Electronic Supplementary Information (ESI)

A novel approach for green synthesis of WO_3 nanomaterials and their highly selective chemical sensing properties

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Results

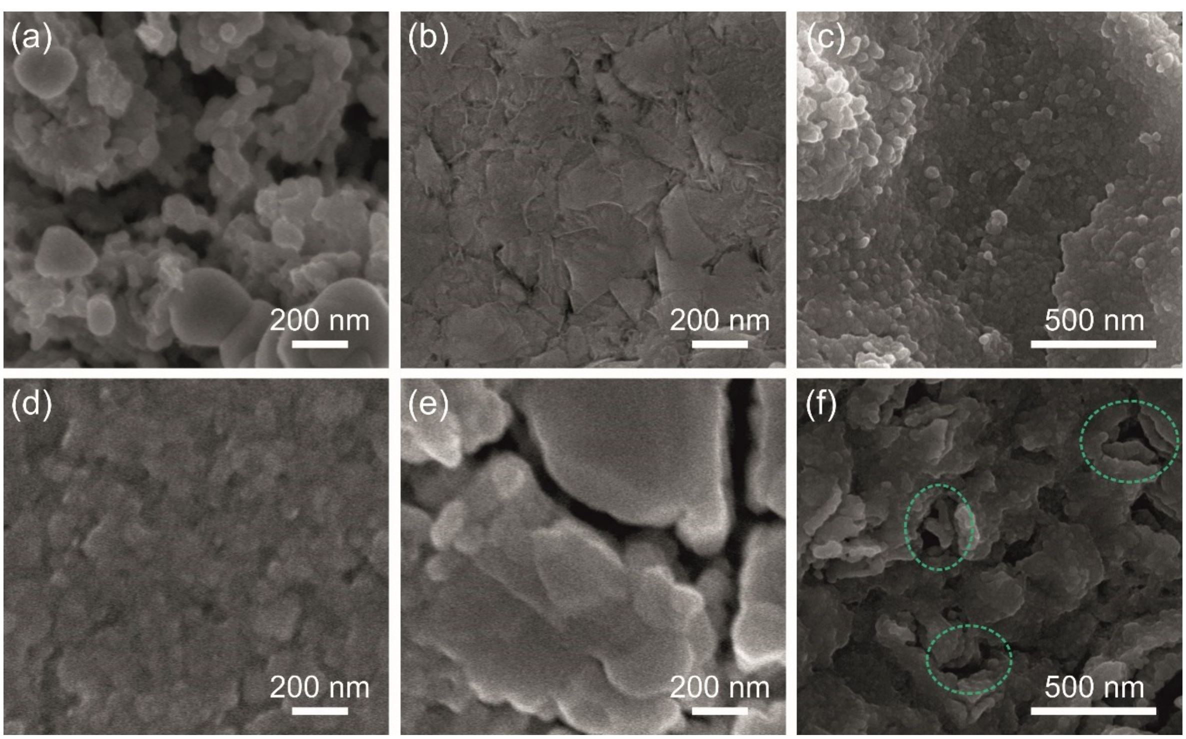

Fig. S1 Morphological analysis of samples carried out by FESEM.: (a) sample prepared in 0.3 mol L^{-1} NaCl containing H_2O at 180 °C for 20 h, (b) sample prepared in distilled H_2O at 160 °C for 20 h (the preparation regimes of WO_3–1 sample without the use of NaCl), c) WO_3–1, (d) sample obtained under the exposure to H_2O vapor when the temperature of the reactor was 110 °C and the treatment time was 30 h, (e) sample prepared under the exposure to H_2O vapor at 140 °C for 35 h, (f) WO_3–2, where the big porous regions observed on the surface of structure are shown with the green dashed lines.

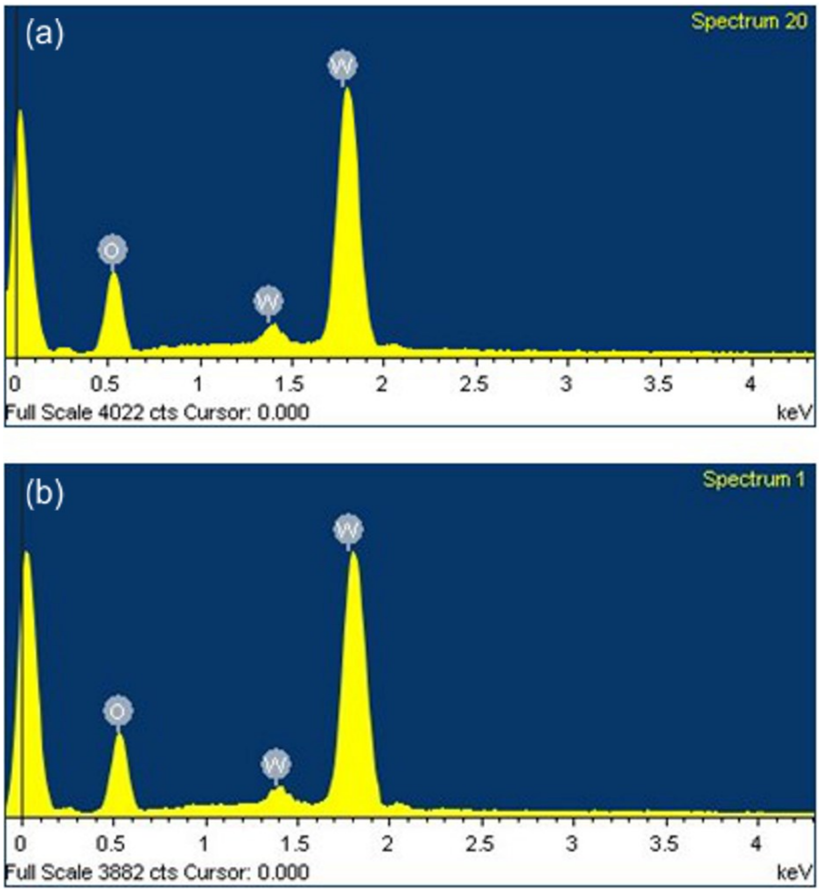

Fig. S2 EDX spectrum of the prepared materials: (a) WO_3–1; (b) WO_3–2. The EDX analysis of the samples were carried out on different areas of each material confirming the presence of expected W and O elements in the WO_3–1 and WO_3–2 structures.

Table S1 Table of the quantitative analysis of WO_3–1 and WO_3–2 materials obtained by EDX

Sample	W (Atomic%, ±2%)	O (Atomic%, ±2%)
WO_3–1	25.2	74.8
WO_3–2	25.6	74.4

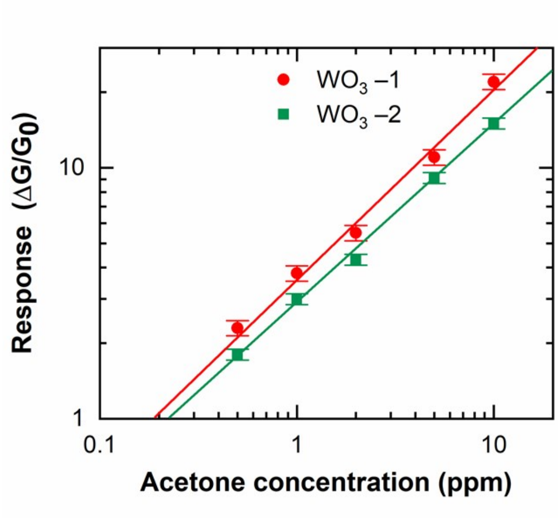

Fig. S3 Calibration curves of the normalized sensing response of WO_3–1 and WO_3–2 samples towards acetone at the operating temperature of 400 °C and RH of 40%. We set the response value ($\Delta G/G_0$) for both sensors to 1 to estimate their LOD. LODs for the WO_3–1 and WO_3–2 are about 170 and 220 ppb, respectively.

Table S2 Sensing parameters of WO_3–1 and WO_3–2 structures towards 500 ppb, 1, 2, 5 and 10 ppm of acetone at 400 °C of operating temperature and 40 % of RH. The response and recovery times of sensors were defined as the time to reach 90% of ΔG when the gas is introduced and to recover to 70% of the baseline conductance in air. The purging/filling time of the test chamber is about 300 s. Therefore, the lower values of response and recovery times registered by the gas test system can be varied depending on the measurement system and the volume of the test chamber.

Sample	Acetone concentration (ppm)	Response	Response time (s)	Recovery time (s)
WO_3–1	0.5	2.3	330	180
	1	3.8	180	180
	2	5.5	210	180
	5	11	180	150
	10	22	900	150
WO_3–2	0.5	1.8	420	180
	1	3	180	180
	2	4.3	300	180
	5	9.1	240	180
	10	15	950	150

Table S3 Dipole moments of the acetone and interfering gases

Gas	Dipole moment (D)
Acetone	2.88
Ethanol	1.69
NH_3	1.47
Ethylene	0
CH_4	0
CO_2	0
CO	0.112

Table S4 Acetone sensing properties of different metal oxide nanostructures. R_0 and R_f are the resistance values of structures in air and in the presence of acetone, respectively. G_0 and G_f are the conductance values of structures in air and in the presence of acetone, respectively

Material	Concentration (ppm)	Responses	Operating temperature (°C)
WO_3 nanofibers[1]	5	7.7 (R_0/R_f)	400
WO_3 nanowires[2]	200	1.4 (R_0/R_f)	300
Carbon-doped porous WO_3[3]	10	13.5 (R_0/R_f)	390
polystyrene–WO_3 nanofibers[1]	5	8.4 (R_0/R_f)	400
CeO_2–WO_3 nanowires[4]	0.5	1.3 (R_0/R_f)	250
Graphene oxide–WO_3 nanofibers[5]	100	35.9 (R_0/R_f)	375
Ag–WO_3 nanosheets[6]	100	12.5 (R_0/R_f)	340
Carbon-doped WO_3 spheres[7]	10	11.5 (R_0/R_f)	300
MO_3–WO_3[8]	100	18.2 (R_0/R_f)	320
Cr_2O_3–WO_3 nanowires[2]	200	4.1 (R_0/R_f)	300
SnO_2 spheres[9]	5	6.6 (R_0/R_f)	400
ZnO–Fe_3O_4 nanoparticles[10]	50	47 (R_0/R_f)	485
WO_3–1 (This work)	0.5	2.5 (G_f/G_0)	300
WO_3–1 (This work)	1	2.7 (G_f/G_0)	300
WO_3–1 (This work)	5	7.8 (G_f/G_0)	300
WO_3–1 (This work)	10	12.4 (G_f/G_0)	300
WO_3–1 (This work)	0.5	3.3 (G_f/G_0)	400
WO_3–1 (This work)	1	4.8 (G_f/G_0)	400
WO_3–1 (This work)	5	12 (G_f/G_0)	400

WO_3–1 (This work)	10	23 (G_f/G_0)	400

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