

Supplementary materials

Polypyrrole with Phosphor Tungsten Acid and Carbide-Derived Carbon: Change of Solvent in Electropolymerization and Linear Actuation.

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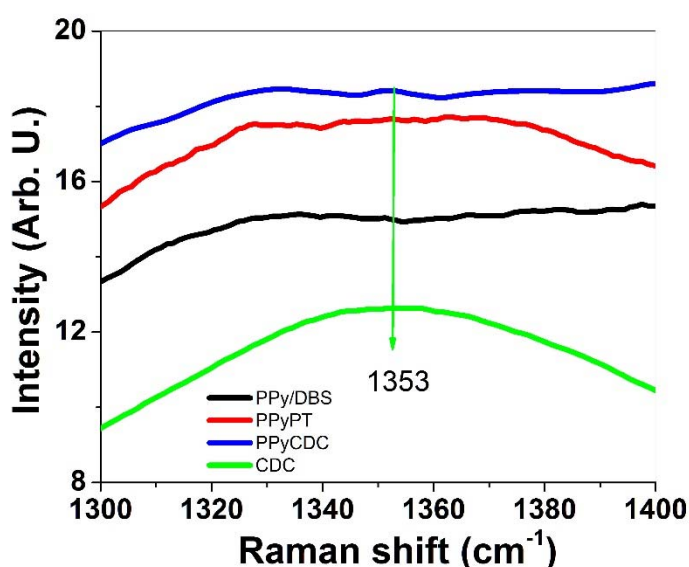


Figure S1. Raman spectra's (1350 – 1450 cm^{-1} , 514 nm) of pristine PPy films in oxidized state (1.0 V) such as PPY/DBS-EG (black line), PPYPT-EG (red line), PPYCDC-EG (blue line) and CDC (green line).

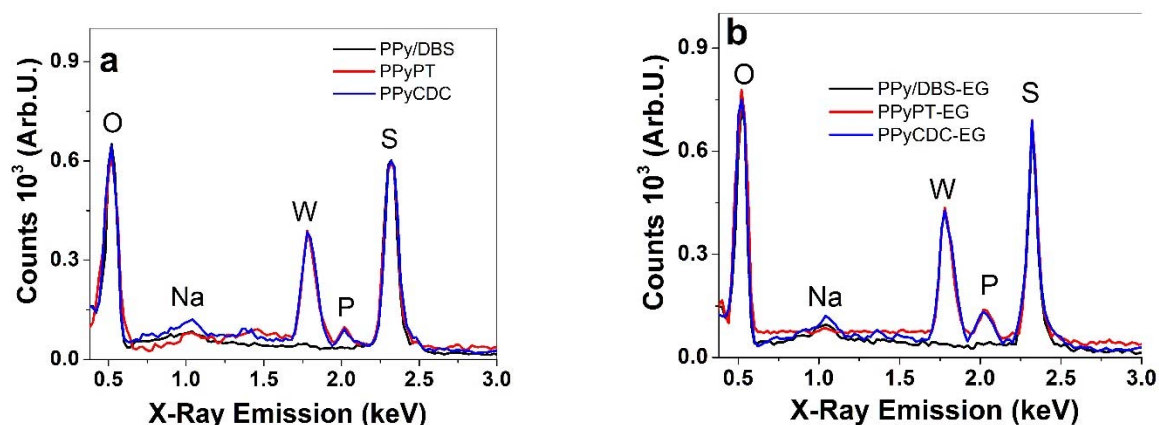


Figure S2. EDX spectroscopy of pristine PPy/DBS and PPy/DBS-EG (black line), PPyPT and PPyPT-EG (red line) and PPyCDC and PPyCDC-EG (blue line) in oxidized state (1.0V) showing in (a), PPy composites made in EG:Milli-Q+ (1:1) and in (b), those made in EG solvent.

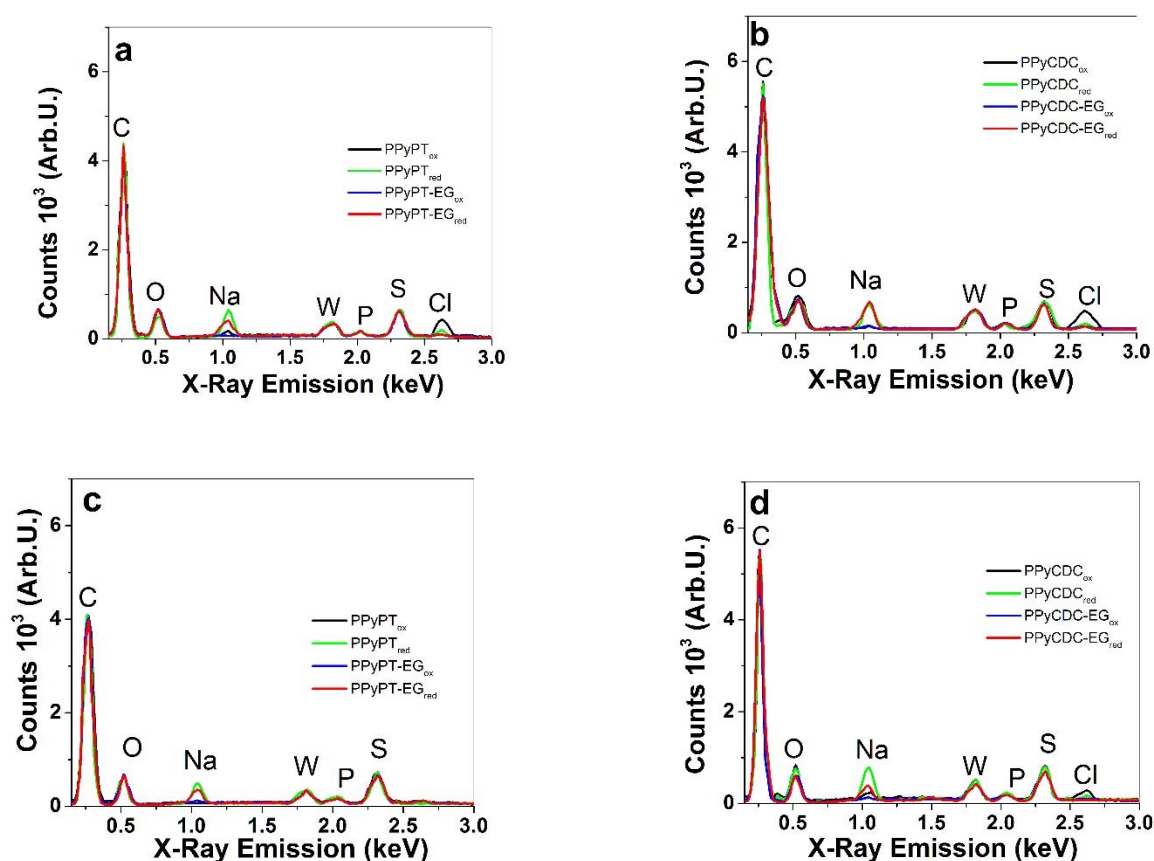


Figure S3. (a), EDX spectroscopy at cross section in oxidized state (5 min, 0.65V) and reduced state (5 min -0.6V) of PPy composite samples such as PPyPT_{ox} and PPyCDC_{ox} (black line), PPyPT_{red}, PPyCDC_{red} (green line), PPyPT-EG_{ox}, PPyCDC-EG_{ox} (blue line) and PPyPT-EG_{red}, PPyCDC-EG_{red} (red line), in (b), PPy samples in NaClO₄-PC and in (c,d), those in NaClO₄-aq electrolytes.

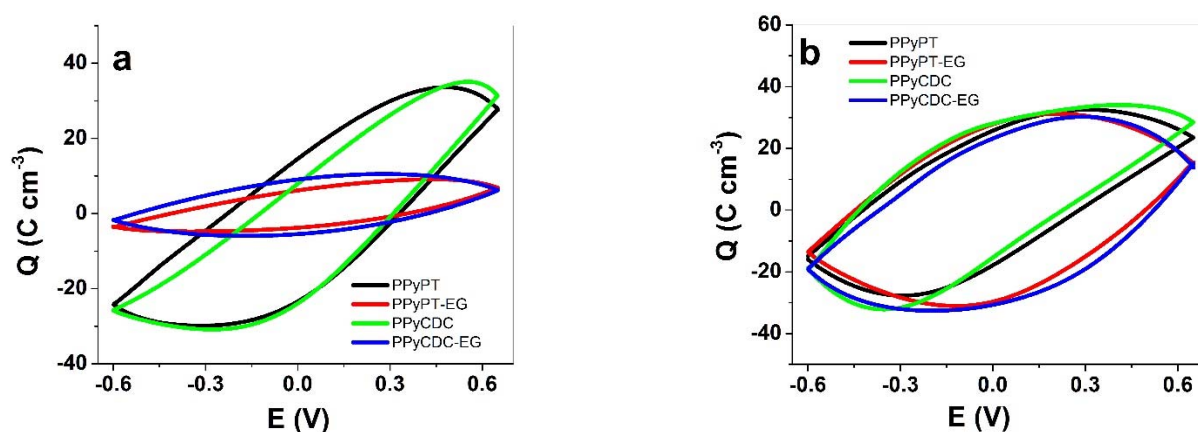


Figure S4. Coulouvoltammetry (3rd cycle) of PPyPT (black line), PPyPT-EG (red line), PPyCDC (green line) and PPyCDC-EG (blue line) of charge density against potential E (0.65V to -0.6 V) performed in (a), of NaClO₄-PC and (b), NaClO₄-aq electrolyte.

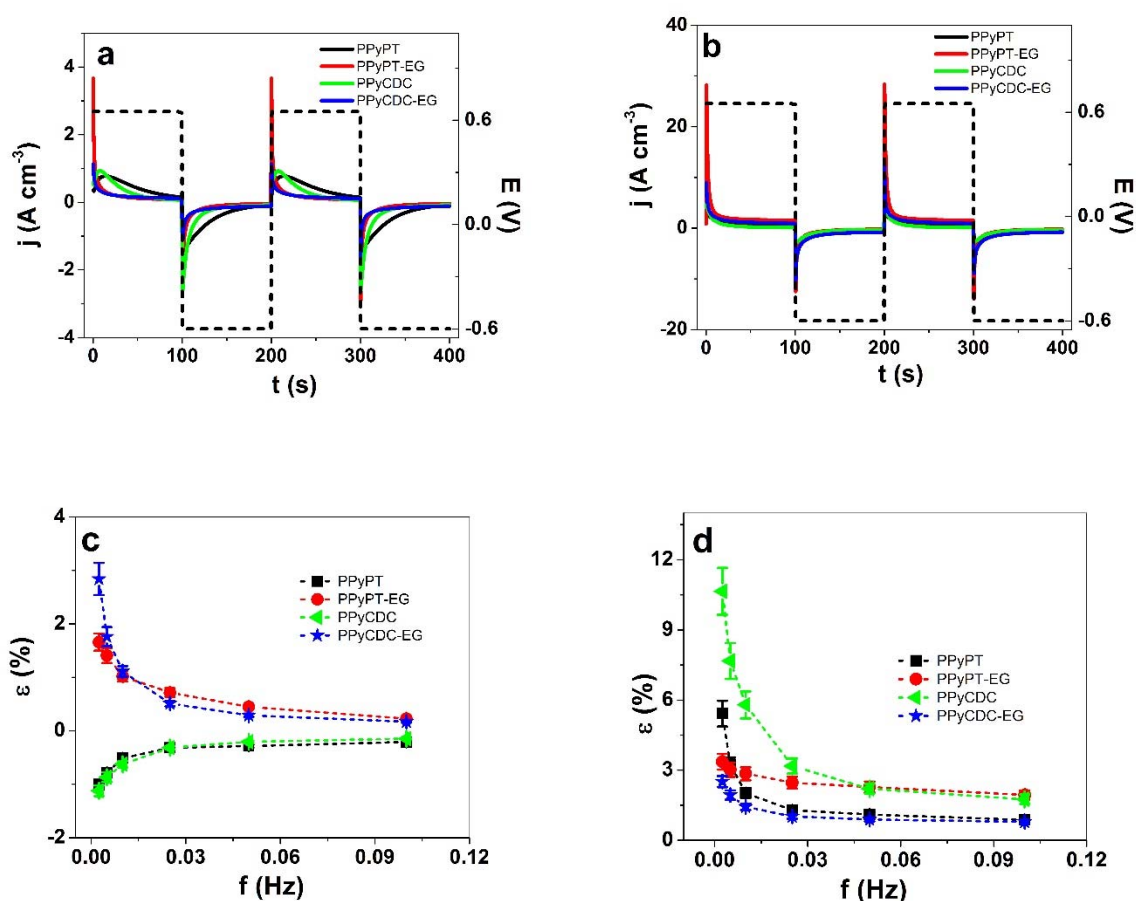


Figure S5. Square potential steps of PPyPT (black line), PPyPT-EG (red line), PPyCDC (green line) and PPyCDC-EG (blue line) showing current density time curves (two subsequent cycles 2nd to 3rd) at applied frequency 0.005Hz at potential range 0.65 to -0.6 V (E , dashed line) using in (a), NaClO₄-PC and in (b), NaClO₄-aq electrolyte. Shown in (c), at applied frequencies (f) in range 0.0025Hz to 0.1Hz the PPyPT (—■—), PPyPT-EG (—●—), PPyCDC (—▲—) and PPyCDC-EG (—★—) in NaClO₄-PC strain ϵ and in (d), in NaClO₄-aq. Negative strain reflecting expansion at oxidation and positive strain expansion at reduction.

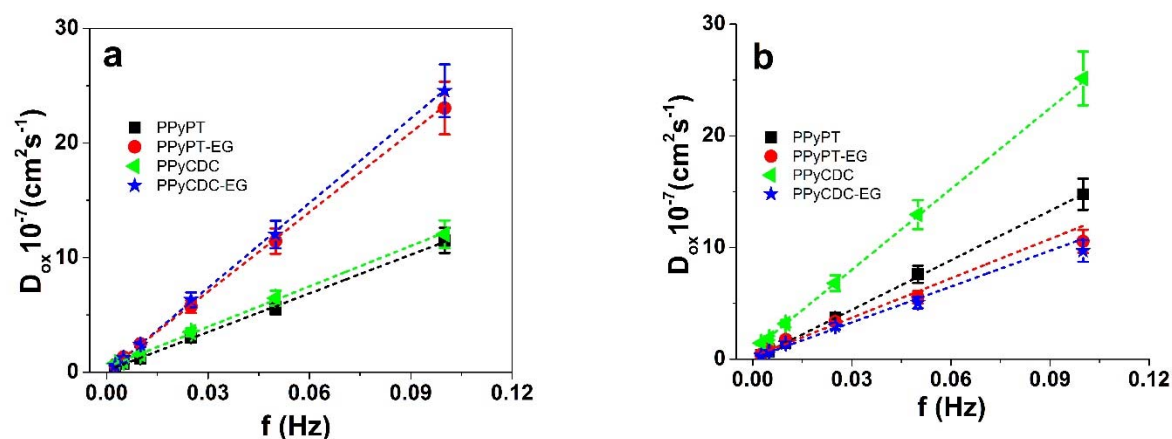


Figure S6. Diffusion coefficients at oxidation D_{ox} of PPyPT (■), PPyPT-EG (●), PPyCDC (▲) and PPyCDC-EG (★) showing in (a), NaClO₄-PC and (b), NaClO₄-aq electrolyte against applied frequencies f (0.0025 Hz to 0.1 Hz). The dashed lines represent the linear fit and shown only for orientation.

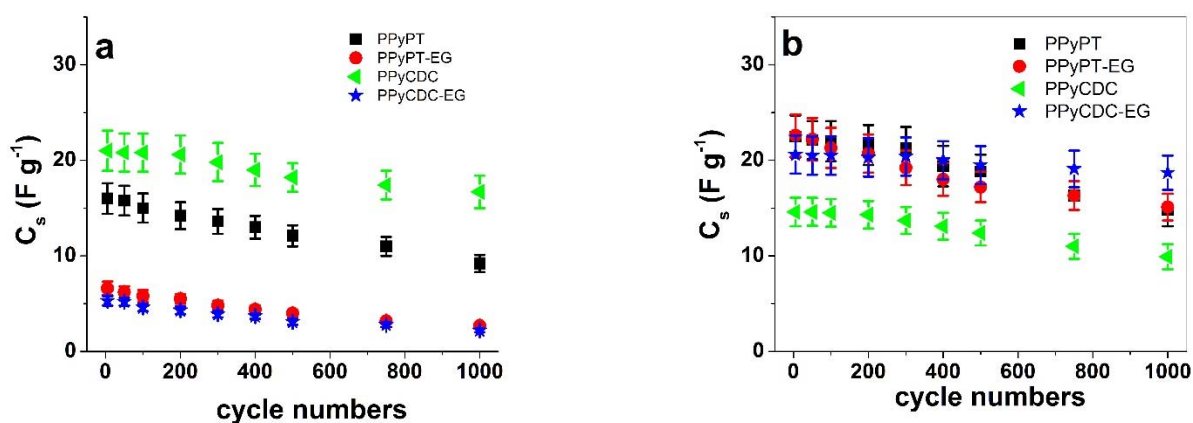


Figure S7. Cycle stability of the specific capacitance C_s against cycle numbers (1000 cycles, 0.1 Hz) at applied current density of $\pm 2 \text{ A g}^{-1}$ of PPy composites such as PPyPT (■), PPyPT-EG (●), PPyCDC (▲) and PPyCDC-EG (★) applied at different electrolytes showing in (a), NaClO₄-PC and (b), NaClO₄-aq.

Table S1. Young's modulus Y of samples such as PPyPT, PPyPT-EG, PPyCDC and PPyCDC-EG from stiffness measurements stretching the film in $1 \mu\text{m}$ (0.1% strain) to obtain the mass (stress kPa) before and after actuation cycles in NaClO₄-PC and NaClO₄-aq electrolytes.

Samples	NaClO ₄ -PC		NaClO ₄ -aq	
	Y [MPa], before	Y [MPa], after	Y [MPa], before	Y , [MPa] after
PPyPT	115 ± 8.7	55.3 ± 5.7	117 ± 11	88.6 ± 8.2
PPyPT-EG	23.7 ± 2.4	22.1 ± 2.2	14.5 ± 1.2	12.9 ± 1.3
PPyCDC	43.5 ± 4.2	36.3 ± 3.5	21.4 ± 2.1	5.2 ± 0.5
PPyCDC-EG	15.6 ± 1.5	14.5 ± 1.3	21.1 ± 2	19.8 ± 1.7