Electronic Supplementary Information (ESI)

Al$^{3+}$-induced far-red fluorescence enhancement of conjugated polymer nanoparticles and its applications in intracellular Al$^{3+}$ ion sensing

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Figure S1: Typical Fourier transform infrared (FT-IR) spectrum of the as-prepared PCzDCN/PST-SO$_3$H NPs recorded using Bruker Vertex80 spectrometer.

This FT-IR spectrum was acquired from a thin layer of PCzDCN/PST-SO$_3$H NPs aqueous dispersion sample between two silicon wafers using Bruker Vertex80 spectrometer. The broad absorption band in the range of 3200-3600 cm$^{-1}$ can be attributable to O-H bonds of H$_2$O. The characteristic absorption peak at 2139 cm$^{-1}$
belongs to the –CN component of the far-red fluorescent conjugated polymer PCzDCN and the peaks at 1648, 1466, 1109, and 1043 cm\(^{-1}\) arise from the –SO\(_3\)H component of the amphiphilic polymer PST-SO\(_3\)H as discussed in the main text.

**Figure S2:** Typical transmission electron microscope (TEM) image of the as-prepared PCzDCN/PST-SO\(_3\)H NPs using Tecnai G\(^2\) 20 S-TWIN TEM.

The NPs sample for TEM characterization was prepared by placing a drop of the as-prepared PCzDCN/PST-SO\(_3\)H NPs aqueous dispersion on a carbon-coated Cu grid, followed by solvent evaporation at room temperature. TEM measurement results of the as-prepared NPs are roughly in accordance with the AFM characterization results as shown in the main text. However, TEM measurements presented a relatively smaller average diameter when compared to the hydrodynamic diameter obtained from DLS, probably attributable to the hydrodynamic swelling effect as the DLS measurement was carried out with the NPs suspended in an aqueous environment while the TEM measurement was made with dry NPs under high vacuum conditions.
**Figure S3:** $\text{Al}^{3+}$-induced fluorescence enhancement of PCzDCN/PST-SO$_3$H NPs as a function of the ratio of sulfonated styrene units (ST-SO$_3$H) to the fluorescent polymer (PCzDCN) in the as-prepared NPs.

The ratio of sulfonated styrene units to the fluorescent polymer (ST-SO$_3$H/PCzDCN) in the complex PCzDCN/PST-SO$_3$H NPs was found to exert significant influence on the $\text{Al}^{3+}$-induced fluorescence enhancement. As discussed in main text, the fluorescence emission of the neat PCzDCN NPs (without PST-SO$_3$H component) was confirmed nearly independent of $\text{Al}^{3+}$. Upon adding the ST-SO$_3$H component into the NPs, $\text{Al}^{3+}$-dependent fluorescence emission was clearly observed. Additionally, by gradually increasing the content of PST-SO$_3$H component in the complex NPs, the extent of $\text{Al}^{3+}$-induced fluorescence enhancement was found augment accordingly, as shown in Figure S3. Specifically, the extent of fluorescence enhancement was found peak when the mass ratio of ST-SO$_3$H to PCzDCN in the as-prepared complex NPs reached 3.5:1 and further increase in the content of ST-SO$_3$H component resulted in obvious decrease in the extent of fluorescence enhancement. For the complex NPs in the present work, it is hypothesized that the hydrophilic ST-SO$_3$H units reside on the surfaces of the NPs and provides coordination sites for metal ions, which was demonstrated indispensable for $\text{Al}^{3+}$ chelating and sensing as discussed in main text. Additionally, the hydrophobic alkyl main chains of PST-SO$_3$H entwine with PCzDCN’s main chains due to hydrophobic interactions in aqueous media. As a result, PST-SO$_3$H could disrupt polymer-polymer interactions of PCzDCN component and therefore reduce aggregation-induced fluorescence quenching within the as-prepared NPs.
Figure S4: Time-lapsed intracellular fluorescence images of Vero cells with internalized PCzDCN/PST-SO$_3$H NPs in Dulbecco’s Modified Eagle medium (DMEM) containing 170 µM Al$^{3+}$. 
**Figure S5:** Time-lapsed intracellular fluorescence images of Vero cells with internalized PCzDCN/PST-SO$_3$H NPs in Al$^{3+}$-free Dulbecco’s Modified Eagle medium (DMEM) buffer.