Supporting information

Metal-organic framework/Nb $_4C_3T_x$ MX ene composites for ultrasensitive detection of dopamine

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Table of Contents

Sl	Contents	Page
No.		No.
1	Section S1: Experimental Procedures	4-7
2	Materials and methods	4-7
3	Scheme S1. Synthesis of $Nb_4C_3T_x$ MXene and exfoliation	5
4	Section S2: Results and Discussion	8-32
5	Fig. S1. FESEM images of synthesized $Nb_4C_3T_x$ MXene	8
6	Fig. S2. (a-c) Observation of exfoliated $Nb_4C_3T_x$ using SEM (a), TEM (b), and HRTEM (c)	8
7	Fig S3. XRD pattern of $Nb_4C_3T_x$ MXenes	9
8	Fig. S4. Raman Spectra of $Nb_4C_3T_x$ MXene and parent Nb_4AlC_3 phase	9
9	Fig. S5. Zeta potential of $Nb_4C_3T_x$ sheets	10
10	Fig. S6. Additional TEM images of ZIF-8/Nb ₄ C ₃ $T_x(75)$	10
11	Fig. S7-11. XRD pattern of all MOF and MOF/Nb ₄ C ₃ T _x composites	11-13
12	Fig. S12-S16. FT-IR spectra of all MOF and MOF/Nb ₄ C ₃ T _x composites	13-15
13	Fig. S17. FESEM elemental mapping of all MOF/MXene composites	16
14	Fig. S18. (a) XPS survey spectrum and corresponding deconvoluted high-	17
	resolution (b) Nb3d, (b) C1s and (c) O1s spectra of $Nb_4C_3T_x$ MXene	
15	Fig. S19-S23. (a) XPS survey spectrum and corresponding deconvoluted of	18-20
	all MOF/Nb ₄ C ₃ T _x composites	
16	Fig. S24. Thermogravimetric analysis profiles of all (a) MOFs and (b)	21
	MOF/MXene composites under air atmosphere	
17	Fig. S25-S28. SEM-Energy dispersive X-ray (SEM-EDX) spectrum and	22-23
	composition analysis of different compositions of ZIF-8/Nb ₄ C ₃ T _x	
18	Fig. S29. SEM-EDX spectrum and composition analysis of ZIF-	24
	67/Nb ₄ C ₃ T _x	
19	Fig. S30. SEM-EDX spectrum and composition analysis of MIL-	24
	$100/Nb_4C_3T_x$	
20	Fig. S31. SEM-EDX spectrum and composition analysis of MIL-	25

	$101/Nb_4C_3T_x$	
21	Fig. S32. SEM-EDX spectrum and composition analysis of HKUST-	25
	$1/Nb_4C_3T_x$	
22	Fig. S33. N ₂ adsorption-desorption isotherms of MIL-101, MIL-101,	26
	HKUST-1 and ZIF-67 and (b) their composites with $Nb_4C_3T_x$	
23	Table S1. Estimated composition of the MOF/Nb ₄ C ₃ T _x composites.	26
24	Table S2. Specific surface area (S_{BET}) of the MOFs and their composite	27
25	Fig. S34. Correlation between the BET surface area and the ZIF-8 content	27
	in the ZIF-8/Nb ₄ C ₃ T _x series	
26	Fig. S35. Nyquist plot of bare GCE (a), $Nb_4C_3T_x$ (b) and ZIF-8 (c)	28
27	Fig. S36. (a) Comparison of the CV responses $ZIF-8/Nb_4C_3T_x(75)$ in the	29
	absence of DA and in the presence of DA and (b) Comparison of the CV	
	responses of all the composites in the presence of 50 μ M DA	
28	Fig. S37. CV responses of ZIF-8/Nb ₄ C ₃ T _x (75)/GCE before and after storing	29
	in HEPES buffer (pH 7) for 20 days at 5 °C.	
29	Fig. S38. DPV responses of ZIF-8/Nb ₄ C ₃ T _x (75) in 20 mM HEPES buffer	30
	solution with different concentrations of DA for the linear range 1-100	
	nM.	
30	Fig. S39. DPV response of ZIF-8/Nb ₄ C_3T_x in 20 mM HEPES buffer	30
	solution in the presence of 500 nM of DA along with ascorbic acid (AA,	
	10 μ M) and uric acid (UA, 10 μ M).	
31	Table S3. The comparison of sensor response of different MXene-based sensors developed for the electrochemical detection of DA adopting DPV	31
	technique.	
32	References	31-32

Section S1: Experimental Procedures

Materials and methods

Chemicals

Niobium Aluminium Carbide Phase (Nb₄AlC₃), L-Tryptophan and hydrofluoric acid (46 wt% in water) were purchased from Sigma-Aldrich. Zn(CH₃COO)₂·2H₂O, Co(NO₃)₂·6H₂O, FeCl₃·6H₂O Cu(NO₃)₂·3H₂O were purchased from Wako-Fujifilm and stored appropriately before use. 2-Methylimidazole (2-MeIM), benzene-1,4-dicarboxylic Acid (H₂BDC), benzene-1,3,5-tricarboxylic Acid (H₃BTC), L-Alanin and L-Phenylalanin were purchased from Tokyo Chemical Industries. Nitric acid (for synthesis, 70 wt%) was purchased from Wako-Fujifilm. Glycine, L-Histidine, L-Glutamic acid, and solvents such as methanol, acetone, toluene, acetonitrile, 2-propanol, and diethyl ether were purchased from Kanto Chemical Co. Freshly deionized (DI) water ($\rho = 18.2 \text{ M}\Omega.\text{cm}$) was used for all experiments.

Instrument:

X-Ray diffraction (XRD), Rigaku X-ray diffractometer, Rigaku, Japan, which is operated with a scanning rate of 5° min⁻¹ using CuK α X-ray radiation ($\lambda = 1.54056$ Å). The transmission electron microscopy and high-resolution transmission electron microscopy (HRTEM) analysis has been carried out at an accelerating voltage of 200 kV using JEOL JEM 2100 plus, Japan, high-resolution transmission electron microscope. The atomic weight percentage and elemental composition of the synthesized nanocomposite was determined from X-ray photoelectron spectroscopy (XPS), Thermo-Scientific ESCALAB Xi+ spectrometer having a monochromatic Al K α X-ray source (1486.6 eV) and a spherical energy analyser, which operates in the CAE (constant analyzer energy) mode using the electromagnetic lens mode. Scanning electron microscopy (SEM) and energy dispersive X-ray analysis (EDX) were performed on a Hitachi SU3500. Infrared spectra were performed on a Perkin Elmer Spectrum, at room temperature.

Synthesis of Nb₄C₃T_x nanosheets

 $Nb_4C_3T_x$ nanosheets was prepared in a typical method.¹ To prepare accordion-like $Nb_4C_3T_x$, 2 g of Nb_4AlC_3 was mixed with 20 mL of 46% aqueous HF solution and stirred at room temperature for 96 hours. The mixture was then washed several times with DI water using a centrifuge at 4000 rpm for 10 minutes until the pH became neutral. The resulting $Nb_4C_3T_x$ was then washed with methanol and dried in a vacuum desiccator. $Nb_4C_3T_x$ was delaminated by probe ultrasonication (3 h), and a suspension was obtained.



Scheme S1. Synthesis of Nb₄C₃T_x MXene and exfoliation

Synthesis of ZIF-8/Nb₄C₃T_x

140 mg of Zn(CH₃COO)₂·2H₂O (0.638 mmol) was dissolved in 10 mL of deionized water. In a separate beaker, 2.18 g of 2-MeIM (26.55 mM) was dissolved in 20 mL of deionized water. Both solutions were mixed with 17 mL of a freshly exfoliated Nb₄C₃T_x solution (10 mg/mL) and stirred at room temperature for an hour. The resulting product (ZIF-8/Nb₄C₃T_x(100)) was collected by centrifugation, washed with deionized water several times, and dried in a vacuum desiccator. Three different composites of ZIF-8/Nb₄C₃T_x were synthesized by taking 25%, 50%, and 75% of the initial salt and ligand concentration compared to ZIF-8/Nb₄C₃T_x(100) such as ZIF-8/Nb₄C₃T_x(25): 35 mg of Zn(CH₃COO)₂·2H₂O; and 0.545 g of 2-MeIM, ZIF-8/Nb₄C₃T_x(50): 70 mg of Zn(CH₃COO)₂·2H₂O and 1.09 g of 2-MeIM and ZIF-8/Nb₄C₃T_x(75): 105 mg of Zn(CH₃COO)₂·2H₂O and 1.635 g of 2-MeIM. To compare, ZIF-8 was also synthesized.²

Synthesis of ZIF-67/Nb₄C₃T_x

140 mg of $Co(NO_3)_2 \cdot 6H_2O$ (0.765 mmol) was dissolved in 5 mL of DI water. In a separate beaker, 2.18 g of 2-MeIM (26.55 mM) was dissolved in 10 mL of DI water. Both solutions were mixed with 17 mL of a freshly exfoliated $Nb_4C_3T_x$ solution (10 mg/mL) and stirred at room temperature for an hour. The product was then collected by centrifugation and washed with DI water several times. Finally, the obtained ZIF-67/Nb₄C₃T_x was dried in a vacuum. For comparison, ZIF-67 was also synthesized.³

Synthesis of MIL-100(Fe)/Nb₄C₃T_x

300 mg of H₃BTC (1.43 mmol) was dissolved in 5 mL of DI water. In a separate beaker 200 mg of FeCl₃· $6H_2O$ (0.74 mmol) was dissolved in 10 mL of DI water. Both the solutions were

mixed with 20 mL of a freshly exfoliated $Nb_4C_3T_x$ solution (10 mg/mL). A small amount of HNO_3 (0.1 mL) was added to the resultant solution and heated in a Teflon-lined stainless-steel autoclave at 150°C for 20 hours. The precipitate was collected by centrifugation and washed thoroughly with DI water and ethanol. The resulting MIL-100(Fe)/Nb₄C₃T_x was dried overnight at 100°C in a vacuum. For comparison, MIL-100(Fe) was also synthesized.⁴

Synthesis of MIL-101(Fe)/Nb₄C₃T_x

415 mg (2.5 mmol) of terephthalic acid (H₂BDC) was dissolved in 10 mL of N, Ndimethylformamide (DMF). In a separate beaker 1.378 g (5 mmol) of FeCl₃·6H₂O was dissolved in 20 mL of DMF. Both the solution was then added to 14 mL of a freshly exfoliated Nb₄C₃T_x solution (10 mg/mL, in wateer) and the resulting mixture was placed in a Teflonlined stainless-steel autoclave and heated at 110°C for 20 hours. Afterward, the precipitate was centrifuged, washed with water, and then ethanol. The resulting MIL-101(Fe)/Nb₄C₃T_x was dried in a vacuum desiccator. Furthermore, MIL-101(Fe) was also synthesized for comparison purposes.⁵

Synthesis of HKUST-1/Nb₄C₃T_x

150 mg of H₃BTC (0.714 mmol), 300 mg of Cu(NO₃)₂·3H₂O (1.24 mmol) and 220 mg of freshly exfoliated Nb₄C₃T_x in the mixed solvent containing equal amounts (8.5 mL) of deionized water, ethanol, and DMF. After stirring for 15 minutes, the mixture was heated to 85°C and kept at this temperature for 24 hours while being stirred. The resulting product was then isolated and washed with methanol and DMF, followed by solvent exchange with dichloromethane. Subsequently, the HKUST-1/Nb₄C₃T_x powder was dried in a vacuum. In order to make a comparison, HKUST-1 was also synthesized.⁶

2-Methylimidazole

Benzene-1,4-dicarboxylic Acid

Benzene-1,3,5-tricarboxylic Acid

Electrode preparations and EIS measurements

Prior to experiments, the GCE was polished with alumina powder. Then, it was sonicated in copious amounts of ethanol and distilled water to obtain a mirror-like surface. 10 mg of each synthesized material was added to 100 mL of 2-propanol and then sonicated until a well-dispersed (ink-like) suspension was formed. 3 μ L of the resulting solution was dropped onto a clean GC electrode and allowed to dry at room temperature.

The electrochemical impedance spectroscopy (EIS) measurements were performed over a frequency range from 100 kHz to 1 Hz at open circuit voltage with 5 mV amplitude voltage. A redox probe of 5 mM K_3 [Fe(CN)₆] in 0.1 M KCl solution was used to conduct the investigation.

Electrochemical detection experiments

Cyclic voltammetry (CV) and differential pulse voltammetry (DPV) were conducted using an ALS electrochemical analyzer (Model: 650D). A three-electrode system was utilized comprising a 3 mm diameter GC as the working electrode, a saturated calomel electrode (SCE) as the reference electrode, and a platinum wire as the counter electrode. All potentials were measured with respect to the SCE electrode. The measurements were performed at room temperature, in a HEPES buffer solution (20 mM) with 0.1 M KCl, and a pH of 7.0.

Section S2: Results and Discussion



Fig. S1. FESEM images of synthesized $Nb_4C_3T_x$ MXene.



Fig. S2. (a-c) Observation of exfoliated $Nb_4C_3T_x$ using SEM (a), TEM (b), and HRTEM (c).



Fig S3. XRD pattern of Nb₄C₃T_x MXenes and of the parent phase Nb₄AlC₃. The absence of peaks related to Nb₄AlC₃ in the pattern of Nb₄C₃T_x confirms the complete etching. Furthermore, the diffraction profile of Nb₄C₃T_x is conform to literature.⁷



Fig. S4. Raman Spectra of Nb₄C₃T_x MXene and parent Nb₄AlC₃ phase.

After the formation of $Nb_4C_3T_x$ sheets, the peak at 675 cm⁻¹ for the Al layer almost disappears. The peaks at 1360 and 1586 cm⁻¹ (D and G bands) are obtained for the presence of carbon. In $Nb_4C_3T_x$, the intensity of these peaks increases, indicating that the surfaces have been exposed to more carbon.



Fig. S5. Zeta potential of $Nb_4C_3T_x$ sheets.



Fig. S6. Additional TEM images of ZIF-8/Nb₄C₃T_x(75).



Fig. S7. XRD pattern of ZIF-8 and ZIF-8/Nb₄C₃T_x.



Fig. S8. XRD pattern of ZIF-67 and ZIF-67/Nb₄C₃ T_x .



Fig. S9. XRD pattern of MIL-100 and MIL-100/Nb₄C₃T_x.



Fig. S10. XRD pattern of MIL-101 and MIL-101/Nb₄C₃T_x.



Fig. S11. XRD pattern of HKUST-1 and HKUST-1/Nb₄C₃T_x.



Fig. S12. FT-IR spectra of ZIF-8 and ZIF-8/Nb₄C₃T_x(75) composite.

The peaks at 995 and 1580 cm⁻¹ correspond to the vibration of the C-N and C=N bonds respectively. The spectra showed stretching vibrations of C-H bonds (2925 cm⁻¹) in both the methyl group and the imidazole ring.⁸⁻¹⁰



Fig. S13. FT-IR spectra of ZIF-67 and ZIF-67/Nb₄C₃T_x composite.

The peaks at 990 and 1572 cm⁻¹ correspond to the vibration of the C-N and C=N bonds respectively. The spectra showed stretching vibrations of C-H bonds (2920 cm⁻¹) in both the methyl group and the imidazole ring.⁸⁻¹⁰



Fig. S14. FT-IR spectra of MIL-100 and MIL100/Nb₄C₃T_x composite.

The characteristic peaks observed at 1630 cm⁻¹, 1450 cm⁻¹, and 1380 cm⁻¹ are correspond to the symmetric and antisymmetric stretching vibration peaks of the H₃BTC skeleton. The strong band observed at 1380 cm⁻¹ and 1450 cm⁻¹ is due to the presence of asymmetric $v_s(COO^-)$

vibrations of carboxyl groups, while the bands observed at 1630 cm⁻¹ are attributed to the symmetric $v_s(COO^-)$ vibrations of carboxyl groups. Additionally, the peaks observed at 710 and 485 cm⁻¹ correspond to the stretching vibration and bending vibration of Fe-O coordination.



Fig. S15. FT-IR spectra of MIL-101 and MIL101/Nb₄C₃ T_x composite.



Fig. S16. FT-IR spectra of HKUST-1 and HKUST-1/Nb₄C₃T_x composite.

The peaks at 1650 cm⁻¹, 1450 cm⁻¹, and 1375 cm⁻¹ are characteristic of the symmetric and antisymmetric stretching vibrations of the H₃BTC skeleton. The presence of asymmetric $v_s(COO^-)$ causes the strong band at 1375 cm⁻¹, while the symmetric $v_s(COO^-)$ vibrations of carboxyl groups are responsible for the band at 1650 cm⁻¹. Furthermore, the peak at 725 cm⁻¹ represents the stretching vibration, while the peak at 490 cm⁻¹ represents the bending vibration of the Cu-O coordination.¹¹



Fig. S17. FESEM elemental mapping of all MOF/MXene composites.



Fig. S18. (a) XPS survey spectrum and corresponding deconvoluted high-resolution (b) Nb3d, (b) C1s and (c) O1s spectra of $Nb_4C_3T_x$ MXene.

The XPS survey spectrum of Nb₄C₃T_x MXene confirms the presence of Nb, C, O, and F elements. The peak for F element appears in Nb₄C₃T_x due to HF treatment (**Fig. S18a**). In **Fig. S18(b)**, the XPS spectrum of the Nb3d region of Nb₄C₃T_x has been deconvoluted to show binding energy peaks at 203.3 eV, 206.4 eV, and 209.7 eV. These peaks are obtained for Nb-C $3d_{5/2}$, Nb-C $3d_{3/2}$, and Nb-O bonds correlated to previously reported literature.¹² In the high-resolution C1s spectrum fitted with four peaks at 282.8, 284.8, 286.9, and 288.8 eV were attributed to C-Nb-T_x, C-C, C-O, and O=C-O, respectively (Fig. S13c). Peaks fitted at 528.9, 530.4, 532, and 533.5 eV in the high-resolution O1s XPS profile can be attributed to Nb-O of C-Nb-O_x, C-Nb-(OH)_x, and H₂O, respectively (**Fig. S18d**).



Fig. S19. (a) XPS survey spectrum and corresponding deconvoluted high-resolution (b) Nb3d,
(c) Zn2p and (d) N1s spectra of ZIF-8/Nb₄C₃T_x.

The XPS survey spectrum of ZIF-8/Nb₄C₃T_x shows peaks attributed to Nb, C, N, O, and F elements. (**Fig. S19a**). The Nb 3d high-resolution XPS spectrum shows three peaks corresponding to Nb-C $3d_{5/2}$, Nb-C $3d_{3/2}$, and Nb-O bonds of Nb₄C₃T_x. (**Fig. S19b**). The peak corresponding to Nb-O increases in ZIF-8/Nb₄C₃T_x compared to individual Nb₄C₃T_x due to higher oxygen functionalities. In the Zn 2p region, two peaks centered at 1021.3 and 1044.3 eV were attributed to the Zn $2p_{3/2}$ and Zn $2p_{1/2}$ of Zn²⁺ (**Fig. S19c**), reflecting the existence of single Zn sites in ZIF-8/Nb₄C₃T_x.¹³ The high-resolution N 1s spectrum was fitted with three characteristic nitrogen species located at 398.9, 400.4, and 401.7 eV, corresponding to pyridinic N, pyrrolic N, and graphitic N, respectively. (**Fig. S19d**).¹⁴



Fig. S20. (a) XPS survey spectrum and corresponding deconvoluted high-resolution (c) Co2p spectrum of ZIF-67/Nb₄C₃T_x.

The peaks observed in the survey XPS spectrum of ZIF-67/Nb₄C₃T_x have been attributed to the corresponding elements of Nb, C, N, O, F, and Co (**Fig. S20a**). The high-resolution Co2p XPS profile has peaks that can be fitted to two spin-orbital splitting of $Co2p_{1/2}$ and $Co2p_{3/2}$. These correspond to Co^{2+} (797.1 and 779.8 eV) and Co^{3+} (795.5 and 782 eV). Additionally, two satellite peaks at approximately 785.7 and 802 eV were observed as shown in **Fig. S20(b).**¹⁵



Fig. S21. (a) XPS survey spectrum and corresponding deconvoluted high-resolution (b) Fe2p spectrum of MIL-100/Nb₄C₃T_x

The survey scans the XPS spectrum of MIL-100/Nb₄C₃T_x and identifies the corresponding elemental composition of Nb, C, O, F and Fe of MIL-100(Fe) and Nb₄C₃T_x (**Fig. S21a**). The high-resolution Fe2p XPS profile has peaks that can be fitted to two spin-orbital splitting of Feo2p_{1/2} and Fe2p_{3/2}. These correspond to Fe²⁺ (710.2 and 723.5 eV) and Fe³⁺ (713 and 726.1

eV), respectively. Additionally, two satellite peaks (indicate as "Sat.") at approximately 717.1 and 730.4 eV were observed as shown in **Fig. 21(b)**.¹⁶



Fig. S22. Deconvoluted high-resolution Fe2p spectrum of MIL-101/Nb₄C₃ T_x .

Similarly, upon analyzing MIL-101/Nb₄C₃T_x using high-resolution XPS spectrum, two different spin-orbital splittings of Fe2p1/2 and Fe2p3/2 were identified at 713 eV and 726.1 eV, respectively. These were attributed to Fe²⁺ (710.2 eV and 723.5 eV) and Fe³⁺ (713.2 eV and 726.1 eV).



Fig. S23. (a) XPS survey spectrum and corresponding deconvoluted high-resolution (b) Cu2p spectrum of HKUST-1/Nb₄C₃T_x.

The survey scans the XPS spectrum of HKUST-1/Nb₄C₃T_x shows the presence of Nb, C, O, F, and Cu elements (**Fig. S23a**). The high-resolution spectrum of Cu2p of HKUST-1/Nb₄C₃T_x fitted with peaks at 953.7 and 951.2 eV, which were assigned to Cu²⁺ and Cu⁺ in Cu $2p_{1/2}$. Similarly, the peaks at 933.5 and 931.8 eV were attributed to Cu²⁺ and Cu⁺ in Cu $2p_{3/2}$ (as shown in **Fig. S23b**).¹⁷ The peaks at 942.6, 938.1, 958.3, and 961.7 eV in the Cu2p region were identified as shake-up satellite peaks.



Fig. S24. Thermogravimetric analysis profiles of all (a) MOFs and (b) MOF/MXene composites under air atmosphere (heating rate: 10 °C/min).

MOF decomposition started at around 280 °C. However, the ZIF-8 is stable (up to 450 °C) as compared to the other MOFs. The $Nb_4C_3T_x$ MXene sheets were partially oxidized to Nb_2O_5 during analysis. Therefore, the mass loss is unreliable in determining the composition of the composites.

EDX quantitative analysis



Fig. S25. SEM-Energy dispersive X-ray (SEM-EDX) spectrum and composition analysis of ZIF-8/Nb₄C₃T_x(25).



EDX quantitative analysis

Fig. S26. SEM-EDX spectrum and composition analysis of ZIF-8/Nb₄C₃T_x(50).

EDX elemental composition



Fig. S27. SEM-EDX spectrum and composition analysis of ZIF-8/Nb₄C₃ $T_x(75)$.



Fig. S28. SEM-EDX spectrum and composition analysis of ZIF-8/Nb₄C₃T_x(100).



Fig. S29. SEM-EDX spectrum and composition analysis of ZIF-67/Nb₄C₃T_x.

Element	Mass%	Atom%
С	13.64±0.07	39.06±0.20
0	11.66±0.10	25.06±0.22
F	0.98±0.04	1.77±0.07
Fe	27.73±0.21	17.08±0.13
Nb	45.99±0.19	17.02±0.07
Total	100.00	100.00

EDX elemental





Fig. S30. SEM-EDX spectrum and composition analysis of MIL-100/Nb₄C₃T_x.

EDX elemental

	Element	Mass%	Atom%	composition
	С	30.76±0.04	49.20±0.06	I I I I I I I I I I I I I I I I I I I
	0	33.66±0.07	40.43±0.09	
	F	1.13±0.03	1.14±0.03	
	Fe	15.39±0.07	5.29±0.02	
	Nb	19.06±0.06	3.94±0.01	
Service Contraction	Total	100.00	100.00	



Fig. S31. SEM-EDX spectrum and composition analysis of MIL-101/Nb₄C₃T_x.





EDX elemental





Fig. S33. N_2 adsorption-desorption isotherms of MIL-101, MIL-101, HKUST-1 and ZIF-67 and (b) their composites with $Nb_4C_3T_x$ (the closed symbols represent adsorption, while the open symbols represent desorption).

Table S1. Estimated composition of the MOF/Nb ₄ C_3T_x composites. The composition was	
derived from SEM-EDX measurements, assuming a formula for the MXenes of Nb ₄ C ₃ (OH)	<u>></u> .

Materials	MOF content (w%)	MXene content (w%)
$\overline{\text{ZIF-8/Nb}_4\text{C}_3\text{T}_x(25)}$	29	71
$ZIF-8/Nb_4C_3T_x(50)$	39	61
$ZIF-8/Nb_4C_3T_x(75)$	63	37
$ZIF-8/Nb_4C_3T_x(100)$	70	30
$ZIF-67/Nb_4C_3T_x$	53	47
$MIL-100/Nb_4C_3T_x$	65	35
$MIL-101/Nb_4C_3T_x$	74	26
$HKUST-1/Nb_4C_3T_x$	66	34

Materials	$\mathbf{S}_{\mathbf{BET}}$ (m ² /g)	_
$Nb_4C_3T_x$	5	_
ZIF-8	1308	
ZIF-67	1715	
MIL-100	1457	
MIL-101	2680	
HKUST-1	1450	
$ZIF-8/Nb_4C_3T_x(25)$	225	
$ZIF-8/Nb_4C_3T_x(50)$	290	
$ZIF-8/Nb_4C_3T_x(75)$	415	
$ZIF-8/Nb_4C_3T_x(100)$	770	
$ZIF-67/Nb_4C_3T_x$	875	
MIL-100/Nb ₄ C ₃ T _x	1150	
$MIL-101/Nb_4C_3T_x$	1440	
HKUST-1/Nb ₄ C ₃ T _x	960	

Table S2. Specific surface area (S_{BET}) of the MOFs and their composites.



Fig. S34. Correlation between the BET surface area and the ZIF-8 content in the ZIF-8/Nb₄C₃T_x series. For intermediate ZIF-8 contents, the points are aligned. Interpolation of this trend to a ZIF-8 content of 0 w% indicates an S_{BET} of 69.0 m²/g. The difference between this trend value and the actual S_{BET} of pure Nb₄C₃T_x (5 m²/g) suggests of texturation of the Nb₄C₃T_x MXenes by the ZIF-8. Note that the porosity for composites is lower than expected from physical mixtures because of interactions between ZIF-8 and Nb₄C₃T_x. However, interfacing both components creates a MXene texturation which is beneficial for sensing.



Fig. S35. Nyquist plot of bare GCE (a), Nb₄C₃T_x (b) and ZIF-8 (c). Note that pristine Nb₄C₃T_x present an even lower charge transfer resistance ($R_{ct} = 175 \Omega$) than ZIF-8/Nb₄C₃T_x(75) ($R_{ct} = 790 \Omega$). However, the absence of texturation induced by ZIF-8 leads to overall worse sensing performances for the pristine Nb₄C₃T_x MXene compared to the composites.



Fig. S36. (a) Comparison of the CV responses ZIF-8/Nb₄C₃T_x(75) in the absence of DA and in the presence of DA and (b) Comparison of the CV responses of all the composites in the presence of 50 μ M DA (20 mM HEPES buffer, pH 7, 0.1 M KCl and scan rate: 50 mV s⁻¹)



Fig. S37. CV responses of ZIF-8/Nb₄C₃ $T_x(75)$ /GCE before and after storing in HEPES buffer (pH 7) for 20 days at 5 °C.



Fig. S38. DPV responses of ZIF-8/Nb₄C₃ $T_x(75)$ in 20 mM HEPES buffer solution with different concentrations of DA for the linear range 1-100 nM.



Fig. S39. DPV response of ZIF-8/Nb₄C₃T_x in 20 mM HEPES buffer solution in the presence of 500 nM of DA along with ascorbic acid (AA, 10 μ M) and uric acid (UA, 10 μ M). Dashed lines represent Gaussian fits for the corresponding peaks. As such, despite being present at a 20-times higher concentration, the interfering analytes UA and AA contributed 0.0% and 1.8%, respectively, to the intensity of the peak related to DA. This demonstrates the excellent selectivity of our sensor.

Materials	Linear range	LOD	Ref.
Ionic liquid/ Ti ₃ C ₂ Cl ₂	10–2000 μM	702 nM	18
Ti ₃ C ₂ T _x /DNA/Pd/Pt	0.2–1000 µM	30 nM	19
perylene diimide (PDI)- $(Ti_3C_2T_x)$	100–1000 µM	240 nM	20

0.5-50 µM

0.1-100 µM

0.4-90 µM

1-100 nM

0.09-0.82 mM

50 nM to 1µM

60 nM

40 nM

120 nM

1.39 µM

29 nM

0.2 nM

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This work

Table S3. The comparison of sensor response of different MXene-based sensors developed for the electrochemical detection of DA adopting DPV technique.

MB: methylene blue

 $ZIF-8/Nb_4C_3T_x$

Ti₃C₂/Holey graphene

MB-MXene-Au

NS-Nb₂C

 Nb_2C/ZnS

 $Nb_4C_3T_x$

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