Printed electrochemical biosensor principles and applications

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Electrochemical biosensors are analytical devices which can recognize their target molecule from sample. The recognition is transduced to electrical signal in proportion to the target molecule.

Electrochemical transduction is based on the movement of electrons in the redox reactions detected when a potential is applied between electrodes.
Screen printed electrochemical biosensors

Advantages of printed sensors
• Inexpensive to mass produce
• Disposable
  ➔ point-of-care/on-site-test applications
  • easy to perform and read, fast results

Screen printed electrode
• Silver/AgCl₂ reference electrode, RE
• Carbon working electrode, WE
• Carbon counter electrode, CE
• Dielectric insulating layer
Need for POC tests
- Rising healthcare costs
  - Centralized labs, early diagnosis demand, careful follow up
- Ageing population
- Demand for personalized medicine
- Environmental regulations

Application areas
- Diagnostics:
  - POC for home use and clinical use
  - glucose, pregnancy, cholesterol, urea, lactate, cardiac markers, drugs…
  - glucose sensor strips on market 25 years
- environment
- food processing and safety
- wellness
- Drugs, alcohol
- Security/ military
Electrochemical sensor principles

25 billion glucose test strips sold 2012
IDTech

Enzymatic sensors
- Glucose \( \rightarrow \) Gluconolactone
- GOX
- \( \text{H}_2\text{O}_2 \)

Sample
- Enzyme layer
- Electrode
- Current measurement

Electrochemical immunosensors
- HRP labelled antibody
- Antigen
- Binding antibody
- Graphite electrode

- Sandwhich Elisa method (or competitive assay) can be used
- Detection based on enzymatic labels attached to antibody
- Multiple steps needed during the reaction
Biosensor test strip manufacturing process

1. Screen printing of electrodes

2. Dispensing biomaterial on the sensor

3. Covering sensor and attaching sample channels/cambers

1. Reference electrode, silver ink
2. Working electrode, counter electrode, graphite ink
3. Insulator layer
4. Ready electrochemical sensor with three overlaying layers

Bioinks (enzymes, stabilizers)
Mediator
Graphite working electrode

Adhesive layers, Lamination, packaging
PrinLab facilities
Oulu University of Applied Sciences
A Part of PrintoCent Pilot Factory

Material printer Dimatix

3D Dispensing system nScrypt

GIN emb pump for dispensing biomolecules

Screen printer EKRA E2

Palmsens portable potentiostat and multichannel potentiostat

SOM100 small scale R2R equipment with flexo, gravure and hot embossing units

Focused on SPE electrochemical biosensors
- Development and manufacturing of prototypes, demos etc.
- Established subcontractor network
- Well equipped analytical and biochemistry laboratory
Saliva alfa amylase sensor for stress monitoring

- Human saliva α-amylase is mainly involved in the digestion of starch in the oral cavity. Several studies have shown that increased levels of salivary α-amylase (sAA) levels are related to physical and psychological stress.
- Potential marker to stress palette with other markers (e.g. cortisol, glucocorticoids)
- Detection based on three enzymatic sensor, published by Dr. Sesay and coworkers.

Detection pathway for saliva α-amylase.
Stress test demonstrator

Detection method: enzymatic and amperometric- measured current is proportional to activity of saliva $\alpha$-amylase. Results can be send to cloud for personal stress profile.

Sample collector, printed amylase sensor and amylase reader. Design Cemis-Oulu, GIN, iSTOC, OUAS

Result is shown in the mobile phone with graphics and number. Developed by iStoc Ltd.

Visit OUAS Demo table!
Oulu Area Network for Printable Biosensors

Research organizations

- Oamk: R&D electrochemical sensors, feasibility studies, small scale manufacturing
- VTT: scale up manufacturing, R&D projects
- University of Oulu
  - Microelectronics and material physics lab: material development and characterization
  - CEMIS Oulu: research and development services for sensor applications

Companies

- Screentec: SPE electrodes
- GIN: dispensing,
- Orion Dianostica: diagnostics
- Detemex: wellness application
- Chaperone: antibodies and testing services
- BioOption: consulting, testing services
- Neficon: design
- iSTOC: mobile readers and cloud services
BioPrint project - Collaborators

Research partners

**UO- Microelectronics**
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- Heli Jantunen
- Jari Juuti
- Mikko Nelo

**VTT**
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- Liisa Kivimäki
- Inka Mustonen
- Sari Taipale

**OUAS**
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- Harri Määttä
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- Niina Torniainen
- Teija Tuhkala
- Tomi Tuomaala

Company Partners

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- Simo Rasi

**Detemex**
- Juha Lampela

**Focal Spec**
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- Sauli Törmälä

**Screentec**
- Antti Taurianen

**Global Innovation Network**
- Markku Känsäkoski
- Matti Koivu

**Orion Diagnostics**
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BioPrint is funded with ERDF fund from Council of Oulu Region
Thank you!

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