Inkjet Printable Ammonia-Selective Platforms For Gas- & Bio-sensing

Aoife Morrin, Karl Crowley, Orawan Ngamna, Eimer O'Malley, Anthony J. Killard, Gordon G. Wallace, Malcolm R. Smyth

National Centre for Sensor Research (NCSR)
Dublin City University
Ireland

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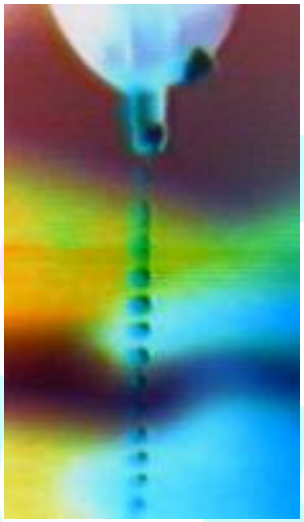
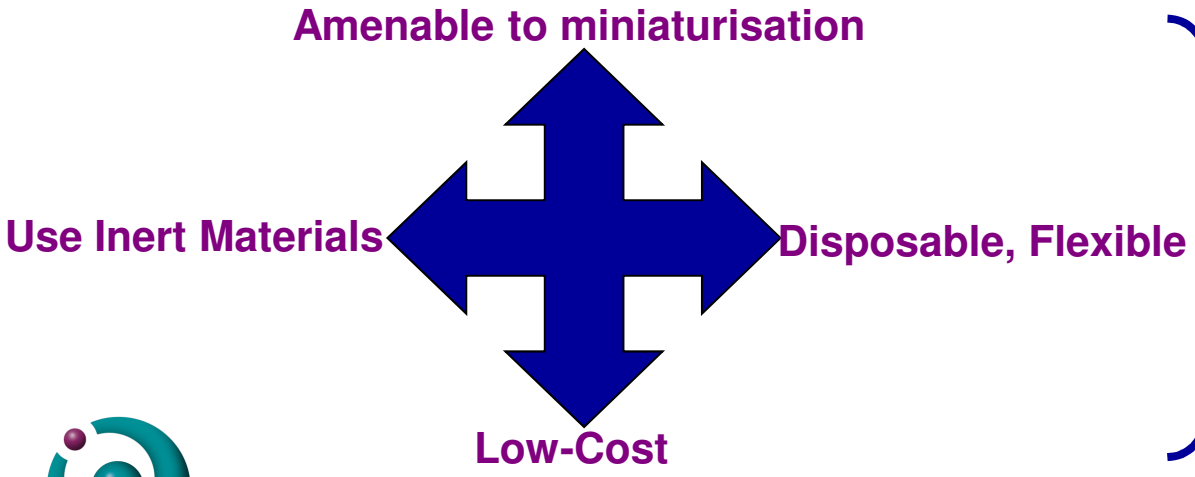
Concept

- Inkjet printable sensors offer a range of benefits by being amenable to low cost mass manufacture
- Such sensors are extremely now possible given the emerging printed electronics industry
- Our research looks to develop these sensors, based primarily on conducting polymer nanoformulations, as a way of mass producing devices for commercially relevant applications



RESEARCH GOAL IS TO DEVELOP ELECTROCHEMICAL SENSOR PLATFORMS



Inkjet Printing is the facilitator

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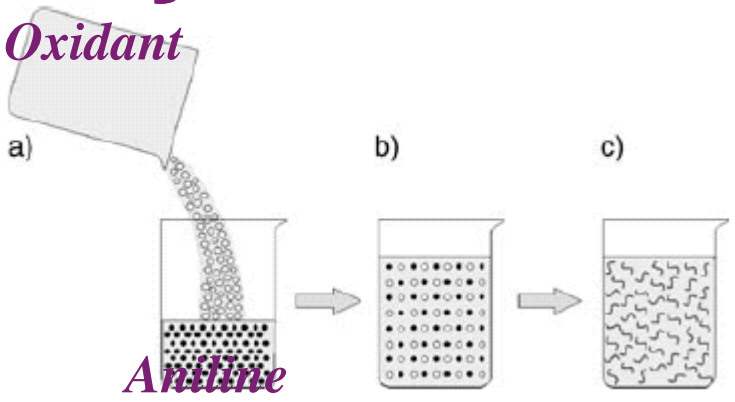
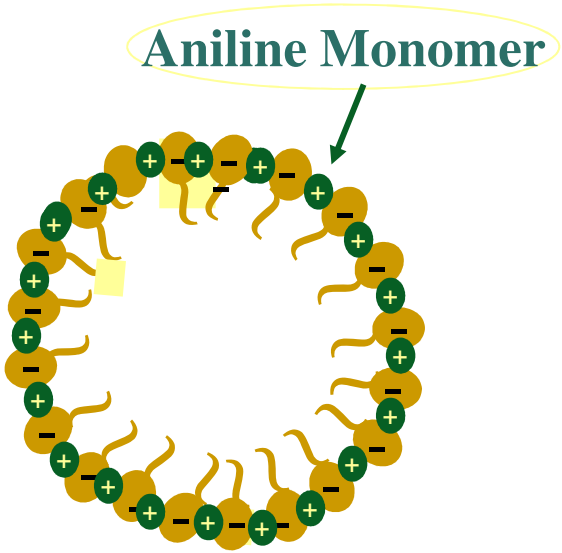
Synthesis of Nanoparticles





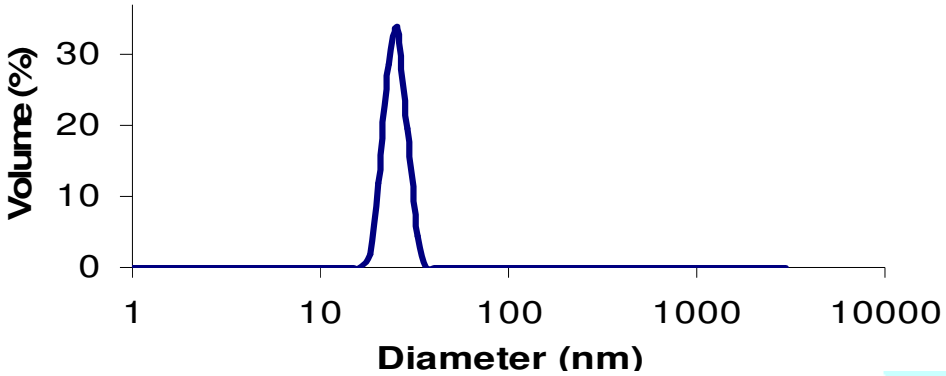
DBSA Micelle

- **Rapid Mixing method***
- **Monomer to Oxidant ratio = 4:1**
- **DBSA added to serve as dopant & surfactant (provide micelle structure to stabilise particles)**
- **SDS present also acts as surfactant for stabilisation**

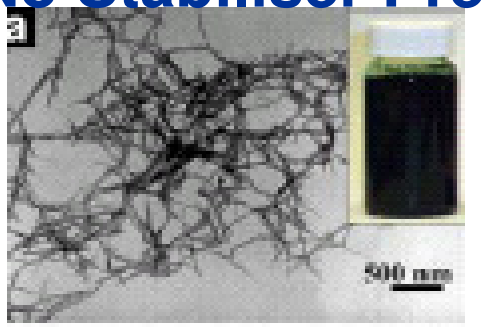
*Jiaxing Huang, Richard B. Kaner, *Angew. Chem. Int. Ed.* **2004**, 43, 5817-5821

Conducting Polymer Nanoparticle Ink

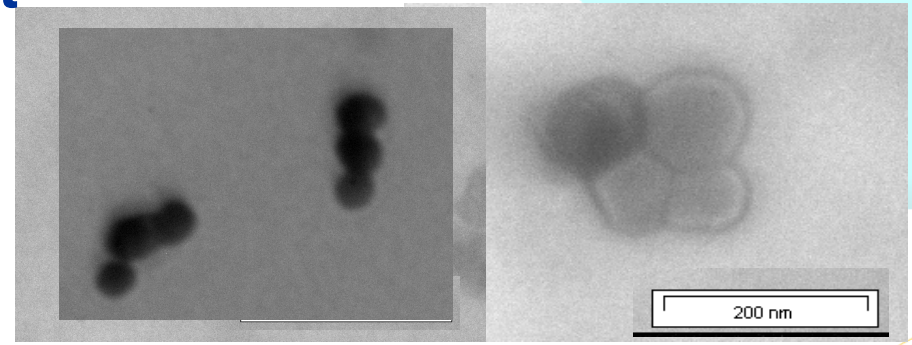
The spherical nature of the nanoparticles was achieved using surfactant, and the resulting nanoparticles had a diameter of 80 nm diameter approx.



No Stabiliser Present



Stabiliser Present



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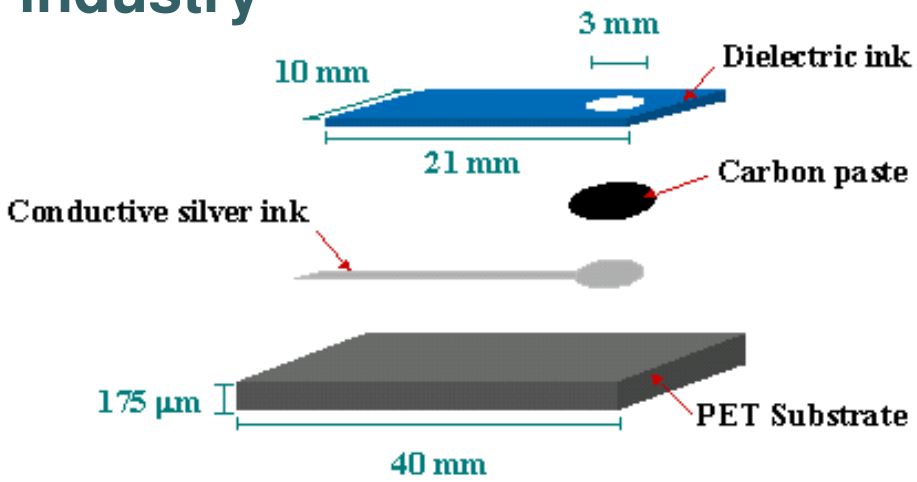
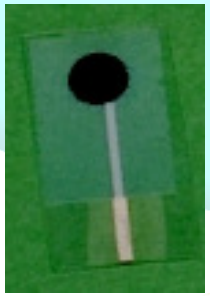
Sensor Platform

- Screen printing
- Low start up and manufacturing cost
- Mass production
- Disposability
- Flexible design process
- Platform for glucose biosensor industry

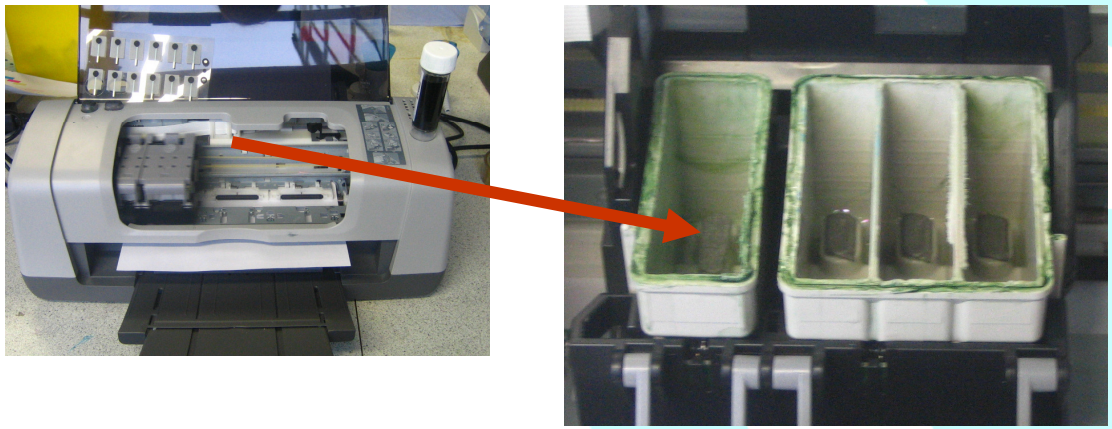




Inkjet Instrumentation for Sensor Modification

(1)

- Epson desktop printer
- Piezo technology
- Favoured over other more expensive single head devices due to the four available reservoirs
- No print parameter optimisation available

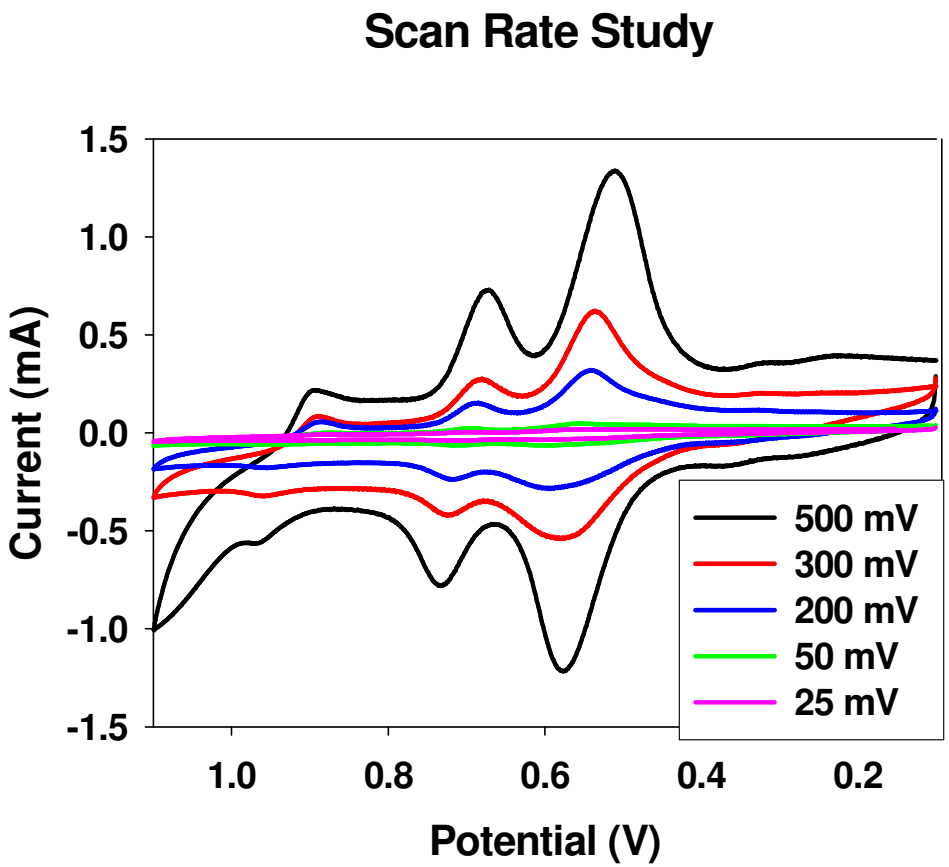


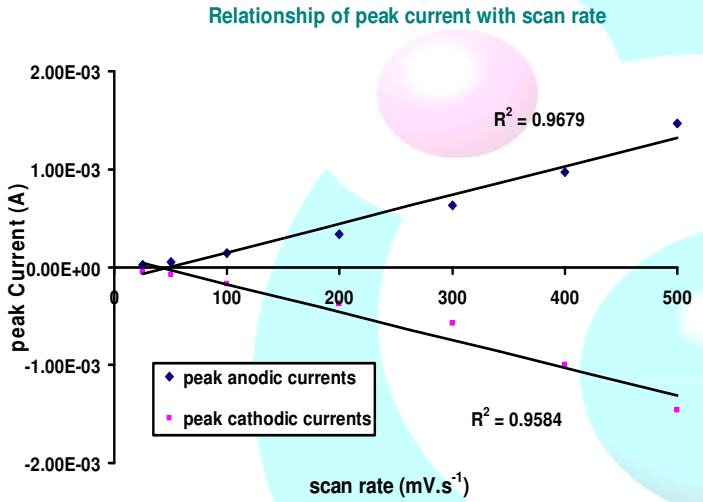
(2)

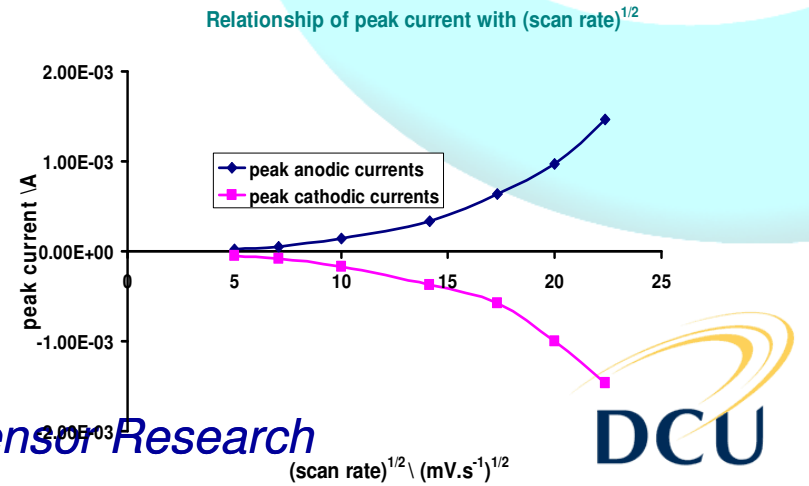
- Dimatix Inkjet Printer
- Piezo technology
- Single head device
- Extremely versatile

Dimatix™

Electrochemistry of Inkjet Printed Polyaniline Sensor







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Sensor Applications

- Chemo- and bio- sensing

- Distinctive benefits in terms of sensitivity and limits of detection for a range of analytes, in particular, ammonia

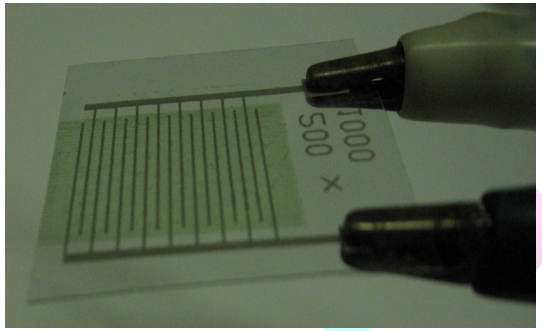
- One aim is to illustrate the applicability of these sensors to gaseous ammonia as this has been identified as a readily addressable commercial need with good opportunities for adoption by the gas sensor industry

- Ammonia is also a metabolic product in enzymatic reactions such as those involving urease and creatinine iminohydrolase. The technology illustrated here should be applicable to rapid biosensor fabrication. Therefore, extension of this technology, by looking to co-deposit the polymer with the enzyme, into the diagnostics field will be explored for analytes such as these

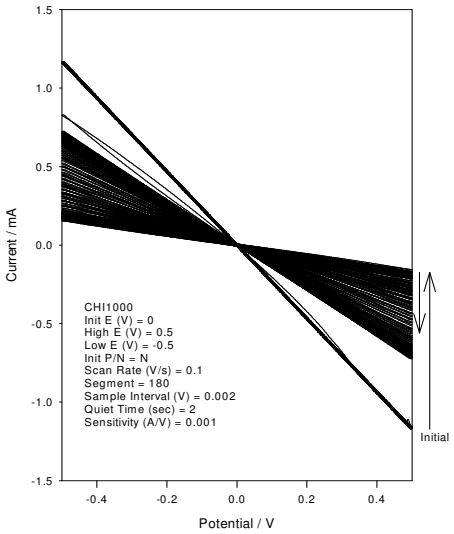
- Have also explored these materials as a proof of concept for horseradish peroxidase (HRP) biosensing

Gaseous Ammonia Sensing

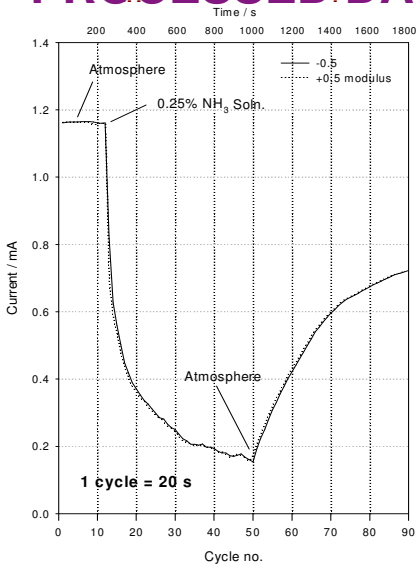
- **PANI nanodispersion inkjet printed onto screen-printed silver inter-digitated array (IDA) design**
- **Conductivity measurements by cyclic voltammetry in presence of ammonia gas**



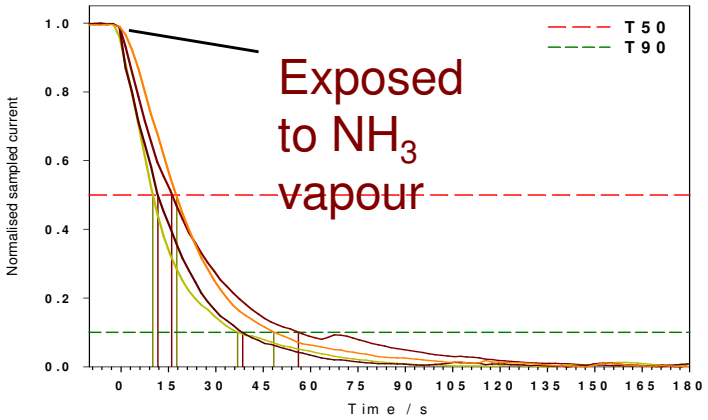
RAW DATA



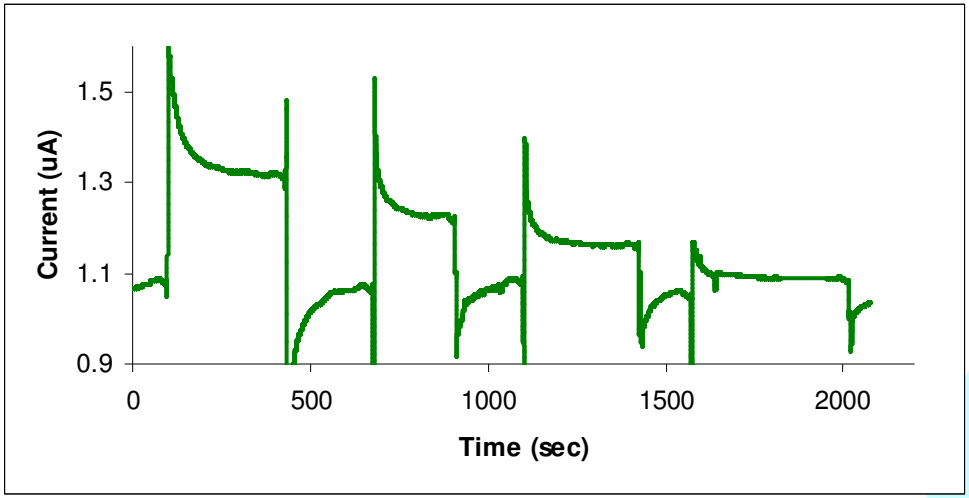
PROCESSED DATA



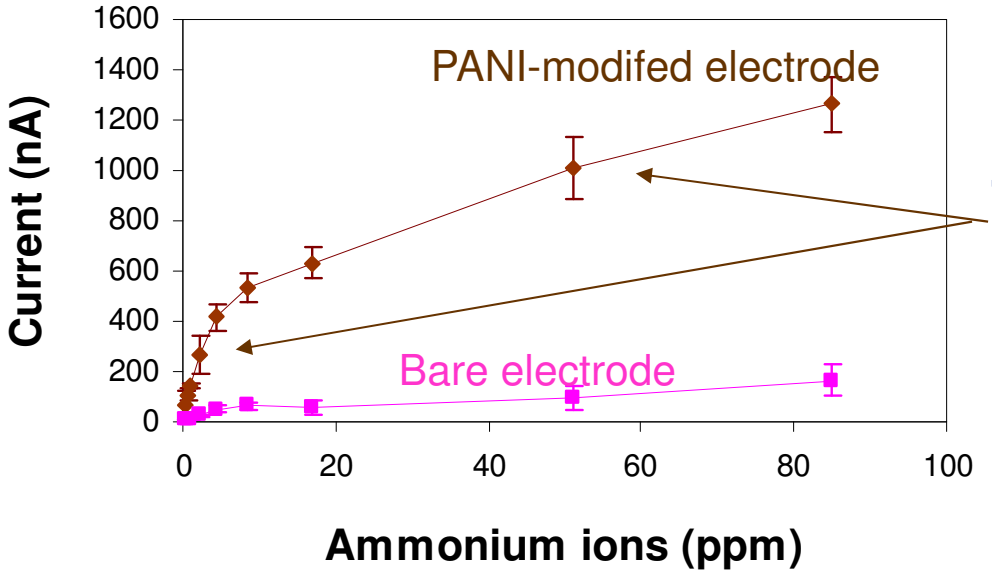
RESPONSE TIME (T90<60s)



Aqueous Ammonia Sensing



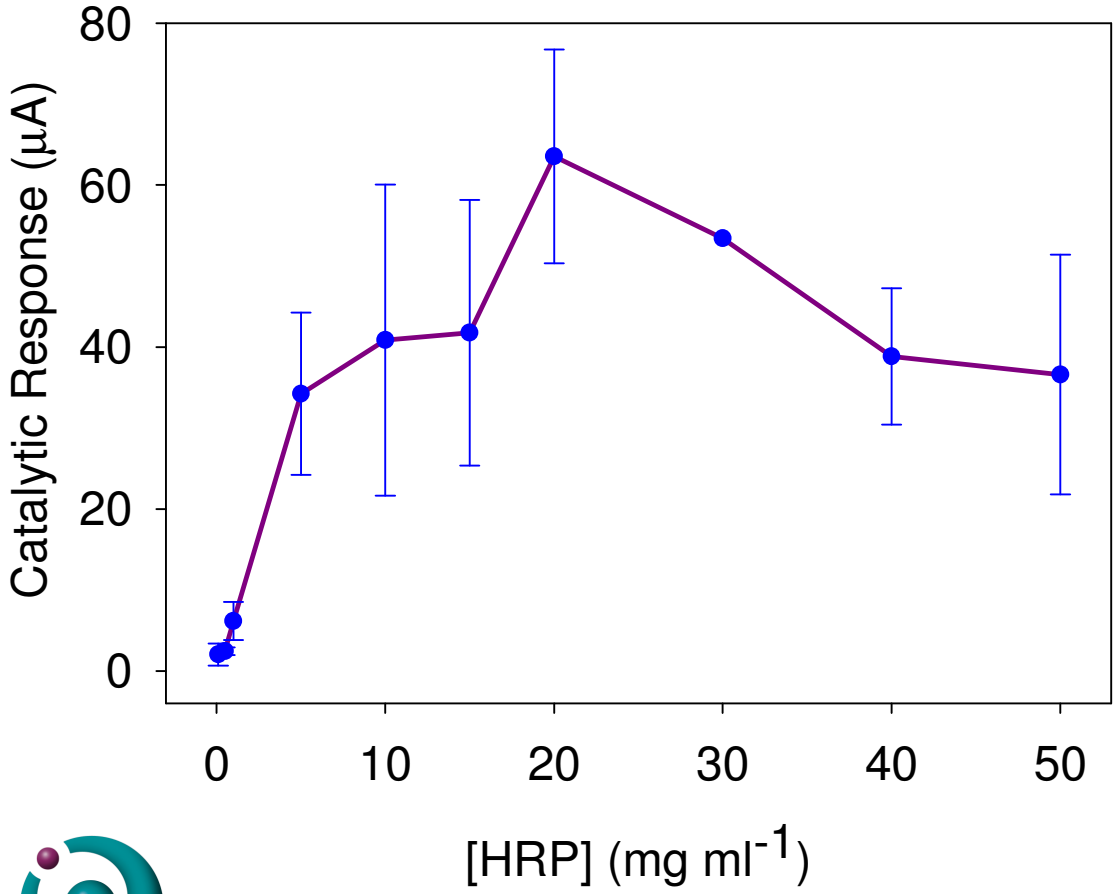
NH_4^+



Two available linear ranges – 0 – 5 ppm & 10 – 90 ppm

Peroxidase Biosensor

- **Single-Step Biosensor Fabrication**
- **Co-deposition of enzyme with nanoparticles**



- **pH of aqueous dispersion of PANI/DBSA < 3**
- **pH adjusted with NaOH**
- **HRP added to pH adjusted dispersion**
- **Solution drop-cast on electrode**
- **Responses to hydrogen peroxide measured amperometrically**

Conclusions

- Developing a generic sensor platform based on conducting polymer nanoparticles
- Sensor platform amenable to gas and liquid-phase sensing
- Development work for gaseous ammonia platform almost completed. Specification of sensor matches performance of many commercial sensors, with a lower manufacturing cost
- Demonstrated that the polymer nanoparticles are biocompatible and can interact electrochemically with the enzyme HRP.

Future Work

- Future work will involve the further development of the biosensor platform for biomedical applications exploiting horseradish peroxidase, urease and creatinine iminohydrolase
- Strategies for biomaterial deposition with conducting polymer will be investigated using the Dimatix™ printer