Supporting Information

Electrochemically controllable emission and coloration using a modified electrode with a layered clay compound containing viologen molecule and Europium(III) complex

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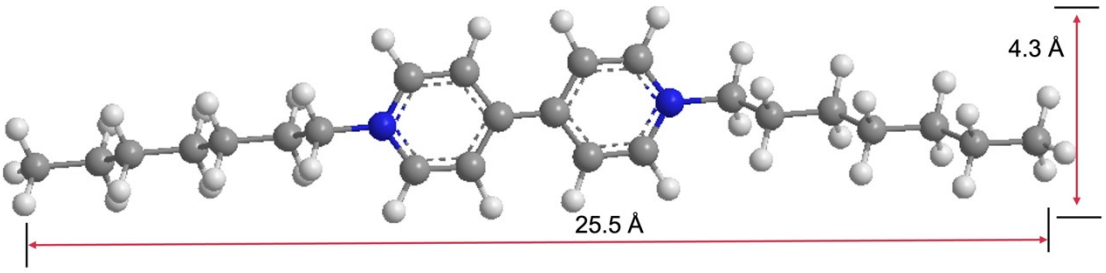
(a)



(b)

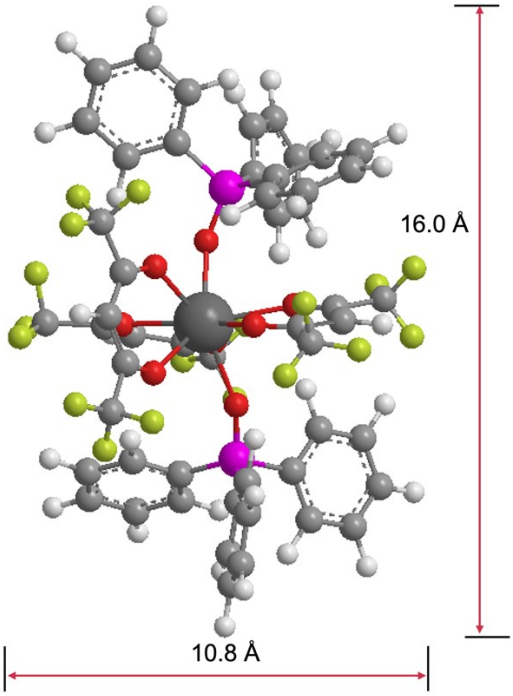


Fig.S1 (a) Chemical structure diagram of HV^{2+} molecules obtained using MM3 calculation in Chem 3D application. Interatomic distances of the HV^{2+} molecules ranging from approximately 0.43 nm to 2.55 nm. (b) Molecular structure diagram of $Eu(hfa)_3(TPPO)_2$ complex drawn using single crystal X-ray measurement data from ref [52] in main text. Interatomic distances of the $Eu(hfa)_3(TPPO)_2$ complex ranging from approximately 1.08 nm to 1.6 nm.

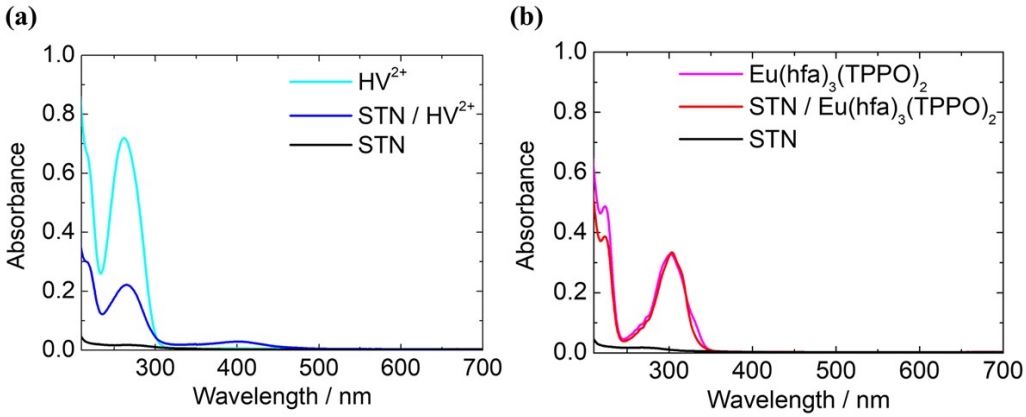


Fig.S2 (a) Absorption spectra of the HV^{2+} solution, STN/HV^{2+} solution, and STN solution; (b) Absorption spectra of $Eu(hfa)_3(TPPO)_2$ solution, STN/$Eu(hfa)_3(TPPO)_2$ solution, and STN solution.

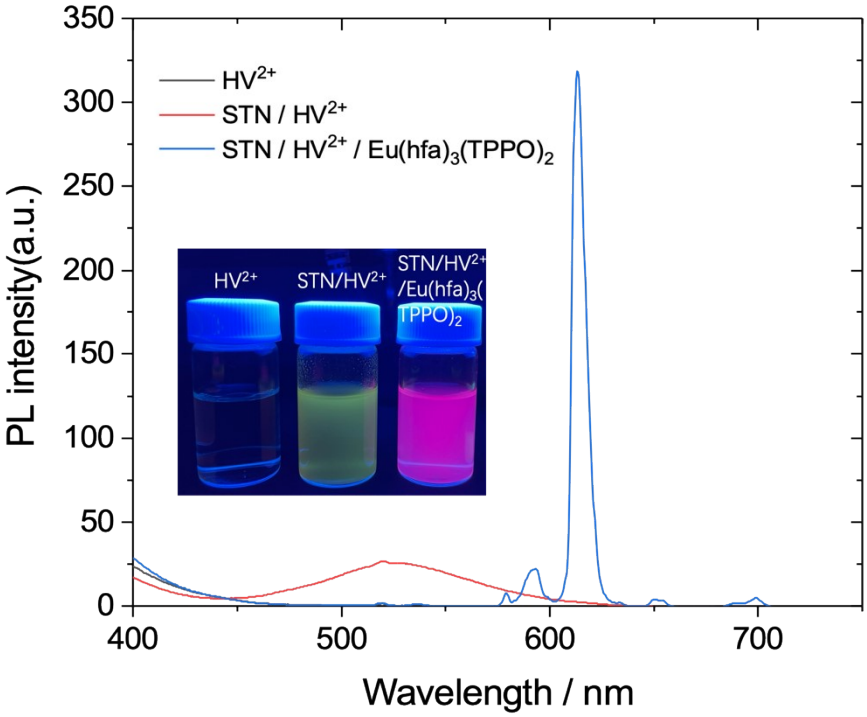


Fig.S3. Emission spectra of HV^{2+}, STN/HV^{2+} and $STN/HV^{2+}/Eu(hfa)_3(TPPO)_2$ solutions with excitation wavelength of 260 nm. Inset: photographs of the solutions under UV irradiation.

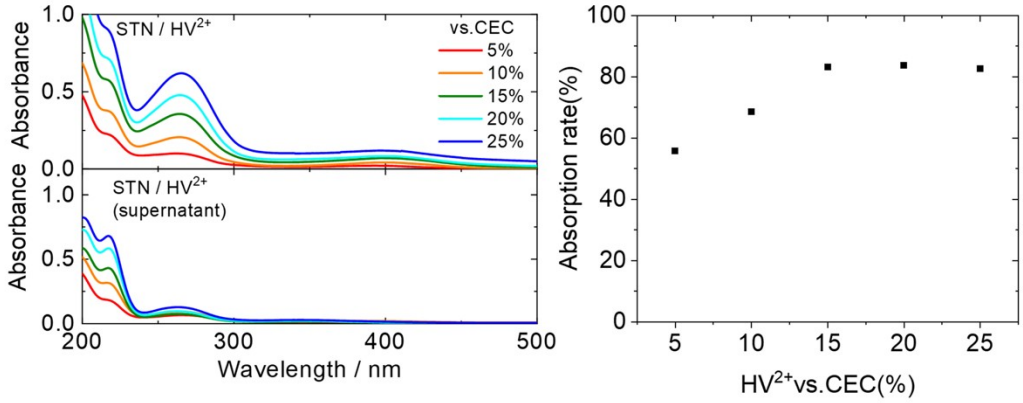


Fig.S4. Absorption spectra of the STN/HV^{2+} hybrid solutions and supernatants (left); (b) Adsorption ratios of HV^{2+} at different ratios (right).

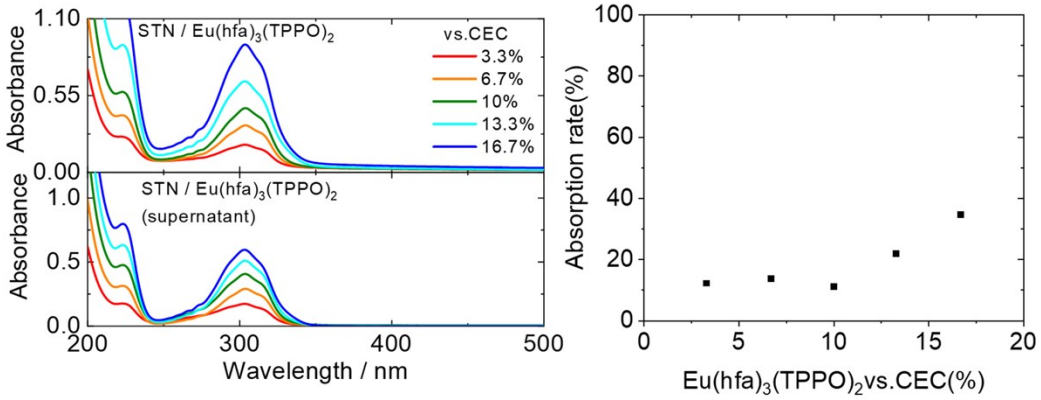


Fig.S5. Absorption spectra of the STN/$Eu(hfa)_3(TPPO)_2$ hybrid solutions and supernatants (left); (b) Adsorption ratios of $Eu(hfa)_3(TPPO)_2$ at different ratios (right).

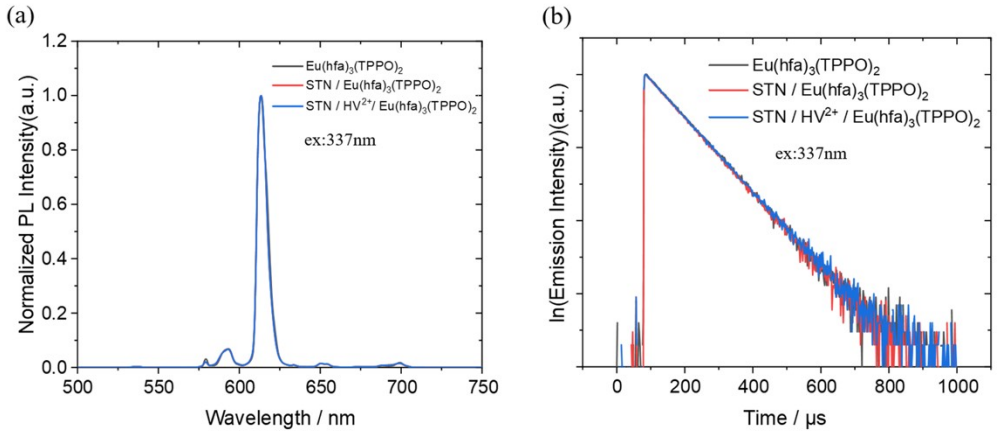


Fig.S6 (a) Normalized emission spectra of $Eu(hfa)_3(TPPO)_2$, $STN/Eu(hfa)_3(TPPO)_2$ and $STN/HV^{2+}/Eu(hfa)_3(TPPO)_2$ in the solution. (b) Emission decay curves of $Eu(hfa)_3(TPPO)_2$, $STN/Eu(hfa)_3(TPPO)_2$ and $STN/HV^{2+}/Eu(hfa)_3(TPPO)_2$ in the solution at 613 nm ($^5D_0 \rightarrow {}^7F_2$). Excitation wavelength was 337 nm.

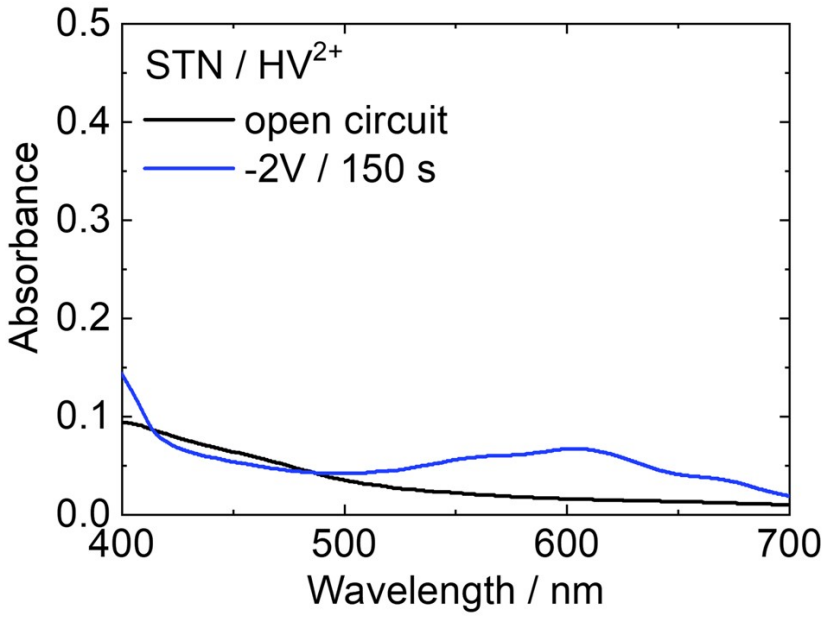


Fig.S7. (a) Absorption spectra of the STN/HV^{2+} film under open circuit condition (black line) and applied -2.0 V for 150 s (blue line)

The donor-acceptor distance is expressed using the following equations.

$$r_{DA} = \left(\sqrt[6]{\frac{1}{E} - 1}\right) \times R_0$$

Here, R_{DA} is the donor–acceptor distance, E is the energy transfer efficiency, and R_0 is the Förster distance. The Förster distance is expressed as follows.

$$R_0^6 = \frac{9\Phi_0(ln10)k^2J}{128\pi^5 n^4 N_A}$$

where Φ_0 is the quantum yield of the donor, κ^2 is the dipole orientation factor (2/3), J is the overlap integral, n is the refractive index of the solvent, and N_A is the Avogadro's constant.
The overlap integral of the absorption spectrum of the electrochromic (EC) material and the emission spectrum of the luminescent material is expressed as follows.

$$J = \int f_D(\lambda)\varepsilon_A(\lambda)\lambda^4 d\lambda$$

where J is the overlap integral ($M^{-1}cm^3$), f_D is the normalized emission spectrum of the luminescent material, and ε_A is the molar extinction coefficient ($Lmol^{-1}cm^{-1}$) of each EC material.