

## Supplementary information

**Enhanced conductivity of sodium versus lithium salts measured by impedance spectroscopy.  
Sodium cobaltacarboranes as electrolytes of choice.**

**Isabel Fuentes<sup>1</sup>, Andreu Andrio<sup>2</sup>, Francesc Teixidor<sup>1,\*</sup>, Clara Viñas<sup>1</sup>, Vicente Compañ<sup>3,\*</sup>.**

<sup>1</sup>Institut de Ciència de Materials de Barcelona. Campus UAB, 08193 Bellaterra, Barcelona (Spain)

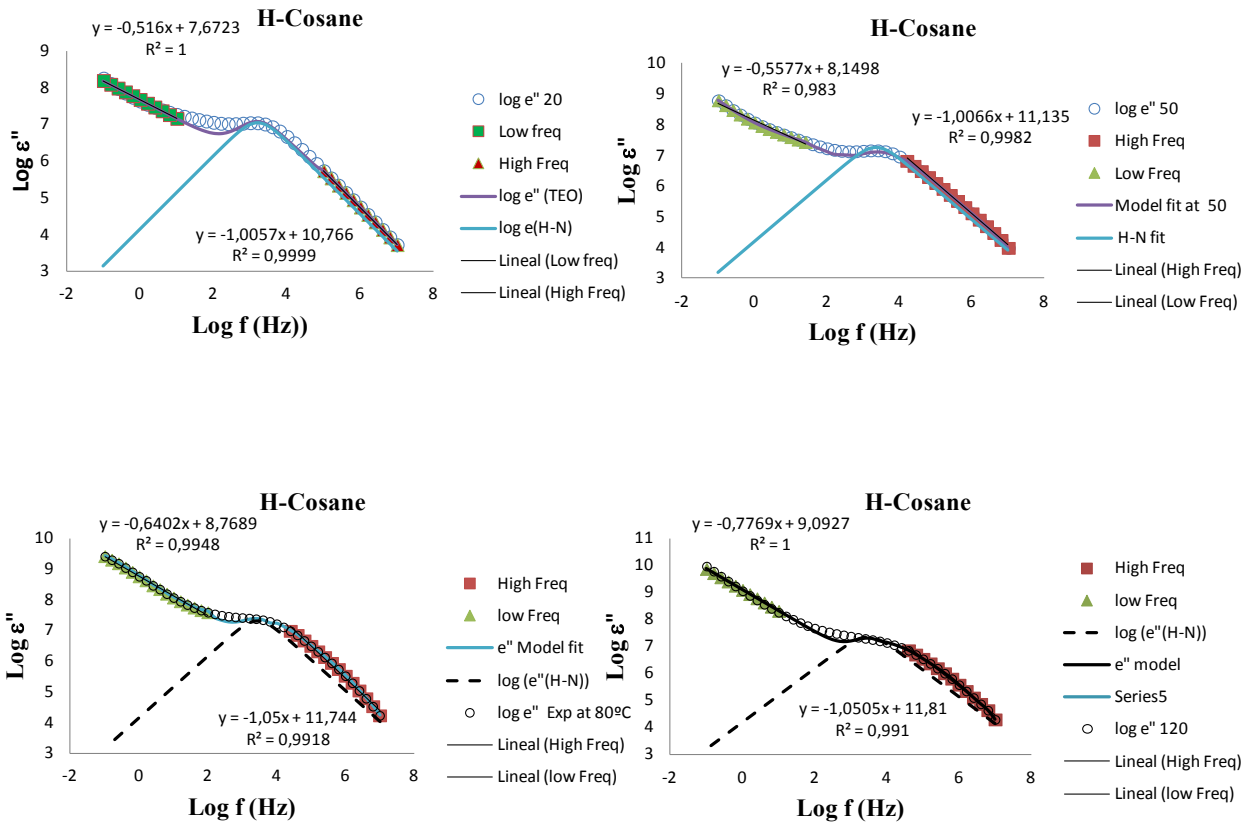
<sup>2</sup>Departamento de Física aplicada. Universitat Jaume I- 12080, Castellón (Spain)

<sup>3</sup>Escuela Técnica Superior de Ingenieros Industriales. Departamento de Termodinámica Aplicada. Universidad Politécnica de Valencia, Camino de vera s/n, 46020 Valencia, (Spain).

\*<sup>1</sup>E-mail: [teixidor@icmab.es](mailto:teixidor@icmab.es)

\*<sup>3</sup>E-mail: [vicommo@upv.es](mailto:vicommo@upv.es)

Fig. S1 shows the dielectric loss spectra as a function of the frequency with the piecewise function for the samples H-Cosane at 20°C, 50°C, 80°C and 120°C, respectively. The experimental data of  $\epsilon''(f)$  are shown as open circles, the fitted electrode polarization contribution as a dotted line, the solid line represent the fit of equation (2). Also we indicate the fit at low and high frequencies where we obtained the values of  $\sigma'$  and  $\sigma_{dc}$ , respectively, by mean of a line. The exponent  $n$  for the fit in the low frequencies region for all cases, is between 0.5-0.7 with a correlation coefficient of the adjust  $r^2= 0.99$ . The linear fit in the high frequencies region had a slope in between 0.98-1, with  $r^2=0.999$ , for all the range of temperatures.



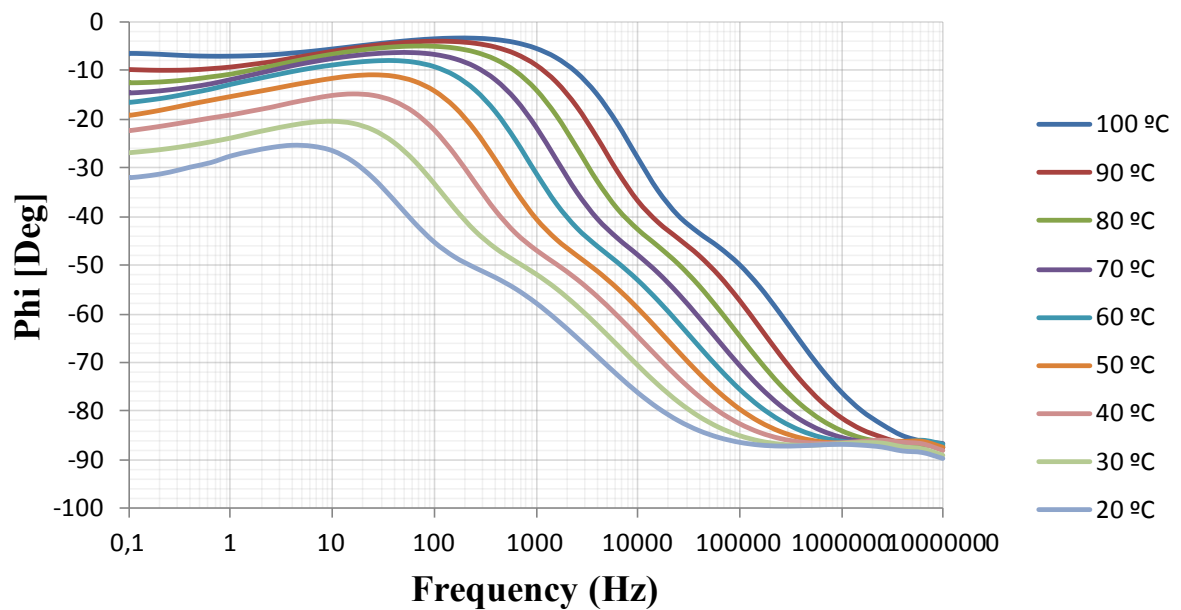
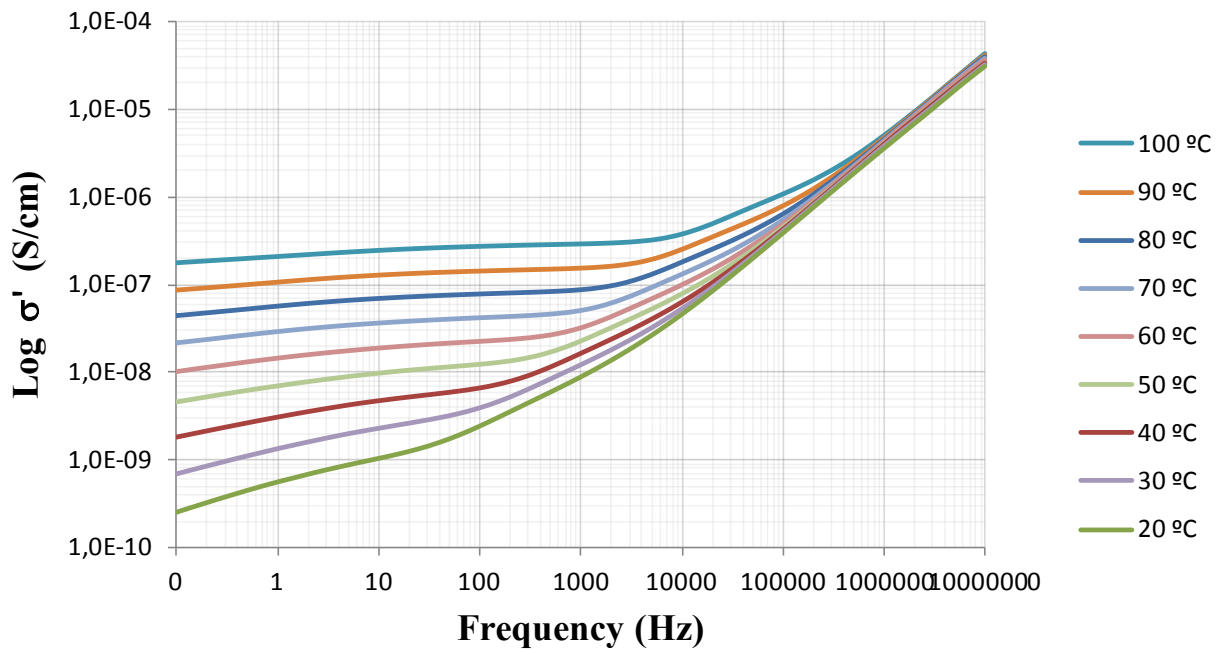
**Fig. S1** Double logarithmic plot of the imaginary part of the permittivity versus the frequency for the H-Cosane sample at 20, 50, 80 and 120°C, respectively In each plot we show the parameters of straight-line at low and high frequencies. Also we fit the Havriliak-Negami expression

$$\frac{\Delta \epsilon_{EP} \cdot \omega \cdot \tau_{EP}}{1 + (\omega \cdot \tau_{EP})^2}$$

at moderate frequencies according the first step in eq.(1).

In figure S1, we have modeled the dielectric loss spectra as a function of the frequency with the piecewise function<sup>30</sup>, for the sample H-Cosane at 20, 50, 80 and 120°C of temperature, respectively. As we can see in the region of moderate frequencies the shoulder has been explained as a Debye relaxation, due to the macroscopic polarization of the ionic charges as consequence of the electric field applied. This relaxation is characterized by a relaxation time  $\tau_{EP}$  that we are obtained and compare with the other samples.

This can be seen by the fact that the plot of  $\log(\epsilon'')$  versus  $\log(\omega \text{ (s}^{-1}\text{)})$  yields a straight-line with slope  $\approx -1$  over an extended range in the region of high frequency. This is the behavior of our samples for all kind of ions incorporated, and for all temperatures studied. From the intersection of this line with  $\log(\omega) = 0$  we have calculate the dc-conductivity ( $\sigma_{dc}$ ) for each temperature.



**Fig. S2** Bode diagram for the sample Li-Cosane in dry conditions at different temperatures (20°C to 100°C). Top: Double logarithmic plot of  $\sigma'$  versus frequency. Bottom: We plot the phase angle versus frequency.

As we can see from Fig. S2, the real part of the conductivity in dry conditions for the sample Li-Cosane vary from  $10^{-9}$  S/cm at 20 °C to around  $10^{-7}$  S/cm at 100°C. A comparison with the same sample in wet conditions (95% RH) shown that the conductivity is about  $2.1 \times 10^{-2}$  at 20°C and  $9,2 \times 10^{-2}$  S/cm at 100°C. These values are more than five orders of magnitude at higher temperatures and more than seven orders of magnitude in case of ambient temperature.