Supporting Information I

Debye length and anionic transport properties on composite membranes based on Supported Ionic Liquid-Like Phases (SILLPS)

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1. Nyquist parameters

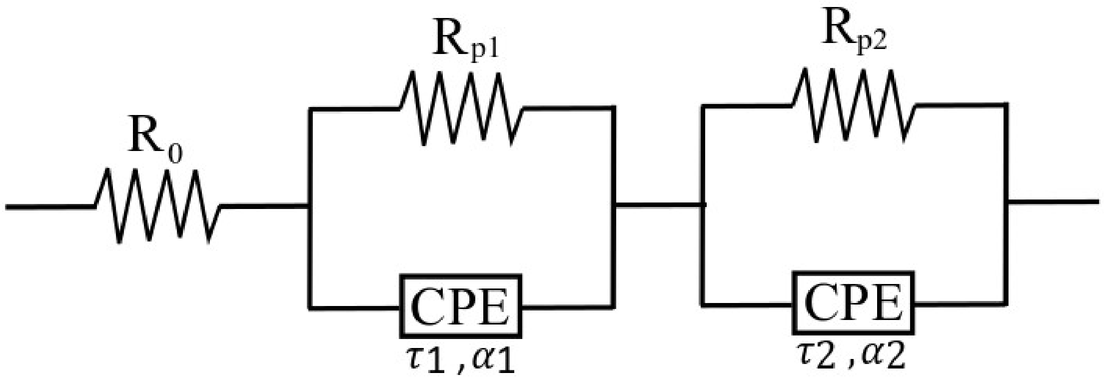


Figure SI-1. Equivalent circuit that comprises a resistance R_{pi} representing the charge transfer resistance at the interface sample/electrode in parallel with a constant phase element (CPE), representing the sample/electrode double layer.

Table SI-1. Values of the different parameters obtained from the fitting of the Nyquist plot experimental data for the real and imaginary impedance of the films using the Eq. (1) in the main text at different temperatures. Errors in the values are less than 10%.

M1							
T [°C]	$R_{p,1}$ [Ω]	α_1	τ_1 [s]	$R_{p,2}$ [Ω]	α_2	τ_2 [s]	R_0 [Ω]
30	1.45E+07	7.78E-01	5.79E-04	5.68E+07	4.66E-01	3.54E+00	5.50E-10
70	1.20E+05	7.35E-01	5.05E-06	7.27E+08	5.09E-01	1.53E+05	5.50E-10
90	1.60E+09	5.88E-01	9.72E+05	2.49E+04	7.09E-01	1.53E-06	5.50E-10
110	4.80E+03	7.75E-01	1.95E-07	4.00E+05	4.51E-01	8.00E+00	0.00E+00
120	2.70E+03	7.75E-01	9.96E-08	3.00E+05	4.51E-01	8.00E+00	0.00E+00
M2							
T [°C]	$R_{p,1}$ [Ω]	α_1	τ_1 [s]	$R_{p,2}$ [Ω]	α_2	τ_2 [s]	R_0 [Ω]
30	8.02E+06	7.30E-01	2.66E-04	2.56E+08	6.20E-01	2.05E+01	7.53E-10
70	3.96E+04	7.98E-01	5.99E-06	1.99E+08	4.94E-01	9.57E+04	0.00E+00
90	6.76E+03	7.98E-01	5.99E-07	7.59E+07	4.84E-01	9.57E+04	0.00E+00

110	5.06E+05	5.52E-01	5.15E+00	1.73E+03	7.77E-01	1.86E-07	0.00E+00
120	8.79E+04	5.52E-01	1.45E+00	9.56E+02	7.97E-01	1.96E-07	0.00E+00
M3							
T [°C]	$R_{p,1}$ [Ω]	α_1	τ_1 [s]	$R_{p,2}$ [Ω]	α_2	τ_2 [s]	R_0 [Ω]
30	8.01E+05	8.54E-01	2.37E-05	2.79E+09	4.84E-01	2.09E+07	0.00E+00
70	7.76E+03	8.38E-01	2.25E-07	1.85E+09	5.58E-01	2.58E+07	0.00E+00
90	1.86E+03	8.38E-01	5.46E-08	1.85E+09	5.58E-01	2.58E+07	0.00E+00
110	6.42E+02	8.22E-01	1.88E-08	6.51E+08	5.83E-01	1.10E+07	0.00E+00
120	4.10E+02	8.22E-01	1.48E-08	6.51E+08	5.83E-01	1.10E+07	0.00E+00
M4							
T [°C]	$R_{p,1}$ [Ω]	α_1	τ_1 [s]	$R_{p,2}$ [Ω]	α_2	τ_2 [s]	R_0 [Ω]
30	5.95E+03	7.84E-01	2.94E-07	1.65E+04	8.72E-01	6.40E-02	0.00E+00
70	3.10E+02	9.00E-01	2.07E-08	3.07E+04	8.32E-01	9.00E-02	6.50E+01
90	9.00E+01	9.90E-01	1.27E-08	2.57E+04	8.32E-01	9.00E-02	6.50E+01
110	3.70E+01	9.90E-01	9.81E-09	4.50E+09	8.00E-01	9.04E+05	4.00E+01
120	1.64E+01	9.90E-01	8.81E-09	4.50E+09	8.00E-01	9.04E+05	4.00E+01
M5							
T [°C]	$R_{p,1}$ [Ω]	α_1	τ_1 [s]	$R_{p,2}$ [Ω]	α_2	τ_2 [s]	R_0 [Ω]
30	2.98E+02	7.40E-01	3.24E-08	3.95E+04	8.50E-01	9.97E-02	0.00E+00
70	3.62E+01	8.00E-01	3.34E-09	2.05E+04	8.40E-01	9.97E-02	0.00E+00
90	1.78E+01	8.60E-01	2.00E-09	2.05E+04	8.53E-01	9.97E-02	0.00E+00
110	9.78E+00	9.50E-01	1.54E-09	1.55E+04	8.53E-01	9.97E-02	0.00E+00
120	7.60E+00	9.90E-01	1.54E-09	1.15E+04	8.53E-01	9.97E-02	0.00E+00

2. Conductivity, dielectric constant and Cole-Cole parameters

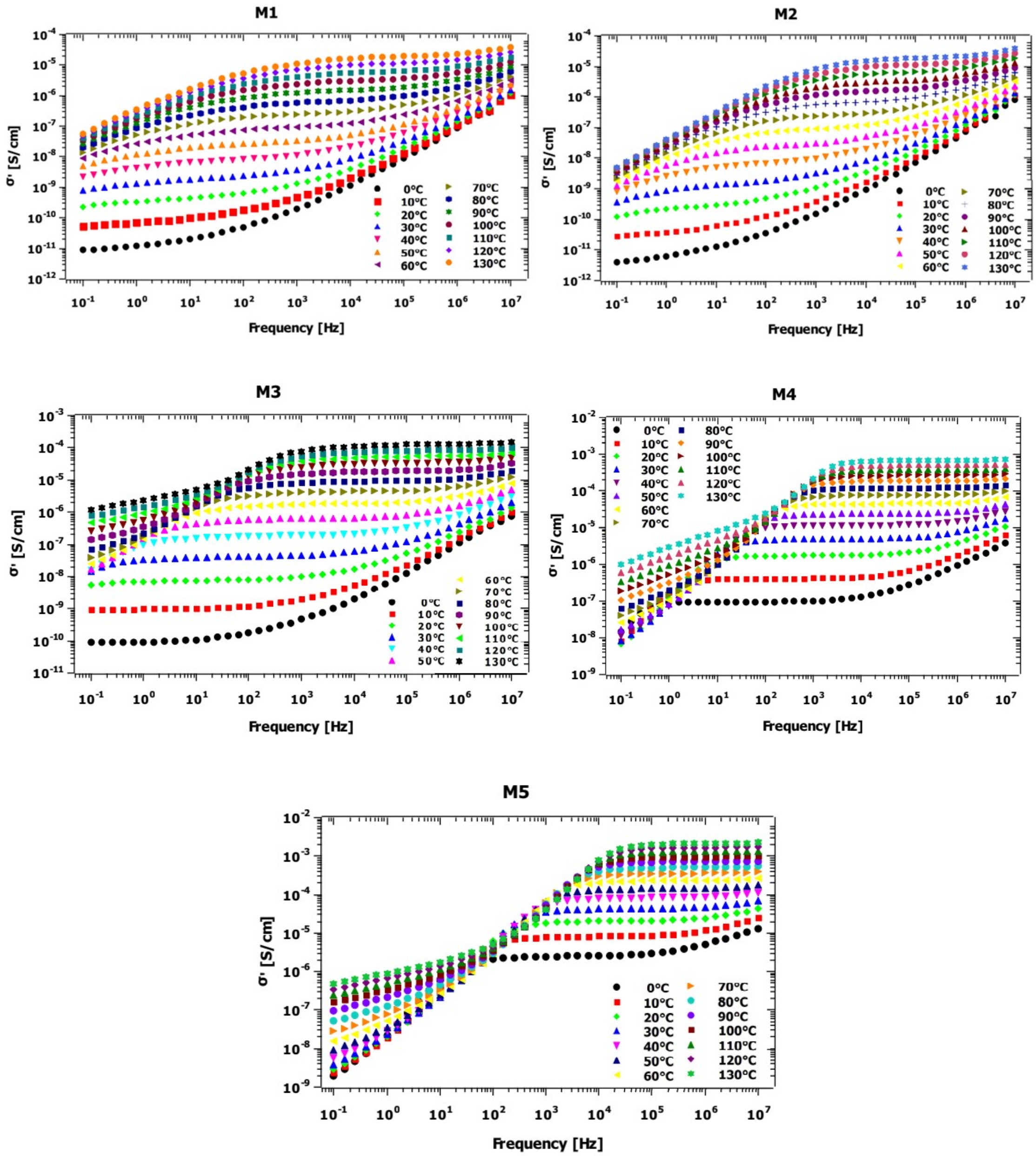
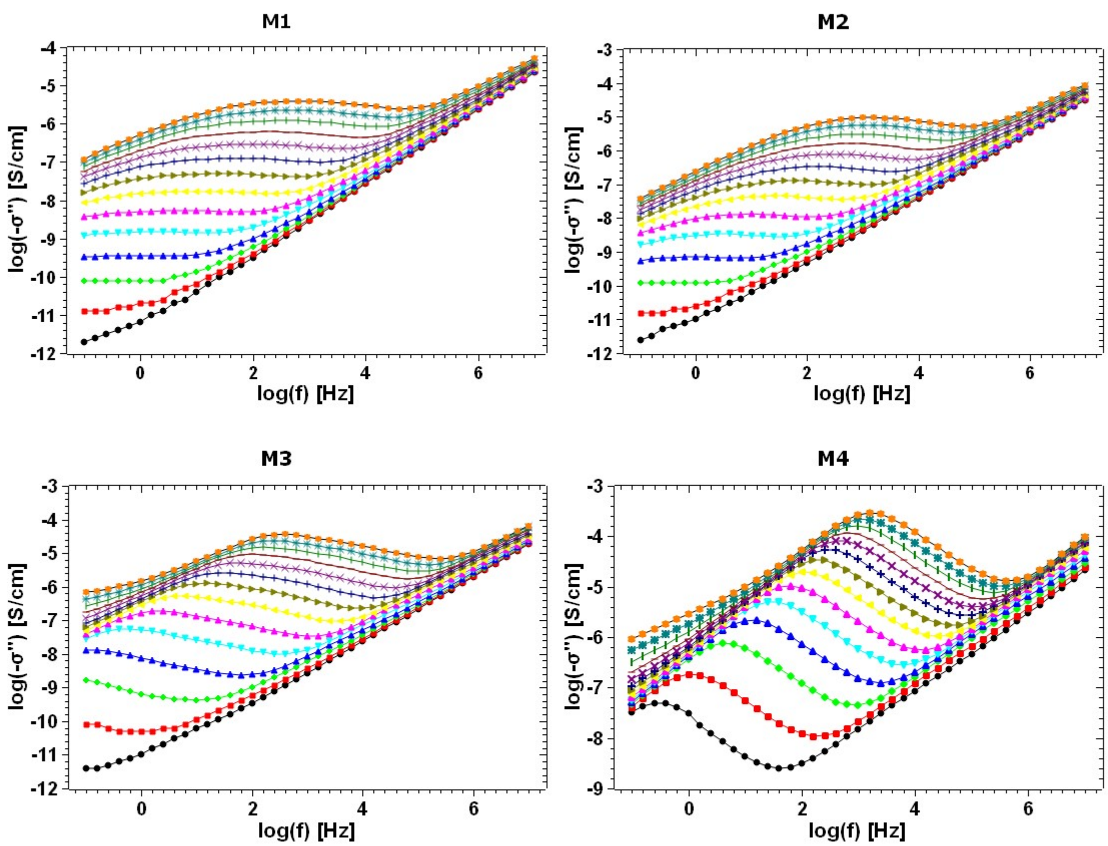


Figure SI-2. Log(σ′) versus log(f) for all the membranes (**M1**-**M5**) in all the range of temperatures

Table SI-2. Calculated values for M, τ_{EP} and α using Eq. (6) in the main text, for the temperatures 20, 40, 40, 80, 100 and 120 ºC. Errors in the values are less than 7%.

	T = 20°C			**T = 40°C**		
Membrane	**M**	**τ_{EP} (s)**	**α**	**M**	**τ_{EP} (s)**	**α**
M1	2.33E+03	9.74E+00	8.90E-01	3.15E+03	6.98E-01	8.95E-01
M2	9.82E+02	5.65E+00	8.72E-01	9.07E+02	2.05E-01	8.92E-01
M3	1.89E+04	3.12E+00	9.72E-01	1.86E+03	2.20E-01	8.28E-01
M4	1.76E+04	2.67E-02	9.93E-01	2.06E+04	3.98E-03	9.93E-01
M5	8.83E+03	8.29E-04	9.82E-01	9.66E+03	2.07E-04	9.85E-01
	T = 60°C			**T = 80°C**		
Membrane	**M**	**τ_{EP} (s)**	**α**	**M**	**τ_{EP} (s)**	**α**
M1	3.72E+03	6.43E-02	9.05E-01	1.60E+03	4.41E-03	9.30E-01
M2	5.64E+02	9.48E-03	9.22E-01	8.20E+02	1.73E-03	9.23E-01
M3	8.49E+03	5.25E-03	9.80E-01	8.82E+03	9.97E-04	9.81E-01
M4	2.37E+04	1.02E-03	9.94E-01	2.62E+04	3.75E-04	9.94E-01
M5	8.89E+03	6.54E-05	9.88E-01	9.63E+03	3.11E-05	9.91E-01
	T = 100°C			**T = 120°C**		
Membrane	**M**	**τ_{EP} (s)**	**α**	**M**	**τ_{EP} (s)**	**α**
M1	2.08E+03	1.11E-03	9.34E-01	2.39E+03	3.48E-04	9.39E-01
M2	1.21E+03	5.01E-04	9.25E-01	1.22E+03	1.39E-04	9.38E-01
M3	8.16E+03	2.76E-04	9.80E-01	9.35E+03	1.97E-04	9.78E-01
M4	3.05E+04	1.81E-04	9.94E-01	3.13E+04	9.42E-05	9.94E-01
M5	7.99E+03	1.48E-05	9.95E-01	7.25E+03	9.01E-06	9.97E-01

Figure SI-3 shows the curves of double logarithmic plot of σ" versus frequency in the whole temperature interval considered for **M1**, **M2**, **M3**, **M4** and **M5**, respectively. From this figure, for each sample at each temperature, the frequency values of the onset (f_{ON}) and full development of electrode polarization (f_{MAX}) were established, respectively, which allowed the calculation of the static permittivity, such as is indicate following Eq. (20). The mean values obtained following the two procedures are gathered in Table SI-4 as theoretical ε_s. Also, for comparison purposes, the values observed from the experimental plots of ε' versus frequency for all the samples were tabulated as experimental ε_s. A comparison between theoretical and experimental results reveals the excellent agreement between the static permittivity values obtained theoretically following Eq. (10) with respect to the experimental ones. A close inspection of these results indicates that ε_s decreases when the temperature increases for the **M1**, **M2**, **M3**, **M4** and **M5**, composite samples.



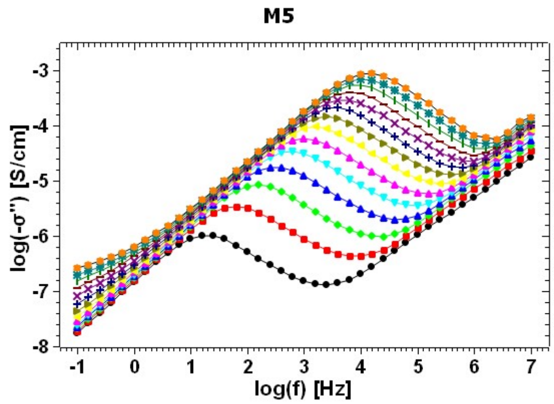
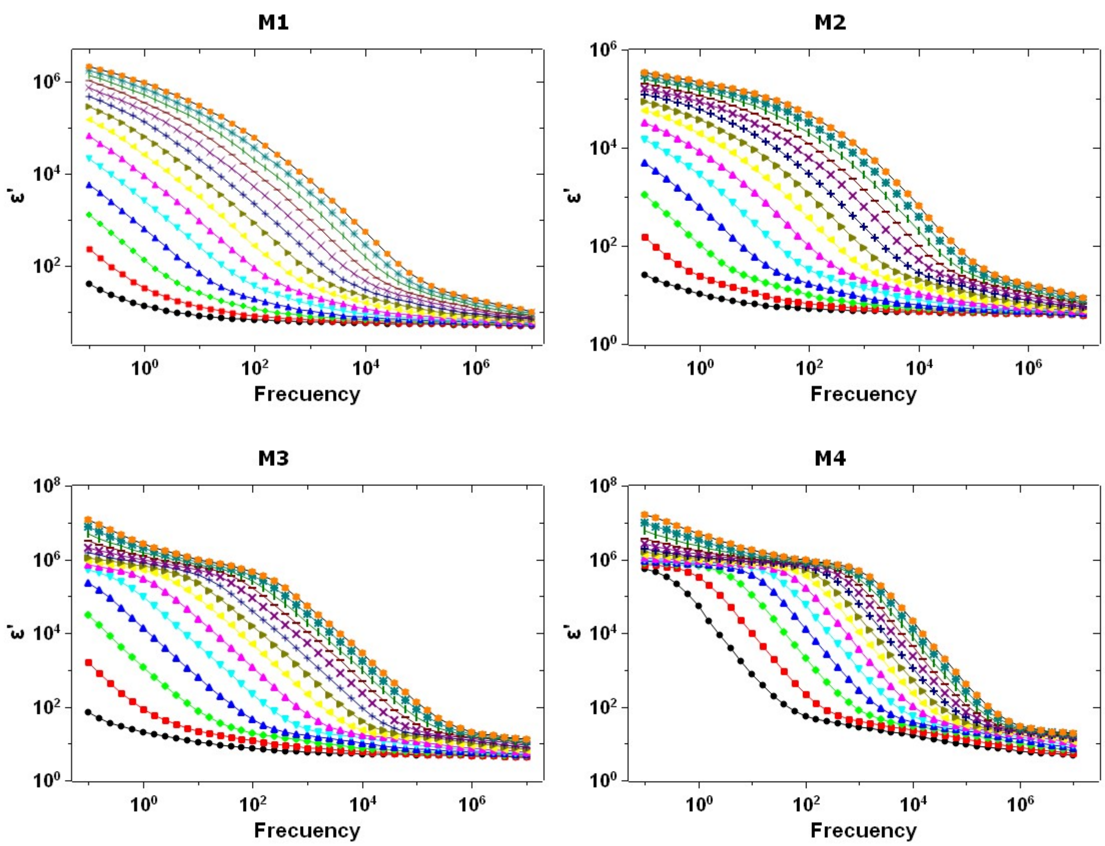


Figure SI-3. Double logarithmic plot of σ" versus frequency in all the range of temperatures (● 0°C, ■ 10°C, ◆ 20°C, ▲ 30°C, ▼ 40°C, ▲ 50°C, ◀ 60°C, ▶ 70°C, + 80°C, x 90°C, - 100°C, | 110°C, ⁕ 120°C, ⁕ 130°C). The values of the f_{ON} and f_{MAX} are determined from this curves and used in the Serghei expression Eq. (20) in the main text.



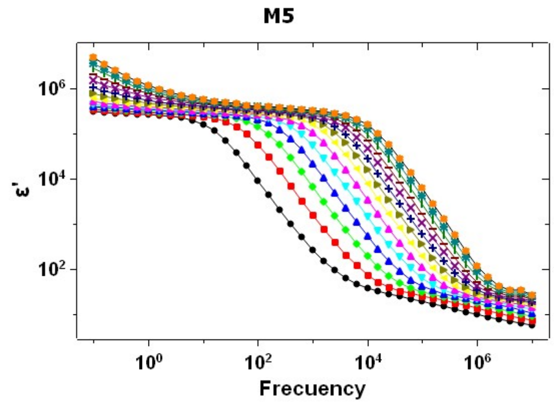


Figure SI-4. Double logarithmic plot of ε' versus frequency for all the studied samples in all the range of temperatures (● 0°C, ■ 10°C, ♦ 20°C, ▲ 30°C, ▼ 40°C, ▲ 50°C, ◄ 60°C, ► 70°C, + 80°C, x 90°C, - 100°C, | 110°C, * 120°C, * 130°C).