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Electro-netting: fabrication of two-dimensional nano-nets for highly sensitive trimethylamine sensing

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Experimental

Materials. A PAA (M_W 250,000, Wako) solution with a concentration of 8 wt% was prepared by dissolving PAA powder in ethanol (95 wt%, Shanghai Zhenxing Chemical Co., Ltd.) with vigorous stirring. NaCl was purchased from Aladdin Chemical Co. China. PAA/NaCl blended solutions were obtained by adding NaCl powder in the PAA solutions with stirring for 24 h. The used NaCl concentrations were 0.1 and 0.2 wt% with respect to the PAA solution. TMA (GCS grade) and other VOCs were purchased from Aladdin Chemical Co. China.

Fabrication of fibrous membranes on QCM. The setup for electrospinning/electro-netting deposition fibrous membranes on the electrode of QCM is depicted in Fig. 1a. The polymer solutions were loaded into a syringe that was attached to a high-voltage power supply (DW-P303-1ACD8) that was capable of generating voltages up to 50 kV. A syringe pump (LSP02-1B) was used to regulate the flow of the solutions at 3 mL h^{-1}. The electrospinning

chamber was kept with the constant temperature at 22 ^{o}C with the selected RH at 25, 45 and 60%, respectively. The fibrous membranes were deposited on the grounded electrode of QCM (5 MHz, AT-cut quartz crystal with Au electrodes) at a 15 cm tip-to-collector distance until the required frequency shift was obtained at a RH of 25%. The coating loads of fibrous membranes on QCM were regulated at about 1100 and 3500 Hz. The resonance frequencies were measured by a QCM digital controller (QCM200, Stanford Research Systems). Fibrous membranes coated QCMs were dried at 25 ^{o}C in vacuum for 12 h prior to the subsequent characterizations.

Apparatus for gas sensing. Schematic diagram of a static-type gas testing system has been described in our previous report.[1] The sensor was installed in the testing chamber (7.64 L) which kept with the constant temperature at 22 ^{o}C and the RH of 50%. A micro injector (HP5062) was used for analyte injections. The concentration of injected analyte in the chamber was calculated in ppm according to the following formula:

$$C = (22.4\rho_2 TV_s / 273MV) \times 10^3$$

where C is the analyte concentration in ppm, ρ_2 the density of liquid analyte in g mL^{-1}, T the temperature in testing chamber in Kelvin, V_s the volume of liquid analyte in μL, M the molecular weight of analyte in g mol^{-1}, and V the chamber volume in liter. The sensing properties of the sensors to analyte were examined by measuring the resonance frequency shifts of QCM which due to the additional mass loading. The resonance frequencies were measured by the frequency counter. The data from the sensors were recorded by a personal computer.

Characterization. The conductivity and viscosity of solutions were measured by an electric conductivity meter (FE30) and a viscometer (CNDJ-79), respectively. The morphology of fibrous membranes was observed by FE-SEM (S-4800). The diameters of fibers were measured by using an image analyzer (Adobe Photoshop CS2). BET surface area was characterized by a surface area analyzer (ASAP 2010).

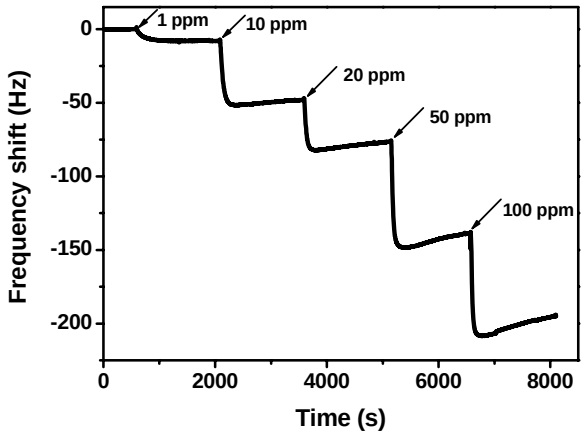

Fig. S1. Response during exposure to increasing TMA concentrations of PAA/NaCl (0.1 wt%) CNMs coated sensor with a coating load of 1100 Hz.

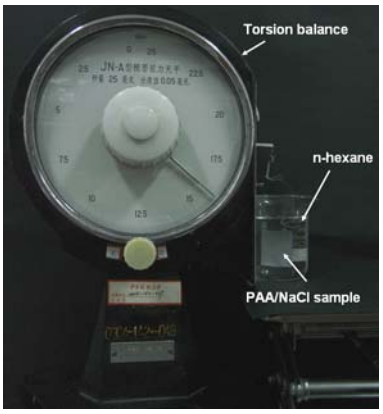

Fig. S2. Optical image of PAA/NaCl CNMs density determination through the liquid displacement method, which were operated as previously described.[2] The liquid container was positioned underneath a torsion balance (JN-A), which was equipped with a below-balance weighing hanger. The membrane sample volume was determined by the difference between the mass of a sample in air and the mass of the same sample submerged in the liquid (n-hexane). The PAA/NaCl CNMs density (ρ) is calculated according to the equation: $\rho = \frac{m_1}{m_1 - m_2}\rho_L$, where m_1 is the weight of the test membrane sample in air and m_2 is the weight of the sample in n-hexane. ρ_L (0.6613 g·cm^{-3}) is the density of n-hexane.

1 X. F. Wang, B. Ding, M. Sun, J. Y. Yu and G. Sun, *Sens. Actuators, B*, 2010, **144**, 11-17.

2 F. Rabier, M. Temmerman, T. Bohm, H. Hartmann, P. D. Jensen, J. Rathbauer, J. Carrasco and M. Fernandez, *Biomass Bioenerg.*, 2006, **30**, 954-963.