

Solid state electrochemical sensor for the detection of hydrogen

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INTRODUCTION

The transition from fossil fuels to renewable energy is a major challenge in addressing climate change. As part of the European Green Deal, the EU aims to cut greenhouse gas emissions by 55% by 2030 and reach net zero by 2050¹. Hydrogen, as a clean energy carrier, plays a key role in sectors such as transport, industry, and energy. However, its use presents safety concerns due to properties like high flammability, wide explosive range, and rapid diffusion. Various hydrogen sensors ² (thermal, catalytic, electrochemical, optical, and mechanical) exist, but many suffer from limited operating ranges (e.g., temperature, humidity, and cross-sensitivity). In this work, we propose a solid-state electrochemical sensor for hydrogen detection that may overcome the limitations of classical electrochemical systems.

EXPERIMENTAL/THEORETICAL STUDY

The sensor was calibrated by subsequent addition of hydrogen to a reservoir with a known volume. A mixing system was added to the reservoir to assure a uniform atmosphere at the time of the sensing. Potentiometric measurements were performed using a palmsens4 (Palmsens, The Netherlands). The sensor scaffold was fabricated by mean of fusion deposition modeling (FDM) 3D printing using a Prusa MK3S (Prusa research, Czech Republic).

RESULTS AND DISCUSSION

Figure 1A, B, and C show, respectively, an image of the sensor, the calibration curve within the range 0.03–1.6% v/v H₂, and the temperature dependence of the sensor's sensitivity. As shown, the sensors exhibit a linear response with respect to the logarithm of hydrogen concentration, in agreement with the Nernst equation. However, the observed sensitivity exceeds the theoretical Nernstian slope of 59 mV/decade, suggesting the contribution of additional mechanisms that enhance the sensor's response. Furthermore, the temperature-dependent behavior indicates not only that the sensor remains functional at elevated temperatures, but also that its performance is not negatively affected, highlighting its robustness under varying thermal conditions.

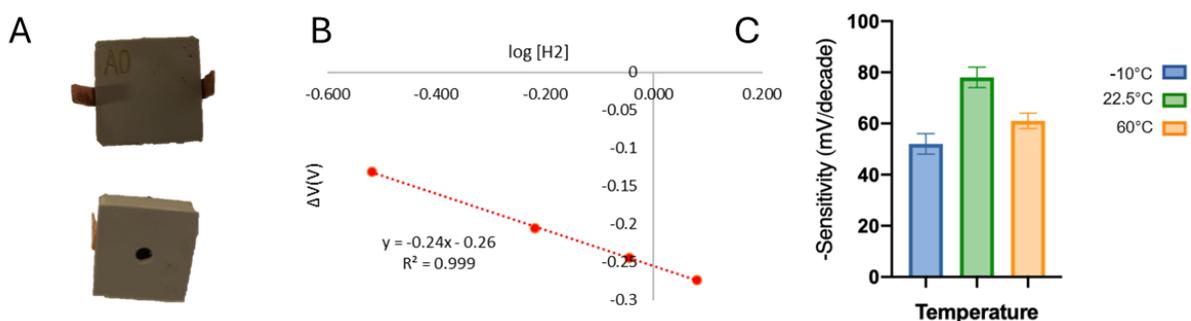


Fig. 1 A) Picture of the solid state hydrogen sensor. B) Typical calibration curve; the variation of the potential is shown as a function of the concentration of hydrogen. C) Sensitivity of the sensor as a function of the temperature in the range – 10 to 60 °C.

CONCLUSION

In this work we presented a solid state electrochemical sensor for the detection of hydrogen. Its solid state nature allows for its function even in harsh conditions where classical electrochemical sensor would fail.

REFERENCES

1. European Commission, “European Clean Hydrogen Alliance,” 2020.
2. G. Korotcenkov, S. Do Han, J. R. Stetter, Chem. Rev. 2009, 109, 1402–1433.