Development of Polyaniline Based Gas Sensor

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Outline

• Introduction
• Materials and Methods
• Experimental results and Discussion
• Conclusions
Introduction

- Increasing atmospheric pollution problems → Higher need of effective and low cost monitoring and controlling systems for detection and quantification of pollution sources

- Standard air pollution measurement: Optical spectroscopy, gas chromatography/spectroscopy
  - Accurate quantification
  - Ability to analyze multiple gas species
  - Reproducibility
  - Complicated and very expensive
  - Massive/Power consumption
  - Time consuming
Introduction

• **Semiconductor gas sensor**
  - Low cost
  - High sensitivity and fast response
  - Low selectivity
  - High power consumption

• **Polymer gas sensor**
  - Low power consumption: Room operating temperature
  - Ease of synthesis
  - Diversity
  - Low cost
Introduction

• **Polyaniline**: one of the most promising conducting polymers for gas sensor

  - Ease of preparation
  - Relatively high electrical conductivity
  - Capable of n-type and p-type doping
  - Good environmental stability
  - Low cost
  - Difficult to dissolve and fabricate in thin film form
  - Need development for microsensor applications
Materials and Methods

Polyaniline synthesis

Aniline 0.08 mol + 1M HCL (91.06 ml) Stirring at 3°C

Mix 89.06 ml of 1M HCl with (NH₄)₂S₂O₈ Stirred at 3°C 3.5 hrs

Green emeraldine hydrochloride precipitate

Powder washed first in water and methanol

Powder was immersed in 0.1 M NH₄OH and washed again

Dry in vacuum 12 h at 60°C
Preparation of Protonation doped polyaniline

236 g MA added into 1000ml (2M MA)

MA/PANI ratio 425.36ml/0.35g

The mixture was shaken 48 hrs

The doped powder was dried at 60 °C for 40 hrs
**Materials and Methods**

**Fabrication of polymer gas sensor**

Dissolved doped Polyaniline powder in N-Methylpyrrolidone (NMP) 0.5 g: 10 ml with 30 min ultrasonic and 2 hrs stirring.

Filter the polymer solution to separate undissolved particle from the solution.

Dropped the solution on an interdigitated Al electrode fabricated on glass slide substrate.

Dry in vacuum oven at 60 °C for 12 hrs.
Experimental results and Discussion

(a) SEM micrograph  (b) X-ray diffraction pattern of polyaniline thin film.

(a) SEM micrograph  (b) X-ray diffraction pattern of polyaniline thin film.
Experimental results and Discussion

Gas Sensing Measurements

- Mass flow controller system
- Stainless steel chamber
- Measuring circuit
- Computer
- Gas sources
- Stainless steel chamber
- Exhaust
- Purified Air
- 1000 ppm CO in N₂
- Gas source
- Measuring circuit
- Computer
- Gas sources
- Stainless steel chamber
- Exhaust
- Mass flow controller
- Gas source
Experimental results and Discussion

Typical time response to CO of the polyaniline thin film with 24 hours dissolved times in NMP

Response time ~ 6 s
Recovery time ~ 6.6 mins
Experimental results and Discussion

Typical time response to CO of the polyaniline thin film with 48 hours dissolved times in NMP

Response time ~ 3 s
Recovery time ~ 2.1 min
Typical sensitivity to CO of polyaniline thin film with different dissolved times in NMP.

- **48 hrs.** Higher sensitivity with longer dissolved time in NMP.
- **24 hrs.**
Experimental results and Discussion

- Maleic acid doping in polyaniline contributed to CO gas sensing.

- Gas sensing characteristics of polyaniline can be improved by increasing dissolved time in NMP.

- Possible explanation

  The longer dissolved times in NMP may lead to higher concentration of MA-doped polyaniline solution before dropping. → Increase in active adsorption area
Conclusions

- Polyaniline thin film gas sensor has been developed by solvent casting technique on interdigitated electrodes.

- The conductivity of the film reproducibly respond upon CO exposure with concentration in the range of 100-500 ppm.

- The polyaniline sensor has shown fast response time and fair recovery time.

- Gas sensing characteristics of polyaniline can be improved by increasing dissolved time in NMP.

- MA-doped polyaniline is a promising candidate for CO sensor with low-concentration and room-temperature detection capability.
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Thank you for your attention