The deployment of NOTT-300 (Al) MOF thin film as NO_2 capacitive based sensor under ambient conditions

Mohamed Rachid Tchalala[a], Osama Shekhah[a], Youssef Belmabkhout[a], Hao Jiang[a], Khaled N. Salama*[b], and Mohamed Eddaoudi*[a]

[a]Functional Materials Design, Discovery, and Development research group (FMD3), Advanced Membranes & Porous Materials Center, Division of Physical Sciences and Engineering King Abdullah University of Science and Technology Thuwal 23955-6900 (Saudi Arabia).

[b]Sensors Lab, Electrical Engineering Program, Division of Computer, Electrical and Mathematical Sciences and Engineering King Abdullah University of Science and Technology Thuwal 23955-6900 (Saudi Arabia).

Table of Contents

1. Materials and methods

Chemicals:

All starting materials utilized in this work were used as purchased without further purification.

Characterization:

The PXRD patterns were recorded on a Panalytical X'pert PRO MPD X-ray Diffractometer with Cu Kα source (λ=0.15418 nm, 45 kV, 40 mA) for CuKα(λ= 1.5418 Å).
Scanning electron microscopy (SEM) images were taken using a Nova NanoSEM 450 scanning electron microscope (FEI) working in the secondary electrons mode at a voltage of 2 kV and a resolution of 2 nm.

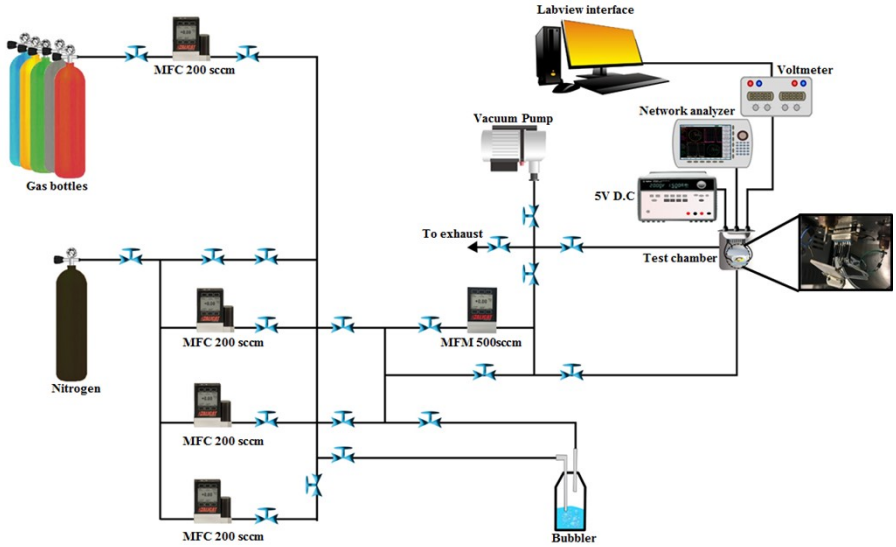
Experimental Procedures:

Preparation of NOTT- 300 (Al):

Synthesis of the NOTT-300 (Al) MOF was carried out solvo-thermally by heating solution containing Biphenyl-3,3′,5,5′-tetracarboxylic acid (60 mg, 0.182 mmol), Al(NO3)3·9H2O (0.34 g, 0. 906 mmol), piperazine (0.10 g, 1.26 mmol) water (10.0 mL), and Nitric acid (2.8M, 2.0 ml), were combined in a 23 mL autoclave and heated to 210 ◦C for 3 days.
The obtained fin microcrystalline product was separated by filtration washed with water, spin coated on top of the IDE chip, and immersed in 10 mL of ethanol for 3 days, during which time the ethanol was replaced three times per day.

Apparatus:

Scheme S1 shows the schematic of the setup used in this study for real-time gas sensing measurements. MFCs (Mass flow controllers) from Alicat scientific Inc. were used to control the flow rate of gases from certified bottles. Stainless steel or perfluoroalkoxy alkane, PFA tubing (in regions requiring flexibility) along with Vernier metering valves (from Swagelok) as a flow regulator were used as delivery lines in the setup. A commercial humidity sensor (Honeywell HIH-4000-003, error less than 0.5%RH) was used to monitor the humidity levels inside the test chamber. The QCM/IDE- based sensors were exposed to the analyte stream until a stable response was attained. Two-port impedance analyzer (Keysight E5071C ENA) circuit was used for monitoring the change in resonance frequency. A LabVIEW interface was used for synchronization and data acquisition by controlling the LCR meter and the multi-meter. This minimized the possibility of data loss.



Scheme S1. Illustrative scheme of gas flow control and dilution system and sensor measurement set-up

2. Supporting Figures:

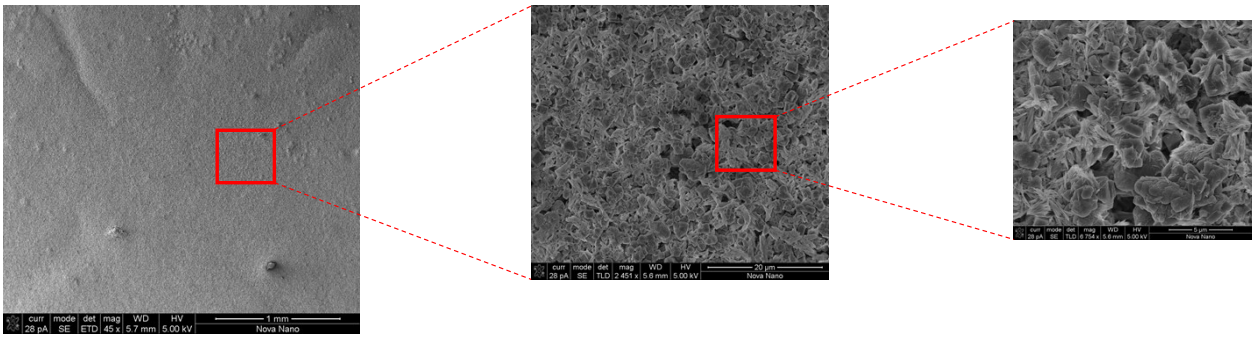


Figure S1. Scanning electron Microscopy images of the thin film NOTT-300 (Al) formation.

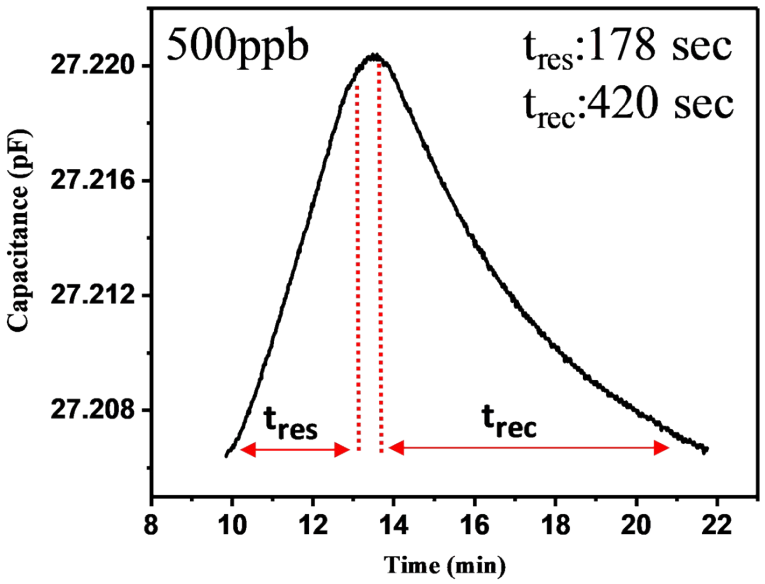


Figure S2. The response and recovery time for NO_2 sensing.

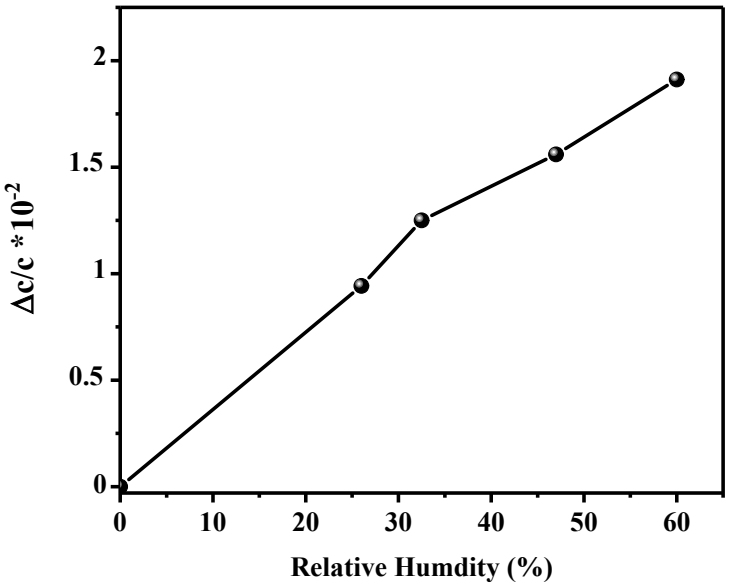


Figure S3. Variation in capacitance with RH change in NOTT-300 (Al).

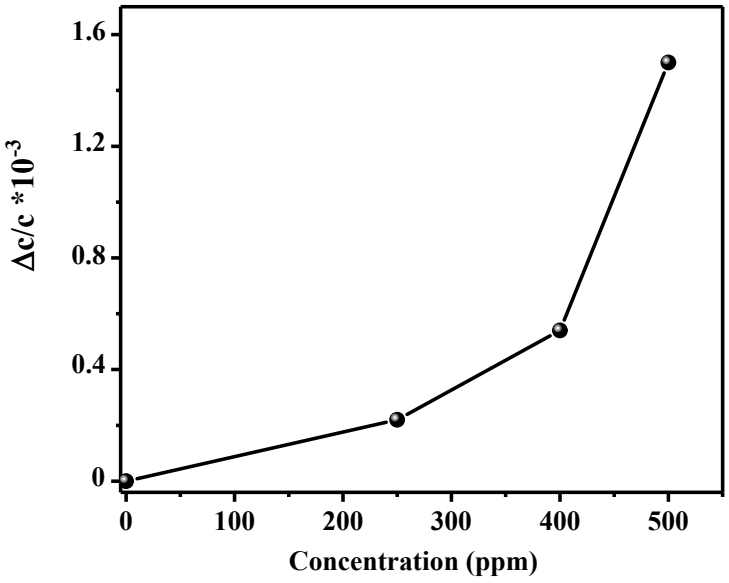


Figure S3. Variation in capacitance with CO_2 change in NOTT-300 (Al).

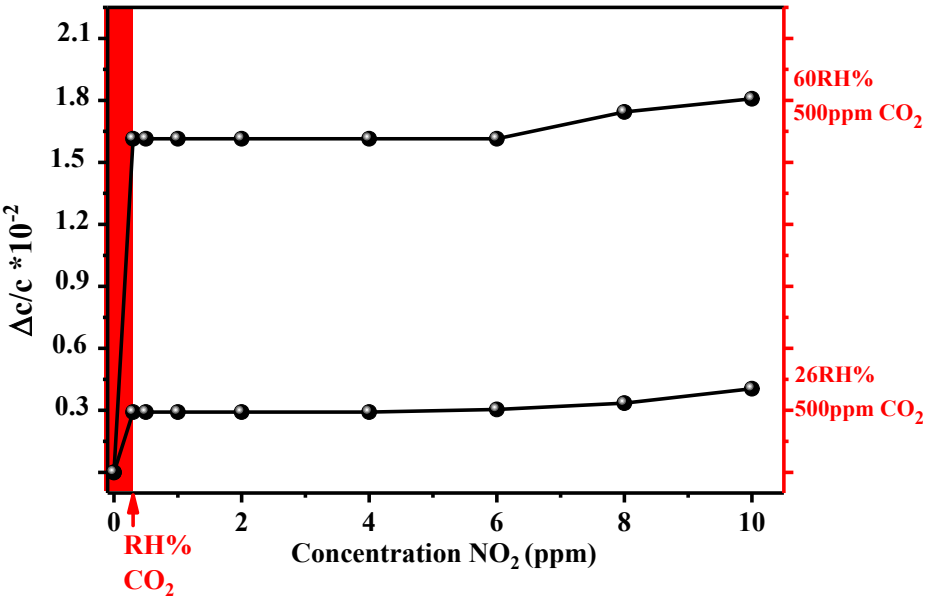


Figure S4. Variation of both Humidity and CO_2 on sensing NO_2 properties of the NOTT-300 (Al) platform.