Electronic Supplementary Material (ESI) for Journal of Materials Chemistry

Supplementary Information for:

Template synthesis of ultra-thin and short carbon nanotubes with two open ends

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S1. Synthesis of AAO films with both sides exposed using the conventional method.

S1.1. Preparation of AAO film

Before anodic oxidization, a pure aluminum sheet (purity: 99.99%) was sonicated in acetone to degrease it and etched in a 5.0 M NaOH solution for about 3 min until bubbles over the surface were observed. The polished aluminum sheet was then anodized under a constant voltage (5–10 V) in a 15–30 wt% sulphuric acid solution at −8 °C for 4 h to obtain a nanoporous alumina layer on the surface of the Al substrate. The AAO film was selectively removed in a H_3PO_4 (6 wt %) and H_2CrO_4 (1.8 wt%) aqueous solution at 60 °C. The remaining Al substrate was then anodized again for a period (determined by the desired film thickness) under the same conditions as that of the first oxidation step.

S1.2. Dissolution of the barrier layer

First, freestanding AAO films were obtained by detaching the formed membrane from the aluminum metal base using the voltage reversal technique. The AAO film was then placed, with the barrier layer face down, on a 5% phosphoric acid solution at 30 °C for 5 min. Finally, the film was carefully lifted off the acid bath, rinsed with distilled water and then washed with alcohol.

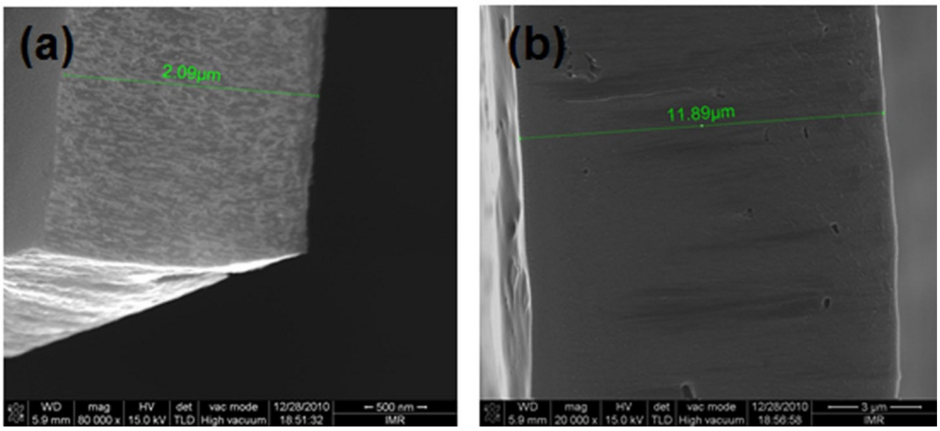

Figure S1, SEM images of AAO films with both faces exposed and having different thicknesses: (a) ~2 µm, (b) ~12 µm.

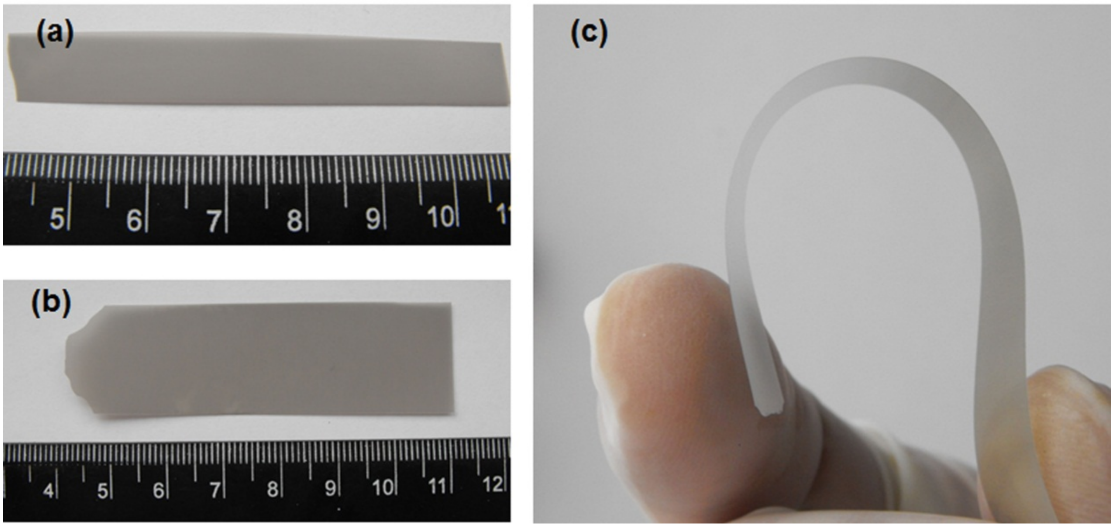

Figure S2 Photographs of the free-standing AAO films: (a) 1 cm in width, (b) 2 cm in width, (c) A bent AAO film showing its good flexibility.

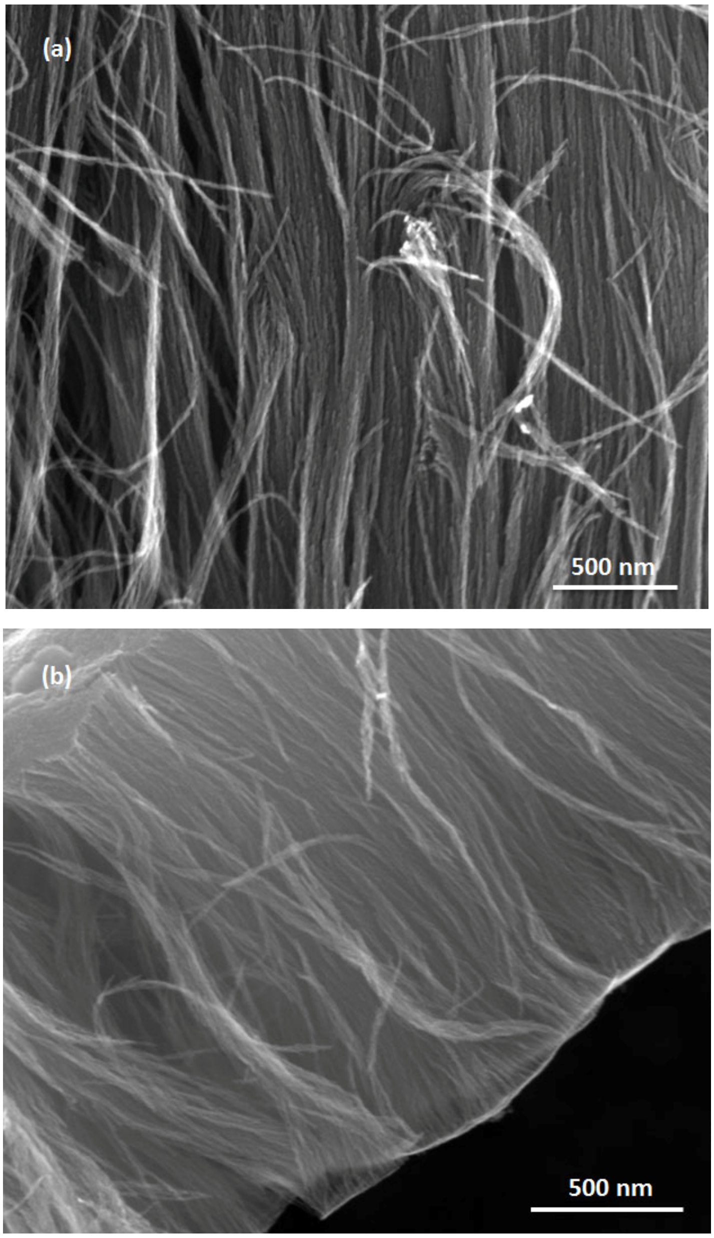

Figure S3 High magnification SEM images of AAO-CNTs with different outer diameters: (a) 14 nm, (b) 7 nm.

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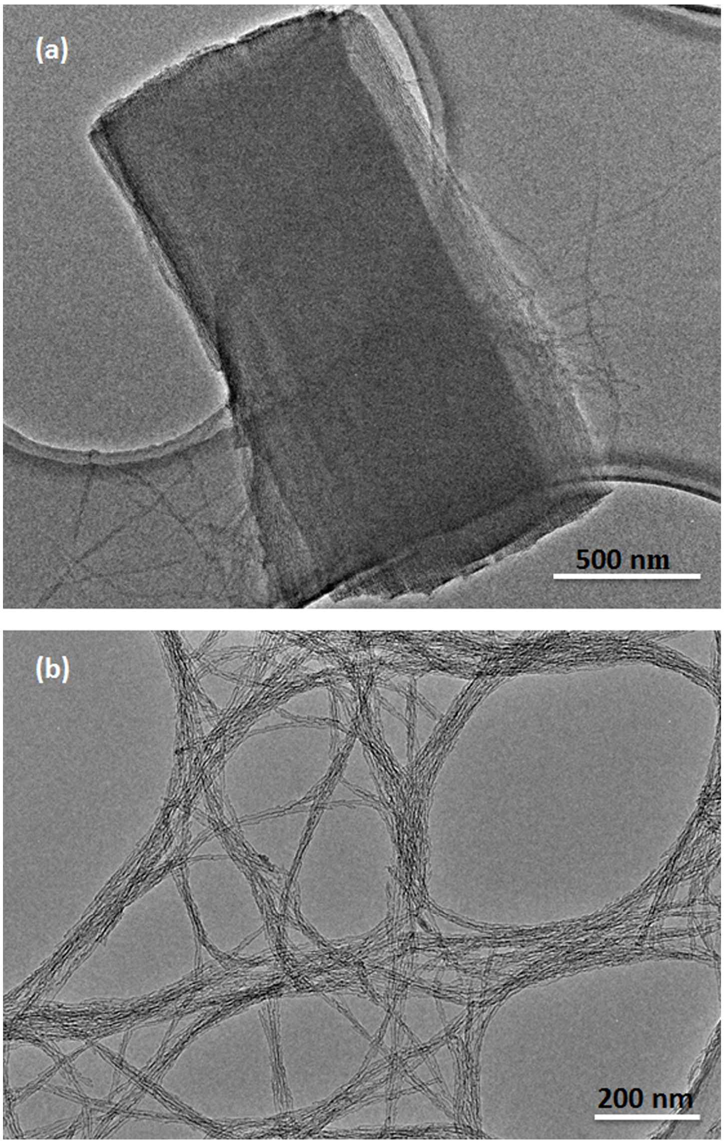

Figure S4 TEM images of the AAO-CNTs with an outer diameter of 7 nm and a length of ~2 µm: (a) low magnification (b) high magnification

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Table S1 BET surface area, wall thickness, inner and outer diameters of the CNTs obtained from AAO film templates with different channel sizes

Sample	$S_{BET}{}^{a}$ (m^2/g)	ID^{b} (nm)	OD^{c} (nm)	WT^{d}(nm)	O/C(AR^{e}%)
CNT 1	520	10	14	2	6.5
CNT 2	560	6	10	2	6
CNT 3	580	4	7	1.5	6

^{a}BET specific surface area determined using the data at P/P_0 = 0.1–0.3. ^{b}Inner diameter calculated using BJH equation from N_2 adsorption isotherm for CNTs . ^{c}Outer diameter calculated using BJH equation from N_2 adsorption isotherm for AAO. ^{d}Wall thickness calculated from the OD and ID. ^{e}Atomic ratio.

Table S2 BET surface area, wall thickness, inner and outer diameters of the CNTs obtained from an AAO film template with a channel size of 14 nm using different CVD times.

Sample	S_{BET} (m^2/g)	ID (nm)	OD (nm)	WT (nm)
CNT1	650	11	14	1.5
CNT 2	450	9	14	2.5
CNT3	265	7	14	3.5