Ionic liquids / Ionogels: New Materials For Inherently Biocompatible Molecular Sensors

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Introduction

- The detection of lactate (LOx) in blood provides a biochemical indicator of anaerobic metabolism in patients with circulatory failure[1].
- Lactate is found in sweat (concentration range between 9 and 23 mM), and plays a role in fatigue, energy metabolism and as a limiting factor in athlete performance[2].
- Detection in sweat offers a less invasive and dynamic way of measuring lactate concentration, particularly during exercise.
- Organic electrochemical transistors (OECTs) have been developed for a variety of bio-sensing applications, including the detection of ions, metabolites and antibodies[3].
- Ionic liquids (ILs) / ionogels have evolved as a new type of material for bio-catalysis, mainly due to their unique and tunable physical properties.[4]

Aim

To develop an enzymatic sensor based on an OECT that uses an ionogel as an integral part of its structure. The strategy we follow involves photopatterning the ionogel over the active area of the OECT, and using it as a reservoir for the enzyme and the mediator.

Experimental

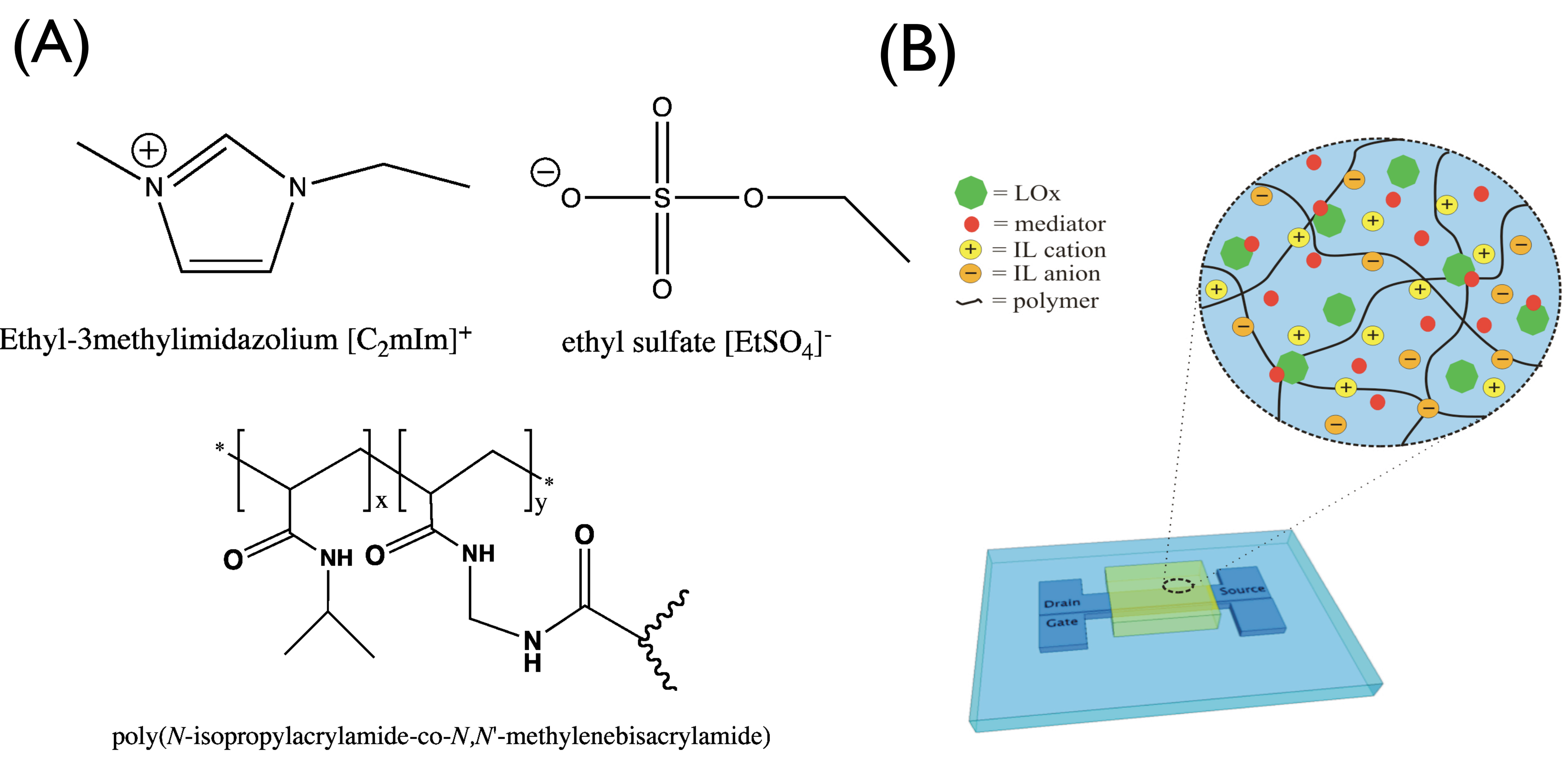

Fig. 1: (A) Ionogel components and (B) a schematic representation of the OECT device with ionogel / enzyme mixture.

- 1-Ethyl-3methylimidazolium Ethylsulfate ($[C_{2}mIm][EtSO_{4}]$) was chosen because of its miscibility with water, thus avoiding mixing problems with the phosphate buffer solution (PBS) containing the analyte (Fig 1A).
- By mixing the IL mixture and the PBS solution containing the LOx enzyme with a ratio of 4 : 1 (17% w/w of water) a clear liquid was obtained.
- The monomers were photo-polymerised within the ionic liquid matrix using a UV irradiation source for 1 minute (Fig 1B).

Results & Discussion

- Fig. 2A depicts the series of reactions that take place upon introduction of the lactate. As a result, more cations from the solution enter and dedope the channel (Fig. 2B) and the modulation of the drain current in response to a voltage pulse at the gate increases.

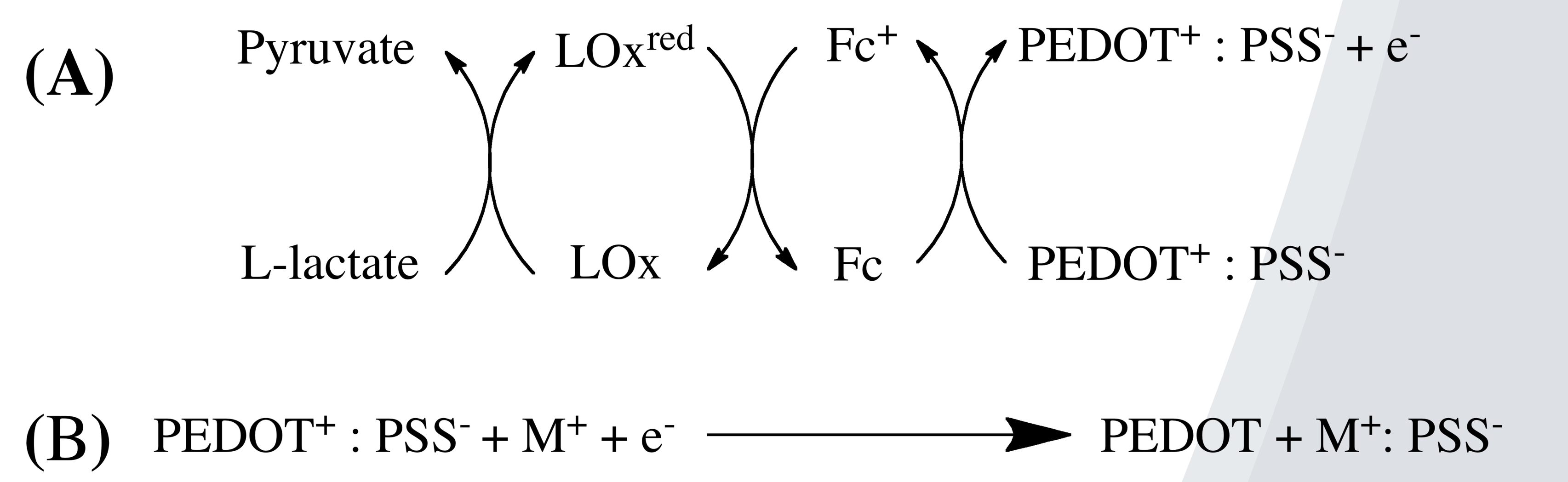

Fig 2: Reactions at the gate electrode (A) and at the channel (B) of the OECT.

- Fig. 3a shows the modulation of the drain current before (t < 15 min) and after the introduction of 20 ml of a PBS solution with the desired lactate concentration.

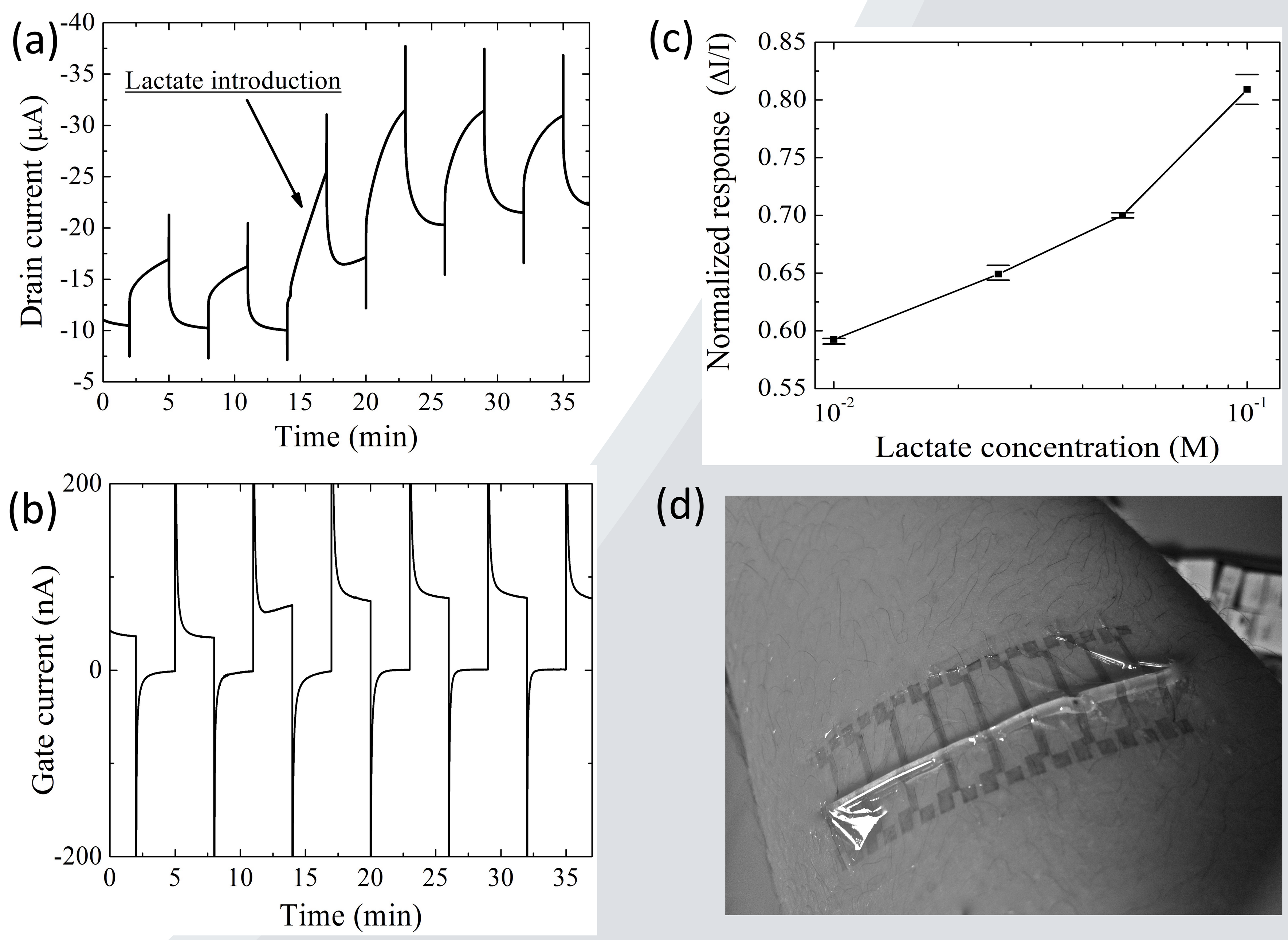

Fig 3: (a) Drain current vs. time with addition of 25 mM lactate indi cated by an arrow, (b) corresponding gate current vs. time, (c) normalized response of the OECT vs. lactate concentration and (d) conformal OECT with gel shown on a forearm.

Conclusions

- Detection of lactate in a relevant physiological range using OECT / ionogel materials achieved.
- First time a solid state electrolyte on a flexible transistor-based biosensor has been reported.
- Significance lies in the configuration of the solid state sensor.

References

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