

Melanin granules extracted from Sepia ink: a nanoscale study of charge carrier transport

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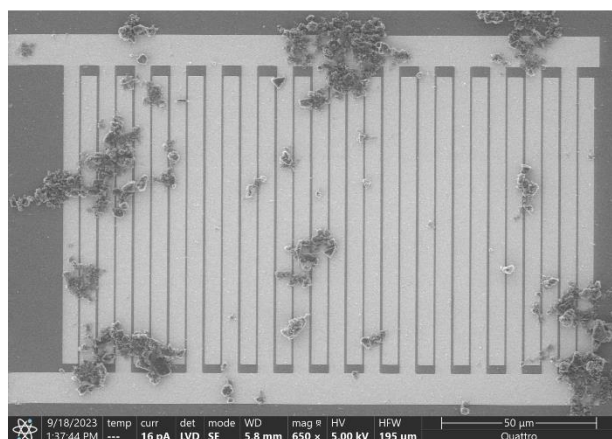
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Scanning Electron Microscopy (*effective channel width*)

SEM images of Sepia melanin drop-casted from a methanol suspension onto Au electrode-patterned SiO₂/Si substrates with interelectrode distances of 700 nm and 400 nm.

SEM images show a partial coverage of the full patterns. The effective channel width (W_{eff}) covered by Sepia melanin and the total channel width of the patterns are reported in Table S1.

A.



B.

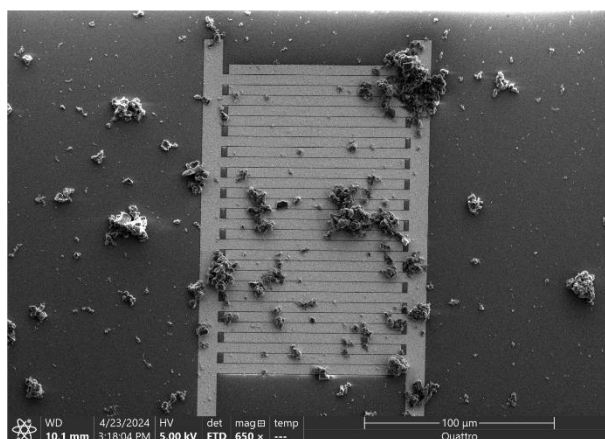


Figure S1. SEM images of Sepia melanin granules drop-cast on an interdigitated Au/Ti electrode-patterned SiO₂/Si substrates with an interelectrode distances of (A) 700 nm and (B) 400 nm, images of full patterns.

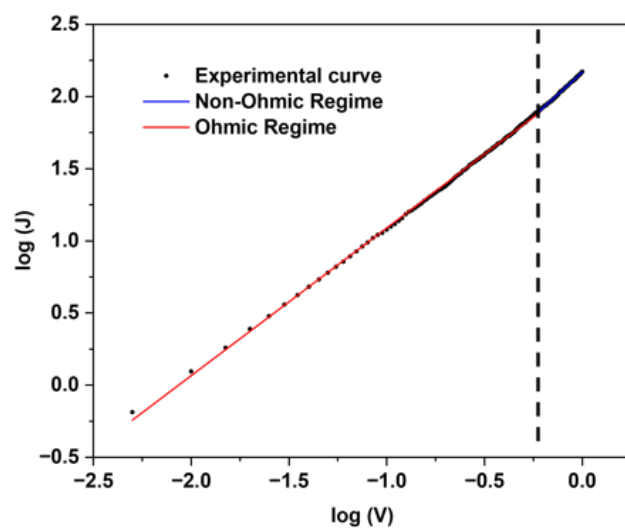


Figure S2. Log (J)-log (V) plot of Sepia melanin drop-casted onto SiO₂/Si displaying a change of slope between the ohmic regime (red, solid line) to the non-ohmic regime (blue, solid line), for the interelectrode distance 700 nm.

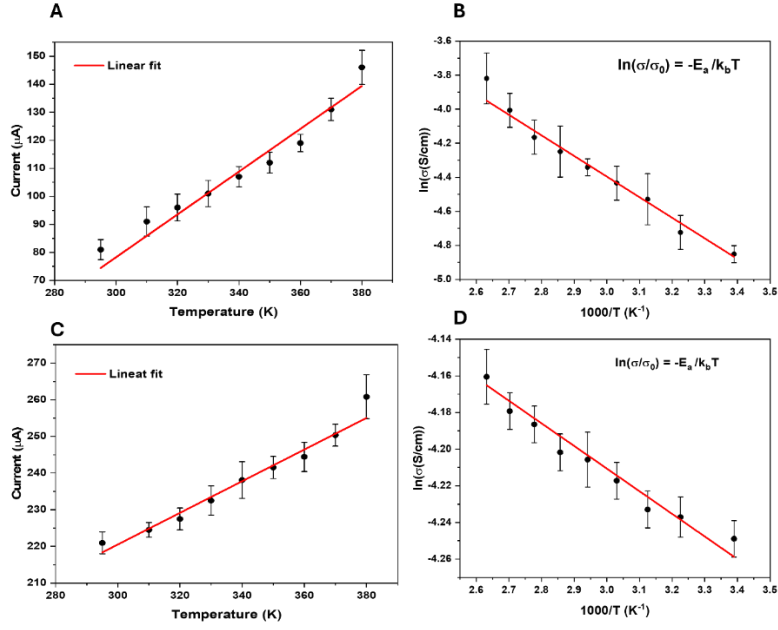


Figure S3. Linear fit $I=I_0+m T$, where I_0 is the intercept on the y axis and m the slope (see main file), for current vs temperature measurements performed on Sepia melanin samples with interelectrode distance 700 nm (A) and 400 nm (C). The linear fits give rates of ca 0.77 and 0.43 $\mu\text{A/K}$ for interelectrode distances of 700 and 400 nm, respectively. Fit with the Arrhenius law $\ln\left(\frac{\sigma}{\sigma_0}\right) = -\frac{E_a}{k_b} \times \frac{1}{T}$, where σ is the electrical conductivity, σ_0 the pre-exponential factor, E_a the activation energy and k_b is Boltzmann constant) for samples with interelectrode distance 700 nm (B) and 400 nm (D).

Table S1. *Effective* channel width, i.e. width covered by Sepia melanin (from Figures S1 A and B), as evaluated using the software ImageJ (see Materials and Methods).

Interelectrode distance (nm)	<i>Effective</i> channel width W_{eff} (μm)	Total channel width (μm) ($W=W_1+W_2+\dots+W_{14}$)	Thickness of the material in the channel t (μm)	<i>Effective</i> area covered by material $A=W_{\text{eff}} \times t$ (μm^2)
700	202 $\pm$ 5	2755	0.3	60.6 $\pm$ 1.5
400	450 $\pm$ 8	2755	0.3	135.0 $\pm$ 2.4

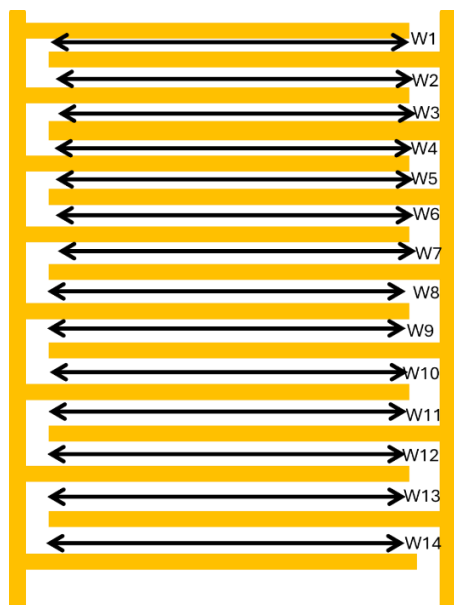
Table S2. Maximum current at the specified electrical bias and conductivity vs T for Sepia melanin (Figures. 4 A and C, Materials and Methods).

Interelectrode distance = 400 nm

Maximum Current at 0.5 V (μA)	Temperature (K)	Conductivity at 0.5 V (S/cm)
220.9 $\pm$ 3.1	295	(1.428 $\pm$ 0.010) $\times 10^{-2}$
224.5 $\pm$ 2.4	310	(1.445 $\pm$ 0.012) $\times 10^{-2}$
227.5 $\pm$ 3.2	320	(1.451 $\pm$ 0.010) $\times 10^{-2}$
232.5 $\pm$ 4.2	330	(1.474 $\pm$ 0.010) $\times 10^{-2}$
238.1 $\pm$ 5.1	340	(1.491 $\pm$ 0.015) $\times 10^{-2}$
241.5 $\pm$ 3.5	350	(1.497 $\pm$ 0.010) $\times 10^{-2}$
244.4 $\pm$ 4.0	360	(1.520 $\pm$ 0.010) $\times 10^{-2}$
250.3 $\pm$ 3.4	370	(1.531 $\pm$ 0.010) $\times 10^{-2}$
264.4 $\pm$ 6.1	380	(1.560 $\pm$ 0.015) $\times 10^{-2}$

Interelectrode distance = 700 nm

Maximum Current at 1 V (μA)	Temperature (K)	Conductivity at 1 V (S/cm)
81.9 $\pm$ 3.5	295	(0.946 $\pm$ 0.005) $\times 10^{-2}$
91.3 $\pm$ 5.2	310	(1.054 $\pm$ 0.010) $\times 10^{-2}$
94.5 $\pm$ 4.8	320	(1.092 $\pm$ 0.010) $\times 10^{-2}$
101.1 $\pm$ 4.7	330	(1.168 $\pm$ 0.010) $\times 10^{-2}$
107.3 $\pm$ 3.6	340	(1.239 $\pm$ 0.005) $\times 10^{-2}$
116.4 $\pm$ 3.7	350	(1.344 $\pm$ 0.010) $\times 10^{-2}$
119.1 $\pm$ 3.1	360	(1.375 $\pm$ 0.010) $\times 10^{-2}$
131.6 $\pm$ 4.0	370	(1.519 $\pm$ 0.005) $\times 10^{-2}$
146.3 $\pm$ 6.6	380	(1.689 $\pm$ 0.010) $\times 10^{-2}$



Scheme S1. Schematic diagram array of fingers of interdigitated patterns where $w_1 + w_2 + \dots + w_{14}$ shows the total width of the channel (in the patterns that we created by e-Line software, there are 29 array of fingers). Total channel width is presented in Table S1.