Electronic Supplementary Material (ESI) for RSC Advances.

Electronic supporting information

Molecularly imprinted polymers on multi-walled carbon nanotubes as an efficient absorbent for preconcentration of morphine and its chemiluminometric determination

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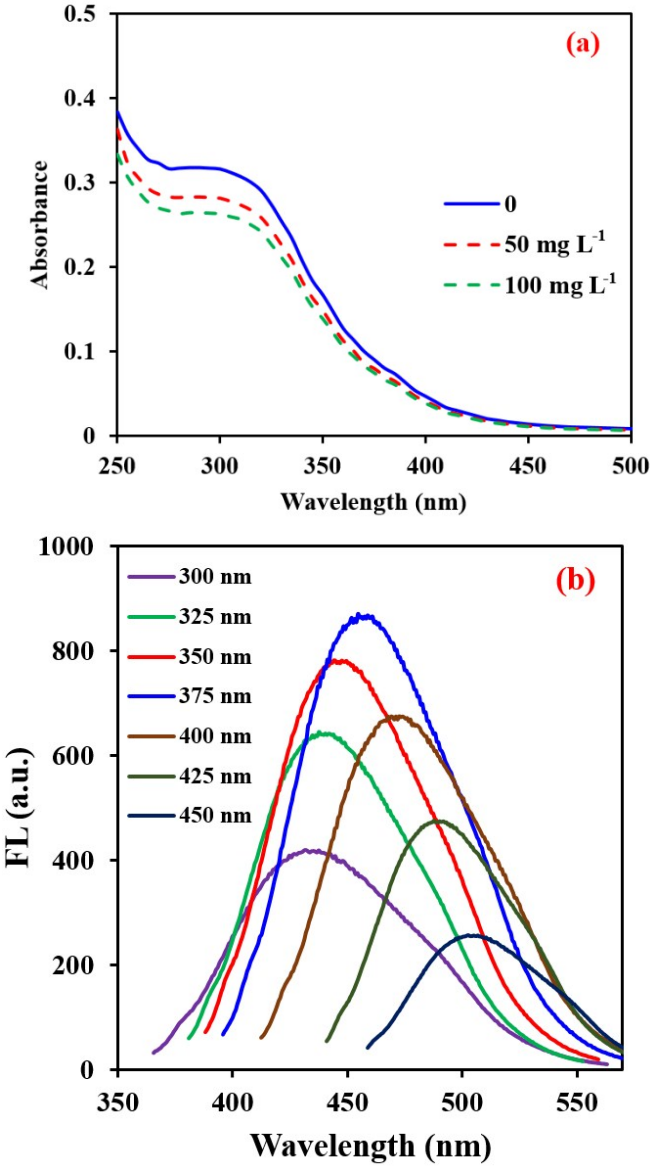

Fig. S1 (a) UV-vis absorption spectra for prepared carbon dots in the presence of different concentrations of morphine; (b) fluorescence emission spectra for carbon dots excited at different wavelengths.

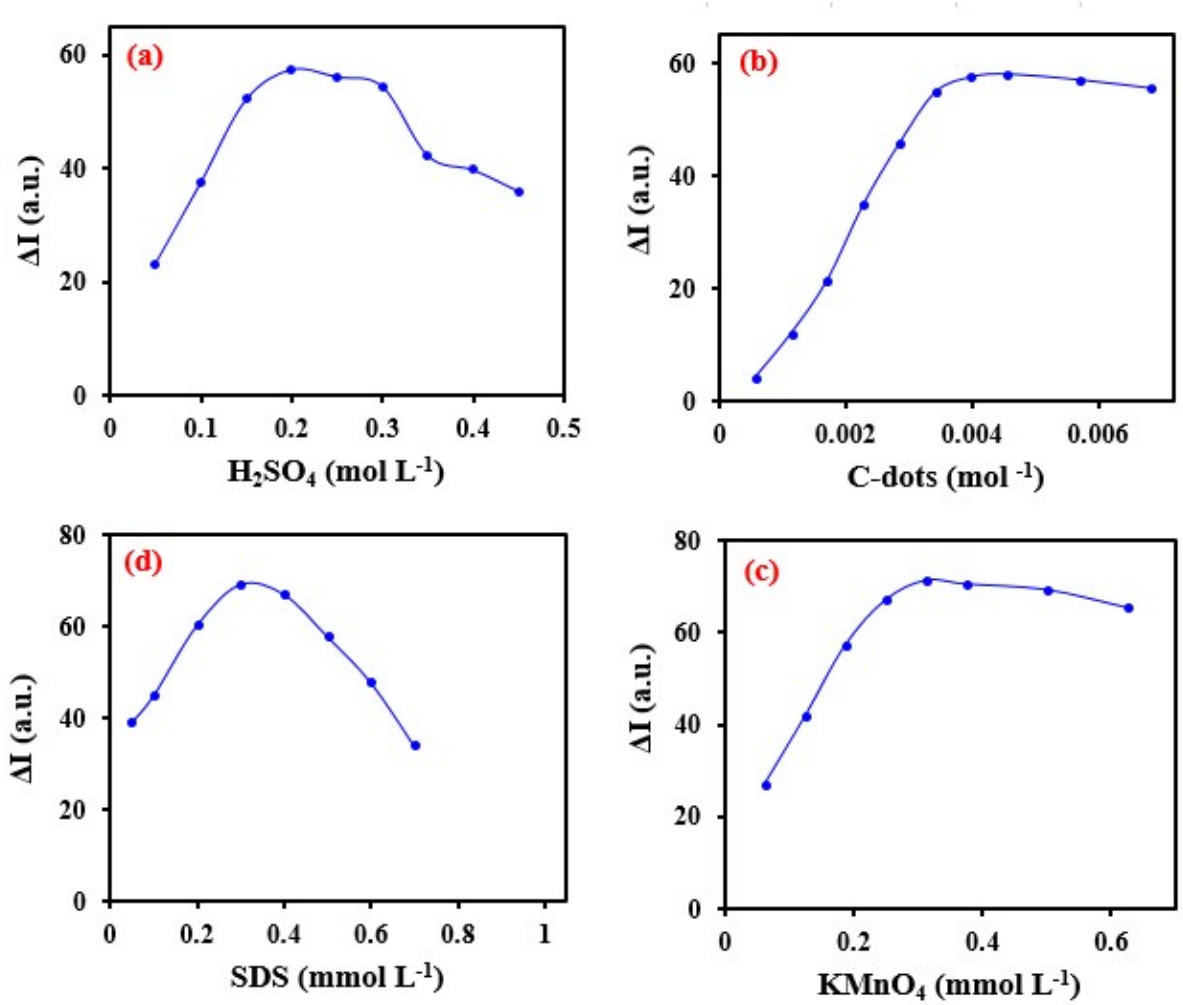

Fig. S2 Effects of (a) H_2SO_4 concentration [4 mmol L^{-1} C-dots, 0.2 mmol L^{-1} $KMnO_4$, 0.3 mmol L^{-1} SDS], (b) C-dots concentration [0.2 mol L^{-1} H_2SO_4, 0.2 mmol L^{-1} $KMnO_4$, 0.3 mmol L^{-1} SDS], (c) $KMnO_4$ concentration [0.2 mol L^{-1} H_2SO_4, 4 mmol L^{-1} C-dots, 0.3 mmol L^{-1} SDS] and (d) SDS concentration [0.2 mol L^{-1} H_2SO_4, 4 mmol L^{-1} C-dots, 0.3 mmol L^{-1} $KMnO_4$] on the ΔI for the determination of extracted morphine (0.4 mg L^{-1}); extraction step was done in optimum condition.

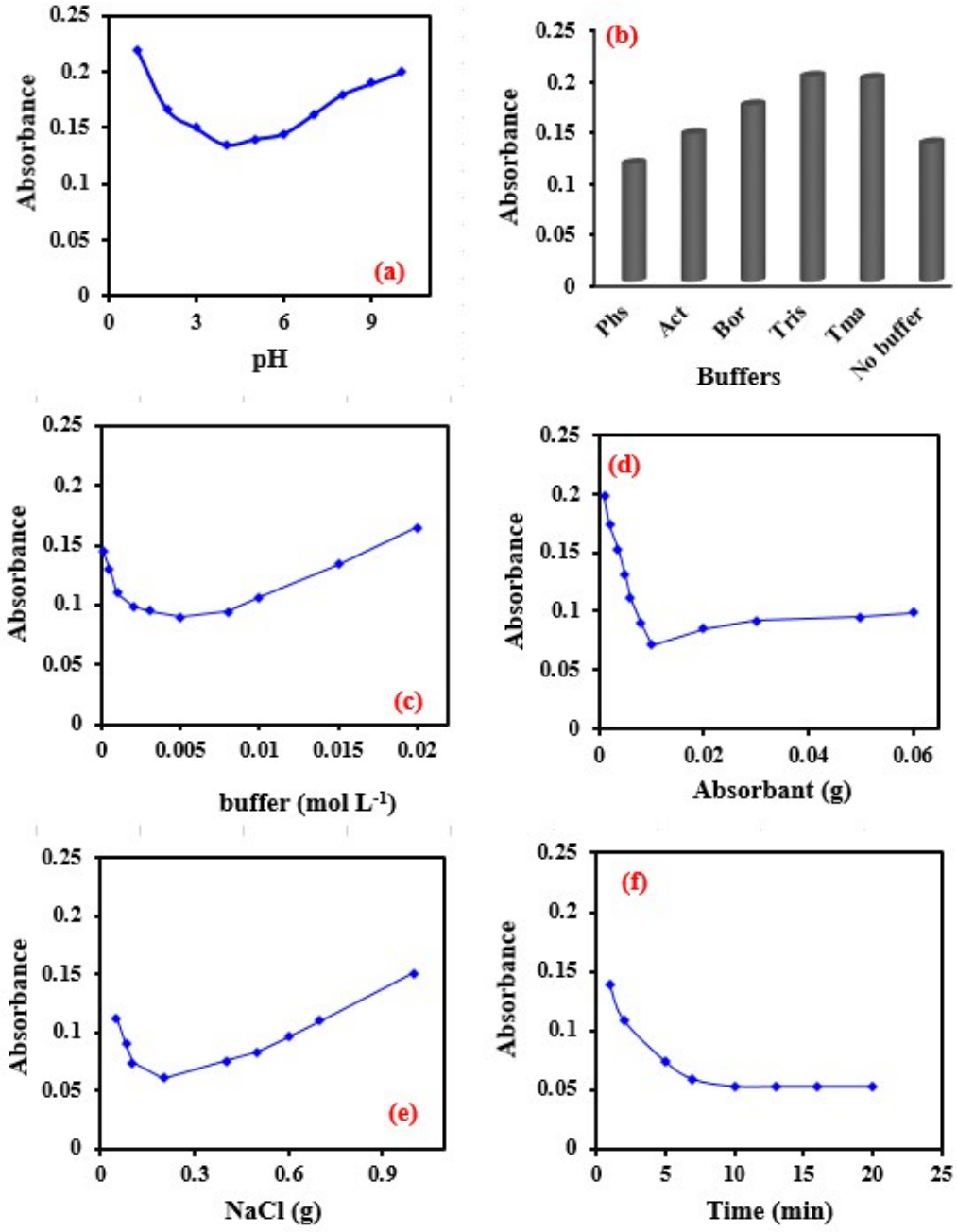

Fig. S3 Absorption of remained extraction solution after the separation of 0.4 mg L^{-1} morphine (a) at different pHs (0.01g CNTs and 0.1 g NaCl in 30 mL solution containing 0.02 mol L^{-1} phosphate buffer); (b) at the presence of different buffers (0.01g CNTs and 0.1 g NaCl in 30 mL solution containing 0.1 mol L^{-1} buffer, pH=4); (c) at different concentrations of phosphate buffer (0.01g CNTs and 0.1 g NaCl in 30 mL solution, pH=4); (d) using different amounts of carbon nanotubes (0.1 g NaCl in 30 mL solution containing 0.005 mol L^{-1} phosphate buffer, pH=4); (e) in the presence of different amounts of NaCl (0.01 g CNTs in 30 mL solution containing 0.005 mol L^{-1} phosphate buffer, pH=4) and (f) in different exposure times.

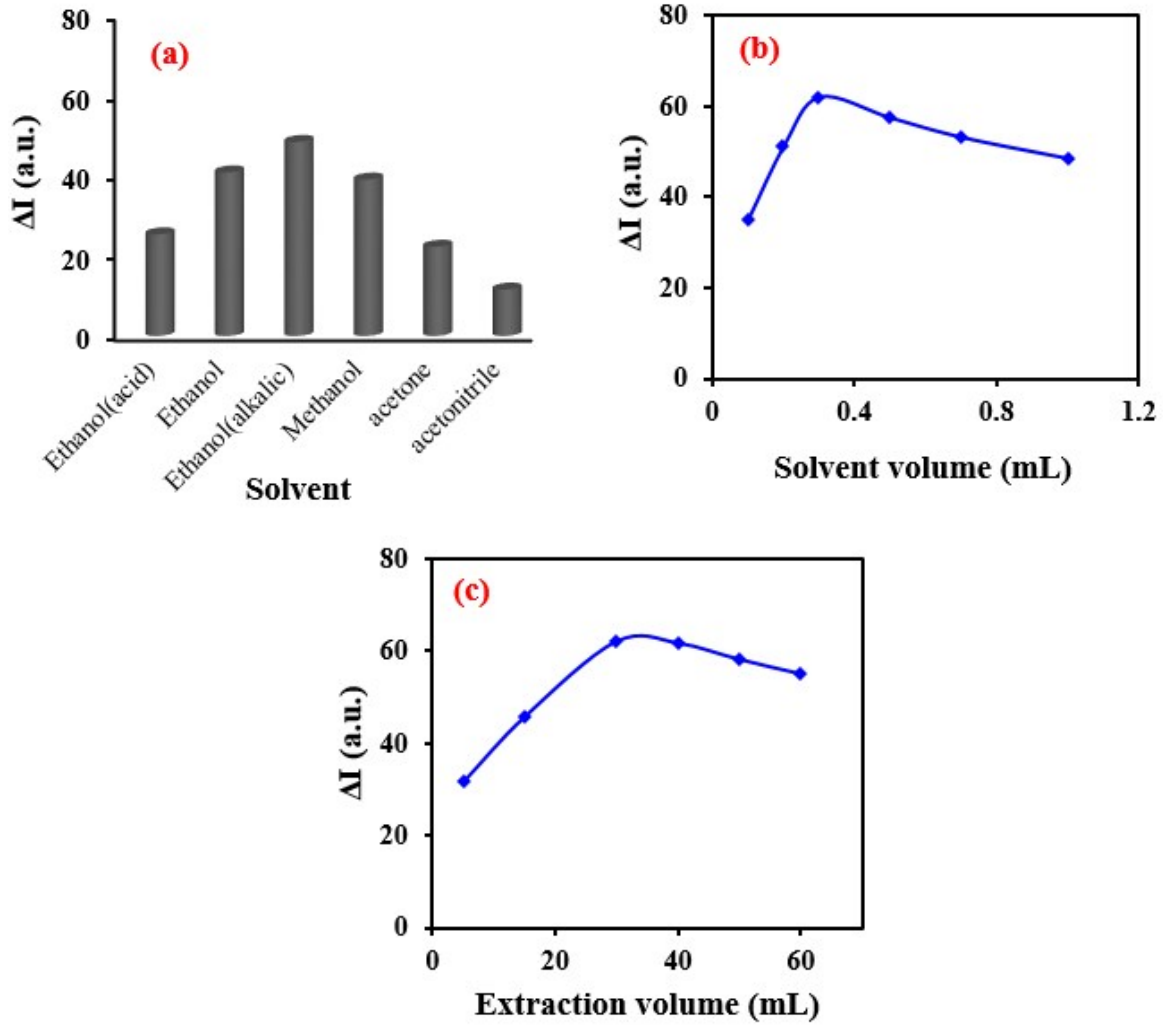

Fig. S4 The effect of (a) type of eluent solvent, (b) eluent volume and (c) extraction solution volume on the desorption of morphine from CNTs surface and its CL signal in $KMnO_4$-carbon dot-SDS system (adsorption and CL system in optimum condition).

Table S1 Interfering effect of some species on the extraction of morphine by developed method

Coexisting substance	Examined Concentration of coexisting substance	ΔA%	Normal concentrations in urine (mol day^{-1})
K^+	0.006	3.5	$(1\text{-}2) \times 10^{-3}$
Na^+	0.17	4	0.11
Al^{3+}	3.5×10^{-7}	3	3.3×10^{-7}
PO_4^{3-}	4×10^{-3}	-4.8	$(0.5\text{-}3) \times 10^{-3}$
Cu^{2+}	10^{-6}	3.4	4.8×10^{-7}
Ca^{2+}	3.3×10^{-3}	1.4	$(0.25\text{-}0.9) \times 10^{-3}$
Mg^{2+}	7×10^{-4}	4.5	$(0.32\text{-}0.5) \times 10^{-3}$
Zn^{2+}	2.7×10^{-5}	4.3	$(2.5\text{-}18.4) \times 10^{-6}$
Lactose	0.01	0.3	$(40\text{-}116) \times 10^{-6}$
Sucrose	0.1	0.7	-
Glucose	1	0.2	0.005-0.15
Lucien	5×10^{-3}	1.1	-
Fe^{3+}	1.5×10^{-6}	3.4	$(0.01\text{-}0.5) \times 10^{-6}$
Glycine	10^{-2}	0.78	-
HCO_3^-	3.2×10^{-1}	4.6	$(1\text{-}24) \times 10^{-2}$
Uric Acid	6×10^{-3}	3.5	$(1.5\text{-}4.4) \times 10^{-3}$
Cl^-	0.3	3.5	0.001-0.002
Fructose	0.01	0.45	$(0.18\text{-}0.36) \times 10^{-3}$

Table S2 Summary of some published methods for the determination of morphine

Method	Sample	LOD ($\mu g\ L^{-1}$)	Linear range ($\mu g\ L^{-1}$)	Ref.
HPLC [a]	Human hair	0.1	1-800	5
ECL	Blood plasma	0.067	0.2-180	2
Electrochemistry	Blood plasma	11.6	$35\text{-}2.1 \times 10^5$	3
Electrochemistry	Human urine and plasma	0.828	2.3-1430	4
GC-MS	Human urine	-	25-2000	9
Spectrophotometry	Human urine and serum	30	70-7980	22
Spectrophotometry	Injection	400	$(1\text{-}32)\times10^3$	23
Spectrophotometry	Human urine	23	100-2500	7
Spectrophotometry	urine and wastewater	180	800-8700	24
Chemiluminescence	synthetic samples	4	10-1000	16
Chemiluminescence	synthetic samples	3	10-1000	17
Our method	Injection, human urine	0.82	3-1200	-

[a] abbreviations: HPLC (High performance liquid chromatography); ECL (Electrochemiluminescence); GC-MS (Gas chromatography- mass spectroscopy); LC-MS (Liquid chromatography- mass spectroscopy).