

Proton Conduction Properties of Metal phosphonates and Application as Fillers in PEMFCs

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INTRODUCTION

Metal phosphonate (MP)-based coordination polymers (CPs) are structurally versatile multifunctional compounds containing different acidic groups such as P-OH; SO₃H, COOH, N⁺-H, etc¹. These features result in the formation of extended H-bond networks and confer a wide range of proton conduction properties to be used as components of membrane electrode assemblies (MEAs).

In this work, the focus is placed on the proton conduction properties of coordination polymers derived from the combination of lanthanide ions with different multifunctional phosphonic ligands, such as phosphonotaurine (2-[bis(phosphonomethyl)amino]-ethanesulfonic acid, H₅SP)² or nitrilo-tris(methylenephosphonic acid) (H₆NMP)³.

EXPERIMENTAL/THEORETICAL STUDY

High-throughput hydrothermal screening has been used to reach optimal synthesis conditions. Their crystal structures were solved *ab initio* from X-ray powder or single-crystal diffraction data. Proton conductivities of the MPs and Nafion®-mixed membranes were determined by electrochemical impedance spectroscopy (EIS).

RESULTS AND DISCUSSION

We report the synthesis and structural features of several members of both families of MPs with compositions: **Ln-H₄NMP-SO₄** [Ln(H₅NMP)(SO₄)(H₂O)₂] or [Ln(H₄NMP)(HSO₄)(H₂O)₄.nH₂O]; and **LnH₂SP** [Ln[H(O₃PCH₂)₂-NH-(CH₂)₂-SO₃]₂·2H₂O]. The presence of the different functional groups in these ligands such as free sulfonic groups or the incorporating sulphate species into the framework of CPs, lead to a wide variety of metal ligand coordination modes and frameworks, which determine their proton conductivity properties, ranged between 10⁻³ and 10⁻² S·cm⁻¹ at 90 °C and 95% RH. Selected materials were studied as fillers for the preparation of Nafion®-mixed membranes, and their responses in proton exchange membrane fuel cells (PEMFCs) were established under operating conditions.

CONCLUSION

The structural role and orientation of the acid groups of the ligand contribute to tune the H-bonding networks and, hence, the proton transfer processes. Preliminary results indicate that these solids perform satisfactorily as fillers of Nafion®-based membranes, showing power and current densities higher than those of the pristine Nafion® in short times.

REFERENCES

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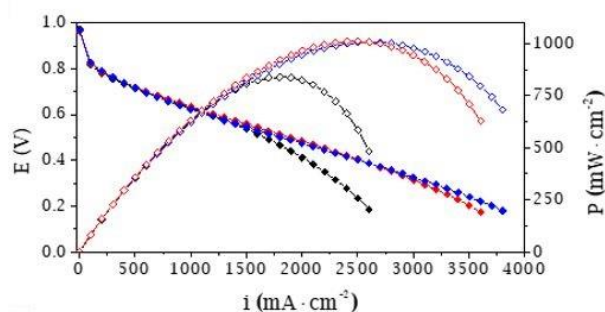


Fig. 1. Polarization and power density curves for Nafion® (black) and composite membranes at 100% RH and different temperatures.



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