Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supplementary information

Strain induced insulator-to-semiconductor transition in conducting polymer composites originating from the auxetic behaviour of hierarchical structures

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Power law at three different regimes corresponding to above, below and at percolation are:

a) When the volume fraction V_f of PANI in the blend just exceeds the percolation threshold V_{fc}, the conductivity of the composite can be predicted by, $\sigma_c \propto \sigma_1 * (V_f - V_{fc})^t$, where, σ_1 is the conductivity of pure PANI and t is the exponent in Power law.

b) When $V_f < V_{fc}$, conductivity of the composite is predicted by, $\sigma_c \propto \sigma_2 * (V_{fc} - V_f)^{-v}$, where, σ_2 is the conductivity of the insulating polymer and v is the exponent in Power law.

c) When $|V_f - V_{fc}| \rightarrow 0$, at the cross-over region, the conductivity of the composite is predicted by, $\sigma_c \propto {\sigma_2}^u * {\sigma_1}^{1-u}$ where, $u = \frac{t}{t+v}$

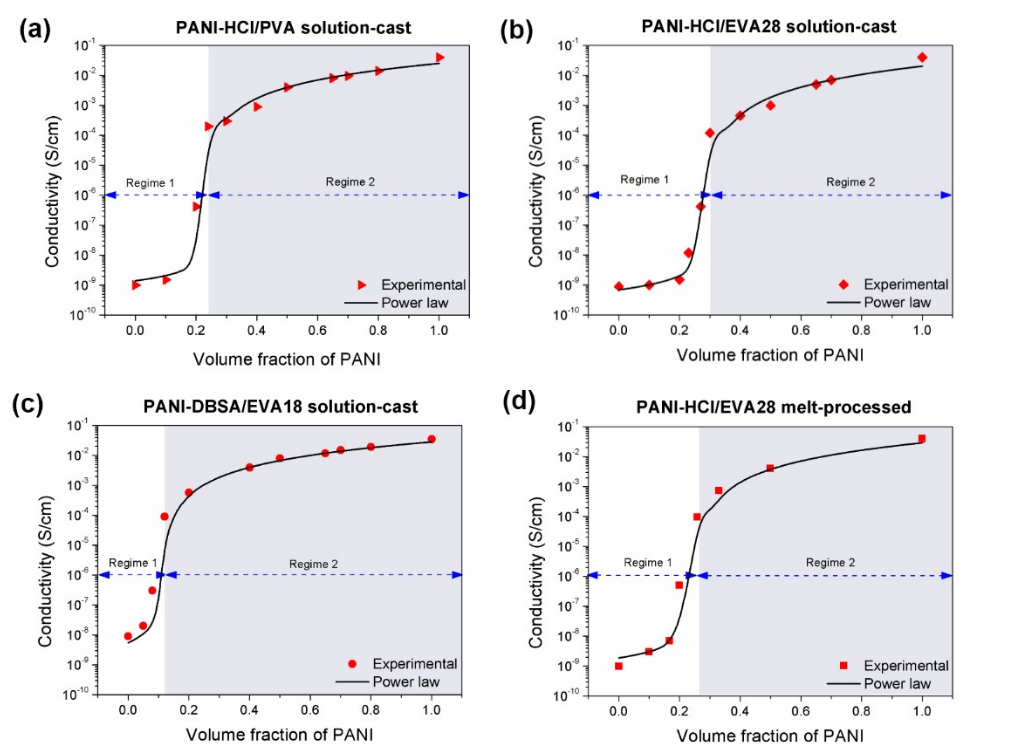

Fig. S1. Conductivity variation with increasing volume fraction of PANI in (a) PANI-HCl/PVA (b) PANI-HCl/EVA28 (c) PANI-DBSA/EVA18 (all solution cast) and (d) PANI-HCl/EVA28 (melt processed), by both experimental and power law fit. Regime 1 corresponds to insulator and Regime 2 to semiconductor.

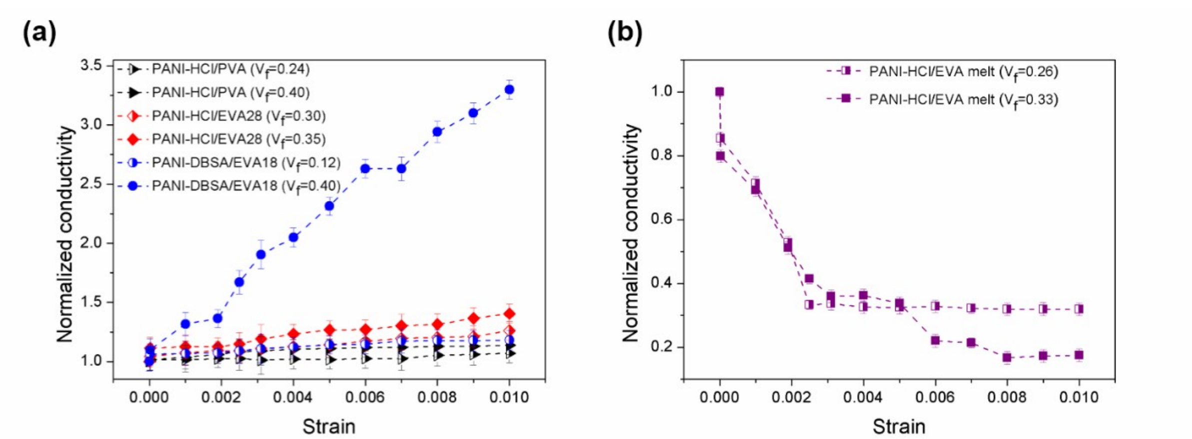

Fig. S2. Conductivity variation with strain at and above percolation threshold for different PANI composites (a) solution cast showing increase and (b) melt processed showing decrease in conductivity with strain. Half-filled symbols represent composites at percolation and closed symbols represent composites above percolation. The lines are to guide the eye.

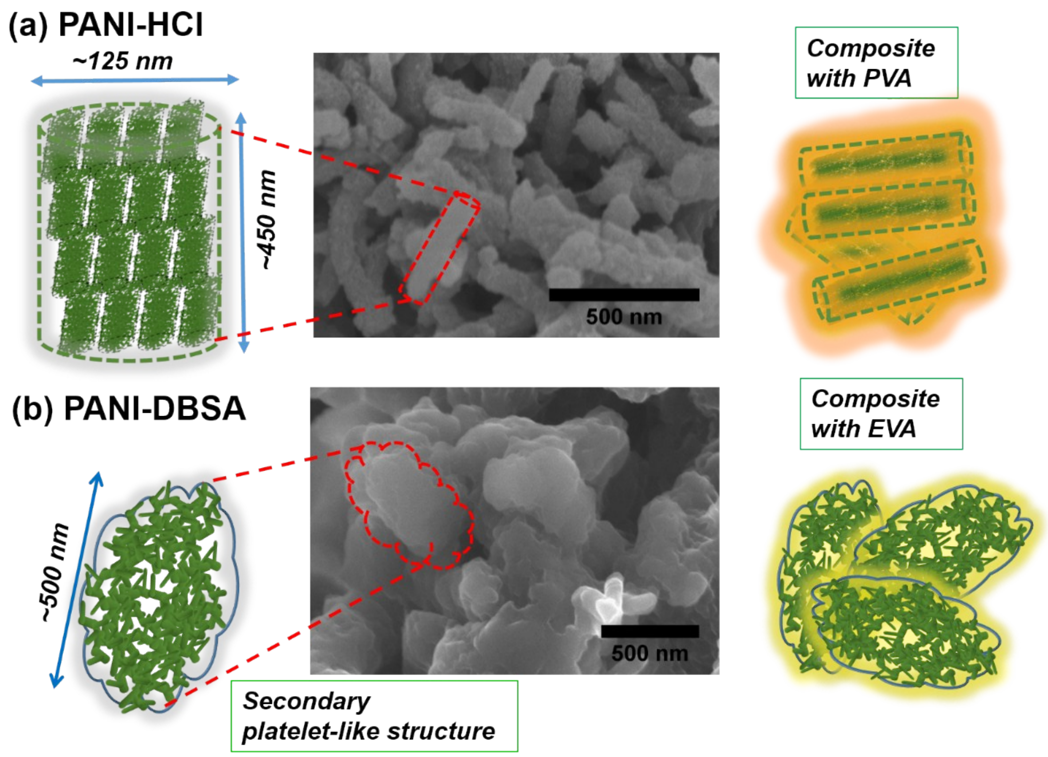

Fig. S3. Schematic and SEM images of (a) PANI-HCl consisting of tertiary rod-shaped agglomerates of ~450 nm length and 125 nm dia formed from secondary agglomerates of ~100 nm size, which are formed by the aggregation of 10 nm primary nano-rods. (b) PANI-DBSA consisting of agglomerated circular platelet-like structures of length ~500 nm and thickness ~10 nm formed by the aggregation of primary nano-rods.

Table S1. Experimentally obtained percolation threshold, power law exponents and conductivity for different PANI composites

Composite	Percolation threshold	Power law exponents		Conductivity at V_{fc} (S/cm)
	V_{fc}	T	v	
PANI-HCl/PVA	0.24	1.70	0.72	2.0×10^{-4}
PANI-HCl/EVA28	0.30	1.90	0.95	1.2×10^{-4}
PANI-DBSA/EVA18	0.12	1.70	0.90	0.90×10^{-4}
PANI-HCl/EVA28 (melt processed)	0.26	1.80	0.98	0.90×10^{-4}

Table S2. Poisson's ratio of PANI composites with 1% strain

Sample	Blend ratio (PANI/ insulating matrix)	Poisson's ratio ϑ_{xy}
PANI-HCl/PVA	0/100	0.42-0.48
	20/80	0.32
	24/76	0.3
	40/60	0.1
PANI-HCl/EVA28	0/100	0.2-0.35
	28/72	0.187
	30/70	0.18
	35/65	0.1
PANI-DBSA/EVA18	0/100	0.2-0.35
	8/92	0.16
	12/88	0.15
	40/60	0.1
PANI-HCl/EVA28 melt processed	0/100	0.37
	26/74	0.15
	33/67	0.12