Wien effect and photo-accelerated interfacial water dissociation across proton permeable graphene electrodes

Eoin Griffin
Junhao Cai
University of Manchester, Oxford Road, Manchester, United Kingdom
eoin.griffin@manchester.ac.uk

The phenomenon known as the Wien effect was previously observed using high-voltage electrolysis cells that produced fields of about 10^7 V m^{-1}. The observation of the Wien effect for the common case of water dissociation has remained elusive. Here we study the dissociation of interfacial water adjacent to proton-permeable graphene electrodes and observe strong acceleration of the reaction in fields reaching above 10^8 V m^{-1}. The observed exponential increase in proton currents is in quantitative agreement with Onsager's theory. The use of graphene as a membrane allows for measuring the proton currents arising exclusively from the dissociation of interfacial water. Illumination of the graphene under visible light produced an order-of-magnitude acceleration of the interfacial water dissociation reaction. The found photo effect is attributed to the combination of graphene's perfect selectivity with respect to protons, which prevents proton−hydroxide recombination, and to proton transport acceleration by the Wien effect. Our findings provide fundamental insights into ion dynamics near atomically thin proton-selective interfaces.

References

[1] J. Cai, E. Griffin. et al, Nat Commun, 13 (2022) 5776
[2] J. Cai, E. Griffin. et al, Nano Lett, 22 (2022) 9566-9570

Figures

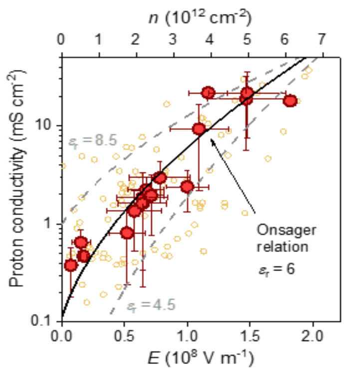

Figure 1: *Proton conductivity through graphene electrode* where *n* is the carrier density. Bottom x-axis, *is Electric field strength* on graphene electrode. Solid curve, best fit of Onsager model to data. Dotted curves, Onsager model for different *dielectric constant.*

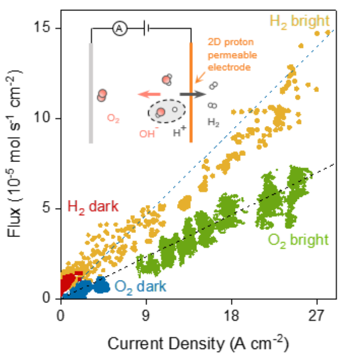

Figure 2: Faradaic efficiency measurements. Hydrogen and oxygen fluxes as a function of I under dark and bright conditions.