Influence of Extracellular Matrix-Mimicking Gel Electrolyte on Electrode Charge Injection

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Introduction

Patient safety

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Safe stimulation guidelines, including Shannon's parameter *k* [1]

$k = \log D - \log Q$

D, charge density
Q, charge/phase

↓

Understanding underlying mechanisms for *k*

Understanding larger polarisation *in vivo* [3]

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k = 1.75 corresponds to platinum oxidation [2]

Tortuous diffusion path increasing polarisation ?

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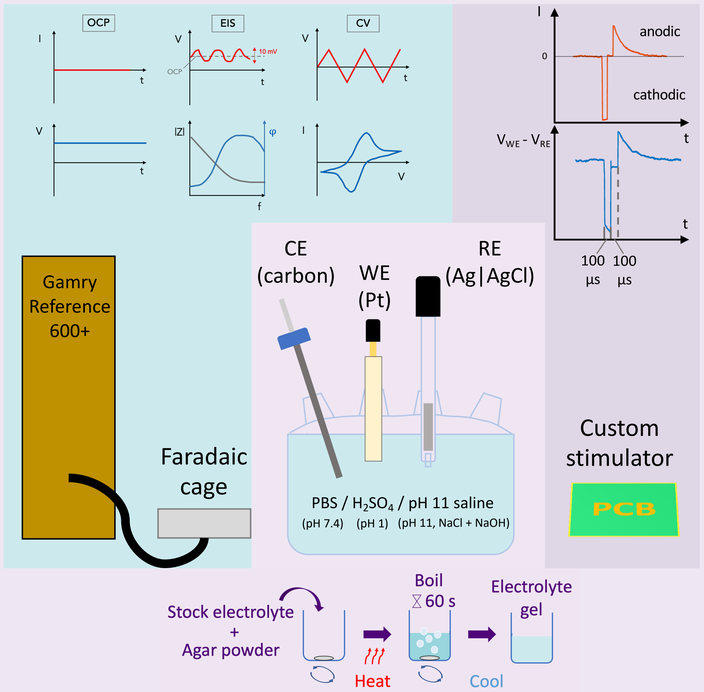
AIM: Study the influence of gellified electrolyte on charge injection and possible damage

Material & Methods



Results

Electrochemical measurements

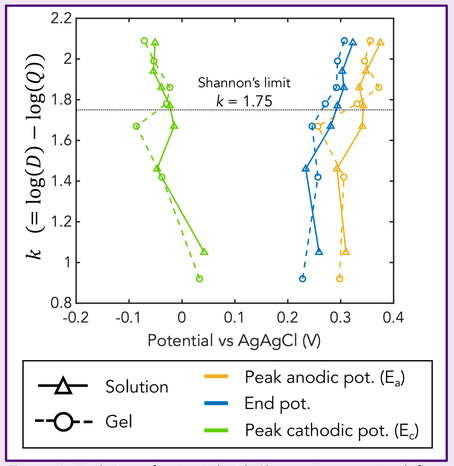


Figure 1: Evolution of potential with Shannon's parameter k for PBS solution versus PBS gel.

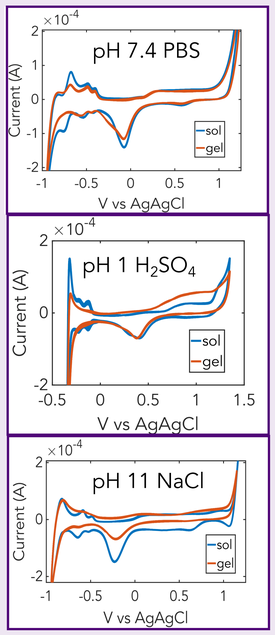


Figure 6: Comparison of a typical CV cycle of solution electrolyte and gel electrolyte for PBS, H_2SO_4 and pH 11 saline.

Statistical analysis

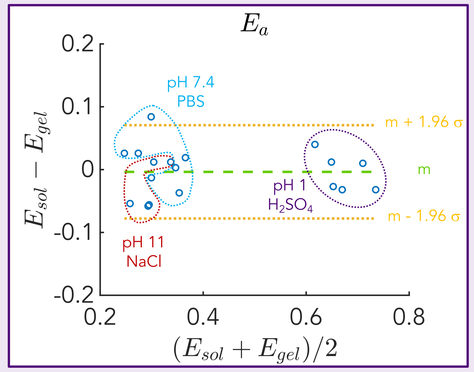


Figure 2: Bland-Altman plot of peak anodic potentials for all k, for each electrolyte.

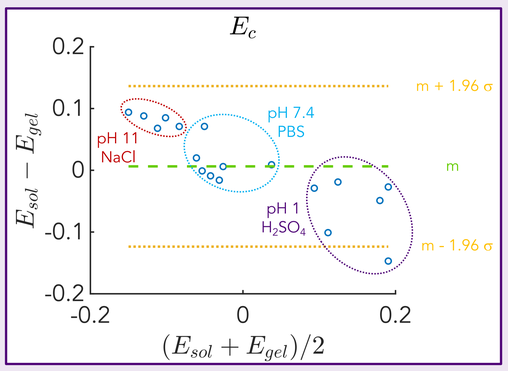


Figure 3: Bland-Altman plot of peak cathodic potentials for all k, for each electrolyte.

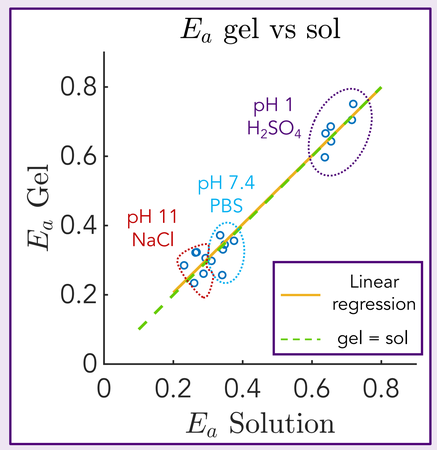


Figure 4: Direct comparison of peak anodic potentials for all k, for each electrolyte.

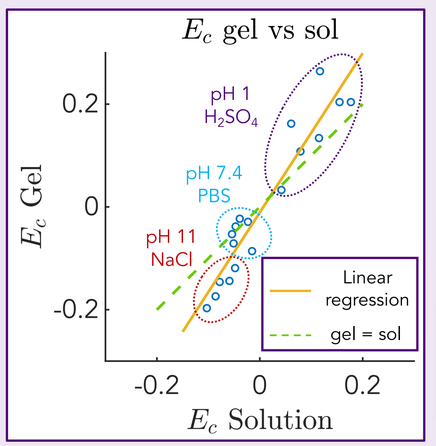


Figure 5: Direct comparison of peak cathodic potentials for all k, for each electrolyte.

	K-S result (95%)	p
E_a	0 (not statistically significant)	1.00
E_c	0 (not statistically significant)	0.43

Table 1: Parameters two-sample Kolmogorov-Smirnov test of gel vs solution electrolytes peak anodic and cathodic potentials.

Linear regression parameters		
y = mx + b	E_a	E_c
m	0.988	1.549
b	0.009	0.011
R^2	0.96	0.90

Table 2: Linear regression parameters of direct comparisons of gel vs solution electrolytes peak anodic and cathodic potentials.

- Peak anodic potentials are not significantly different for solution and gel electrolytes.
- Peak cathodic potentials are not statistically significantly different but do show a substantially different trend at extreme pH.
- Lower pH correlates with larger cathodic excursions in gels and higher pH with larger cathodic excursions in solutions.

Conclusion

Platinum electrodes show similar behaviours in gel electrolytes and solution electrolytes, however, **cathodic potential excursions during repeated pulsing exhibit substantial differences**, which are not statistically significant.

A **combined effect of pH and gellification** is shown, with oxide reduction onset delay possibly explaining the discrepancy.

References

1. R.V. Shannon. *A model of safe levels for electrical stimulation.* IEEE Transactions on biomedical engineering, 39(4):424–426, 1992.
2. D.W. Kumsa et al. *Electron transfer processes occurring on platinum neural stimulating electrodes: pulsing experiments for cathodic-first/charge-balanced/biphasic pulses for 0.566≤ k≥ 2.3 in oxygenated and deoxygenated sulfuric acid.* JNE, 13(5):056001, 2016.
3. S. F. Cogan. *Neural stimulation and recording electrodes.* Annu. Rev. Biomed. Eng, vol. 10, p. 275-309., 2008.

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