Enhancing currents with carbonaceous particles dispersed in flowing electrolytes

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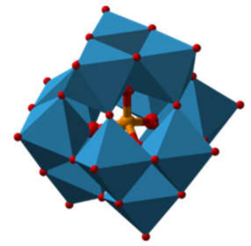
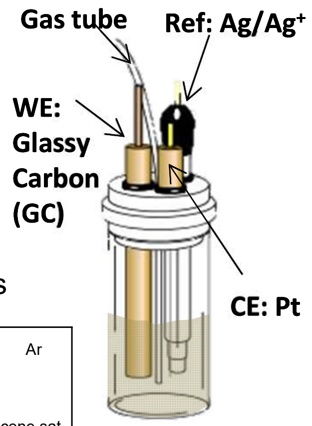


Introduction

Use of a slurry of conductive carbon particles in a flow cell instead of a carbon felt could represent an alternative design of potentially lower cost and better scalability [1]. Charge transport in such systems is complex, and a better understanding is necessary to optimize their efficiency. In particular the carbon amount increases viscosity, and requires being kept at low levels. We report here the study of the interactions between carbon and a redox system at low carbon loadings.

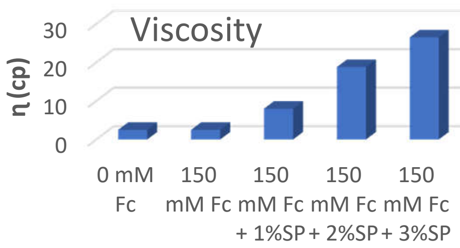
Experimental

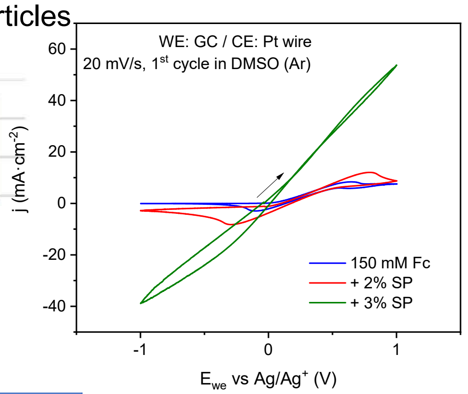
Tests were in 0.1 M t-butyl ammonium perchlorate (TBAP) in DMSO, with Super P (SP) carbon black suspensions in 3-electrode cells, and optional stirring to mimic flow cell operation.

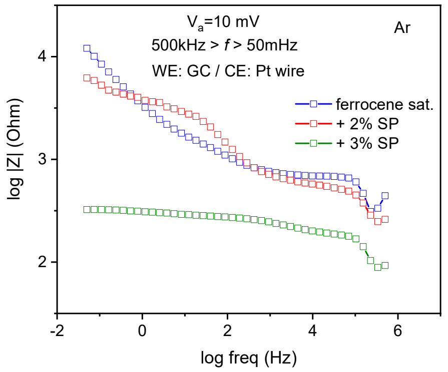


Ferrocene (Fc)

Ferrocene ($C_{10}H_{10}Fe$) is an ideal and interesting redox system for organic media. We study its interactions with carbon particles

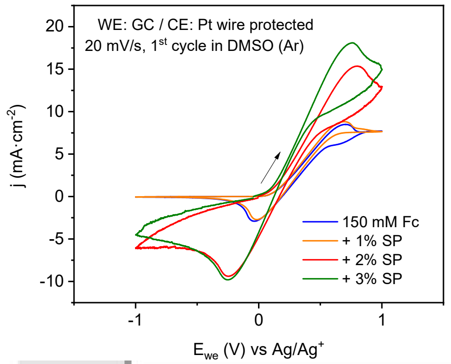


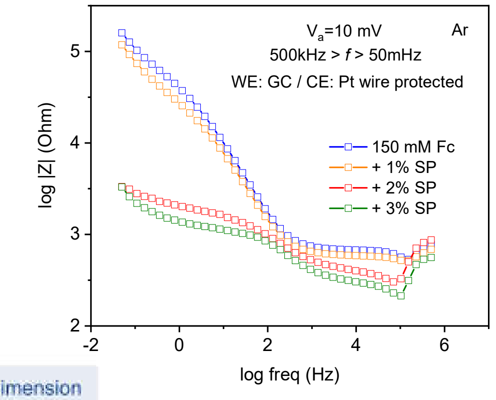




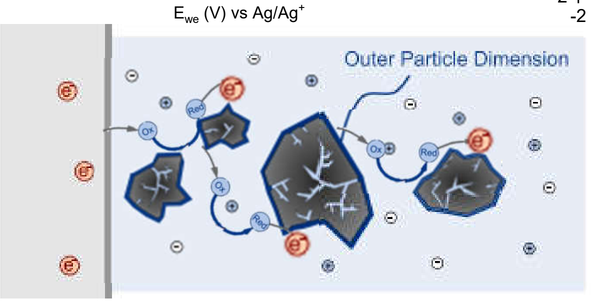
	D (cm²/s)	A (mm²)
Fc 150 mM	$1{,}95\cdot10^{-6}$	7,07
+ 1% SP	$6{,}09\cdot10^{-7}$	7,70
+ 2% SP	$2{,}59\cdot10^{-7}$	13,40
+ 3% SP	$1{,}84\cdot10^{-7}$	15,79

- Fc diffusion decreases when adding SP, carbon inhibits particles diffusion
- Effective area increases when adding SP: extended electrode





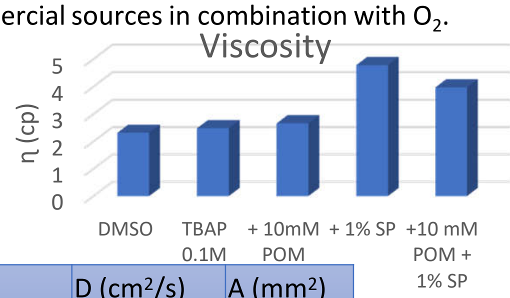
	R_{sol} (Ohm)
Fc 150 mM	538,7
+ 1% SP	512,6
+ 2% SP	312,1
+ 3% SP	224,1



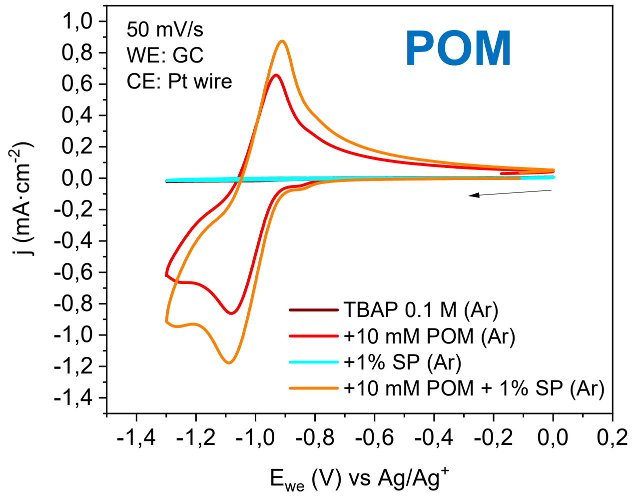
SYNERGY BETWEEN MEDIATOR AND CONDUCTING AGENT: Redox couple is enhancing the charge transfer at lower carbon black Super P %w/w resulting in higher j, lower overpotentials and lower impedance

Polyoxometalates (POMs) and oxygen

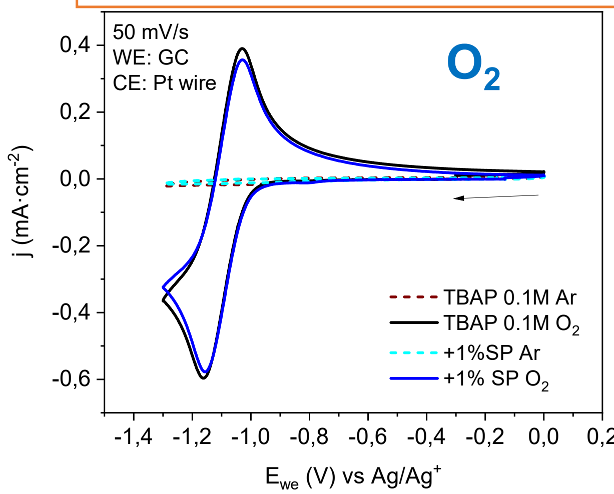
POMs are stable and reversible multielectron redox systems with remarkable catalytic properties, that are able to enhance oxygen reduction and evolution reactions [2]. We used $TBA_4(SiW_{12}O_{40})$, easily prepared from commercial sources in combination with O_2.

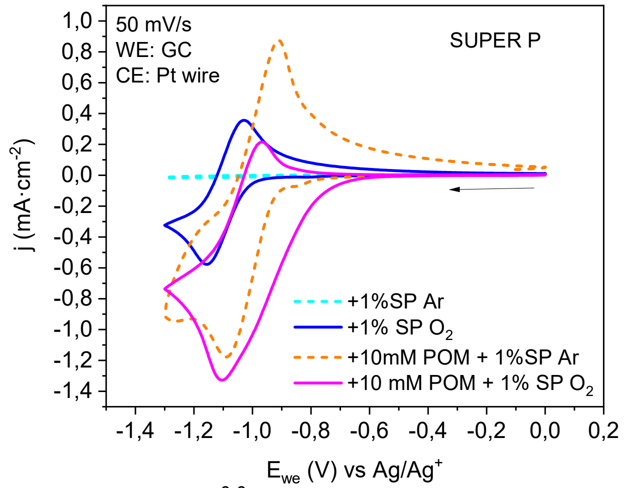


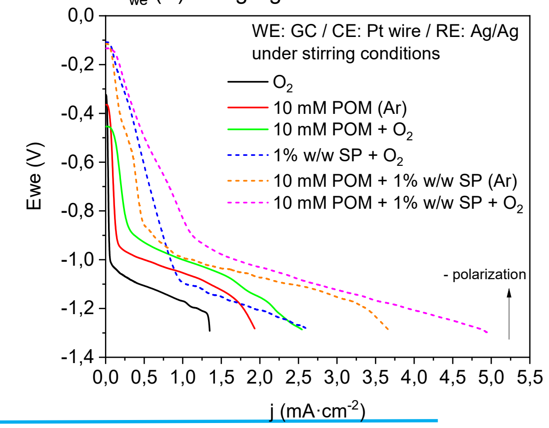
	D (cm²/s)	A (mm²)
10mM POM	$6{,}38\cdot10^{-7}$	7,07
+ 1% SP	$4{,}28\cdot10^{-7}$	14,78



With POMs Just 1% SP has no effect on the oxygen redox, instead with POMs larger j and electrode area, and lower D are observed







Conclusions

- Anticipation of percolative effects: O_2 < Fc < POM
- Synergy between carbon and redox mediator observed at steady and particularly at stirred conditions
- Interesting perspective for a O_2-based RFB

Acknowledgements

This project has received funding from the Spanish Government (MAT2017-91404-EXP, RTI2018-097753-B-I00, CEX2019-000917-S) and the Spanish National Research Council (PTI-FLOWBAT2021).

References

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