

## **Ionic conductivity and dielectric properties of bulk SPP-PEG hydrogel as Na<sup>+</sup> ion based SPE material for energy storage applications**

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### **Supporting Information**

#### **Materials:**

All the chemicals are purchased from commercially available sources as sodium polyphosphate (Graham's salt,  $\geq 68\%$  P<sub>2</sub>O<sub>5</sub> basis (acidimetric)) from Merck (CAS: 10361-03-2) and Polyethylene glycol 600 from Merck.

#### **Characterization:**

IR spectrum recorded by FT-IR Spectrometer with ATR Accessory (Model FTIR 4700, Make: JASCO, Tokyo) within the range of 4000-500 cm<sup>-1</sup>. Thermal analysis was recorded by TGA-DTA (Perkin-Elmer STA 6000) within the temperature range of 30°C to 700°C under inert atmosphere and the heating rate was 2°C per minute for range 30°C to 150°C and 10°C per minute for 150°C to 700°C temperature. SEM images of the polymers were captured by a FEI Quanta 200D8374 ESEM instrument (Netherland) with EDAX setup. For surface morphology analysis we perform SEM analysis at low vacuum and less energy (10-15/KV) condition, this condition was choose to prevent the surface of material from charring by electron beam. XRD spectrum recorded by bench-top XRD Rigaku Miniflex 600 Desktop X-Ray Diffraction System, Rigaku Corporation. XRD analysis was performed with 1.54059 wavelength, step size 0.2 and scan rate 5°/minute within 5° to 80° range. Solid state cyclic voltammetry (CV) performed by Keithley power source meter 2450 Instruments with scan

rate of 50 mV/s and voltage range -1V To +3.2V. Linear sweep voltammetry was carried out by using Keithley power source meter 2450 Instruments with scan rate of 50 mV/s and voltage range -1V To +5V. Ionic transference number measurement was carried out by using Keithley power source meter 2450 Instruments at potential of 1V. EIS for conductivity study performed by Wayne Karr impedance analyzer model 6500B made by Wayne Karr instrument UK at 1V potential and frequency range 20 Hz to 10 MHz. Dielectric measurements are performed by Wayne Karr impedance analyzer model 6500B made by Wayne Karr instrument UK at 1V potential and frequency range 20 Hz to 1 MHz. Here we take data for SPP-PEG hydrogel electrolyte film at a varying temperature from 20°C to 80°C for conductivity and dielectric analysis.

#### Sample preparation and experimental conditions for impedance analysis:

Taking 1.20g of SSP-PEG HYDROGEL and making a very thick circular film of 0.4 cm with 0.72 cm diameter. Because the sample was sticky hence it was left on the sample holder made up of copper to make a proper interface between electrodes and sample film. After 5-10 minute duration sample was ready to analyze. All the electrochemical, conductivity and dielectric analysis was performed using solid state method.

**Table S1:** The values of  $\sigma_{ac}$ ,  $A$ ,  $n$ ,  $R^2$ ,  $C_b$ ,  $\epsilon_b N$ ,  $\mu$  and  $V_d$  for different temperature.

$T$ (°C)	$\sigma_{dc}$ (mS/cm)	$A$	$N$	$R^2$	$C_b$ ( $\times 10^{-8}$ F)	$\epsilon_b$ (F/cm)	$D$ ( $m^2/s$ )	$\mu$ ( $m^2/Vs$ )	$V_d$ (m/s)
20	0.212	$3.38 \times 10^{-11}$	1.16	0.999	3.88	438520	$3.265 \times 10^{-09}$	$1.29 \times 10^{-7}$	$3.21 \times 10^{-5}$
30	0.383	$5.02 \times 10^{-12}$	1.25	0.988	2.97	335514	$8.680 \times 10^{-09}$	$3.32 \times 10^{-7}$	$5.81 \times 10^{-5}$
40	0.523	$5.43 \times 10^{-11}$	1.10	0.993	3.39	383334	$6.092 \times 10^{-09}$	$2.26 \times 10^{-7}$	$7.93 \times 10^{-5}$
50	1.01	$1.63 \times 10^{-9}$	0.87	0.995	3.12	352447	$1.120 \times 10^{-08}$	$4.02 \times 10^{-7}$	$1.53 \times 10^{-4}$
60	1.98	$7.96 \times 10^{-8}$	0.76	0.995	2.90	327892	$2.057 \times 10^{-08}$	$7.16 \times 10^{-7}$	$3.00 \times 10^{-4}$
70	3.20	$4.07 \times 10^{-8}$	0.65	0.988	2.15	242870	$3.353 \times 10^{-08}$	$1.13 \times 10^{-6}$	$4.85 \times 10^{-4}$

80	5.23	7.22 x 10 <sup>-7</sup>	0.48	0.977	1.41	160202	4.375 x 10 <sup>-08</sup>	1.44 x 10 <sup>-6</sup>	7.93 x 10 <sup>-4</sup>
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## New Project

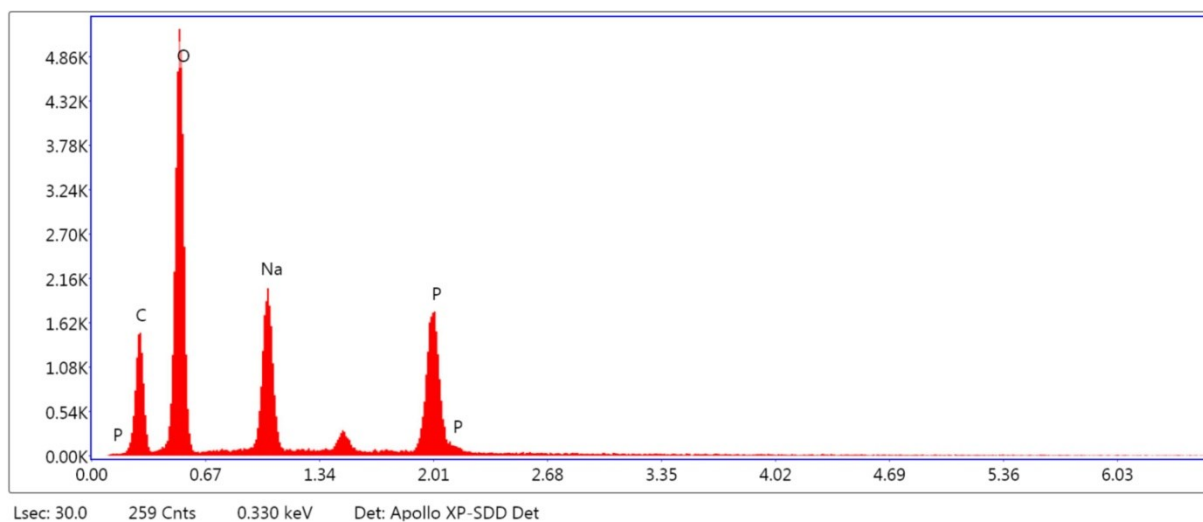
Author: NST physics  
Creation: 02/02/2021 2:59:44 PM  
Sample Name: EDX

## Added Spectra

2/2/2021 2:59:44 PM

Mag: 1001 Takeoff: 35.1 Live Time(s): 30 Amp Time(μs): 6 Resolution:(eV)129

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## eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	R	A	F
C K	27.3	37.7	287.7	9.8	0.0975	1.0836	0.9732	0.3300	1.0000
O K	41.4	42.9	1040.1	7.2	0.2195	1.0236	0.9924	0.5179	1.0000
NaK	14.4	10.4	472.7	5.6	0.0965	0.9165	1.0145	0.7293	1.0031
P K	16.9	9.1	519.5	3.5	0.1407	0.8687	1.0354	0.9530	1.0047

