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# Screen printed maltose sensor using the SIRE technology

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## Abstract

The **SIRE (Sensor with Injectable Recognition Element) technology** was developed by the Swedish Company Chemel [1]. BVT has acquired the SIRE technology and continues the development of this technology. The original **SIRE sensor was miniaturized** (see Fig. A) **by Thick Film Technology (TFT)**. Its function is demonstrated on the **detection of maltose**. The sensor was used to continously monitor the decrease of maltose **during beer production**.

The SIRE sensor uses the **concept of soluble enzymes** (see reaction equations below) **into a reaction chamber** separated from the sample by a **semi permeable dialysis membrane**. The analyte, in this case maltose, enters into the reaction chamber by diffusion. The **analyte reacts with the recognition enzymes creating $H_2O_2$** which **is oxidized on a screen printed Pt electrode. The current corresponds to the amount of analyte**.

$$\text{Maltose} \xrightarrow{\alpha-glucosidase} 2\ \text{a-D-glucose}$$

$$\text{a-D-glucose} \xrightarrow{mutarotase} \beta\text{-D-glucose}\ ^*$$

$$\beta\text{-D-glucose} + O_2 \xrightarrow{glucose-oxidase\ (GOD)} \text{D-Gluconolacton} + H_2O_2$$

$$H_2O_2 \xrightarrow{working\ Pt-electrode\ of\ amperometric\ sensor} 2\ H_2O + O_2 + 4e^-$$

* *The equilibrium (isomerization) between the alpha and beta anomers of glucose is also established spontaneously in solution. However, the rate of establishment and the resulting ratio of glucose anomers depends on many factors, such as temperature, pH, and the presence of other substances in the solution.*

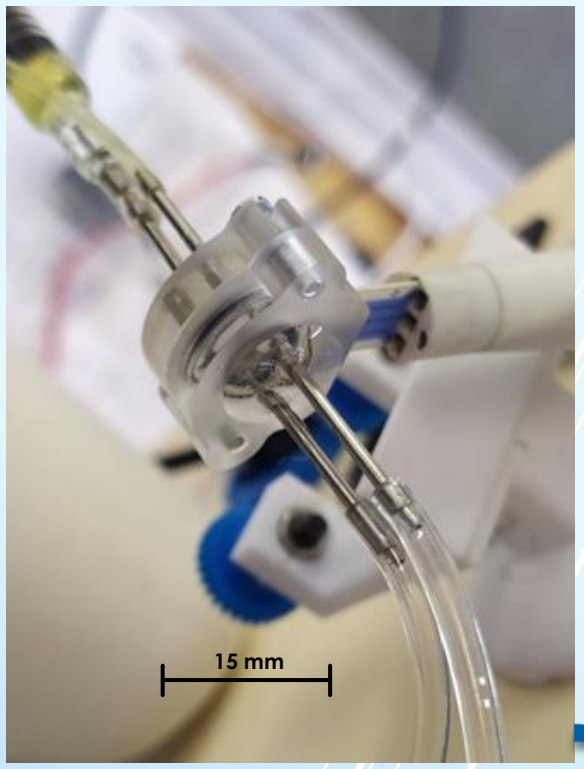



*Fig. A1: AC1.W2.RS SIRE sensor, miniaturised by Thick Film Technology by BVT*

## Results

- Different enzymes for SIRE sensor were tested. The **α-glucosidase only from Megazyme** (typ) **worked** better than a-glucosidase and mutarotase from Sigma (see Fig. B)
- The **system worked 14 days** with **one load of enzyme**
- Excellent correlation and repoducibility was obtained (see Fig. C)
- **The calibration curve for maltose is linear in range 0.5 – 20 mM**.
- The **limit of detection is lower than 0.1 mM**
- The typical **correlation coefficient is 0.998** in whole linear range.
- The **sensor was used for continuous monitoring of maltose** decrease **during beer fermentation** (see scheme on Fig. D and Fig. E)
- The **concentration of maltose was diluted** to optimum measuring range **by analytical microdialysis** [2]

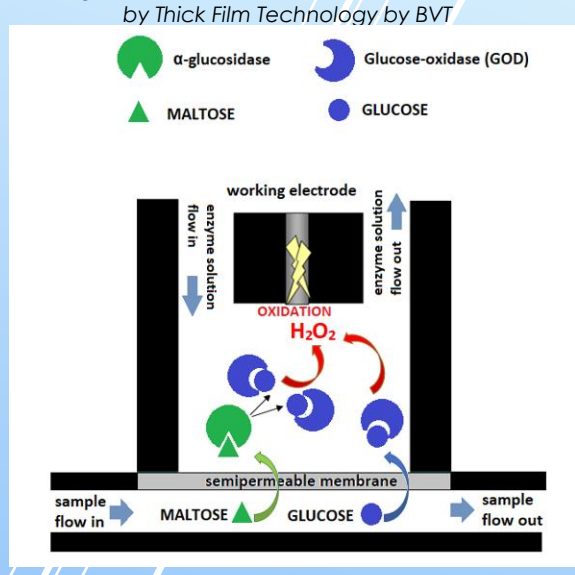
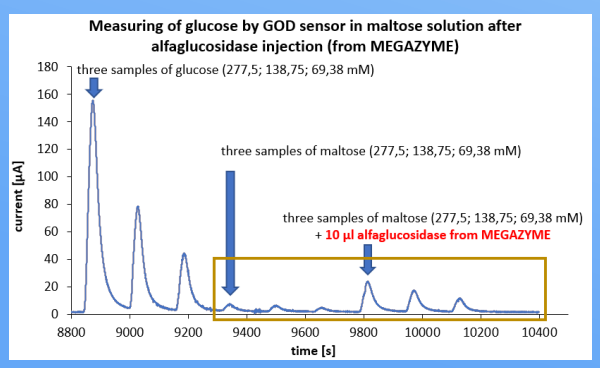



*Fig. A2: A scheme of modified SIRE technology reaction chamber with liquid enzymes (GOD and alfaglucosidase)*



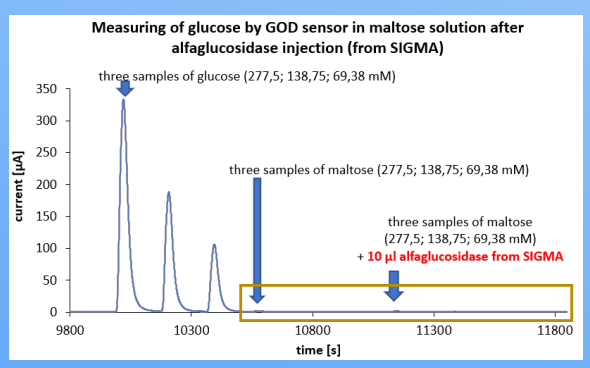




*Fig. B: Comparison of alpha glucosidase enzyme activity from MEGAZYME and SIGMA (the same enzyme activity should be achieved in both measurements)*

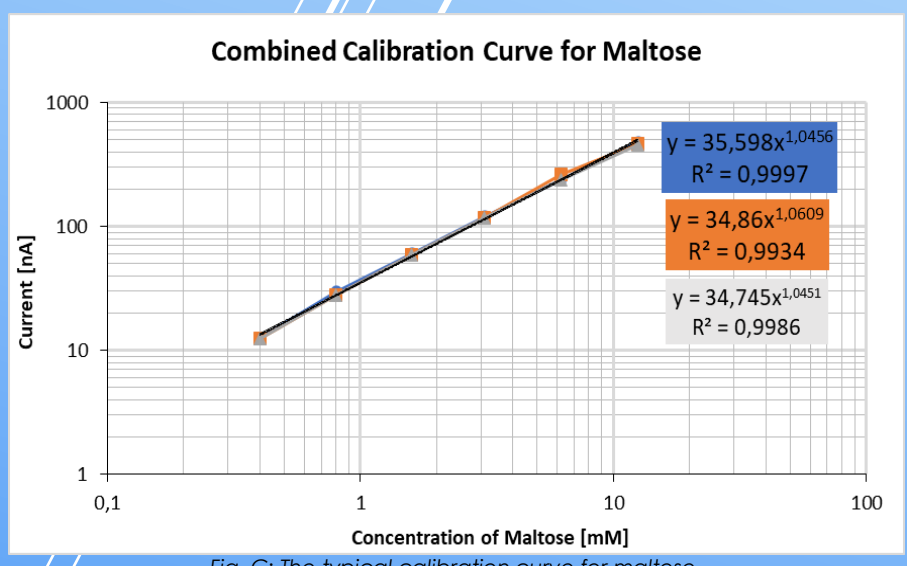



*Fig. C: The typical calibration curve for maltose*

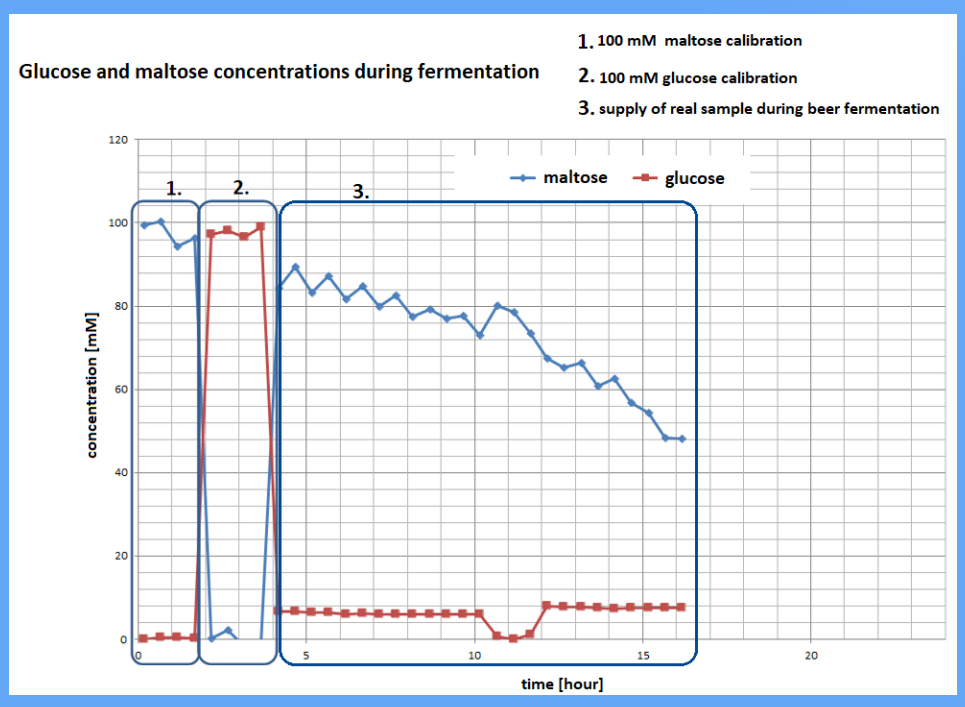



*Fig. E: Example of Glucose and maltose sensor response during real fermentation*

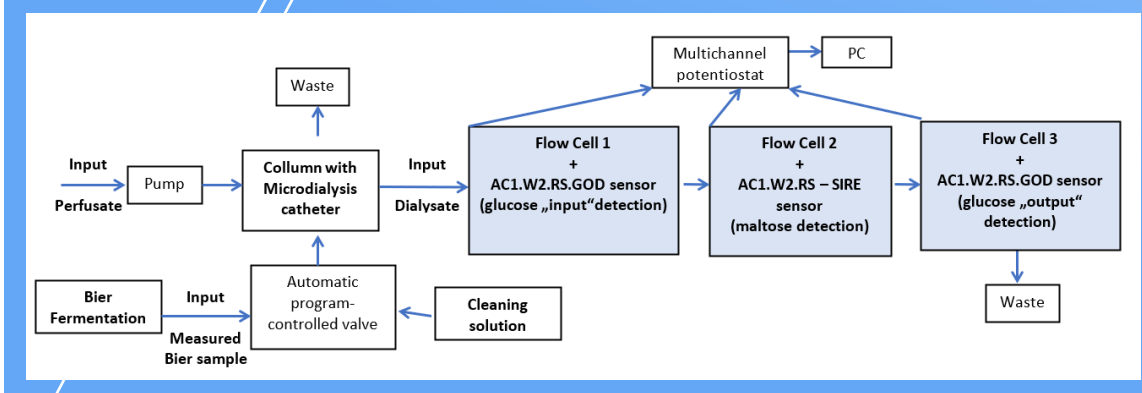



*Fig. D: scheme of experimental design of continuous measurement of glucose and maltose during beer fermentation*

**Acknowledgement:**
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**Reference:**
[1] KRIZ, Dario. *Use of a chemical sensor, Chemel AB: Amperometric enzyme electrodes for analytes in body fluids, e.g. glucose in blood*. US6214206B1. Uděleno October 23, 2000. Zapsáno June 19, 1997.

[2] O'CONNELL, Mark Thomas a Jan KREJCI. Microdialysis techniques and microdialysis-based patient-near diagnostics. *Analytical and Bioanalytical Chemistry* [online]. 2022, 414(10), 3165-3175 [cit. 2022-06-06]. ISSN 1618-2642.