Electronic Supplementary Information (ESI) for

Fabrication of a One-dimensional Tube-in-tube Polypyrrole/Tin oxide Structure for Highly Sensitive DMMP Sensor Applications

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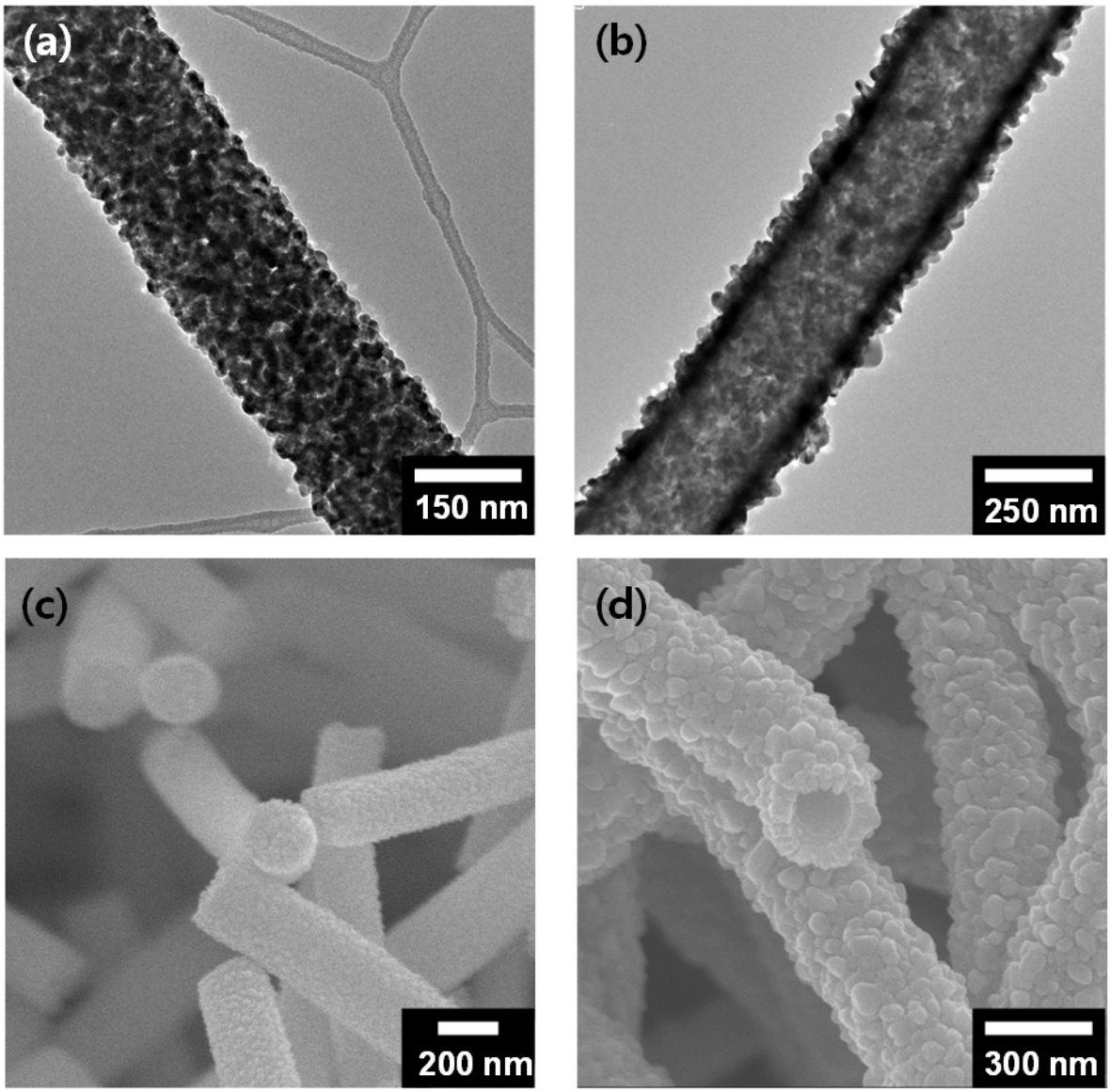

Fig. S1. (a, c) Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) images of the SnO_2 fibers. (b, d) TEM and SEM images of the SnO_2 tubes.

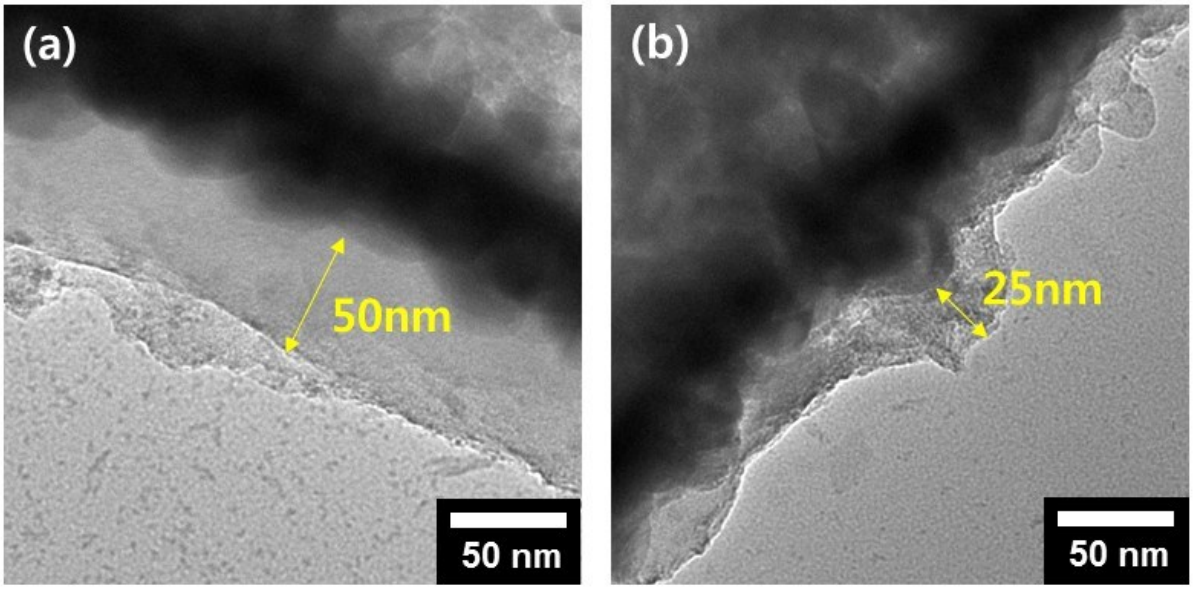

Fig. S2. Transmission electron microscopy (TEM) images of the PPy@SnO_2 tube in tube by conducting the VDP step at different temperature (a)60°C and (b)100°C.

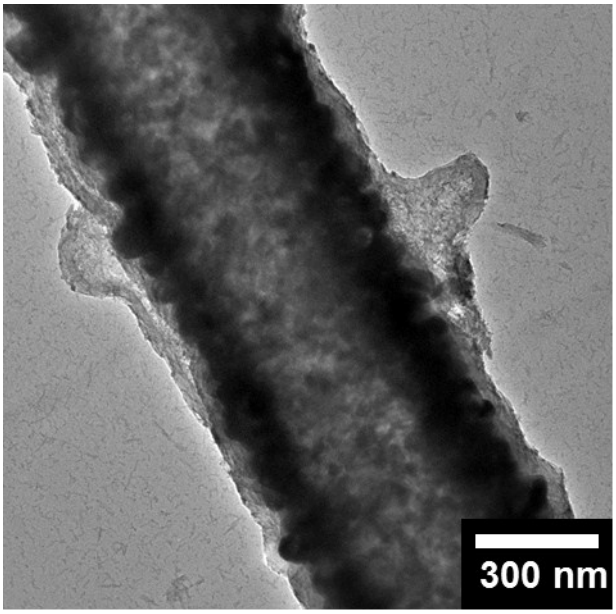

Fig. S3. TEM image of the morphology of the PPY coated SnO_2 tube structure after VDP method in ambient state.

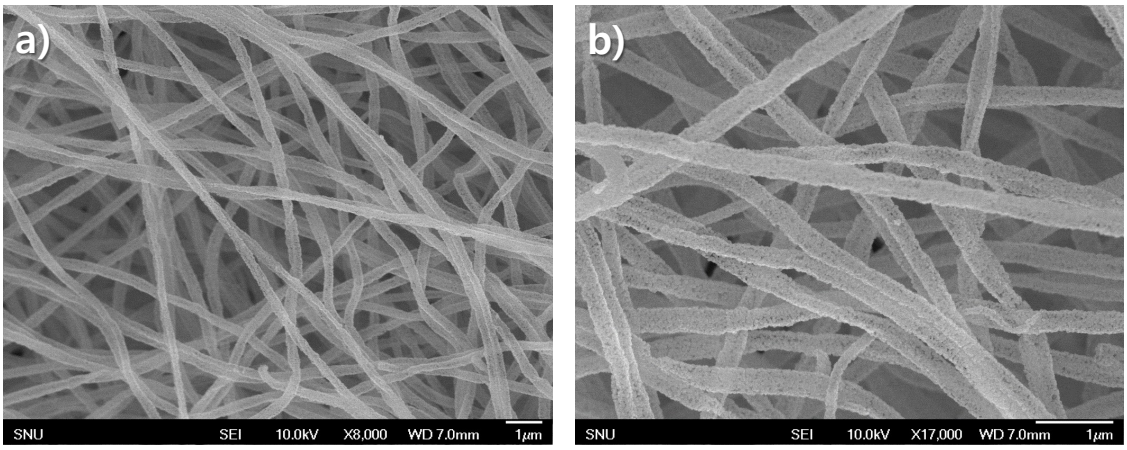

Fig. S4. (a) Low-and (c) high-resolution FE-SEM images of the tube-in-tube SnO_2.

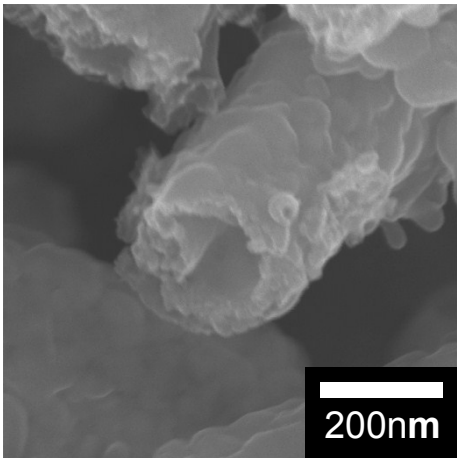

Fig. S5. High-resolution SEM image of the PPy@SnO_2 tube in tube.

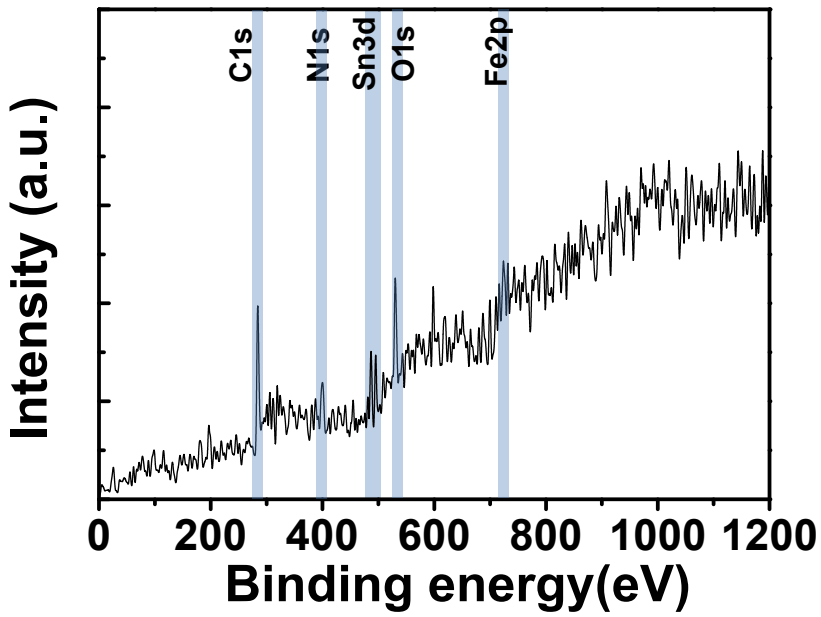

Fig. S6. . X-ray photoelectron spectroscopy (XPS) analysis of a fully scanned spectra (0–1200 eV).

Fig.S6 shows the overall XPS spectroscopy of the PPy@SnO_2 tube in tube over the range of 0-1200eV; carbon, nitrogen, oxygen, tin, and iron atoms were present. Based on the XPS peak, it is considered that the small quantities of iron atom originated from FeCl3 solution is still exist.

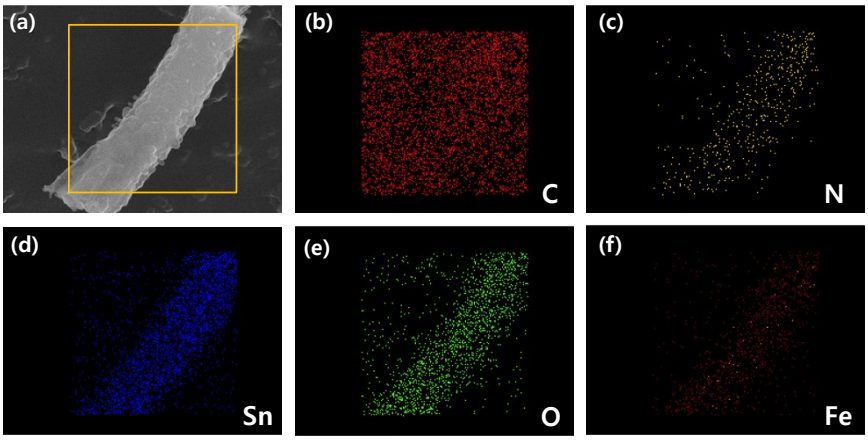

Fig. S7. EDS dot mapping of PPy@SnO_2 tube in tube surface components indicating (a)overall SEM image, (b)carbon, (c)nitrogen, (d)tin, (e)oxygen and (f)iron

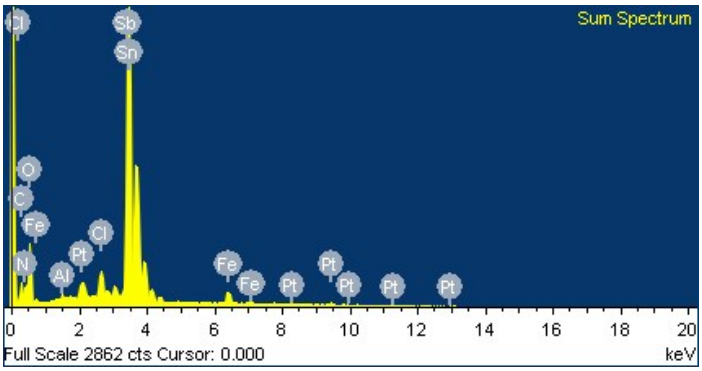

Fig. S8. EDX spectrum of the PPy@SnO_2 tube in tube surface

Table S1. Summarized elemental distribution of the PPy@SnO_2 tube in tube

Element	Weight%	Atomic%
C K	5.42	14.30
N K	5.64	12.77
O K	27.71	54.94
Al K	0.31	0.36
Cl K	1.50	1.35
Fe K	2.15	1.22
Sn L	51.54	13.77
Sb L	3.66	0.95
Pt M	2.07	0.34

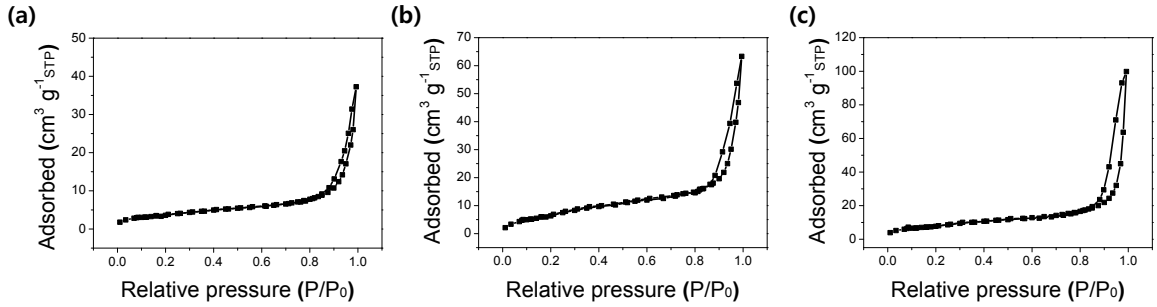

Fig. S9. Nitrogen adsorption–desorption isotherm curves of (a) Fiber, (b) Tube, and (c) Tube-in-tube.

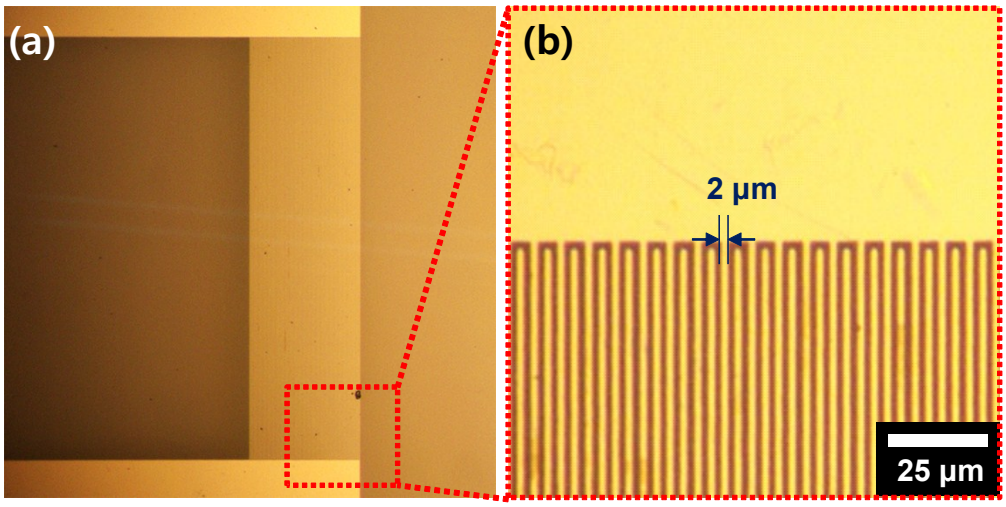

Fig. S10. (a) Low- and (b) high-resolution optical microscopy images of the interdigitated array (IDA) electrode.

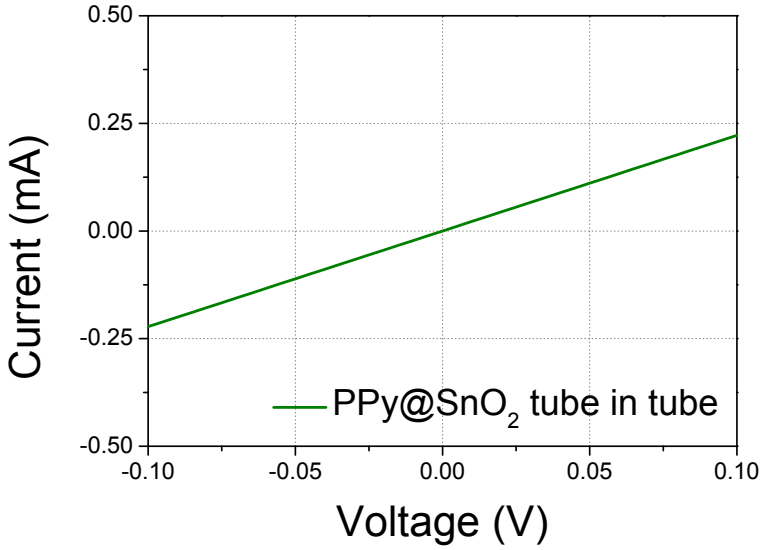

Fig. S11. Current–voltage (*I–V*) curve of the tube-in-tube PPy@SnO_2 sensor electrode.

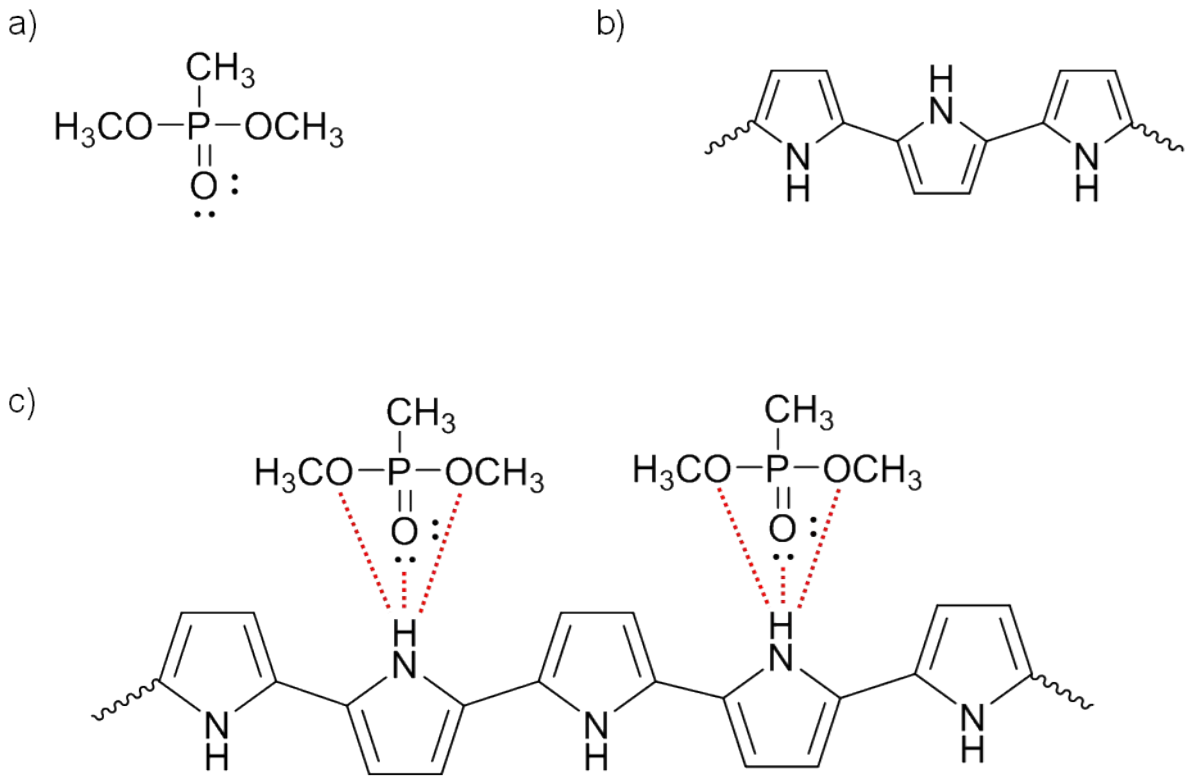

Fig. S12. Molecular structures of (a) dimethyl methylphosphonate (DMMP) and (b) polypyrrole (PPy). (c) Schematic diagram describing the effect of hydrogen bonding on PPy.

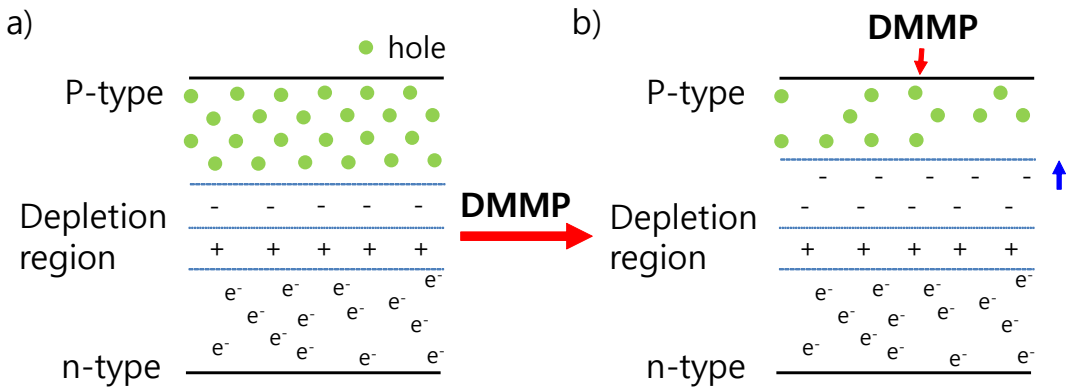

Fig. S13. Schematic diagram of the formation of a p-n junction.

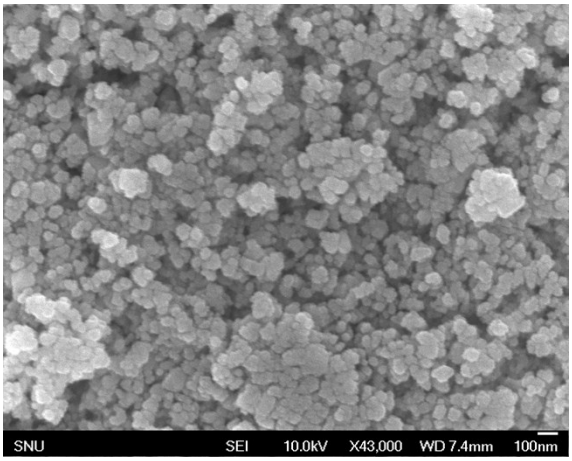

Fig. S14. SEM image of the PPy@SnO_2 nanoparticles.

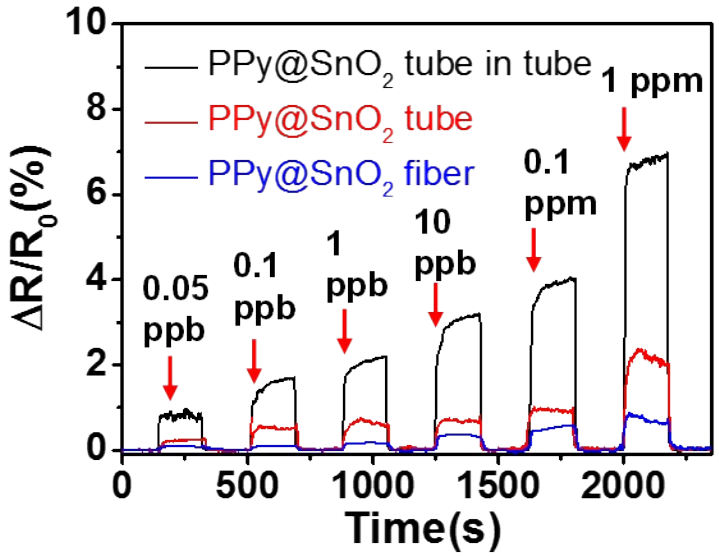

Fig. S15. Real-time monitoring of PPy@SnO_2 having different one-dimensional (1D) structures after sequential exposure to DMMP.

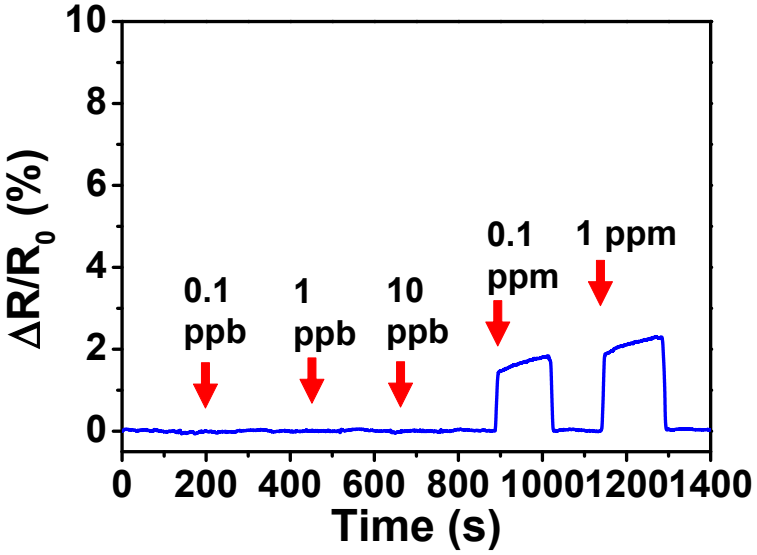

Fig. S16. Real-time responses of the PPy@SnO_2 nanoparticles upon periodic exposure to dimethyl methylphosphonate(DMMP); 0.1 ppb to 1 ppm.

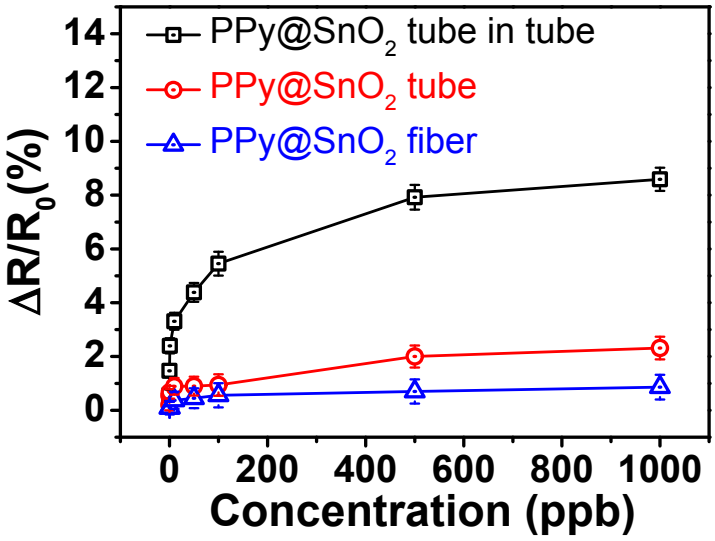

Fig. S17. Changes in sensitivity as a function of DMMP concentration calculated from the real-time responses.

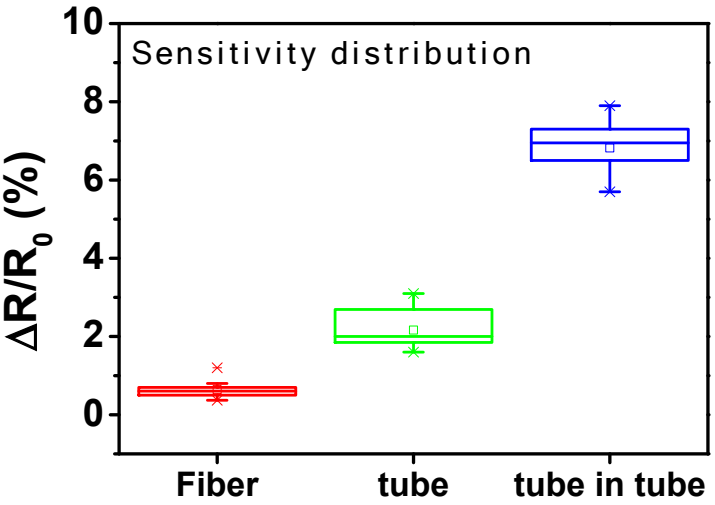

Fig. S18. Variation and comparison of the sensitivity parameter. These parameters were evaluated from 10 devices fabricated at 1 ppm