

# **Ionogel-biosensor: Novel Ionogels Based on Ionic Liquids as platforms to measure Enzyme Activity of Glucose Oxidase in Real Time**

**Caroline Barry**

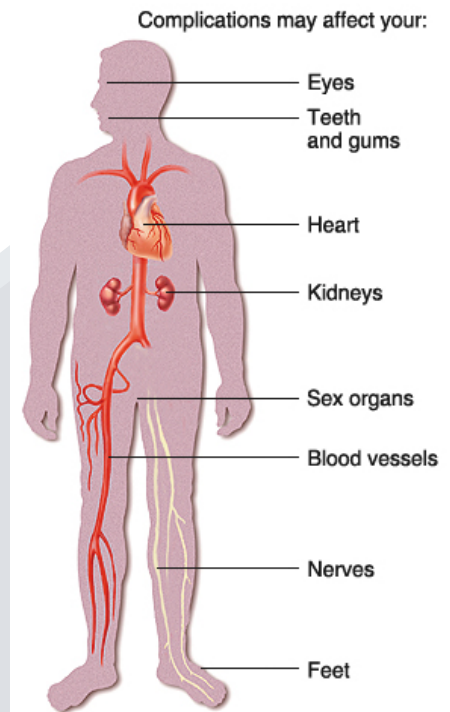
**Adaptive Sensors Group, National Centre for Sensor  
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Dublin City University, Dublin 9, Ireland**

# Outline

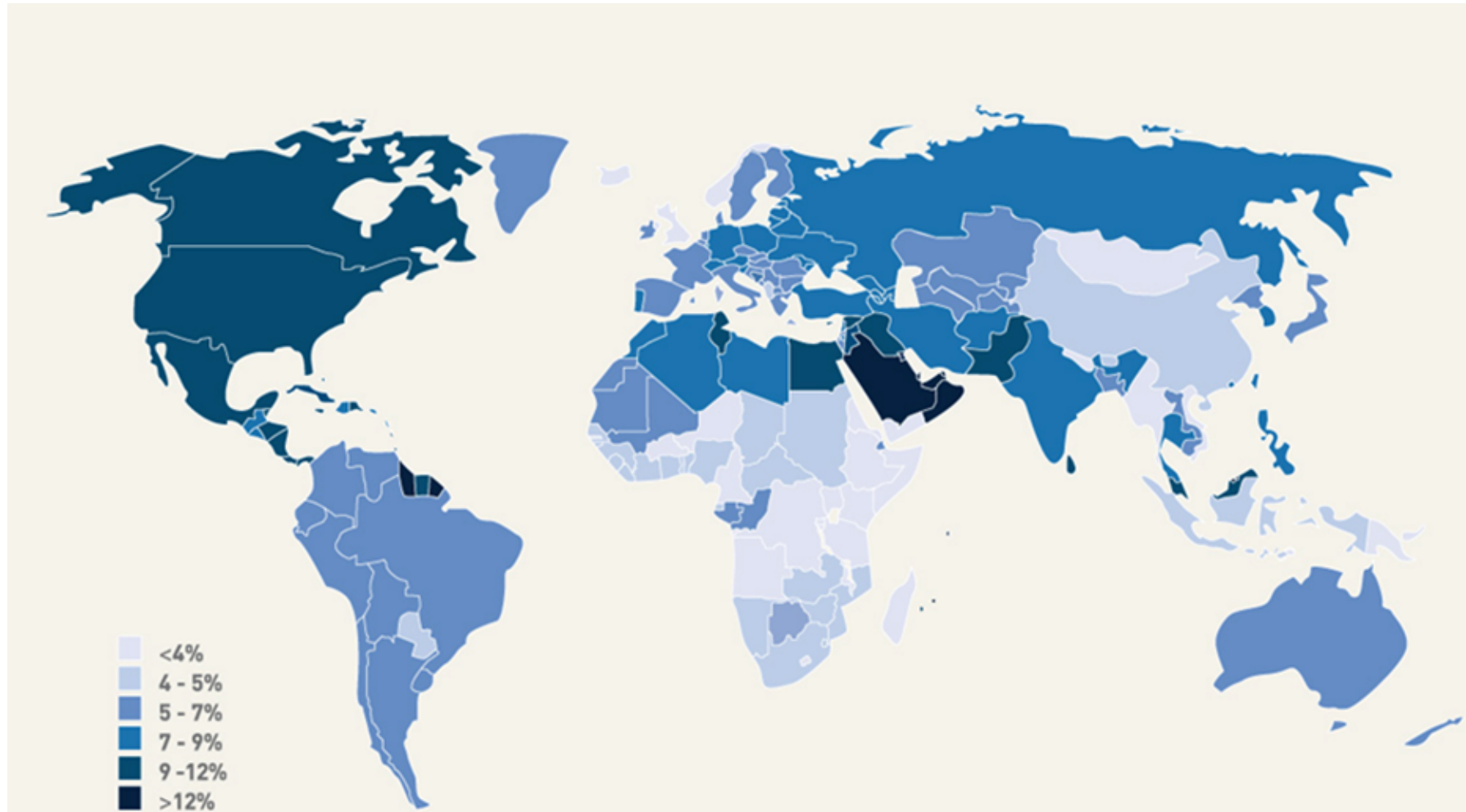
- **Diabetes**
- **Ionic liquids**
- **Ionogels**
- **Colorimetric and electrochemical analysis**
- **Conclusion**
- **Future outlook**

# Background of Project

- **Diabetes:** chronic disease when the pancreas does not produce enough insulin or the body cannot effectively use the insulin it produces.
- **Insulin** is a hormone that regulates blood sugar levels.
- **Types of diabetes:**
  - Type 1 diabetes
  - Type 2 diabetes
  - Gestational diabetes
- **11.6%** of total health care budget in 2010.

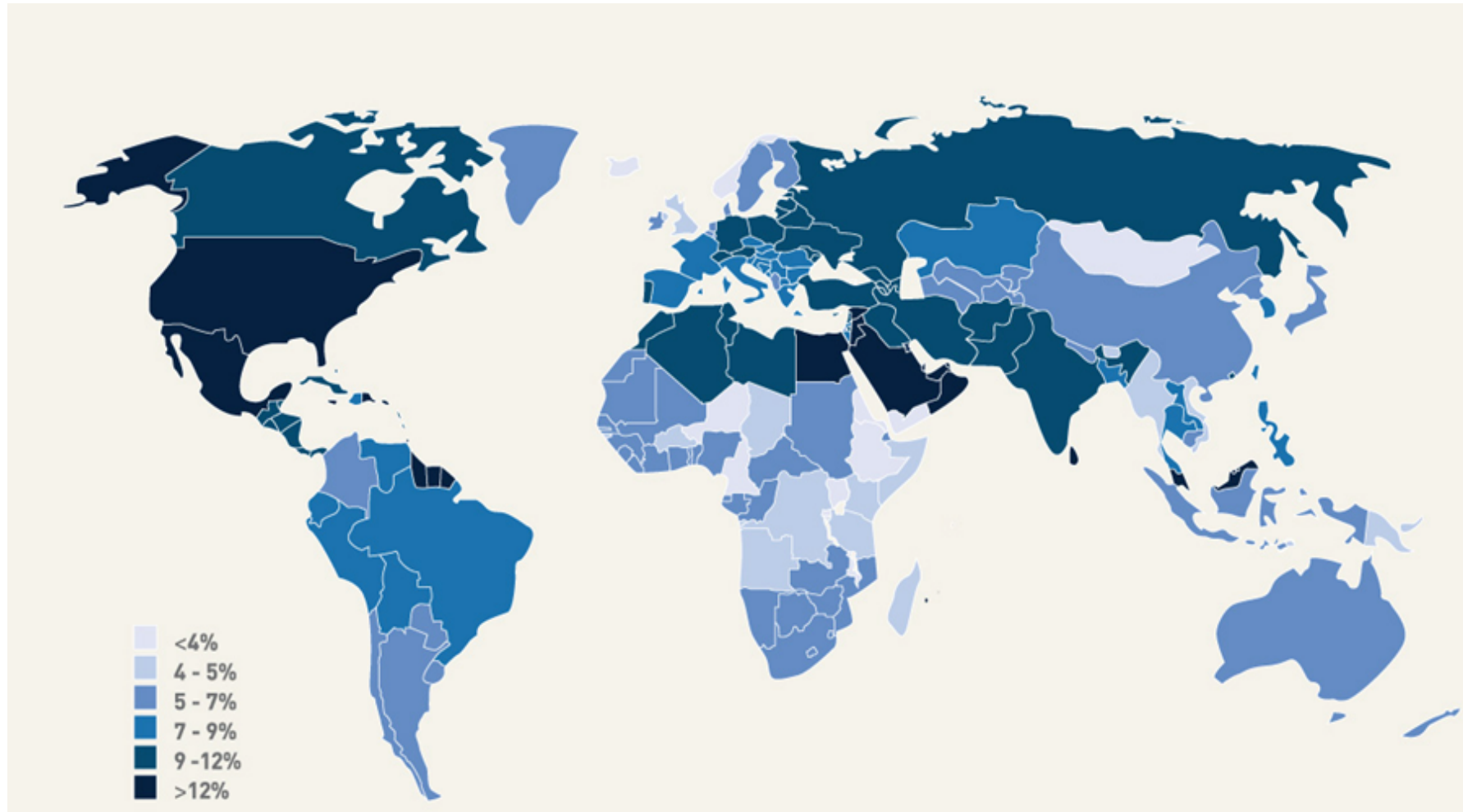


# Prevalence (%) estimates of diabetes (20-79), 2010



*IDF Diabetes Atlas 4<sup>th</sup> edition, © International Diabetes Federation, 2009.*

# Prevalence (%) estimates of diabetes (20-79), 2030



*IDF Diabetes Atlas 4<sup>th</sup> edition, © International Diabetes Federation, 2009.*

# Current Technology



Walmart relion blood glucose monitor



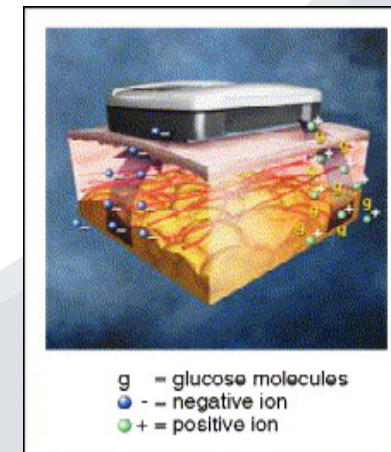
GlucoSure blood glucose monitor



OneTouch ultra blood glucose biosensor



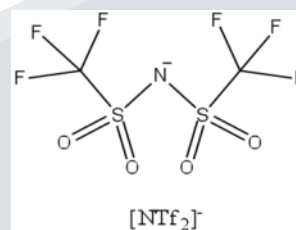
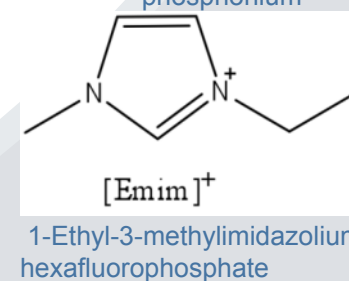
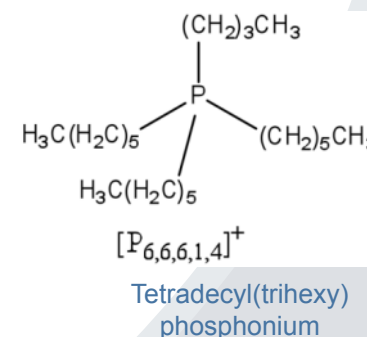
Accu-Chek active meter



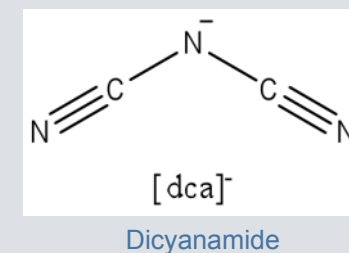
Glucowatch®

# Ionic liquids

- Ionic Liquids (ILs) are low melting point salts (<100°C).
- Entirely composed of ions: cations and anions.
- Properties:
  - Negligible vapour pressure
  - High thermal stability
  - Large electrochemical window
  - Non-volatile
  - Conductive
- ‘Designer solvents’
  - Acidic
  - Basic



Bis(trifluoromethyl)sulfoniimide



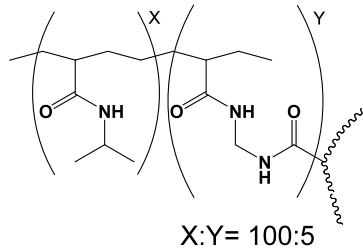
# Applications of ILs

- **Applications**
  - Catalytic reactions
  - Electrolytes
  - Separation science
  - Polymer chemistry
  - Solvent replacement
  
- **Bio-applications**
  - Enzyme catalyst
  - Whole cell biotransformation
  - Antimicrobial activity
  - Gene therapy
  - DNA Extraction
  - Immunosensors
  
- **Glucose Oxidase**
  - Enzymatic catalysis (Wu *et al.*, 2009)
  - Electrochemical characterization (Shan *et al.*, 2009)

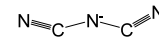
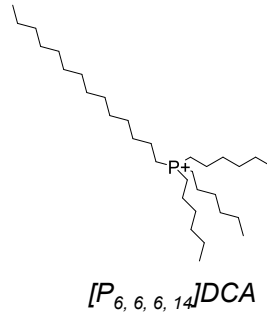


# Preparation of Ionogel

*Ionogels: Ionic liquid polymer gels*



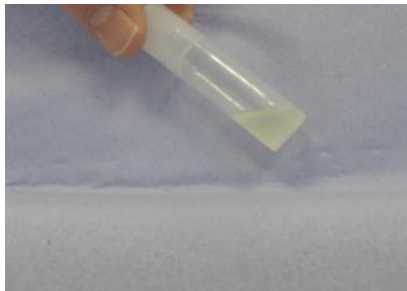
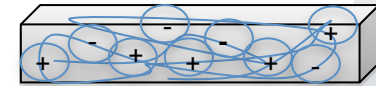
Polymer poly(N-isopropylacrlamide)  
N,N-methylene-bis(acrylamide)



Photopolymerized  
UV light

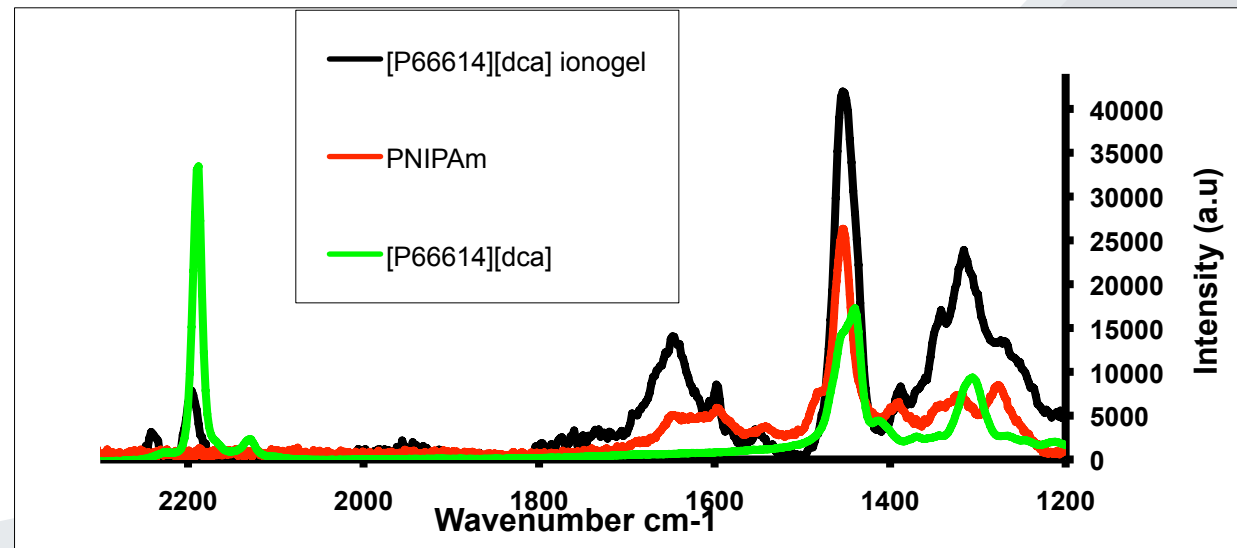
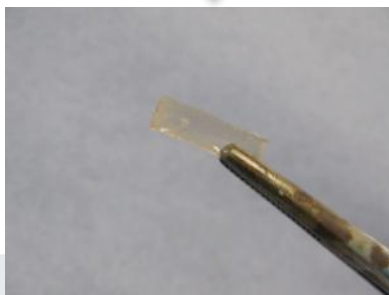


Photoinitiator

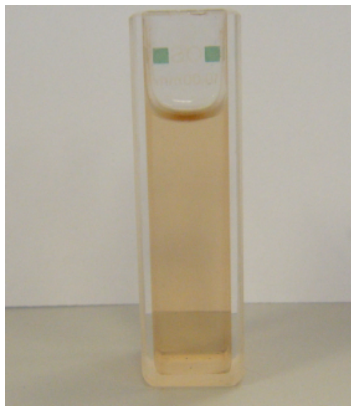
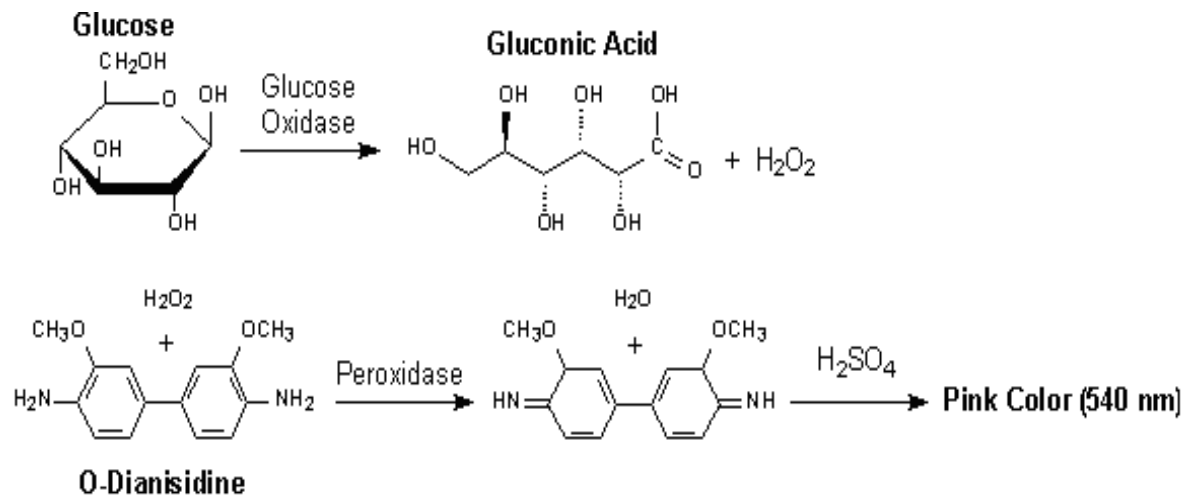


Photopolymerized  
UV light

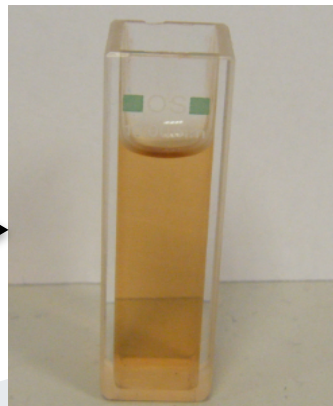
Photoinitiator



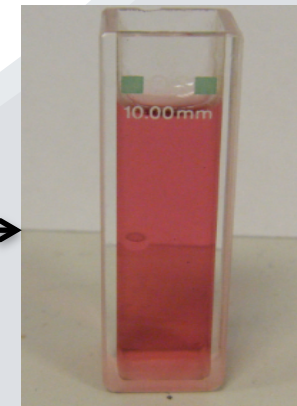
# Colorimetric Assay for Glucose Oxidase (GOx)



Rxn cocktail: 1.7% (w/v) Glucose.  
0.17mM o-dianisidine, 10ul peroxidase  
enzyme



Rxn cocktail: 1.7% (w/v) Glucose.  
0.17mM o-dianisidine, 10ul peroxidase  
enzyme, 10ul GOx



Reaction stopped with H<sub>2</sub>SO<sub>4</sub>

<http://www.sigmaldrich.com/life-science/metabolomics/enzymatic-kits.html>

# Enzyme Assay of Glucose Oxidase (GOx) (Ionogel)



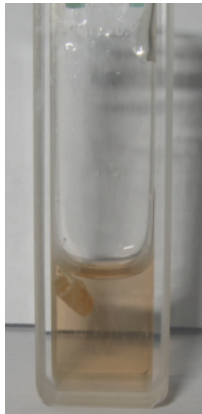
0.17mM o-dianisidine in buffer, 10 $\mu$ l  
peroxidase enzyme GOx ionogel



0.17mM o-dianisidine in buffer, 10 $\mu$ l  
peroxidase enzyme, GOx ionogel  
40 $\mu$ l of glucose (10% w/v)



Reaction stopped with H<sub>2</sub>SO<sub>4</sub>



0.17mM o-dianisidine in buffer, 10 $\mu$ l  
peroxidase enzyme, ionogel (-GOx)

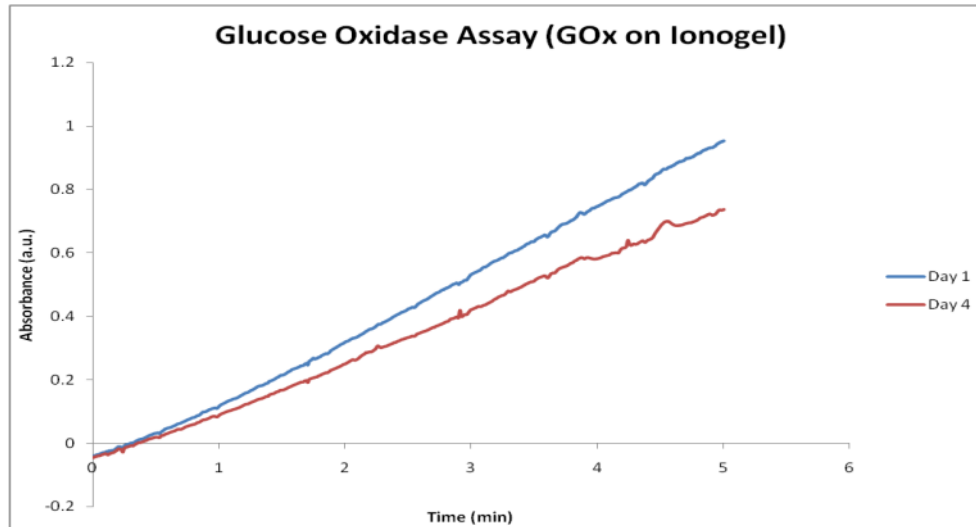


0.17mM o-dianisidine in buffer, 10 $\mu$ l  
peroxidase enzyme, ionogel (-GOx)  
40 $\mu$ l of glucose (10% w/v)

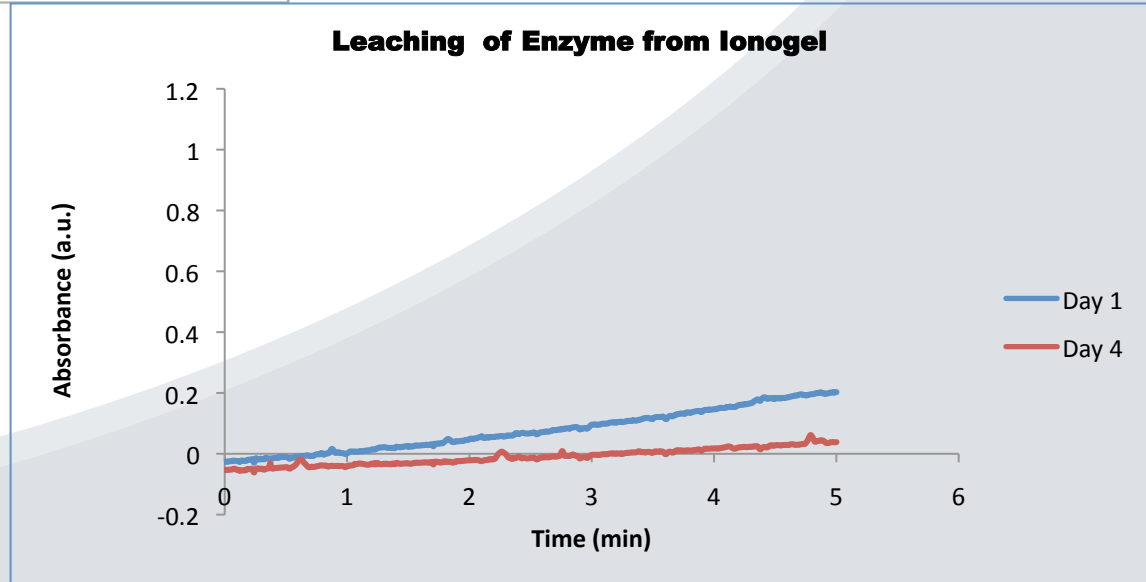


Reaction stopped with H<sub>2</sub>SO<sub>4</sub>

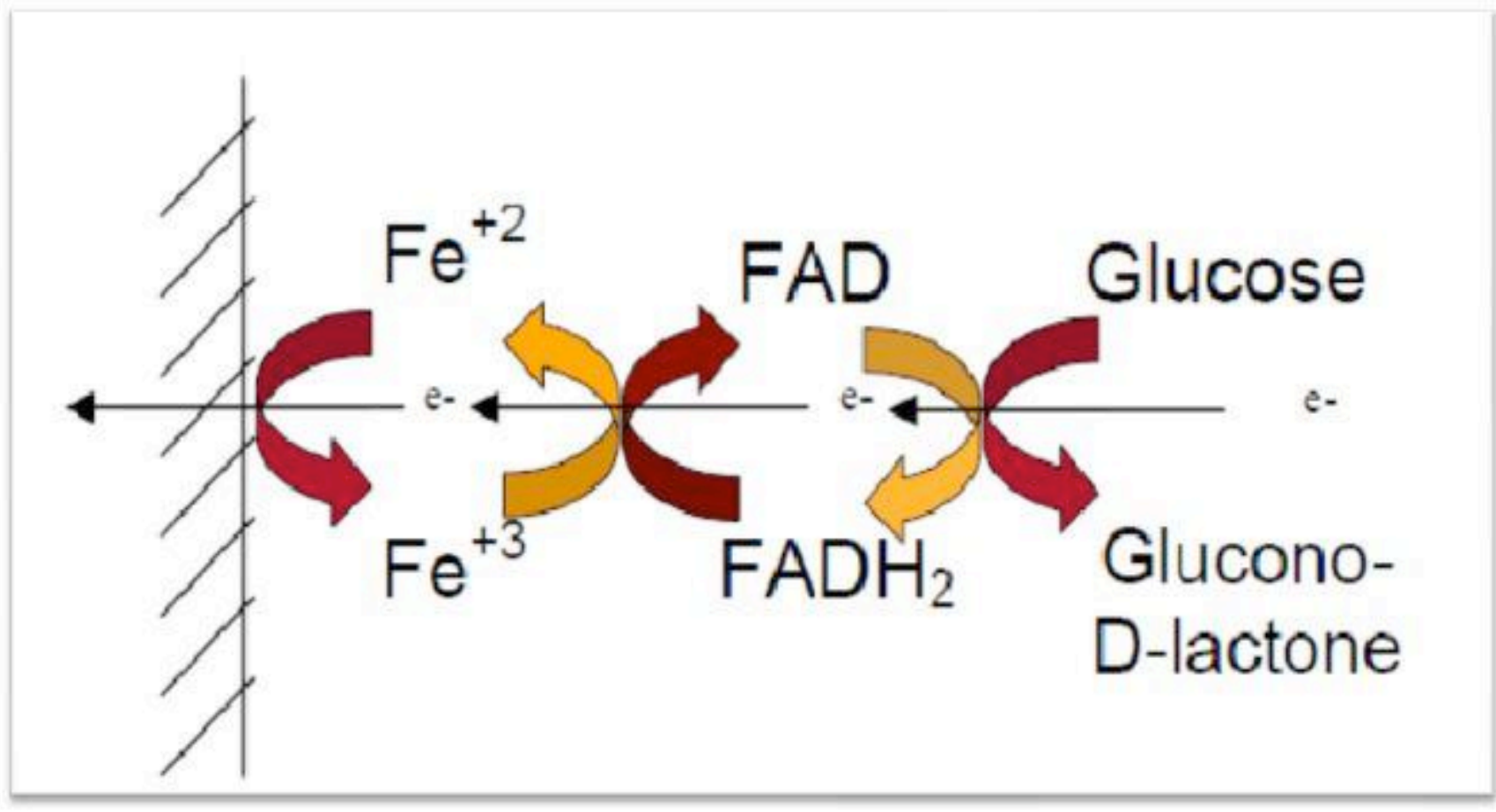
# Glucose Oxidase Assay (GOx on ionogel)



Enzyme Unit/ml  
— 7.6  $\mu\text{mol}/\text{min}/\text{ml}$   
— 3.6  $\mu\text{mol}/\text{min}/\text{ml}$

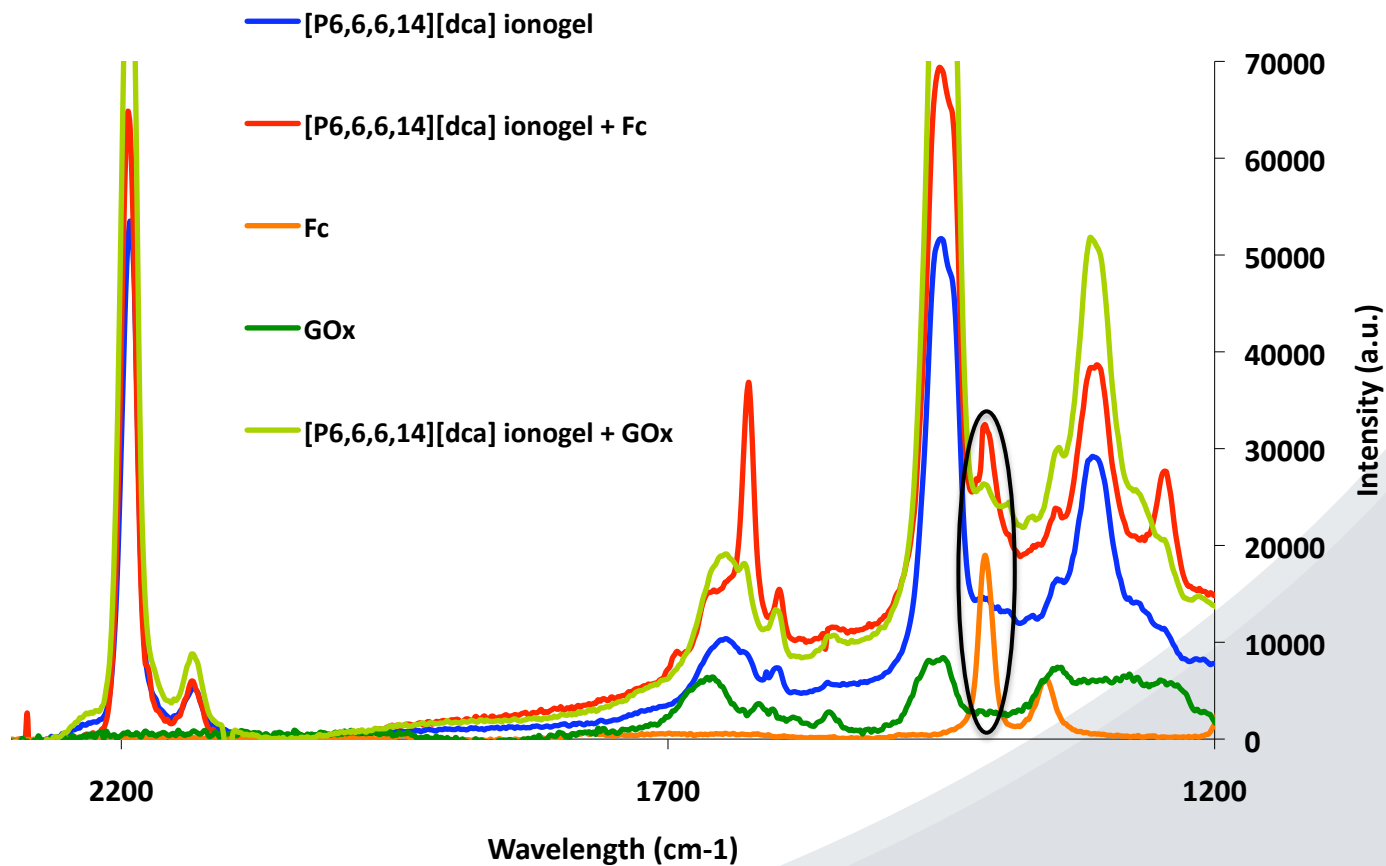


# Principle of Electrochemical Biosensors

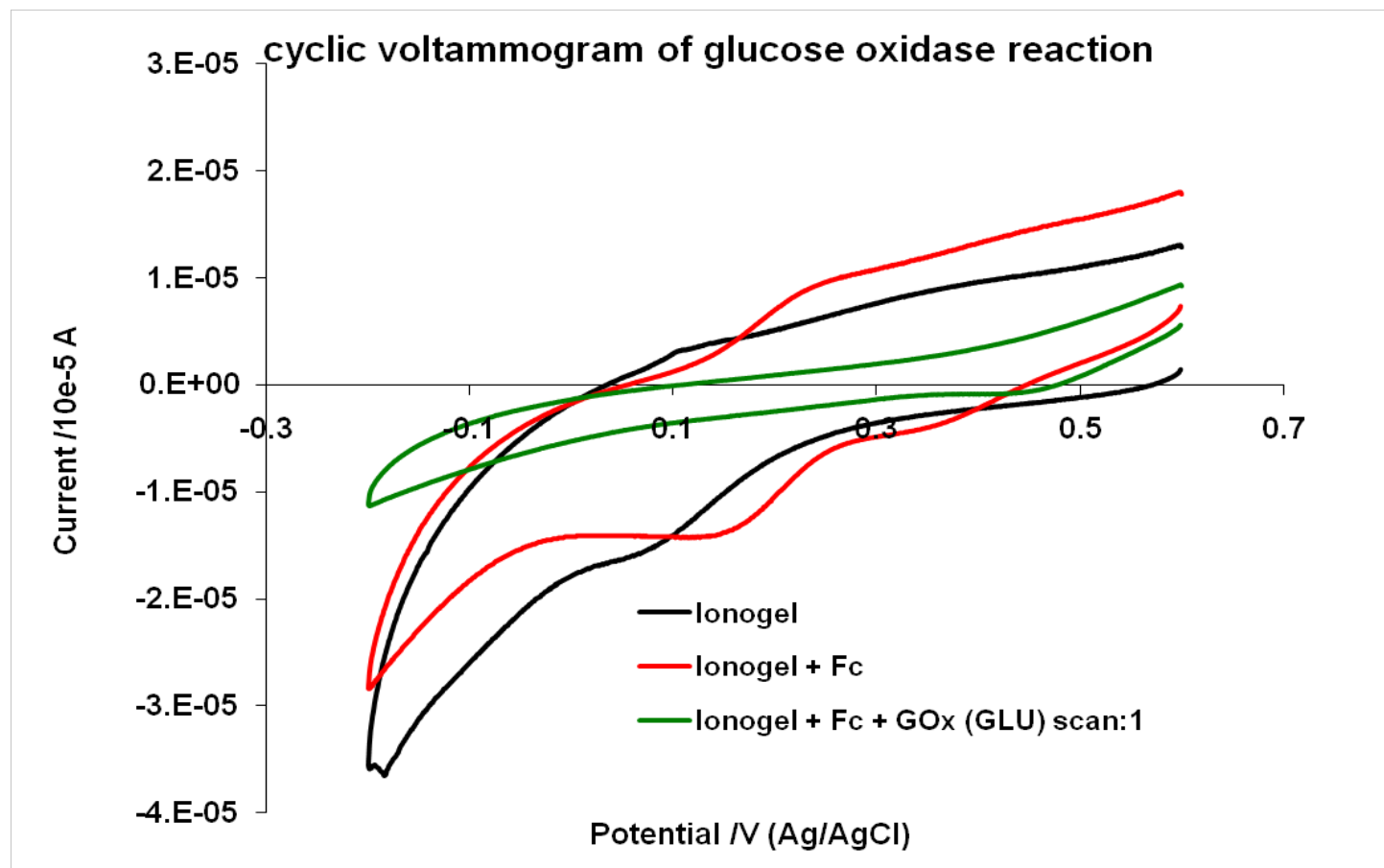


Harper, A.C. 2005. *Modified Electrodes for Amperometric Determination of Glucose and Glutamate Using Mediated Electron Transport*. Thesis. PhD. Virginia Polytechnic Institute and State University

# Characterization of Ionogel for Electrochemical Determination



# Electrochemical results of Ionogel



# Conclusion

- **Two ionogels: colorimetric and electrochemical.**
- **Colorimetric assay shows that the enzyme is active in ionogel.**
- **Electrochemical: Incorporated ferrocene and GOx into ionogel, results show a correlation between the enzyme in buffer and enzyme in ionogel.**



# Future Outlook

- **Determination of the 'life time' of the enzyme.**
- **Optimisation of the electrochemical and colorimetric procedure.**
- **Integrate the assay onto a microfluidic chip.**

# Acknowledgments

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