in H₂O
4. Fluorescence quantum yields of **PIP-TPE** in MeOH with different fractions of glycerol
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7. Live cell and Fixed cell fluorescent imaging of **PIP-TPE** in Hela cells
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10. Theoretical calculations of **PIP-TPE**, protonated **PIP-TPE** and **PIP-TPE** in bulk

1. NMR spectra of PIP-TPE and VT-NMR spectra of protonated PIP-TPE

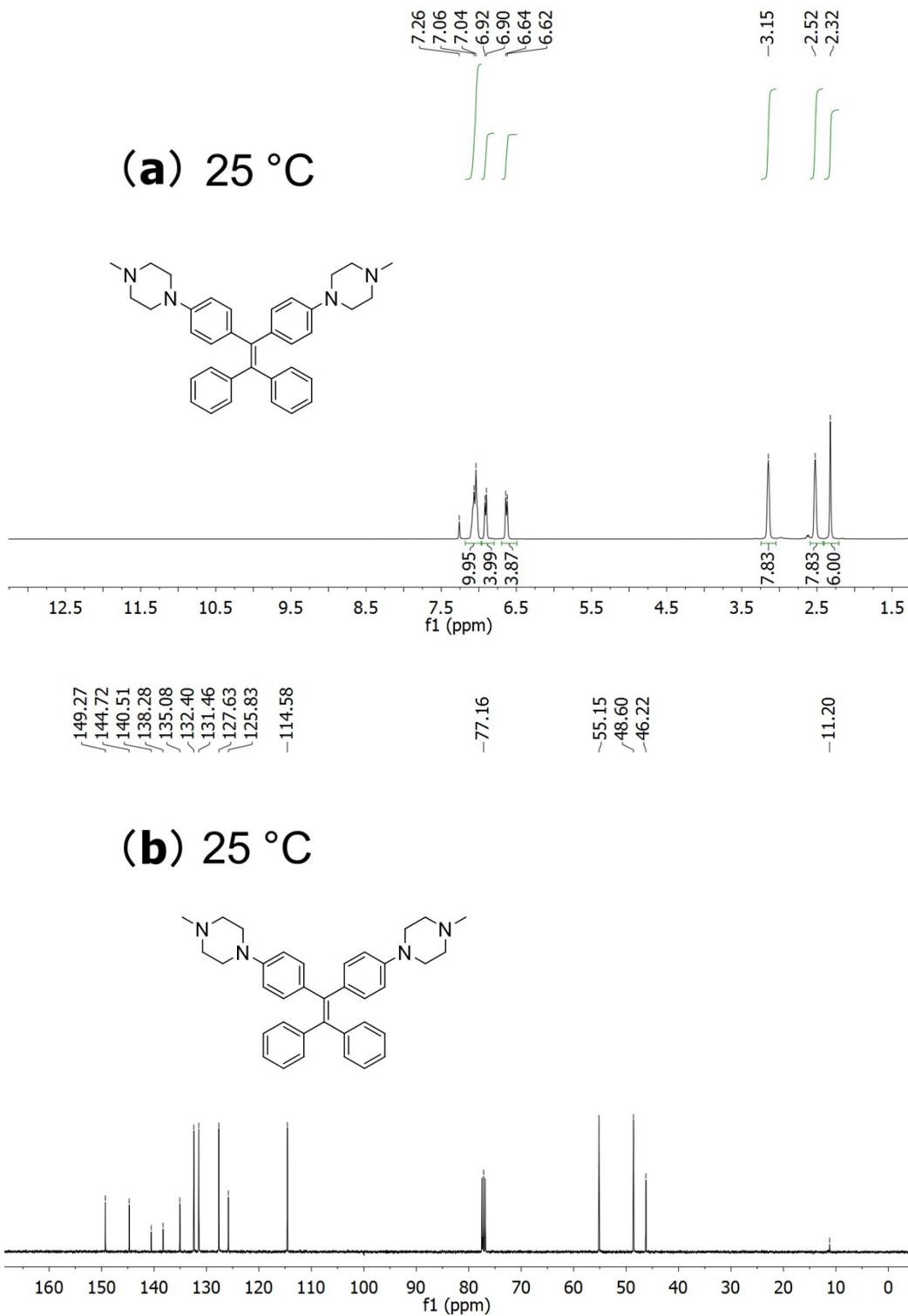
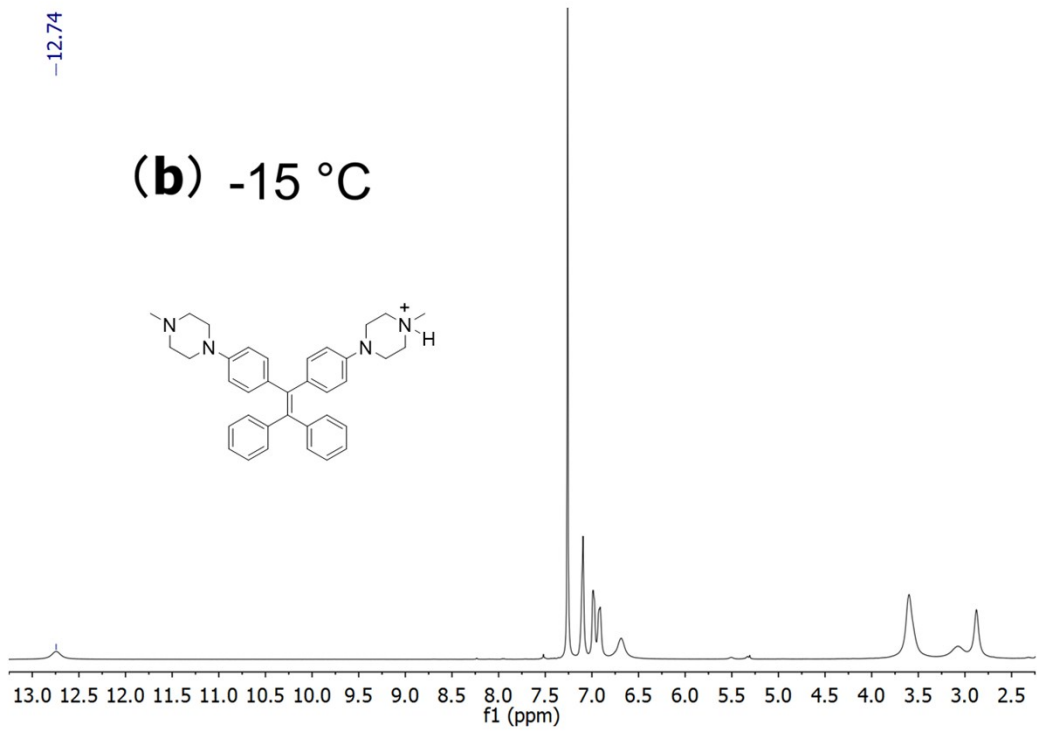
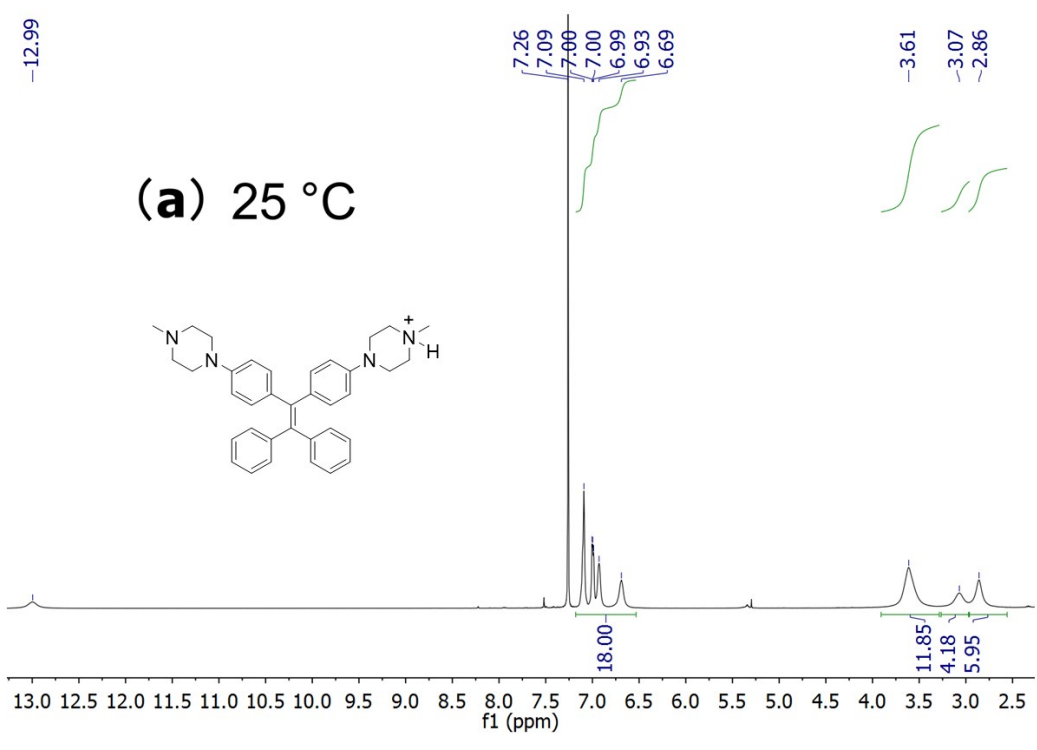


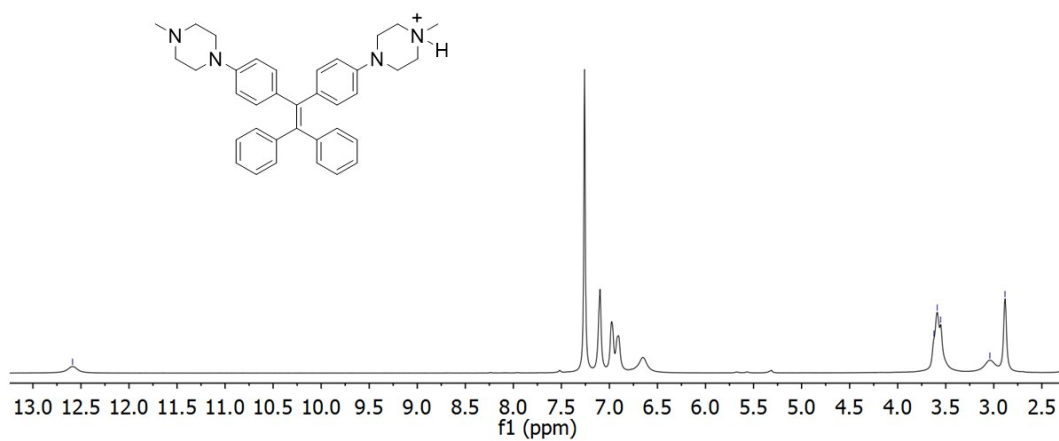
Figure S1 (a) ^1H -NMR (400.132 MHz, CDCl_3/TMS) and (b) ^{13}C -NMR (100.632 MHz, CDCl_3/TMS) of PIP-TPE



-12.59

3.62
3.59
3.55
3.04
2.88

(c) -35 °C



-12.46

3.64
3.61
3.56
3.52
3.04
2.90

(d) -56 °C

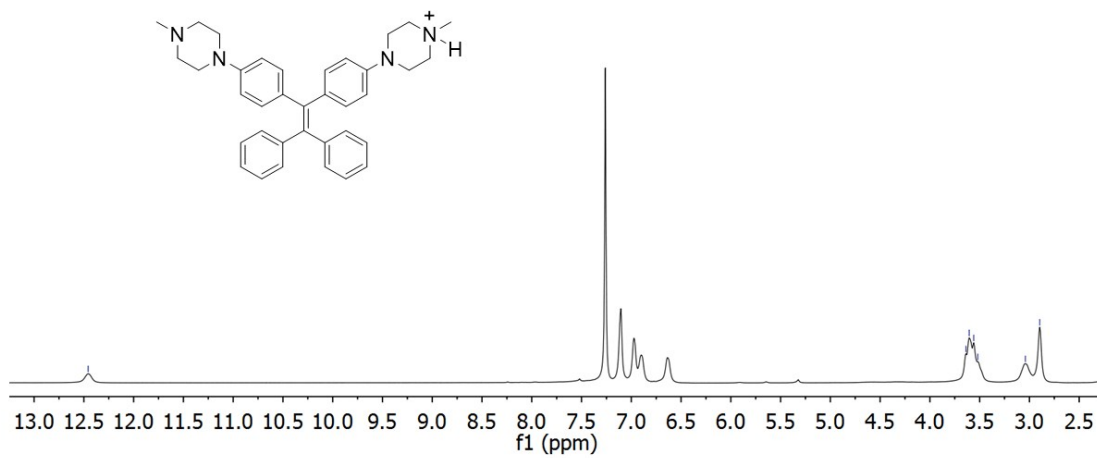


Figure S2 VT-¹H NMR of protonated PIP-TPE (400.132 MHz, CDCl₃)

2. Single Crystal X-ray Crystallography of PIP-TPE

Table S1 The crystallographic details of the compound **PIP-TPE**

| Compound | PIP-TPE |
|--|--|
| CCDC No. | 1555412 |
| empirical formula | C ₃₆ H ₄₀ N ₄ |
| formula weight | 528.72 |
| crystal dimensions, mm | 0.25 × 0.1 × 0.08 |
| crystal system | monoclinic |
| space group | <i>P2₁/c</i> |
| a/Å | 13.1123(13) |
| b/Å | 20.5840(16) |
| c/Å | 11.2600(9) |
| α/° | 90 |
| β/° | 99.391(9) |
| γ/° | 90 |
| Volume/Å ³ | 2998.4(5) |
| Z | 4 |
| ρ _{calc} , mg/mm ³ | 1.171 |
| F(000) | 1136.0 |
| λ/ Å | MoKα (λ = 0.71073) |
| μ/mm ⁻¹ | 0.069 |
| temperature/K | 100.00(10) |
| 2θ range for data collection | 6.544 to 51.992 |
| reflections collected | 17830 |
| independent reflections. (R _{int}) | 5841 (0.1229) |
| data/restraints/parameters | 5841/0/363 |
| goodness-of-fit on F ² | 1.000 |
| R ₁ ,wR ₂ [I>=2σ (I)] | 0.0679, 0.0990 |
| R ₁ ,wR ₂ [all data] | 0.1569, 0.1222 |
| largest diff. peak/hole / e Å ⁻³ | 0.20/-0.23 |

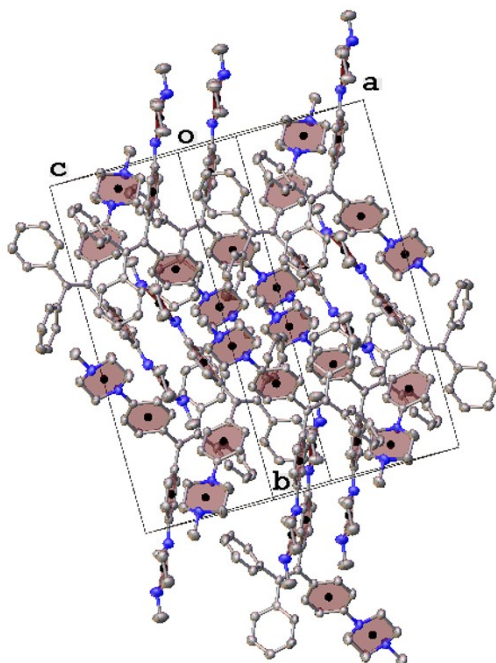


Figure S3 Crystal packing of **PIP-TPE** (piperazines and their neighboring phenyls are highlighted in red)

3. Confocal images of PIP-TPE in H₂O

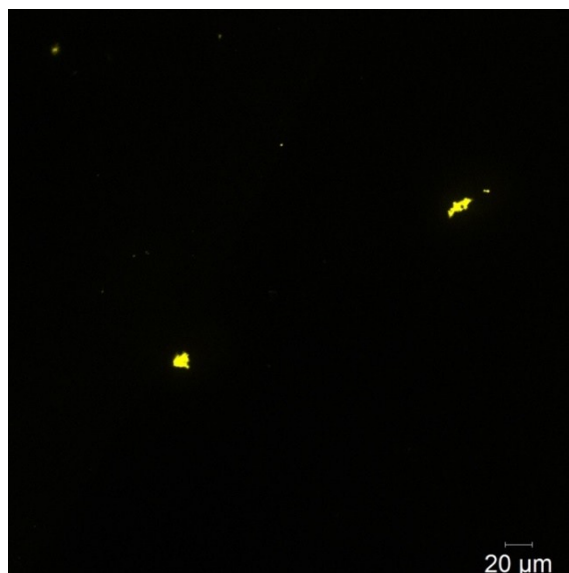


Figure S4 Confocal image of **PIP-TPE** as amorphous particles in H₂O (50 μM), Scale bar = 20 μm.

4. Fluorescence quantum yields of PIP-TPE in MeOH with different fractions of glycerol

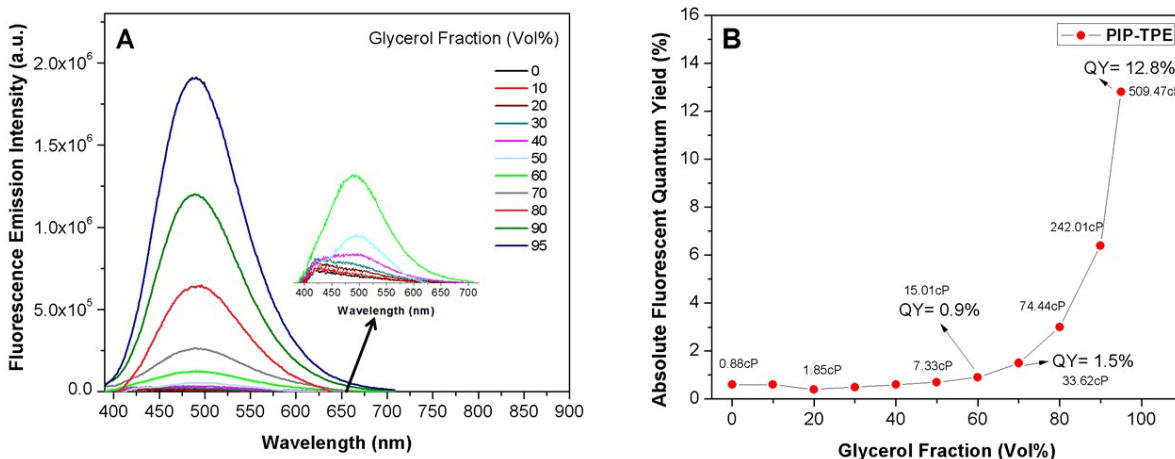


Figure S5 Photoluminescent intensity PL (A) and absolute fluorescence quantum yields Φ_{PL} (B) of PIP-TPE ($10^{-5}M$) in MeOH with different fractions of glycerol; all data were collected under $\lambda_{ex} = 360nm$ at $25^\circ C$.

5. Particle sizes of PIP-TPE in aqueous buffer solutions

The Particle sizes of PIP-TPE in aqueous buffer solutions were measured on a Zeta potential analyzer (Brookhaven, ZETAPLUS).

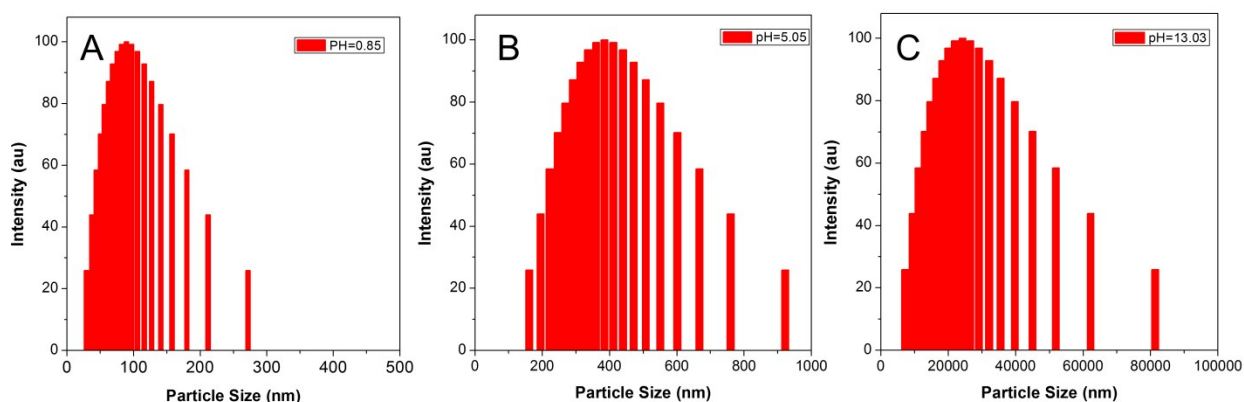


Figure S6 The particle sizes of PIP-TPE in aqueous buffer solutions of pH 0.85, 5.05 and 13.03

($0.8 \times 10^{-5} \text{M}$) are 89 nm, 385 nm and $24.2 \mu\text{m}$, respectively.

6. Viscosity measurement

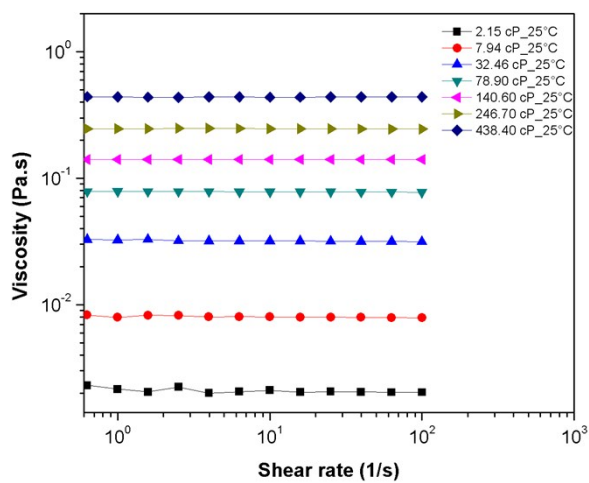


Figure S7 The viscosity of aqueous buffer-glycerol mixtures at $25 \pm 0.5^\circ\text{C}$.

7. Live cell and Fixed cell fluorescent imaging of PIP-TPE in HeLa cells

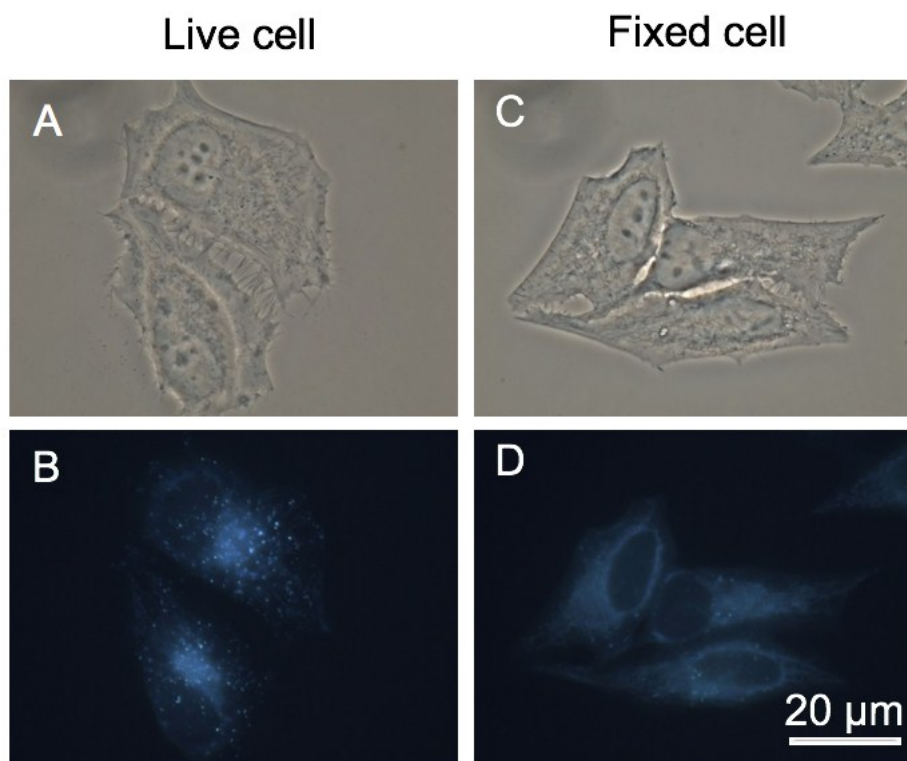


Figure S8 (A and C) Bright field and (B and D) fluorescent images of HeLa cells incubated with 1 μM **PIP-TPE** for 15min then (A-B) without treatment or (C-D) with 2mL 4% PFA (paraformaldehyde) treatment for 15 min. Excitation wavelength: 330-385 nm; Scale bar = 20 μm .

8. MTT of PIP-TPE

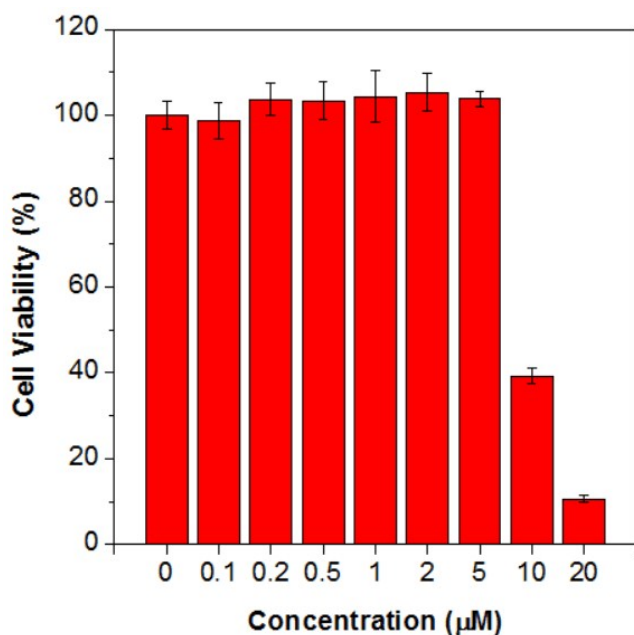


Figure S9 Cell viability of HeLa cells after incubation with different concentrations of **PIP-TPE**.

9. Photostability of PIP-TPE

For the photostability test, the cells were imaged by a confocal microscope (Zeiss Laser Scanning Confocal Microscope; LSM7 DUO) using ZEN 2009 software (Carl Zeiss). **PIP-TPE** was excited at 405 nm (2% laser power) and LysoTracker Red was excited at 560 nm (2% laser power).

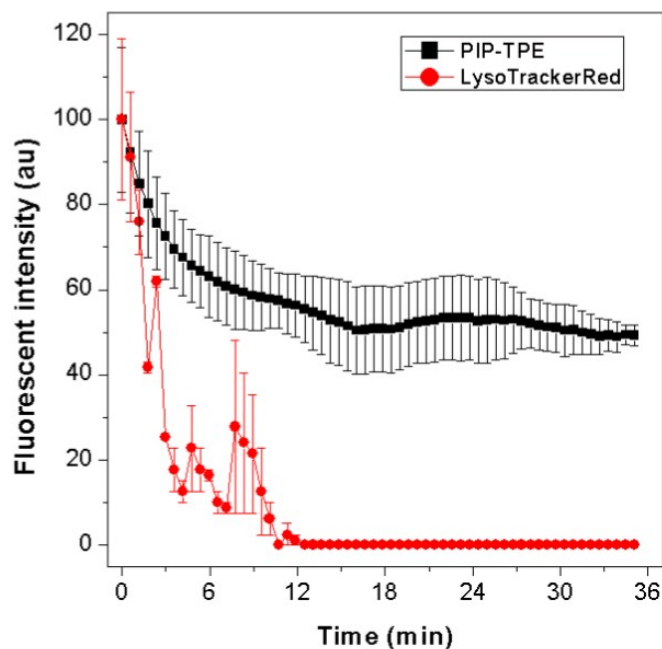


Figure S10 The photostability of **PIP-TPE** and LysoTracker Red

10. Theoretical calculations of **PIP-TPE**, protonated **PIP-TPE** and **PIP-TPE** in bulk

Quantum mechanical calculations for the **PIP-TPE** single molecule in solution were performed at the DFT level of theory using B3LYP functional^[1-4] and 6-31G(d) basis set as implemented in the D0.1 version of the Gaussian 09 software package.^[5] The bulk solvent (water) effect has been modeled using the polarizable continuum model (PCM).^[6] Possible static correlations in the system were modeled using Grimme's density functional empirical dispersion corrections as implemented in the D0.1 version of the Gaussian 09.^[7] The equilibrium solvation method was employed for geometry optimization and vibrational frequency calculations. The solution-phase Hessian of S_0 was evaluated analytically at the DFT level indicated above and had no negative eigenvalues.

The photophysical properties of **PIP-TPE** in the aggregated state were analyzed using ONIOM(QM:MM) approach, an integrated quantum mechanics: molecular mechanics (QM:MM) method.^[8-11] In the two-layer ONIOM calculation the system was divided into two parts, a selected centrally located **PIP-TPE** molecule was treated by a DFT/TD-DFT (QM) method using B3LYP functional^[2-4, 12] while the packing surroundings in the crystal (40 **PIP-TPE** molecules) were treated by a low-level method, molecular mechanics (MM) method, the

Universal Force Field (UFF).^[13] Geometry optimization, vibrational frequency and excited state calculations were performed using the 6-31G(d) basis set as implemented in the D0.1 version of Gaussian 09 software package. The solid-phase Hessian of S_0 was evaluated analytically at the DFT level, while that of S_1 was calculated numerically at the TD-DFT level. The electrostatic interactions in the model were calculated semiclassically incorporating the MM charges into the QM Hamiltonian (electronic embedding).^[11,14] In our QM/MM model we neglect possible intermolecular excitonic couplings and assume that the intramolecular motions dominate the photophysical process.

During the QM/MM simulations, only the central **PIP-TPE** (QM) molecule was active for optimization, while all the surrounding **PIP-TPE** (MM) molecules remained rigid. No symmetry constraints were imposed during the optimizations in both solution and solid phases. The above PCM and QM/MM methods have been shown to be successful in dealing with varieties of AIEgens with both structure and excited-state decay rates.^[15-16]

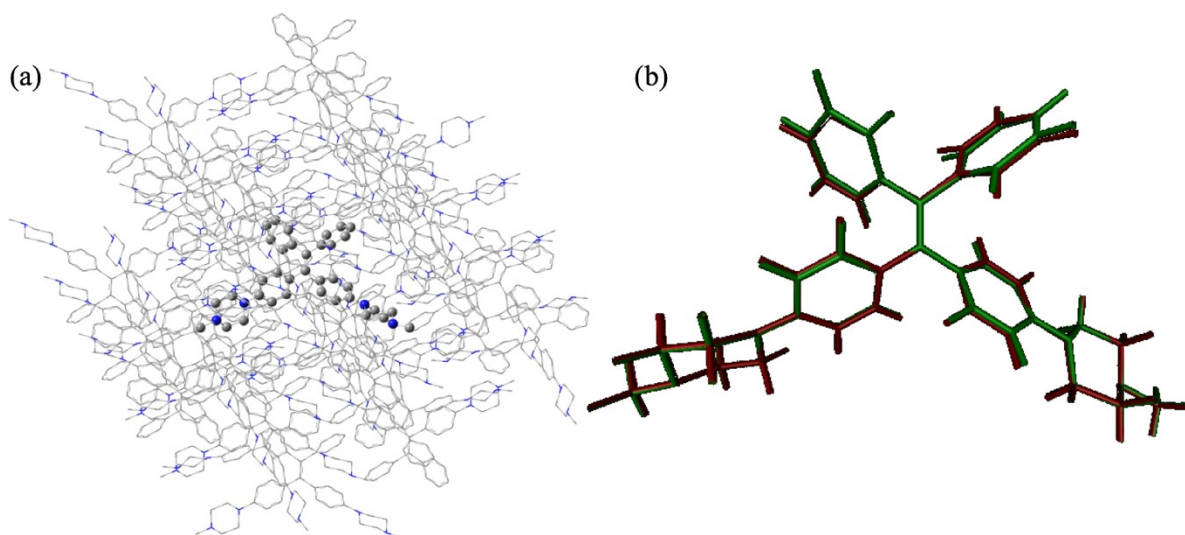


Figure S11 (a) Optimized 40-molecule **PIP-TPE** cluster with **PIP-TPE**_(bulk) molecule in the ground state calculated using ONIOM QM:MM model of with the high-level part of model shown using ball-and-stick representation, and the low-level part of the model using wire representation; (b) overlay of the optimized ground state (S_0) and first excited state (S_1) structures of **PIP-TPE**_(bulk) (green = S_0 ; red = S_1).

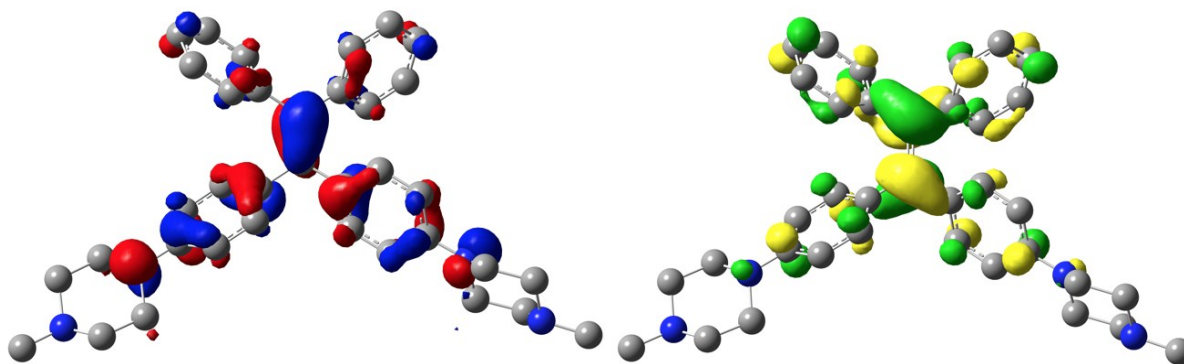


Figure S12 The HOMO (left) and LUMO (right) in **PIP-TPE**. Hydrogen atoms are omitted for clarity. HOMO and LUMO are depicted at *iso* value of 0.04.

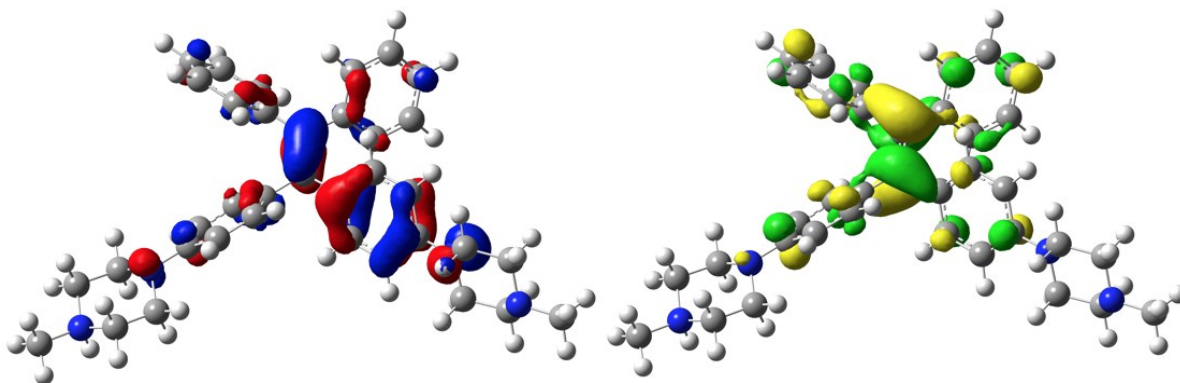


Figure S13 The HOMO (left) and LUMO (right) of **PIP-TPEH⁺_(soln)**; HOMO and LUMO are depicted at *iso* value of 0.04.

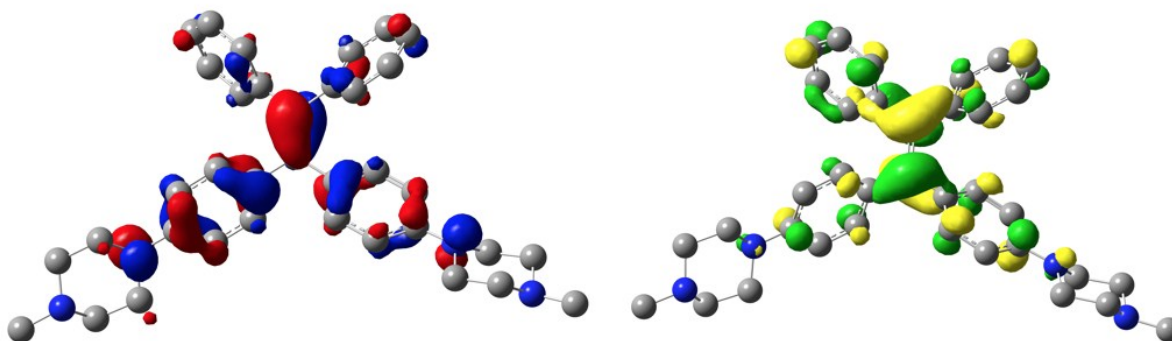


Figure S14 The HOMO (left) and LUMO (right) of **PIP-TPE_(bulk)**; Hydrogen atoms are omitted for clarity; HOMO and LUMO are depicted at *iso* value of 0.04.

Optimized Geometries

(1) S_0 geometry of PIP-TPE:

| | | | |
|---|-----------|-----------|-----------|
| H | 8.553326 | -4.939947 | -0.583412 |
| C | 8.441546 | -4.156319 | 0.174012 |
| H | 8.553326 | -4.939947 | -0.583412 |
| H | 8.738111 | -4.570623 | 1.143887 |
| H | 9.140668 | -3.334923 | -0.076379 |
| N | 7.051193 | -3.721223 | 0.230072 |
| C | 6.846716 | -2.707599 | 1.264005 |
| C | 5.374553 | -2.316616 | 1.346374 |
| N | 4.892658 | -1.828556 | 0.044673 |
| C | 3.672087 | -1.125318 | 0.036358 |
| C | 3.483932 | -0.031768 | 0.910047 |
| C | 2.309771 | 0.706892 | 0.894377 |
| C | 1.261041 | 0.406145 | 0.005610 |
| C | -0.004760 | 1.189077 | -0.003464 |
| C | -0.018872 | 2.556911 | 0.003193 |
| C | 1.199243 | 3.370309 | -0.278158 |
| C | 2.008899 | 3.100925 | -1.395756 |
| H | 1.748290 | 2.272735 | -2.047618 |
| C | 3.135150 | 3.876037 | -1.668507 |
| H | 3.744634 | 3.651835 | -2.540114 |
| C | 3.476018 | 4.941604 | -0.830027 |
| H | 4.354470 | 5.545305 | -1.041287 |
| C | 2.673046 | 5.230187 | 0.276998 |
| H | 2.926803 | 6.058516 | 0.933384 |
| C | 1.541667 | 4.458587 | 0.543421 |
| H | 0.916399 | 4.692071 | 1.400792 |
| C | -1.250934 | 3.345466 | 0.294852 |
| C | -2.052951 | 3.051673 | 1.411873 |
| H | -1.777235 | 2.221207 | 2.054668 |
| C | -3.190711 | 3.805684 | 1.695555 |
| H | -3.794027 | 3.562666 | 2.566421 |
| C | -3.551117 | 4.874334 | 0.869098 |
| H | -4.438546 | 5.461588 | 1.089019 |
| C | -2.755955 | 5.187175 | -0.236873 |
| H | -3.024681 | 6.018110 | -0.883952 |
| C | -1.613107 | 4.436525 | -0.514296 |
| H | -0.994251 | 4.689026 | -1.370958 |
| C | -1.252163 | 0.379281 | -0.018057 |

| | | | |
|---|-----------|-----------|-----------|
| C | -1.401656 | -0.740425 | 0.821281 |
| H | -0.597579 | -1.002971 | 1.503254 |
| C | -2.563251 | -1.499963 | 0.822691 |
| H | -2.651614 | -2.322771 | 1.524927 |
| C | -3.635588 | -1.198418 | -0.046075 |
| C | -3.474027 | -0.098488 | -0.913006 |
| H | -4.245300 | 0.154413 | -1.631064 |
| C | -2.312813 | 0.670171 | -0.887857 |
| H | -2.221972 | 1.511051 | -1.568871 |
| N | -4.818729 | -1.958166 | 0.002377 |
| C | -5.960484 | -1.509545 | -0.792985 |
| H | -5.805736 | -1.707138 | -1.868555 |
| H | -6.087272 | -0.431432 | -0.661513 |
| C | -7.238633 | -2.206476 | -0.328006 |
| H | -7.472130 | -1.874804 | 0.703640 |
| H | -8.068116 | -1.892289 | -0.971906 |
| N | -7.103251 | -3.659892 | -0.403443 |
| C | -8.339867 | -4.332307 | -0.023747 |
| H | -8.216161 | -5.416319 | -0.123113 |
| H | -9.151268 | -4.016327 | -0.688596 |
| H | -8.646079 | -4.115830 | 1.018108 |
| C | -5.979969 | -4.089850 | 0.428038 |
| H | -5.870370 | -5.177273 | 0.343959 |
| H | -6.150549 | -3.850597 | 1.496917 |
| C | -4.687603 | -3.422388 | -0.031993 |
| H | -3.872269 | -3.740094 | 0.618682 |
| H | -4.450487 | -3.757665 | -1.056803 |
| C | 1.441538 | -0.691755 | -0.847609 |
| C | 2.617120 | -1.440787 | -0.842246 |
| H | 2.696321 | -2.285604 | -1.516523 |
| H | 0.643174 | -0.969524 | -1.530537 |
| H | 2.201977 | 1.546788 | 1.573930 |
| H | 4.277232 | 0.253970 | 1.593734 |
| C | 5.121309 | -2.817040 | -1.007973 |
| C | 6.598984 | -3.202592 | -1.059808 |
| H | 6.737225 | -3.977225 | -1.822831 |
| H | 7.190359 | -2.317834 | -1.369918 |
| H | 4.840260 | -2.383915 | -1.972172 |
| H | 4.512722 | -3.725379 | -0.850842 |
| H | 4.783092 | -3.192818 | 1.664914 |
| H | 5.253407 | -1.540458 | 2.103174 |
| H | 7.452675 | -1.800133 | 1.068933 |
| H | 7.162448 | -3.116505 | 2.230820 |

(2) S₀ geometry of PIP-TPEH⁺_(soln):

a. UV-vis calculation:

Excited State 1: Singlet-A 3.2557 eV 380.82 nm f=0.4960 <S**2>=0.000

142 ->143 0.70477

b. Optimized Geometry

| | | | |
|---|-----------|-----------|-----------|
| H | 8.430775 | -5.100743 | -0.582951 |
| C | 8.366107 | -4.284555 | 0.144997 |
| H | 8.430775 | -5.100743 | -0.582951 |
| H | 8.684288 | -4.667993 | 1.120683 |
| H | 9.078285 | -3.494181 | -0.161893 |
| N | 6.990678 | -3.808554 | 0.229075 |
| C | 6.847952 | -2.748994 | 1.226438 |
| C | 5.389325 | -2.318070 | 1.344303 |
| N | 4.870335 | -1.872133 | 0.041598 |
| C | 3.664477 | -1.145249 | 0.045821 |
| C | 3.516133 | -0.026188 | 0.895255 |
| C | 2.356132 | 0.734601 | 0.887010 |
| C | 1.281463 | 0.431941 | 0.030190 |
| C | 0.029691 | 1.235521 | 0.024821 |
| C | 0.026084 | 2.602139 | 0.012252 |
| C | 1.249340 | 3.403646 | -0.280390 |
| C | 2.052776 | 3.117116 | -1.397934 |
| H | 1.784499 | 2.284055 | -2.040442 |
| C | 3.182644 | 3.882655 | -1.682471 |
| H | 3.787562 | 3.646259 | -2.553974 |
| C | 3.533190 | 4.953978 | -0.855388 |
| H | 4.414676 | 5.549911 | -1.075754 |
| C | 2.736577 | 5.258619 | 0.251856 |
| H | 2.998199 | 6.091640 | 0.899059 |
| C | 1.601009 | 4.497231 | 0.529717 |
| H | 0.980001 | 4.743223 | 1.386680 |
| C | -1.202577 | 3.400995 | 0.289387 |
| C | -2.009387 | 3.127376 | 1.407841 |
| H | -1.738120 | 2.307813 | 2.066235 |
| C | -3.145845 | 3.889641 | 1.674936 |
| H | -3.753093 | 3.662940 | 2.547408 |
| C | -3.499296 | 4.945695 | 0.829863 |
| H | -4.385499 | 5.539430 | 1.036836 |
| C | -2.698877 | 5.238431 | -0.277999 |
| H | -2.962506 | 6.059752 | -0.939205 |
| C | -1.557376 | 4.480141 | -0.538810 |
| H | -0.934127 | 4.716645 | -1.396784 |

| | | | |
|---|-----------|-----------|-----------|
| C | -1.229763 | 0.440210 | 0.025277 |
| C | -1.407516 | -0.634139 | 0.915473 |
| H | -0.625058 | -0.864851 | 1.632756 |
| C | -2.574237 | -1.386935 | 0.917829 |
| H | -2.696987 | -2.174276 | 1.655514 |
| C | -3.604643 | -1.125027 | -0.005848 |
| C | -3.423606 | -0.069383 | -0.915011 |
| H | -4.173211 | 0.153011 | -1.665937 |
| C | -2.261087 | 0.699625 | -0.887100 |
| H | -2.145778 | 1.510923 | -1.599209 |
| N | -4.786441 | -1.910546 | 0.031843 |
| C | -5.917992 | -1.465603 | -0.772626 |
| H | -5.762457 | -1.638571 | -1.852378 |
| H | -6.071693 | -0.393338 | -0.629503 |
| C | -7.198424 | -2.158061 | -0.318793 |
| H | -7.430160 | -1.917192 | 0.720543 |
| H | -8.040879 | -1.884155 | -0.955818 |
| N | -7.049511 | -3.661432 | -0.385266 |
| C | -8.300950 | -4.373809 | 0.037312 |
| H | -8.145122 | -5.446596 | -0.078271 |
| H | -9.121034 | -4.038611 | -0.598105 |
| H | -8.501252 | -4.127640 | 1.080233 |
| C | -5.841823 | -4.097803 | 0.413283 |
| H | -5.736720 | -5.176683 | 0.289093 |
| H | -6.059096 | -3.865451 | 1.457831 |
| C | -4.602114 | -3.361073 | -0.072973 |
| H | -3.766341 | -3.684184 | 0.547487 |
| H | -4.371707 | -3.660302 | -1.111032 |
| H | -6.873001 | -3.910146 | -1.365899 |
| C | 1.422017 | -0.691176 | -0.797784 |
| C | 2.582555 | -1.462552 | -0.799218 |
| H | 2.628522 | -2.325726 | -1.452737 |
| H | 0.603817 | -0.971663 | -1.455622 |
| H | 2.280345 | 1.592527 | 1.548006 |
| H | 4.328878 | 0.262308 | 1.554294 |
| C | 5.043420 | -2.903722 | -0.980254 |
| C | 6.508589 | -3.328583 | -1.064627 |
| H | 6.601642 | -4.135124 | -1.800939 |
| H | 7.111178 | -2.472267 | -1.428364 |
| H | 4.743139 | -2.498808 | -1.950835 |
| H | 4.417887 | -3.789756 | -0.771343 |
| H | 4.789483 | -3.164882 | 1.720913 |
| H | 5.315403 | -1.508729 | 2.071741 |
| H | 7.468135 | -1.865818 | 0.973150 |
| H | 7.187892 | -3.125943 | 2.197975 |

(3) S₁ geometry of PIP-TPEH⁺_(soln):

| | | | |
|---|-----------|-----------|-----------|
| H | 9.114386 | -4.463417 | -0.073077 |
| C | 9.030758 | -3.415189 | 0.233603 |
| H | 9.114386 | -4.463417 | -0.073077 |
| H | 9.639233 | -3.269667 | 1.132707 |
| H | 9.453397 | -2.786040 | -0.573175 |
| N | 7.637715 | -3.099628 | 0.528635 |
| C | 7.483700 | -1.721453 | 0.989539 |
| C | 6.033477 | -1.447648 | 1.374379 |
| N | 5.125890 | -1.724884 | 0.251735 |
| C | 3.873108 | -1.126990 | 0.215000 |
| C | 3.699270 | 0.229339 | 0.602308 |
| C | 2.471022 | 0.849055 | 0.523085 |
| C | 1.294696 | 0.168521 | 0.085319 |
| C | 0.037681 | 0.858046 | 0.008560 |
| C | 0.041001 | 2.342353 | -0.029324 |
| C | 0.674387 | 2.992084 | -1.150966 |
| C | 0.898003 | 2.278151 | -2.365940 |
| H | 0.537084 | 1.257399 | -2.444702 |
| C | 1.537687 | 2.865443 | -3.449620 |
| H | 1.672824 | 2.292489 | -4.363925 |
| C | 2.009430 | 4.182397 | -3.373894 |
| H | 2.516916 | 4.637048 | -4.219989 |
| C | 1.832800 | 4.897977 | -2.181038 |
| H | 2.220532 | 5.910185 | -2.094043 |
| C | 1.184900 | 4.323708 | -1.095890 |
| H | 1.107382 | 4.883532 | -0.170159 |
| C | -0.611182 | 3.047167 | 1.051825 |
| C | -0.774304 | 2.423425 | 2.322668 |
| H | -0.360383 | 1.430596 | 2.472565 |
| C | -1.424155 | 3.062128 | 3.370161 |
| H | -1.511996 | 2.559083 | 4.330197 |
| C | -1.966464 | 4.343513 | 3.199672 |
| H | -2.481972 | 4.838302 | 4.017959 |
| C | -1.849884 | 4.967617 | 1.950972 |
| H | -2.292238 | 5.948109 | 1.791317 |
| C | -1.191494 | 4.339949 | 0.900505 |
| H | -1.160429 | 4.825417 | -0.069122 |
| C | -1.243532 | 0.189538 | -0.034783 |
| C | -1.484038 | -1.088651 | 0.547168 |
| H | -0.683363 | -1.590416 | 1.079829 |
| C | -2.734744 | -1.677636 | 0.526426 |
| H | -2.879326 | -2.627273 | 1.033434 |
| C | -3.835264 | -1.042828 | -0.090006 |

| | | | |
|---|-----------|-----------|-----------|
| C | -3.624934 | 0.233900 | -0.647625 |
| H | -4.433778 | 0.762968 | -1.139421 |
| C | -2.375568 | 0.834353 | -0.600324 |
| H | -2.248333 | 1.816883 | -1.043915 |
| N | -5.099204 | -1.676645 | -0.077558 |
| C | -6.260573 | -0.891646 | -0.476792 |
| H | -6.303432 | -0.729949 | -1.568161 |
| H | -6.222373 | 0.089991 | 0.001225 |
| C | -7.544803 | -1.562469 | -0.001570 |
| H | -7.568888 | -1.640107 | 1.086973 |
| H | -8.423894 | -1.018321 | -0.350101 |
| N | -7.642455 | -2.974026 | -0.534087 |
| C | -8.904132 | -3.660967 | -0.098799 |
| H | -8.934976 | -4.648616 | -0.558780 |
| H | -9.755509 | -3.063312 | -0.424473 |
| H | -8.892572 | -3.748230 | 0.987819 |
| C | -6.406984 | -3.759068 | -0.152791 |
| H | -6.491525 | -4.746589 | -0.609729 |
| H | -6.422210 | -3.852727 | 0.934888 |
| C | -5.156079 | -3.034368 | -0.627925 |
| H | -4.295320 | -3.614776 | -0.294982 |
| H | -5.128402 | -3.014708 | -1.731620 |
| H | -7.664797 | -2.914799 | -1.559259 |
| C | 1.488780 | -1.182224 | -0.324358 |
| C | 2.722549 | -1.804082 | -0.265276 |
| H | 2.790046 | -2.836007 | -0.588308 |
| H | 0.653753 | -1.740601 | -0.732581 |
| H | 2.388095 | 1.891320 | 0.814710 |
| H | 4.552106 | 0.811698 | 0.933166 |
| C | 5.310548 | -3.070231 | -0.293006 |
| C | 6.780412 | -3.318062 | -0.633693 |
| H | 6.889841 | -4.355279 | -0.969948 |
| H | 7.068348 | -2.660812 | -1.478484 |
| H | 4.728732 | -3.170333 | -1.211539 |
| H | 4.960493 | -3.833207 | 0.421910 |
| H | 5.757968 | -2.085898 | 2.230143 |
| H | 5.938160 | -0.409383 | 1.689588 |
| H | 7.798775 | -0.994068 | 0.214907 |
| H | 8.117577 | -1.565113 | 1.869661 |

(4) **S₀ geometry of PIP-TPE_(bulk):**

| | | | |
|---|----------|-----------|-----------|
| C | 2.255700 | -4.413300 | 11.498100 |
|---|----------|-----------|-----------|

| | | | |
|---|-----------|------------|-----------|
| C | 3.597200 | -4.683500 | 11.414200 |
| C | 1.751200 | -3.074300 | 11.916000 |
| C | 2.340800 | -2.373600 | 12.983800 |
| C | 1.955600 | -1.092000 | 13.336200 |
| C | 0.934800 | -0.421700 | 12.627100 |
| C | 0.272600 | -1.157500 | 11.626800 |
| C | 0.675500 | -2.444400 | 11.273300 |
| C | 1.223900 | -5.429500 | 11.146800 |
| C | 0.092800 | -5.660700 | 11.950800 |
| C | -0.865900 | -6.610700 | 11.619600 |
| C | -0.758100 | -7.378000 | 10.436100 |
| C | 0.349400 | -7.110000 | 9.602400 |
| C | 1.311500 | -6.173300 | 9.961400 |
| C | -0.361900 | 4.961000 | 13.799800 |
| C | 0.630400 | 1.381100 | 14.264100 |
| C | 0.770400 | 2.894600 | 14.352000 |
| C | -0.273400 | 3.125400 | 12.226200 |
| C | -0.373900 | 1.604700 | 12.080800 |
| C | -4.760100 | -11.020100 | 8.746400 |
| C | -1.562700 | -9.042400 | 8.824300 |
| C | -2.454300 | -10.277000 | 8.743600 |
| C | -3.933700 | -9.420100 | 10.356900 |
| C | -3.088600 | -8.161500 | 10.528800 |
| C | 4.652900 | -3.626400 | 11.486600 |
| C | 4.610600 | -2.486100 | 10.666600 |
| C | 5.584200 | -1.494100 | 10.767000 |
| C | 6.618200 | -1.620200 | 11.695700 |
| C | 6.701300 | -2.766200 | 12.486300 |
| C | 5.738500 | -3.767200 | 12.370900 |
| C | 4.148300 | -6.065200 | 11.270600 |
| C | 3.816000 | -7.084000 | 12.179500 |
| C | 4.406700 | -8.342800 | 12.084700 |
| C | 5.324700 | -8.614400 | 11.068700 |
| C | 5.675600 | -7.610500 | 10.166700 |
| C | 5.103500 | -6.345200 | 10.276800 |
| N | 0.641600 | 0.926800 | 12.877200 |
| N | -0.338200 | 3.517400 | 13.632900 |
| N | -1.697100 | -8.371900 | 10.115900 |
| N | -3.840600 | -9.917600 | 8.993300 |
| H | 3.141300 | -2.844400 | 13.535900 |
| H | 2.483300 | -0.604600 | 14.147400 |
| H | -0.569900 | -0.709300 | 11.122600 |
| H | 0.156300 | -2.958200 | 10.469500 |
| H | -0.037400 | -5.093000 | 12.866500 |
| H | -1.692800 | -6.761600 | 12.303400 |
| H | 0.467700 | -7.617900 | 8.655400 |

| | | | |
|---|-----------|------------|-----------|
| H | 2.145400 | -5.997900 | 9.290300 |
| H | -1.237400 | 5.376900 | 13.291900 |
| H | -0.434500 | 5.208700 | 14.864200 |
| H | 0.544400 | 5.454200 | 13.398900 |
| H | -0.324000 | 1.086800 | 14.724300 |
| H | 1.435600 | 0.902000 | 14.812600 |
| H | 1.755500 | 3.197000 | 13.948400 |
| H | 0.741100 | 3.204100 | 15.402300 |
| H | -1.111900 | 3.584300 | 11.689200 |
| H | 0.663800 | 3.472400 | 11.750800 |
| H | -0.242100 | 1.347400 | 11.027300 |
| H | -1.385400 | 1.294600 | 12.389400 |
| H | -5.784300 | -10.639500 | 8.796400 |
| H | -4.600900 | -11.408300 | 7.736400 |
| H | -4.651900 | -11.855300 | 9.460900 |
| H | -1.809200 | -8.361100 | 7.990000 |
| H | -0.525600 | -9.358400 | 8.698700 |
| H | -2.089200 | -11.046600 | 9.447900 |
| H | -2.394000 | -10.695800 | 7.740200 |
| H | -4.975800 | -9.165100 | 10.571600 |
| H | -3.613400 | -10.191100 | 11.082000 |
| H | -3.113900 | -7.866700 | 11.576900 |
| H | -3.550500 | -7.350200 | 9.945200 |
| H | 3.793800 | -2.376300 | 9.960400 |
| H | 5.529000 | -0.614800 | 10.133000 |
| H | 7.357900 | -0.837400 | 11.805800 |
| H | 7.512400 | -2.862900 | 13.201800 |
| H | 5.807000 | -4.658300 | 12.988800 |
| H | 3.102600 | -6.875000 | 12.970300 |
| H | 4.176300 | -9.104800 | 12.823600 |
| H | 5.794600 | -9.590700 | 11.001200 |
| H | 6.394700 | -7.819200 | 9.382300 |
| H | 5.389400 | -5.558400 | 9.584900 |

(5) S₁ of PIP-TPE_(bulk).

a. PL calculation:

Excited State 1: Singlet 2.6320 eV 471.07 nm f=0.4194 <S**2>=0.000

142 ->143 -0.70627

b. Optimized geometry:

| | | | |
|---|-----------|------------|-----------|
| C | 2.246700 | -4.406100 | 11.486300 |
| C | 3.659300 | -4.675500 | 11.368000 |
| C | 1.760300 | -3.111500 | 11.952900 |
| C | 2.434800 | -2.343900 | 12.943100 |
| C | 2.044100 | -1.064400 | 13.286400 |
| C | 0.956400 | -0.430600 | 12.643600 |
| C | 0.241200 | -1.200100 | 11.700000 |
| C | 0.627400 | -2.488700 | 11.365400 |
| C | 1.248800 | -5.406000 | 11.110700 |
| C | 0.036600 | -5.551100 | 11.839400 |
| C | -0.923800 | -6.488500 | 11.509400 |
| C | -0.755100 | -7.355200 | 10.394200 |
| C | 0.438600 | -7.202100 | 9.645600 |
| C | 1.408500 | -6.284600 | 10.007800 |
| C | -0.350400 | 4.952400 | 13.797000 |
| C | 0.656100 | 1.377700 | 14.269100 |
| C | 0.790300 | 2.891800 | 14.354000 |
| C | -0.268700 | 3.109900 | 12.231100 |
| C | -0.366600 | 1.587800 | 12.094400 |
| C | -4.770000 | -11.003200 | 8.748100 |
| C | -1.558200 | -9.051200 | 8.805400 |
| C | -2.457100 | -10.281400 | 8.749800 |
| C | -3.924300 | -9.413400 | 10.358400 |
| C | -3.083900 | -8.151100 | 10.531400 |
| C | 4.652600 | -3.600000 | 11.346100 |
| C | 4.488100 | -2.395100 | 10.619000 |
| C | 5.427100 | -1.373900 | 10.704200 |
| C | 6.520100 | -1.487600 | 11.567800 |
| C | 6.717000 | -2.673600 | 12.284800 |
| C | 5.816100 | -3.719900 | 12.156700 |
| C | 4.208700 | -6.022300 | 11.307300 |
| C | 3.731100 | -7.114900 | 12.080600 |
| C | 4.325000 | -8.368300 | 11.973100 |
| C | 5.343600 | -8.608200 | 11.046400 |
| C | 5.807700 | -7.553300 | 10.247100 |
| C | 5.269500 | -6.286800 | 10.391400 |
| N | 0.660100 | 0.920700 | 12.883500 |
| N | -0.323900 | 3.508100 | 13.636700 |
| N | -1.703500 | -8.322300 | 10.066900 |
| N | -3.839800 | -9.908000 | 8.994300 |
| H | 3.285000 | -2.782700 | 13.445200 |
| H | 2.622300 | -0.535400 | 14.036200 |
| H | -0.622100 | -0.765400 | 11.216700 |
| H | 0.076500 | -3.017700 | 10.594500 |
| H | -0.129700 | -4.920700 | 12.706400 |
| H | -1.799700 | -6.563600 | 12.141200 |

| | | | |
|---|-----------|------------|-----------|
| H | 0.609800 | -7.791200 | 8.757000 |
| H | 2.297900 | -6.191400 | 9.397100 |
| H | -1.229300 | 5.364200 | 13.291400 |
| H | -0.418400 | 5.204800 | 14.860700 |
| H | 0.552600 | 5.446500 | 13.389400 |
| H | -0.296100 | 1.080400 | 14.733000 |
| H | 1.463800 | 0.895100 | 14.811700 |
| H | 1.772600 | 3.198200 | 13.947000 |
| H | 0.761600 | 3.203600 | 15.403700 |
| H | -1.112800 | 3.564700 | 11.699100 |
| H | 0.663700 | 3.456900 | 11.746600 |
| H | -0.246400 | 1.321200 | 11.041500 |
| H | -1.374500 | 1.278100 | 12.417000 |
| H | -5.790300 | -10.613000 | 8.797800 |
| H | -4.613800 | -11.393300 | 7.738500 |
| H | -4.668100 | -11.838100 | 9.463600 |
| H | -1.786900 | -8.392400 | 7.950500 |
| H | -0.523000 | -9.378200 | 8.704900 |
| H | -2.097400 | -11.042100 | 9.466300 |
| H | -2.396700 | -10.717000 | 7.753700 |
| H | -4.964100 | -9.158000 | 10.582300 |
| H | -3.599700 | -10.186000 | 11.079900 |
| H | -3.076300 | -7.885600 | 11.588100 |
| H | -3.570300 | -7.328200 | 9.987300 |
| H | 3.624900 | -2.291600 | 9.970800 |
| H | 5.302400 | -0.473800 | 10.110100 |
| H | 7.209100 | -0.663400 | 11.695800 |
| H | 7.565500 | -2.758800 | 12.958300 |
| H | 5.956300 | -4.630200 | 12.731500 |
| H | 2.950300 | -6.941200 | 12.814100 |
| H | 4.025900 | -9.164800 | 12.646400 |
| H | 5.796900 | -9.590900 | 10.968700 |
| H | 6.585400 | -7.730500 | 9.511800 |
| H | 5.627800 | -5.473700 | 9.768300 |

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