Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Electronic Supplementary Information

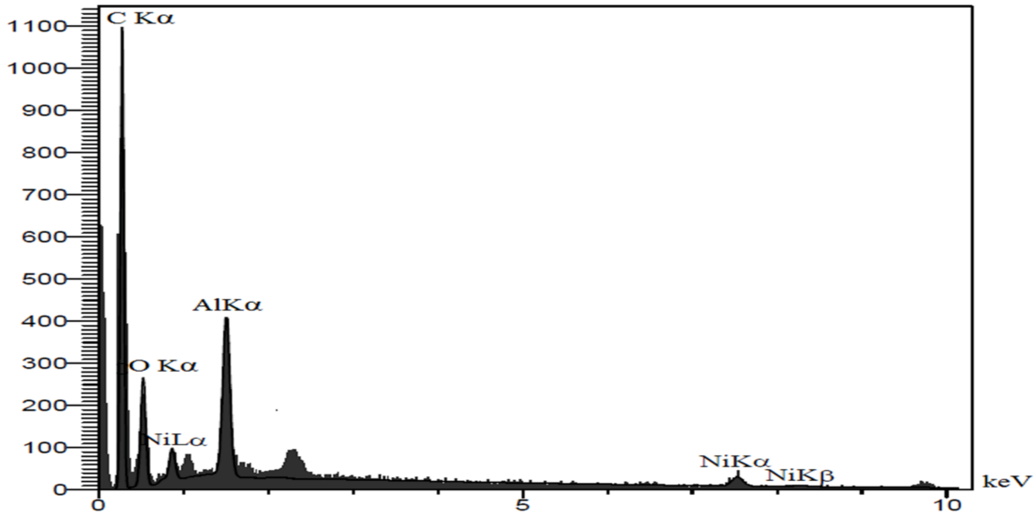
Supercapacitive Properties of Coiled Carbon Nanotubes Directly Grown on Nickel Nanowires

F. Hekmat[a], B. Sohrabi[*, a], M. S. Rahmanifar[b], M. R. Vaezi[c]

[a] Department of Chemistry, Surface Chemistry Research Laboratory, Iran University of Science and Technology, P.O. Box 16846-13114, Tehran, Iran.

[b] Faculty of basic science, Shahed University, Tehran, Iran.

[c]Advanced Materials Research Center, Materials and Energy Research Center, Karaj, Iran.



Quantitative Results

Elt	Line	Int	Error	K	Kr	W%	A%	ZAF
C	Ka	179.2	35.7798	0.7237	0.3115	64.14	73.29	0.4855
O	Ka	62.1	35.7798	0.1248	0.0537	26.87	23.05	0.1999
Al	Ka	131.3	5.4132	0.0926	0.0399	5.64	2.87	0.7065
Ni	Ka	10.8	0.3433	0.0589	0.0253	3.35	0.78	0.7568
				1.0000	0.4304	100.00	100.00	

Fig. S1: EDX spectra of coiled CNT/Ni-NWs electrode, before dissolving AAO membrane.

Fig. S1 shows the results of EDX analysis of the AAO after deposition of coiled CNTs by using catalytic chemical vapor deposition. The EDXs results prove the presence of CNTs and Ni nanowires on the AAO/Al based substrate.

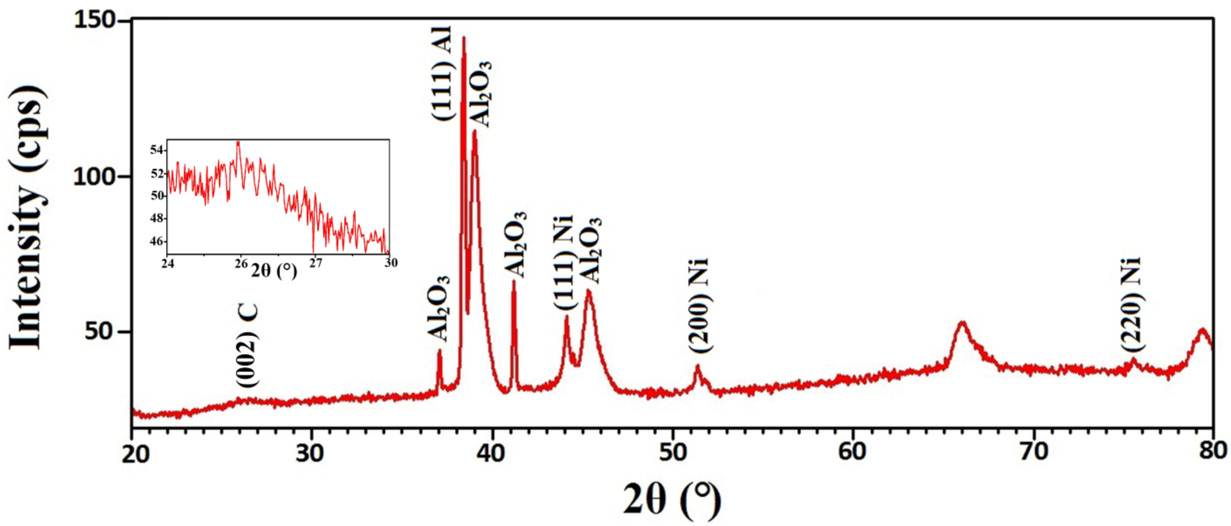


Fig. S2: The XRD pattern of the coiled CNT/Ni-NW electrode before removing the AAO template.

Fig. S2 shows the XRD pattern of a coiled CNT/Ni-NW electrode before dissolving the AAO membrane. The observation of the characteristic peak of the CNT at *2θ* value of 26.22º corresponding to (002) crystal plane without any other peaks indicates the formation of CNT which probably contain defects within the carbon network (JCDPS, card no 00-025-0284). The low intensity of this peak can be attributed to the amorphous CNT structures, which can remove after dissolving the AAO template.[1,2] The inset is a high magnification image which shows the characteristic peak of CNTs. The strong peaks at *2θ* values of 44.47º, 51.83º, and 75.48º proved the formation of highly crystalline nickel (JCDPS, card no 01-070-1849). The XRD peaks are trustworthy indicates the formation of AAO on the Al template (JCDPS, card no 00-004-0858 and 01-089-2837, respectively). Moreover, the observation of the peak at $2\theta = 38.366°$ (111) can be attributed to the presence of Al in the electrode (JCDPS, card no 01-089-2769).

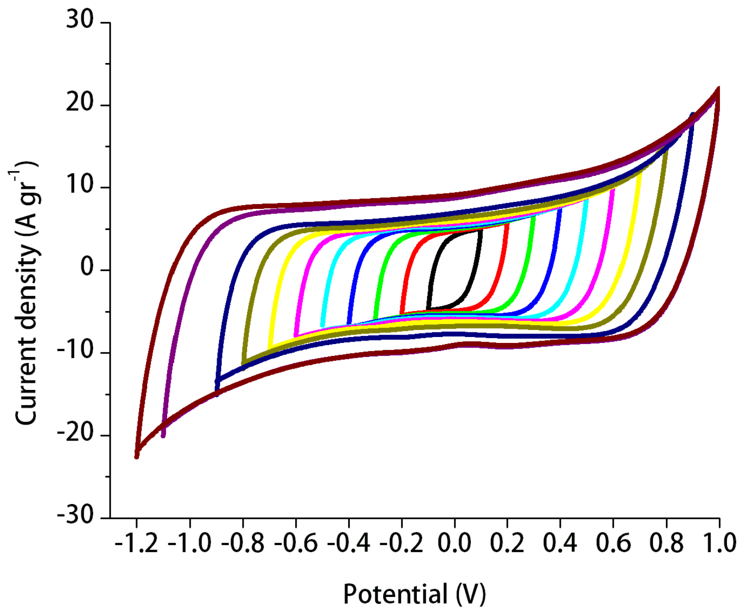


Fig. S3: Cyclic voltammetry of coiled CNT/ Ni-NW based electrode in Na_2SO_4 (1M) taken at 100 mVs^{-1} .

The cyclic voltammetric study was used to determine a suitable working potential window for the prepared electrodes. Fig. S3 shows CVs of the coiled CNT based electrode at different working potential windows at a scan rate of 100 mV s^{-1} in 1M Na_2SO_4. As it known, the stability of potential window is tightly depends on the pH of the electrolyte and also the nature of the electrode material.[2] In this study a neutral medium (Na_2SO_4, 1M) is used as electrolyte, so the potential window would be wider than alkaline and acidic mediums, this property can be attributed to the low concentration of H^+ and OH^- in neutral electrolyte for inducing gas evolution reactions.[3] On the other hand, it has been demonstrated that the carbon based material posses good stability in neutral aqueous electrolyte (specially in Na_2SO_4 aqueous electrolyte)[3-5].

Therefore, the nearly rectangular shapes of CVs with wide potential window suggest that the coiled CNT/Ni-NWs electrode exhibits superior capacitive behavior over a large working potential window.

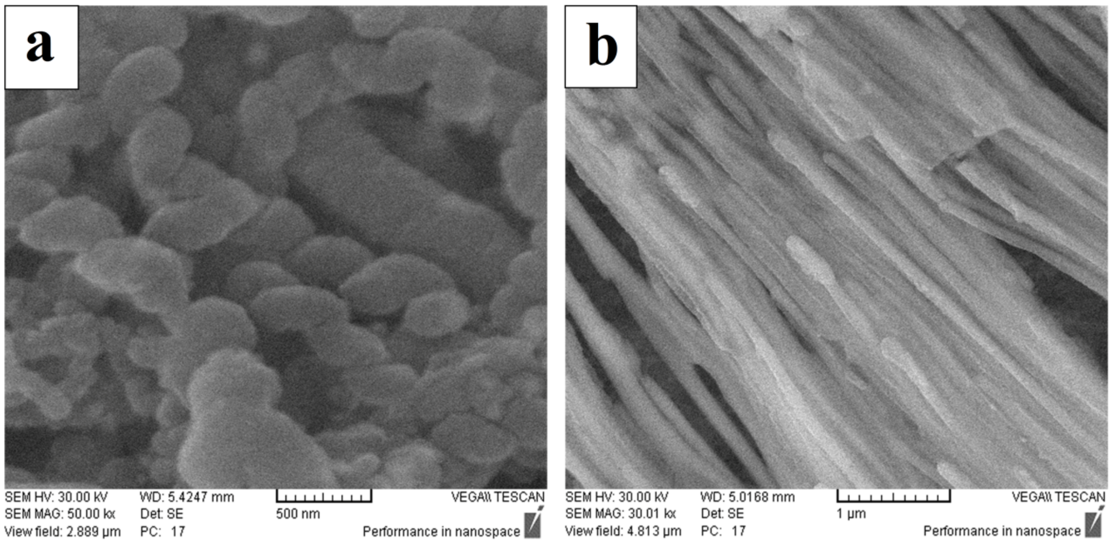


Fig. S4: The SEM image of the (a) coiled CNTs and (b) Ni-NWs after 6000 charge-discharge cycles.

Fig. S4 illustrates the SEM images of coiled CNTs and Ni-NWs after 6000 charge-discharge cycles. The images clearly show the cycle stability of the coiled CNTs (Fig. S3a), and also the Ni-NWs (Fig. S4b). As it can be seen, increasing the thickness in compare with Fig. 2, can be attributed to the wrapping CNTs and Ni-NWs with the salt (Na_2SO_4), after drying of the electrode.

References:

(1) Y. Yusof and M. R. Johan, *CrystEngComm*, 2014, DOI: 10.1039/c4ce01083c.

(2) D. K. Singh , P.K. Iyer and P.K. Giri, *Diam. Relat. Mater*. 2010, 19, 1281.

(3)M. P. Bichat, E. Raymundo-Piňero and F. Béguin, *Carbon* 2010, 48, 4351.

(4)L. Demarconnay, E. Raymundo-Piñero and F. Béguin, *Electrochem. Commun*. 2010, 12, 1275.

(5)Q. T. Qu, B. Wang, L. C. Yang, Y. Shi, S. Tian and Y. P. Wu, *Electrochem. Commun*. 2008, 10, 1652.