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Electronic Supplementary Information

Enhanced electrochromic performance of WO₃ nanowire networks

grown directly on fluorine-doped tin oxide substrates

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Fig. S1 SEM images and schematic diagrams of the nanostructured WO₃ thin films prepared in the presence of $C_4H_4O_4$ and $SC(NH_2)_2$ using different concentrations of HCI: (a) 0 M, (b) 3 M, (c) 6 M, and (d) 9 M.

S2. Raman Spectra

The vibrational modes of the WO₃ thin films prepared under different conditions were investigated by Raman spectroscopy. In the spectrum three vibrational modes were observed at 257, 772 and 931 cm⁻¹, which reveals hexagonal WO₃.¹⁻³ The Raman band at 257 cm⁻¹ is related to the O-W-O bending mode and the peak at 772 cm⁻¹ is attributed to O-W-O stretching modes. The Raman band at 931 cm⁻¹ is ascribed to the W=O stretching mode.⁴



Fig. S2 Raman spectra of the WO₃ samples prepared under different conditions.

WO ₃ films samples	R _s (ohm)	R _{ct} (ohm)	W _R (ohm)
3 h	20.77	54.94	63.32
6 h	19.94	65.99	73.32
Seed	21.29	118.9	75.23
Annealed	21.02	43.33	62.14

Table S1 Resistance and Warburg diffusion values of WO_3 thin films achieved by fitting the EIS data to equivalent circuit



Fig. S3 Stability test of the WO_3 nanowires films prepared under 3 or 6 h solvothermal treatment time and film prepared under 3 h solvothermal treatment time with a seed layer.



Fig. S4 UV-vis spectra of the WO_3 sample prepared with a seed layer (left) and the annealed 3 h sample without seed layer (right) and digital photos of color changes.



Fig. S5 SEM images of WO_3 films prepared by the solvothermal method for 3 h: without a seed layer (a, b, c), and with a seed layer (d, e, f).



Fig. S6 SEM images of the 3 h WO₃ nanowire film after annealing at 400 $^\circ$ C in N₂.



Fig. S7 SEM images of the annealed sample before and after 1000 cycling test.

From the SEM images the top of the nanowires were etched in part during the long term cycling test when protons and electrons were inserted and extracted in the films. Therefore, the active surface area of the films decreased and affected the final electrochromic performance.

References

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