Supporting Information for

Ionic Liquid-based Dual-Mode Nano-optode for Ultra-Sensitive Detection of Perchlorate Ions

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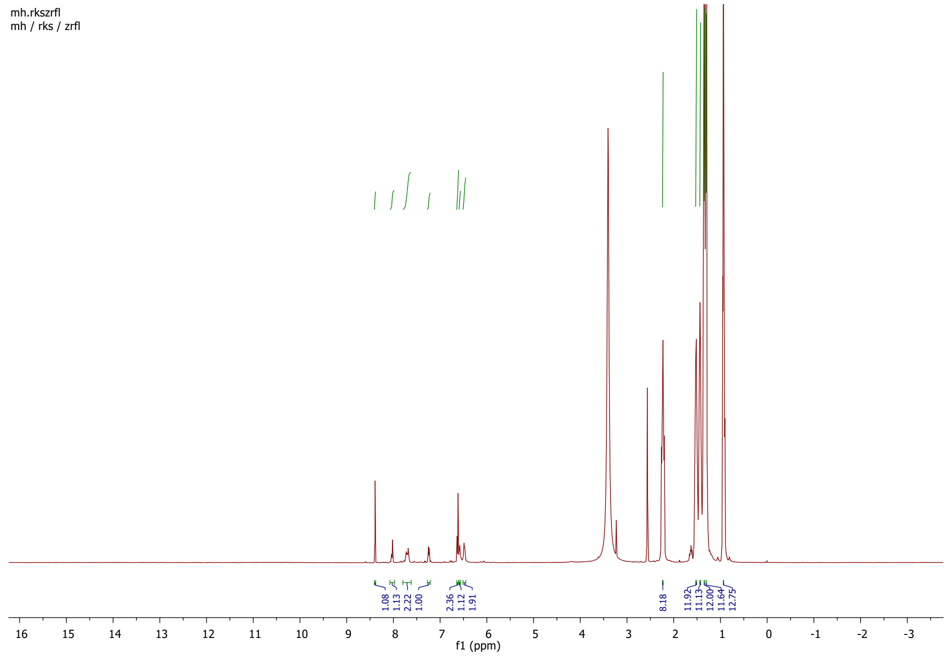

Fig. S1. ^{1}H NMR spectrum (DMSO, 400 MHz) of **XBIL**

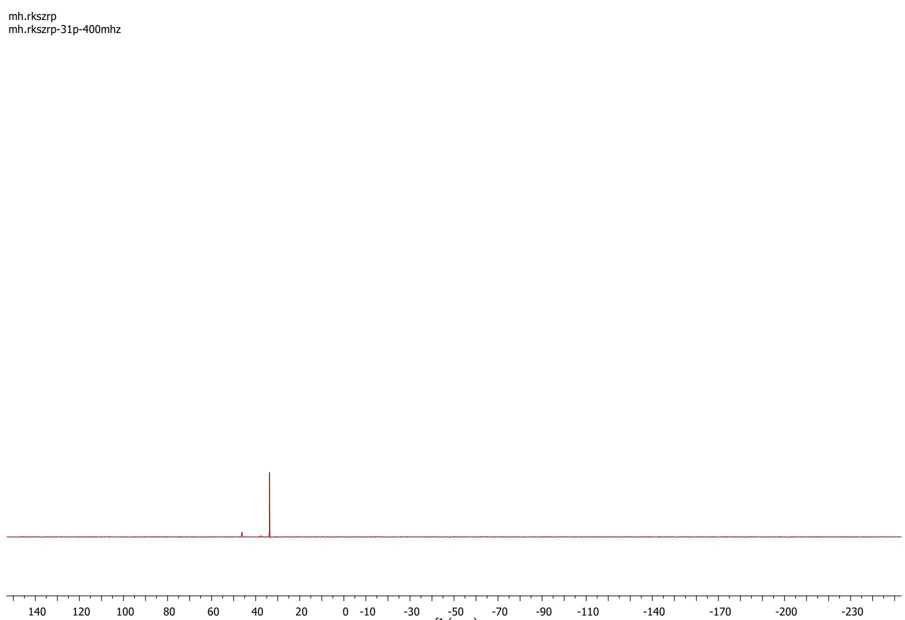

Fig. S2. ^{31}P NMR spectrum (DMSO, 400 MHz) of **XBIL**.

^{1}H NMR (400 MHz, DMSO): 8.392 (s, 1H), 8.035-8.020 (d,1H), 7.762-7.683 (m, 2H), 7.250-7.235 (d, 1H), 6.634-6.616 (d, 2H), 6.580 (s, 1H), 6.489-6.474 (d, 2H), 2.235(m, 8H), 1.516

(m,12H), 1.437(m, 11H),1.344 (m, 12H), 1.303 (m, 12H), 0.937 (m, 13H) ^{31}**P NMR** (400 MHz, DMSO, δ (ppm): 34.39

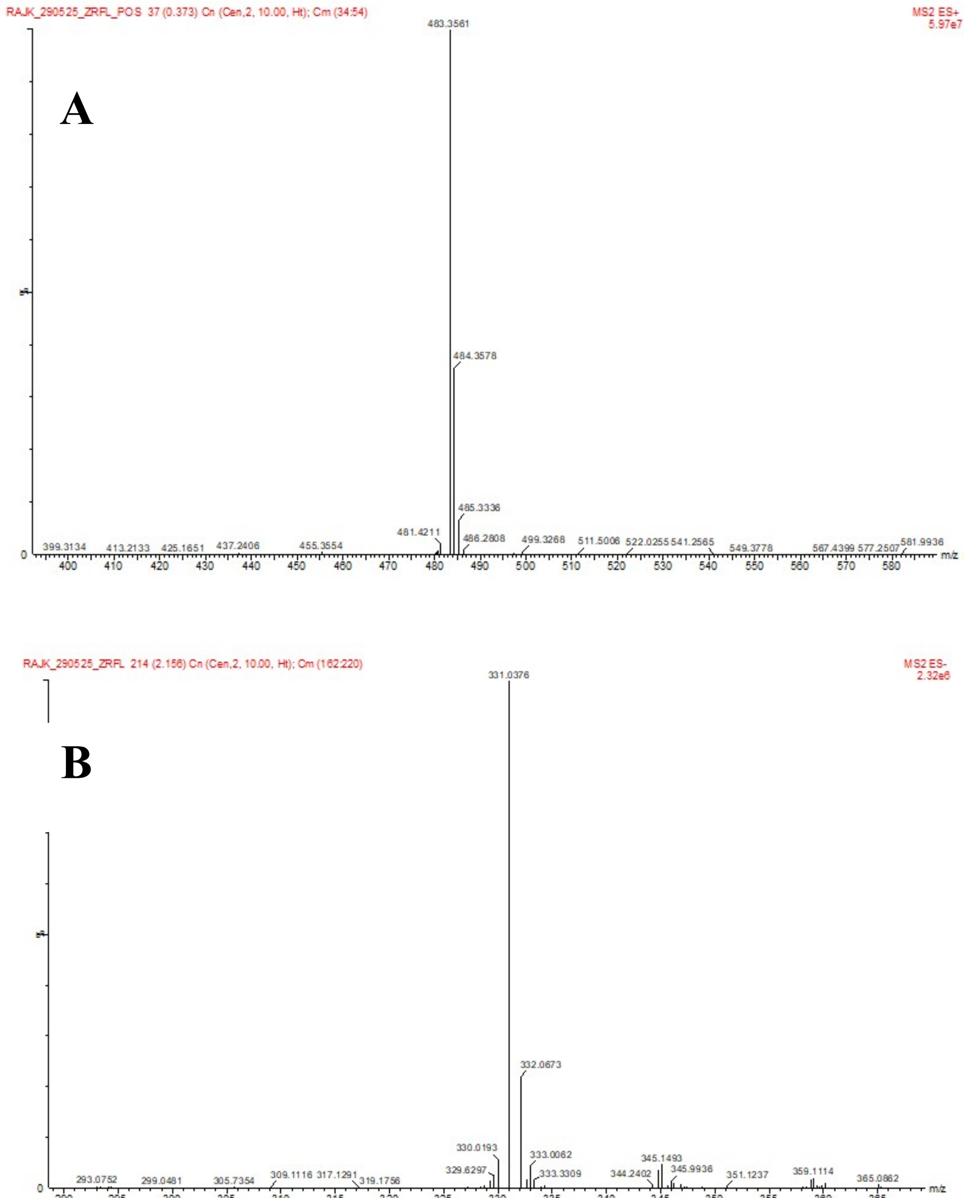

Figure. S3. LC-MS spectra of **XBIL**; **(A)** positive ion mode and **(B)** negative ion mode.

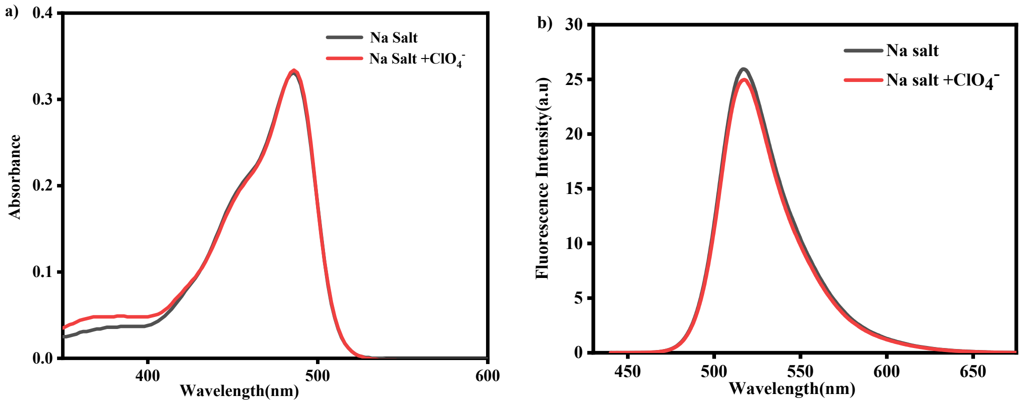

Fig. S4. Comparative analysis of the parent moiety and its complex upon the addition of ClO_4^- by (a) spectrophotometric, (b) Fluorometric method.

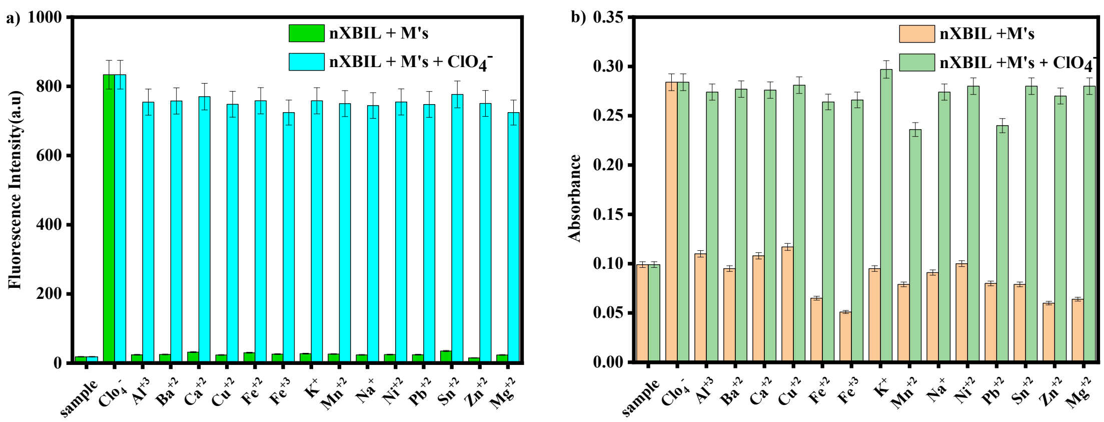

Fig. S5. Bar diagram demonstrating the selectivity of the **nXBIL** towards ClO_4^- in the presence of various interfering metal ions: **(a)** fluorometric (emission at 516 nm), **(b)** UV-visible spectrophotometric studies (absorption at 454 nm)

Table. S1 Calculated ΔG values at various temperatures.

Temperature(℃)	**ΔG** (Jmol^{-1})	**ΔH** (Jmol^{-1})	**ΔS** (Jmol^{-1} K^{-1})
10	-27126.1067	-23440.58	85.86
20	-28084.1186		

30	-29042.13055
40	-30000.14245
50	-30958.15434
60	-31916.16623

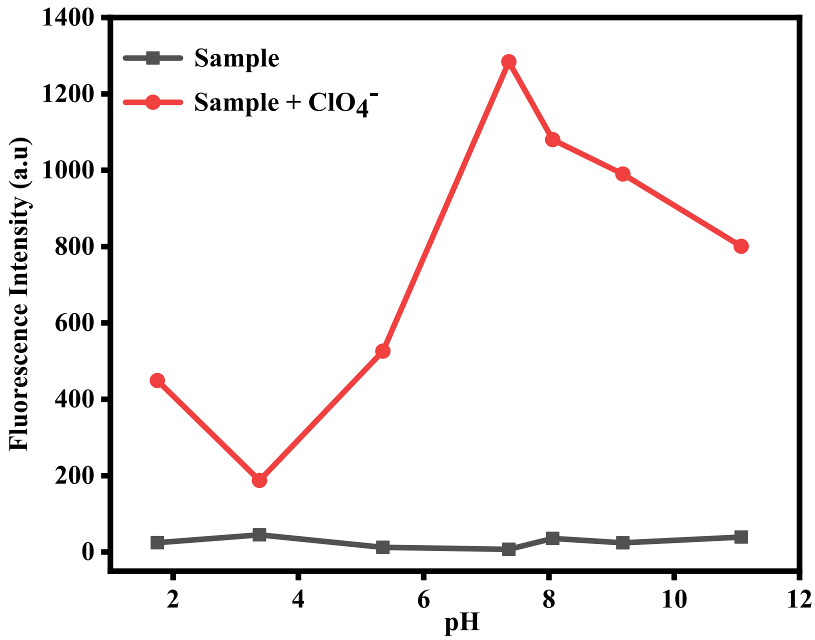

Fig. S6. Effect of pH on the photoluminescence of **nXBIL** in the absence and presence of ClO_4^- at 25°C

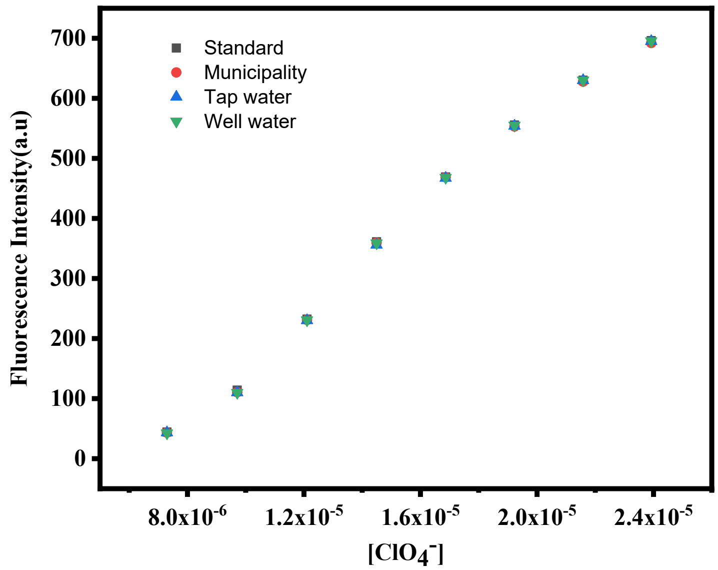

Fig. S7. Estimation of the concentration of ClO_4^- added in river, tap, and well water samples following the standard curve.

Table S2. Determination of ClO_4^- ion in various water samples

Sample	Added (μM)	Found (μM)	Recovery (%)
River water	2.44	2.41	98.74
	4.87	4.70	96.51
	7.29	7.12	97.67
	9.70	9.41	96.97
	12.11	12.03	99.44
	14.49	14.42	99.52
	16.86	16.84	99.85
	19.23	19.14	99.53
	21.58	21.50	99.61
	23.9	23.78	99.42
Tap water	2.44	2.42	99.17

	4.87	4.85	99.52
	7.29	7.17	98.37
	9.70	9.37	96.57
	12.11	11.99	99.05
	14.49	14.28	98.56
	16.86	16.80	99.61
	19.23	19.17	99.71
	21.58	21.57	99.96
	23.9	23.88	99.85
Well water	2.44	2.42	99.17
	4.87	4.85	99.57
	7.29	7.01	96.06
	9.70	9.36	96.49
	12.11	1.20	99.35
	14.49	14.40	99.39
	16.86	16.82	99.76
	19.23	19.21	99.89
	21.58	21.57	99.98
	23.9	23.90	99.92

Table S3. Comparison of different chemosensors introduced for detecting ClO4- ions over the last few decades with our prepared **nXBIL**.

Structure	Medium	Optical signaling	LOD	Ref. No.

Methylene Blue−Modified gold nanoparticles	Ultrapure water	Colorimetric	24µM	1
[Pt(terpy)Br]-PVA hydrogel sensor	acetic acid/ water/ethanol (0.5:1:1, v/v) mixed solution	turn-on luminescence	25 nM	2
1-(4-Biphenyl)benzimidazolium based dipodal system	HEPES buffer (0.01 M)	quenching of fluorescence intensity	100 nM	3
Ion-selective electrodes using multi-walled carbon nanotubes as ion-to-electron transducers	water	-	$10^{-7.4}$ M	4
1-(2-(3′, 6′-bis(diethylamino)-3-oxospiro[isoindoline-1,9′-xanthene]-2-yl)ethyl)thiourea	HEPES buffer (0.1 M in CH_3CN/water, 4/1, v/v, pH 7.4)	colorimetric and fluorimetric	1×10^{-7} M.	5
Perylenediimide-based chemosensor	HEPES buffer (10% DMSO) (v/v) (pH 7.4)	fluorescence quenching	60 nM	6
Benzoimidazole-based	HEPES buffer – 2% DMSO, pH 7.4	fluorescence based	1.6 µM	7
CHEMFET devices based on plasticized PVC membranes containing the phosphadithiamacrocycle.	-	Potentiometrically	$3x10^{-7}$M	8
ISE devices based on plasticized PVC membranes containing the phosphadithiamacrocycle.	-	Potentiometrically	$8x10^{-7}$M	8

Anion-Selective Membranes	-	Total Reflection X-ray Fluorescence	0.8 ng/mL	9
Novel polymeric membrane (PME) electrodes based on a phosphorous(V)-tetraphenylporphyrin complex.	Acetonitrile	UV-Vis, Fluorescence, and Potentiometrically.	5 µM	10
Coated glassy carbon (CGCE) electrodes based on a phosphorous(V)-tetraphenylporphyrin complex.	Acetonitrile	UV-Vis, Fluorescence, and Potentiometrically.	0.7 µM	10
gold–silica composite nanoparticle substrates for perchlorate	-	surface-enhanced Raman spectroscopy	10^{-6} M	11
pyrene butyrate ionic liquid	water	fluorimetric	7.17 nM	12
Xanthene benzoate-based ionic liquid	**water**	**Colorimetric and fluorometric**	**0.15 nM**	**This work**

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