Sensors for Volatile Chemicals: Room Temperature Ammonia and Humidity Sensing

Sensors for Volatile Chemicals: Room Temperature Ammonia and Humidity Sensing

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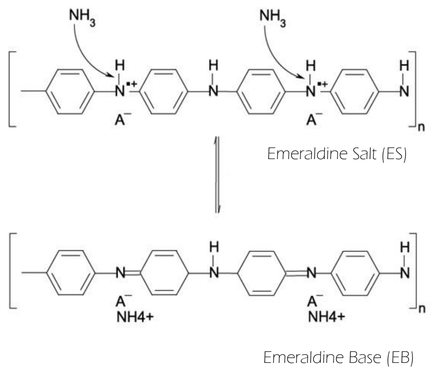
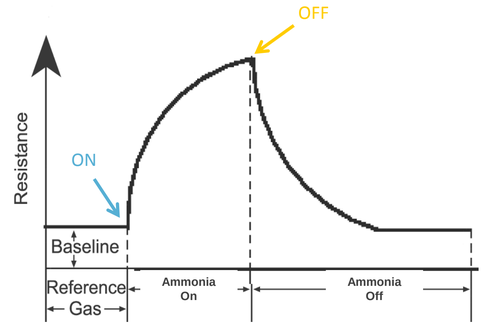
Abstract

- ✓ Ammonia: one of the main analytes encountered during food spoilage. Also important in environmental monitoring.
- ✓ Polyaniline: an intrinsically conducting polymer (ICP), known to be sensitive to ammonia.
- ✓ It is difficult to fabricate thin polyaniline layers with common solution-based deposition techniques; polyaniline is not solution processable!
- ✓ We have developed a simple technique: **"vapour-phase deposition polymerisation (VDP)"** to make a Nafion-doped polyaniline sensing layer on flexible substrates. VDP is compatible with high-throughput sensor fabrication methods
- ✓ Nafion®: a perfluorosulfonic acid polymer with PTFE backbone which imparts thermally and chemically stability. A novel dopant for polyaniline!
- ✓ The composite sensor shows sensitive, rapid and reversible response to very low concentrations of ammonia vapour in the range of 250-1500 ppb at room temperature.
- ✓ It is a good humidity sensor as well!

Sensing Mechanism

Doped polyaniline exhibits p-type semiconductor characteristics; electron-supplying gases such as NH_3 reduce the charge-carrier (polaron) concentration and decrease the conductivity.

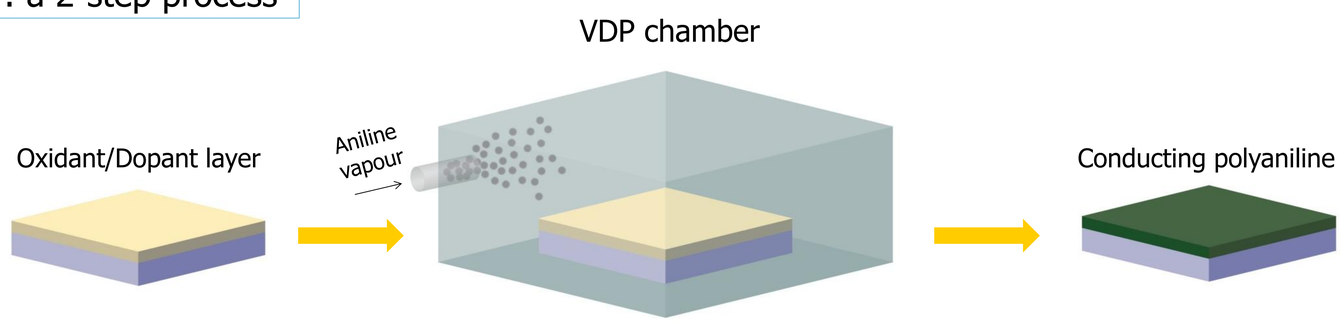




Using Nafion as the polymeric dopant not only enhances the stability of the conducting polymer, but also imparts interesting gas sensing properties to it.

Vapour-phase deposition polymerisation (VDP)

VDP: a 2-step process

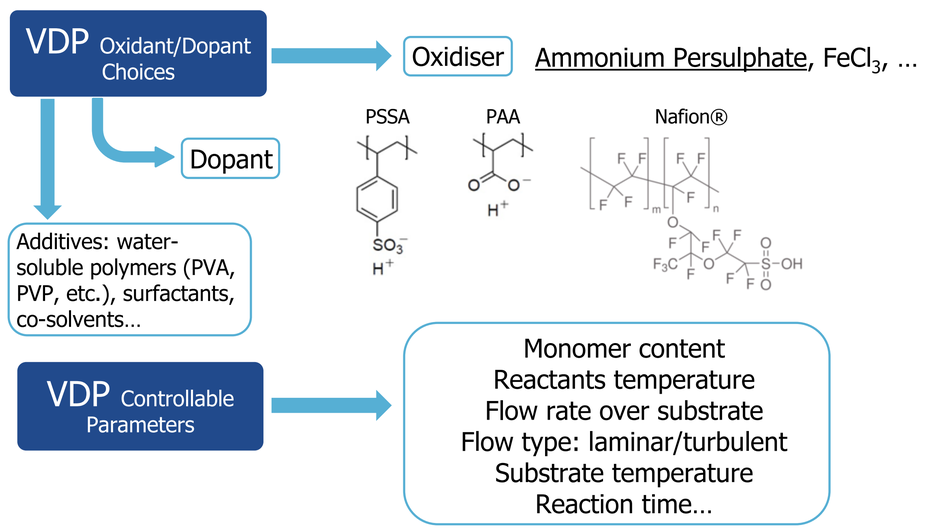


Step 1: The is first coated with the Oxidant/Dopant layer → drop casting, spin coating, inkjet printing, etc. can be employed.

Step 2: The substrate is then exposed to aniline (monomer) vapour → polymerisation starts on the substrate:

Eventually: A thin conducting polyaniline layer is formed in-situ on the substrate

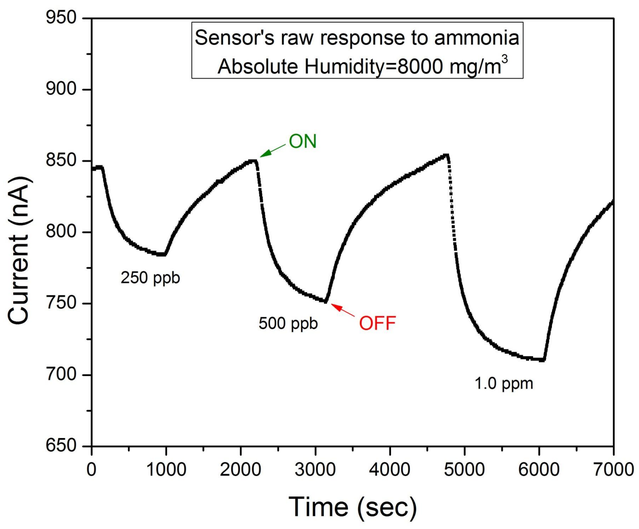
VDP: a flexible technique



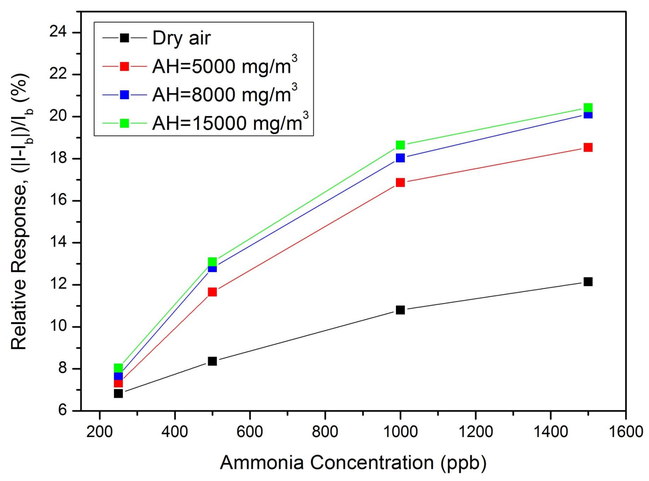
Substrate: Upilex® incorporating interdigitated gold electrodes with 20 μm gap size

Results

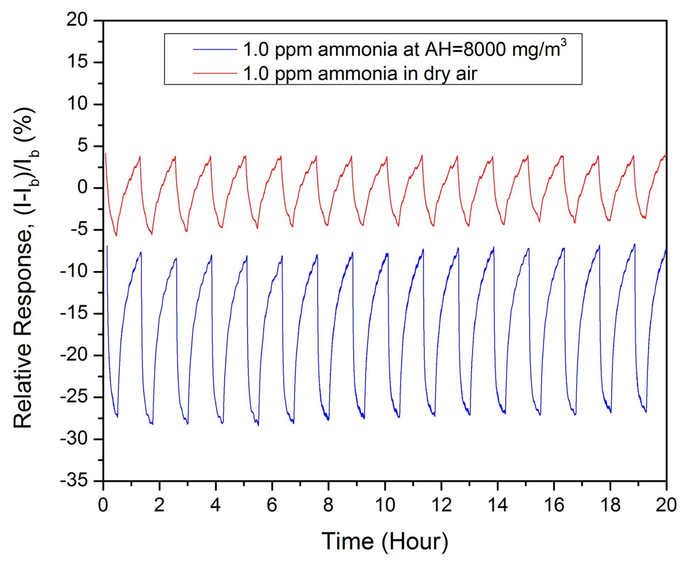
- ✓ Sensor shows sensitive, fast and reversible response to sub-ppm concentrations of ammonia vapour generated by a permeation tube. The sensor is operated at room temperature.



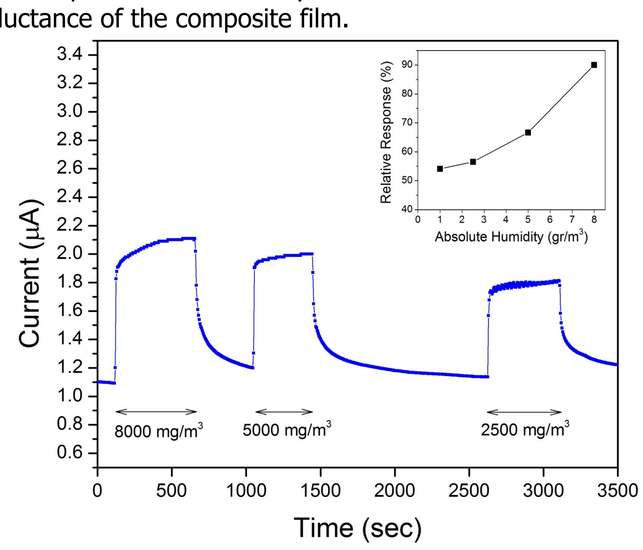
- ✓ The sensor response is amplified in the presence of water vapour. The humidity is no more an undesirable interferent!



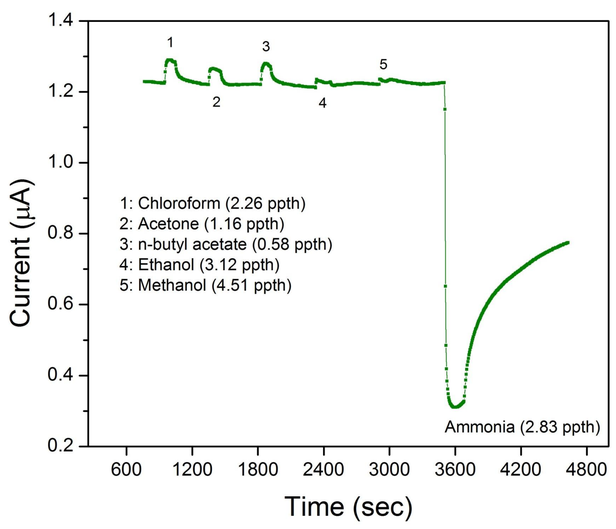
- ✓ Repeatability test of the sensor to 1.0 ppm ammonia is shown. The sensor at humid environment works better.



- ✓ Nafion-doped polyaniline sensor can be used as a humidity sensor as well. Water molecules ionise the terminal $–SO_3H$ groups and increase proton conductivity. This increases the electrical conductance of the composite film.



- ✓ The response to ammonia is at least 10 times the response to other VOCs.



Conclusion

An ammonia sensor that can work in humid environment is realised on flexible substrates using vapour phase deposition polymerisation technique. The sensor can be used in smart tags for monitoring of perishable goods during the transportation chain.

Acknowledgment

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