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Multi-stabilized hybrid membranes for fuel cell and electrolyzer

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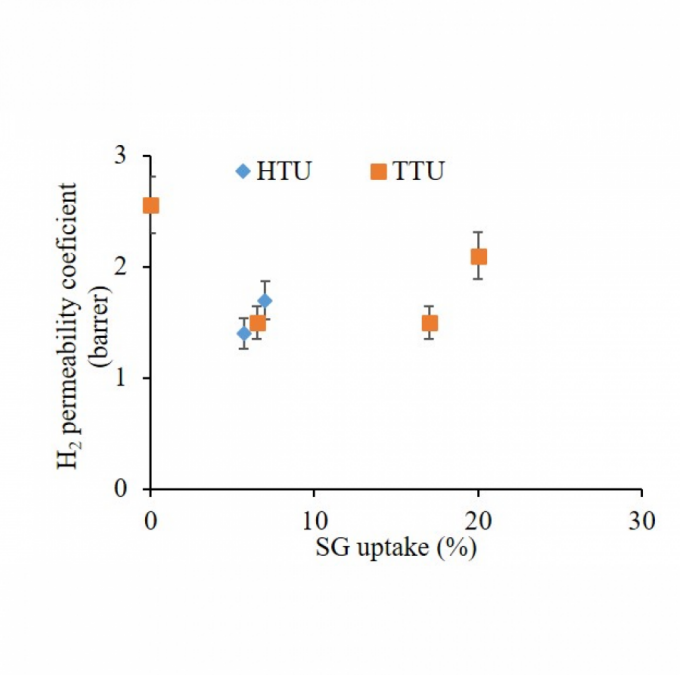
PURPOSE OF THE ABSTRACT

The ecological and energy transition appears essential to meet growing energy needs while respecting environmental constraints. The quest for alternative forms of energy continues at a rapid rhythm with the development of new techniques and tools to capture and use energy from renewable and clean sources. The storage of the intermittent renewable energy sources remains a major challenge. The production of hydrogen by electrolysis (e.g. by proton exchange membrane electrolyzers (PEMWEs)) provides chemical storage of the electrical energy produced. This chemically stored energy can be converted back into electrical energy by polymer electrolyte membrane fuel cells (PEMFCs). The PEMWE/PEMFC couple appears to be a promising

solution for sustainable development. In this context, PEMFCs are receiving a lot of attention with the aim to improve the polymer electrolyte membrane (PEM) properties. Indeed, the membrane has a key role in the devices as it acts as an electrode separator and proton conductor. Nafion membrane has been widely used in PEMFCs. However, its low thermo-mechanical properties restrict their operating range to temperature below 95 °C. There is thus a crucial need for the development of new membranes to succeed in a large-scale development of PEMFCs. Polyaromatic membranes are of great interest, and sulfonated Poly (Ether Ether Ketone) membrane (sPEEK) is among the most promising ones thanks to its good thermal stability (Tg=200°C) and lower cost [1]. However, sPEEK polymers are more susceptible to radical attack when compared to Nafion. Improving the resistance to ageing while keeping good intrinsic properties of the sPEEK membrane, such as high enough gas barrier properties and moderate hydration properties, is necessary for the development of more efficient PEMFCs systems. With the aim of developing performant and highly stabilized hybrid membranes derived from sPEEK polymers an original and versatile approach based on Sol Gel (SG) chemistry has been used in our research group. The direct introduction of SG precursors bearing chemical degradation inhibitors into the hydrophilic domains of the host sPEEK membrane is performed followed by the growth of the active 3D SG network, without polymer dissolution step, in order to improve all the properties of the commercial PEM [2]. The advantages of the SG impregnation route are: (i) conservation of the nano-domains of the initial membrane; (ii) better dispersion of the active phase within the membrane, and (ii) improved mechanical stability thanks to the presence of a 3D SG network that acts as a reinforcer. The use of SG precursors of sacrificial type and bearing Thio-urea functions has been studied. Two SG precursors, varying by their functionality were used and their influence on the thermal, hydration and gas permeability properties of the membrane were evaluated in order to establish structure/properties relationships for the design of more durable membranes. N-phenyl,N'[3-(triethoxysilyl)propyl]thiourea (TTU) and N,N'bis[3-(triethoxysilyl)propyl]thiourea (HTU) precursors, bearing respectively one Si(OR)3 group and two Si(OR)3 groups, were used in this work. The SG uptake, defined as the weight ratio of the SG phase to the sPEEK_NS membrane used to prepare the hybrid membrane, was ranging from 0 to 7% for HTU and from 0 to 20% for TTU and a good reproducibility was obtained. The sol gel networks acted as an impermeable phase, increasing the membranes gas and water barrier properties. In the whole range of SG investigated, all studied hybrid membranes, exhibited lower hydrogen permeability than reference sPEEK membrane.

FIGURES



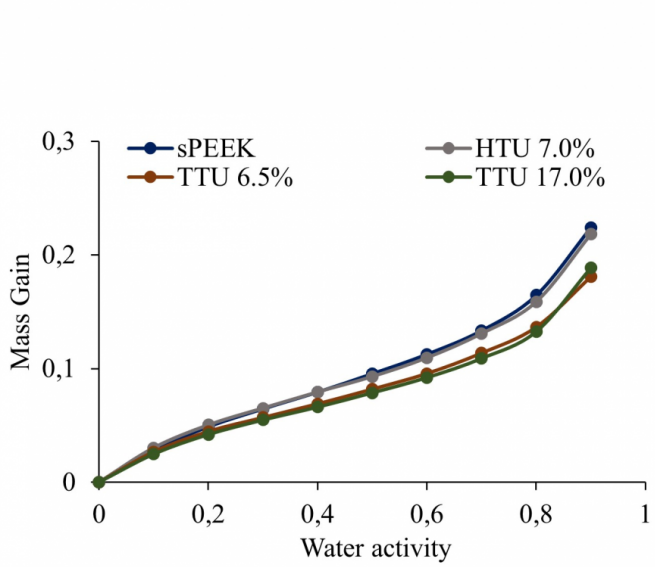


FIGURE 1

Figure 1.

Evolution of hydrogen permeability coefficients measured at 23 °C as function of the SG uptake

FIGURE 2

Figure 2.

Water sorption isotherms expressed as water uptake as function of the water activity

KEYWORDS

PEMFC | Sol-Gel | Hydrid Membranes | Permeability

BIBLIOGRAPHY

[1] X. Sun, S. Simonsen, T. Norby, A. Chatzitakis, Membranes, 2019, 9, 83

[2] N. Huynh, J.P. Cosas Fernandes, P.A. Bayle, M. Bardet, E.Espuche, J.Dillet, J.-C.Perrin, A.El Kaddouri, O.Lottin, V.H. Mareau, H. Mendail-Jakani, L.Gonon, J. Pow.Sour.,2020, 462, 228164