Table S1 Comparison of the proposed optode with the reported Pb^{2+} optical and potentiometric sensors.

Reagent	Method	Response time	Measuring range (M)	Detection limit (M)	Ref.
α-Nitroso-β-naphthol sorbed zirconium(IV) tungsto phosphate	Potentiometric sensor	40 sec	1.0×10^{-6}– 5.0×10^{-5}	1.0×10^{-5}	[51]
Capric acid	Potentiometric sensor	15 sec	1.0×10^{-5}– 1.0×10^{-2}	6.0×10^{-6}	[52]
Dimethyl benzotetrathia fulvalene	Potentiometric sensor	20 sec	1.0×10^{-5}– 1.0×10^{-2}	8.0×10^{-6}	[53]
Cetylpyridinium chloride	Potentiometric sensor	20 sec	7.9×10^{-7}– 1.0×10^{-4}	4.8×10^{-7}	[54]
3,3,5,5-Tetramethyl-N-9-anthrylmethyl) benzidine	Optode (Fluorescence)	2.0–10 min	2.0×10^{-7}– 2.0×10^{-3}	2.0×10^{-7}	[55]
5,10,15,20-Tetra-(3-bromo-4-hydroxyphenyl)porphyrin	Optode (Fluorescence)	4.0 min	5.0×10^{-6}– 5.0×10^{-4}	2.0×10^{-8}	[56]
Dioxaoctanediamide	Optode (Absorption)	20–200 min	5.0×10^{-7}– 5.0×10^{-1}	3.2×10^{-10}	[57]
(1,10-Dibenzyl-1, 10-diaza-18-crown-6	Optode (Absorption)	20 min	1.0×10^{-8}– 5.0×10^{-5}	1.0×10^{-8}	[58]
4-(thiazol-2-yldiazenyl)benzene-1,3-diol	Optode (Absorption)	5.0 min	6.0×10^{-9} – 8.0×10^{-5}	1.75×10^{-9}	[42]
5-(2′-bromophenylazo)-6-hydroxy-pyrimidine-2,4-dione	Optode (Absorption)	5.0 min	4.00–144 ng mL^{-1}	1.20 ng mL^{-1}	[59]
Gallocynine	Optode (Reflectance)	5.0 min	4.8×10^{-7}– 4.8×10^{-3}	2.9×10^{-7}	[60]
2-amino-4-(4-nitrophenyl) diazenyl) pyridine-3-ol	Optode (Absorption)	5.0 min	6.0–160 ng mL^{-1}	1.80 ng mL^{-1}	This work

Table S2 Ultra trace detection of Pb^{2+} and Pb^{4+} speciation in mixtures

Serial no.	Pb^{2+}–Pb^{4+}	Pb taken (ng mL^{-1})		Pb found (ng mL^{-1})		Error (ng mL^{-1})	
		Pb^{2+}	Pb^{4+}	Pb^{2+}	Pb^{4+}	Pb^{2+}	Pb^{4+}
1	1:1	50	50	49.8	50.3	0.2	0.3
2	1:1	50	50	50.5	49.5	0.5	0.5
3	1:1	50	50	50.4	49.7	0.4	0.3
Mean error: $Pb^{2+}{}_{=} \pm 0.5$, $Pb^{4+}{}_{=} \pm 0.5$; SD: $Pb^{2+}{}_{=} \pm 0.004$, $Pb^{4+}{}_{=} \pm 0.003$							
1	1:5	20	100	19.8	100.2	0.2	0.2
2	1:5	20	100	20.1	99.7	0.1	0.3
3	1:5	20	100	20.2	100.4	0.2	0.4
Mean error: $Pb^{2+}{}_{=} \pm 0.2$, $Pb^{4+}{}_{=} \pm 0.4$; SD: $Pb^{2+}{}_{=} \pm 0.003$; $Pb^{4+}{}_{=} \pm 0.005$							
1	1:10	12	120	12.4	124.8	0.4	0.2
2	1:10	12	120	11.6	125.1	0.4	0.1
3	1:10	12	120	11.7	124.9	0. 3	0.1
Mean error: $Pb^{2+}= \pm 0.4$; $Pb^{4+}= \pm 0.4$ SD: $Pb^{2+}= \pm 0.006$; $Pb^{4+}= \pm 0.005$							

Table S3 Ultra-trace levels of lead in various surface soil samples

Serial no.	Lead (μg g^{-1})[a]		Sample source
	Proposed optode	ICP-AES	
S	68.50 ± 1.5 [b]	69.00 ± 1.5[b]	Roadside soil (Benha–Cairo highway)
S_4	75.00 ± 2.0	75.50 ± 2.0	Industrial soil (Catron Company, Benha)
S_2	9.50 ± 1.5	9.50 ± 1.5	Agricultural soil (Benha University campus)
S6	5.80 ± 1.6	6.00 ± 1.6	Marine soil (Bay of Benha)
S_1[c]	170.0 ± 1.2	171.0 ± 1.2	Traffic soil (Benha bus terminal, Benha)
S_3	105.5 ± 1.8	105.0 ± 1.8	Paint soil (Shoubra Paint, Qhalubia)

[a] Average of six analyses of each sample.

[b] The measure of precision is the standard deviation.

[c] Composition of the soil samples: C, N, P, K, Na, Ca, Mg, Cu, Fe, Pb, NO_3, NO_2, Zn, SO_4, Mn, Mo, Co, etc.

Table S4 Analysis of gasoline samples (n = 6).

Samples	Pb spike ($ng\,mL^{-1}$ Pb in the form of $Pb(C_2H_5)_4$)	Found[d] ($ng\,mL^{-1}$)		Recovery (%)	t-test[e]	F-value[f]
		Optode	ICP-AES			
Gasoline A[a]	0	13.0±0.1	12.7±1.2			
	15	28.4±0.3	26.9±1.4	101.52	1.87	3.65
	30	43.6±0.4	42.0±1.5	98.36	1.56	3.48
	45	72.5±0.2	73.4±1.1	100.96	1.96	4.21
Gasoline B[b]	0	11.5±0.3	11.8±1.5			
	20	31.0±0.2	32.3±1.2	101.12	1.23	2.97
	40	52.0±0.5	51.3±1.6	99.52	1.55	3.39
	60	70.7±0.4	73.5±1.5	99.47	1.42	3.25
Gasoline C[c]	0.0	13.5±0.2	13.4±1.7			
	30	44.4±0.4	42.8±1.4	99.74	1.64	3.57
	60	63.2±0.3	64.7±1.7	100.63	1.70	3.86
	90	105.0±0.5	102.2±1.6	99.32	1.31	3.12

[a,b,c]: Gasoline samples collected from different gas station of the Port Said, Benha, and El-Mahdena cities of Egypt, KAS.

[d] Average of six analyses of each sample.

[e] Tabulated t-value for five degrees of freedom at P (0.95) is 2.57

[f] Tabulated F-value at P (0.95) is 5.05.