Electronic Supplementary Material (ESI) for RSC Advances.

SUPPORTING INFORMATION

High electrochemical performance of ink solution based on manganese cobalt sulfide/reduced graphene oxide nanocomposites for supercapacitor electrode materials

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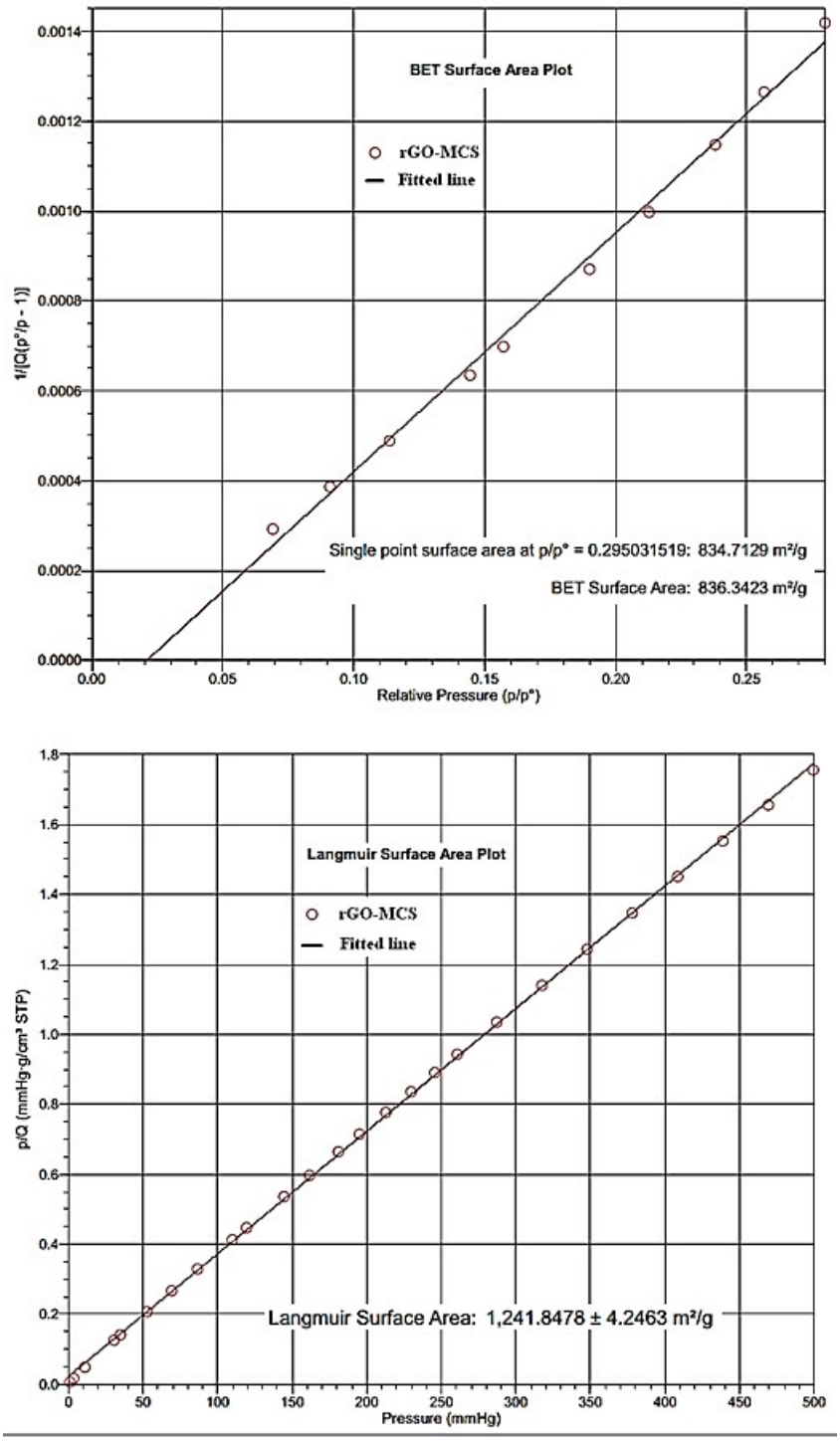

Fig. S1. Results of surface area analysis of rGO-MCS powder.

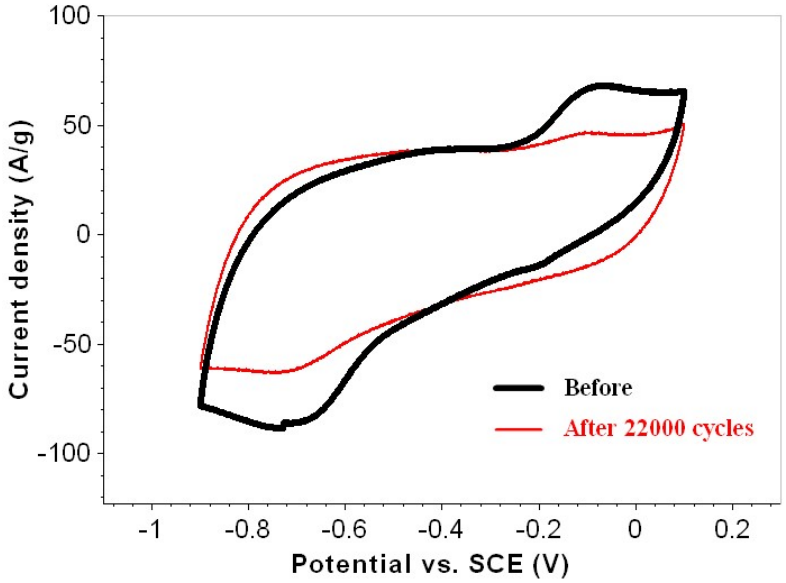

Fig. S2. CV curves of the MCS/rGO at scan rate of 20 mVs^{-1} before and after 22000 working cycles

Table S1: Specific capacitance values as a function with the morphology, type of composite and dopant for various potential ranges.

Sample	*Potential (V)*	*Electrolyte*	*Reference electrode*	*Specific capacitance ($F\ g^{-1}$)*	*Ref.*
$MnCo_2S_4$ nanorods @ NiCo	*0.0 – 0.60*	*KOH 6M*	*Hg/HgO*	*2010 (at 1 A g^{-1})*	*[1]*
$MnCo_2S_4$ nanowires	*-0.1 – 0.50*	*KOH 3M*	*Saturated calomel electrode (SCE)*	*2067 (at 1 A g^{-1})*	*[2]*
Mn-Co-S-Se nanowires	*-0.1 – 0.80*	*KOH 2M*	*Hg/HgO*	*2509 (10 mA cm^{-2})*	*[3]*
$MnCo_2S_4$ nanotubes	*0.0 – 0.60*	*KOH 6M*	*SCE*	*2667 (10 A g^{-1})*	*[4]*

$MnCo_2S_4$/ $FeCo_2S_4$ @carbon	*0.0 – 0.60*	*KOH 3M*	*Hg/HgO*	*2806 (at 1 A g^{-1})*	*[5]*
$MnCo_2S_4$ nanoflakes	*0.0 – 0.6*	*-*	*-*	*3215 (at 1 A g^{-1})*	*[6]*
$CoMnS_4$ nanoflowers	*-0.2 – 0.50*	*KOH 2M*	*-*	*3469 (at 1 A g^{-1})*	*[7]*
Mn-Co-N-S nanotube	*-0.1– 0.80*	*KOH 1M*	*Hg/HgO*	*3794 (at 1 A g^{-1})*	*[8]*
$MnCo_2S_4$ nano-urchins	*0.0 – 2.5*	*1.0 M sodium perchlorate ($NaClO_4$) in propylene carbonate/ethylene carbonate (PC/EC) stabilized with fluoroethylene carbonate*	*Pure sodium flakes were tailored into same size as the active electrodes and used as the counter/reference electrodes*	*4036 (at 2 mV s^{-1})*	*[9]*
C-doped $MnCo_2S_4$ nano-cubes	*0.0 – 0.45*	*KOH 3M*	*Ag/AgCl (3 M KCl)*	*4204 (at 5 A g^{-1})*	*[10]*
$MnCo_2S_4$ nanoparticles/RGO	***-0.9 – 0.10***	***KOH 6M***	***SCE***	***3812.5 (at 2 A g^{-1})***	***This work***

References

[1] H. Liang, T. Lin, S. Wang, H. Jia, C. Li, J. Cao, J. Feng, W. Fei, J. Qi, A free-standing manganese cobalt sulfide@cobalt nickel layered double hydroxide core-shell heterostructure for an asymmetric supercapacitor, Dalton Transactions. 49 (2019) 196–202. https://doi.org/10.1039/c9dt03974k.

[2] S. Liu, S.C. Jun, Hierarchical manganese cobalt sulfide core–shell nanostructures for high-performance asymmetric supercapacitors, Journal of Power Sources. 342 (2017) 629–637. https://doi.org/10.1016/j.jpowsour.2016.12.057.

[3] Z. Fu, H. He, S. Chen, Y. Wang, M. Ma, M. Ye, Mn-Co-S-Se Nanowires for Energy Storage and Conversion, ACS Applied Nano Materials. 3 (2020) 7428–7437. https://doi.org/10.1021/acsanm.0c01006.

[4] P. Li, X. Ma, F. Liu, J. Tan, Y. Zhao, L. Wang, K. Zhu, Facile Fabrication of MCo2S4 (M = Mn, Ni) Nanotube Arrays for High-Performance Supercapacitors, Electronic Materials Letters. 15 (2019) 462–470. https://doi.org/10.1007/s13391-019-00148-5.

[5] Y. Huang, F. Cui, J. Bao, Y. Zhao, J. Lian, T. Liu, H. Li, MnCo2S4/FeCo2S4 "lollipop" arrays on a hollow N-doped carbon skeleton as flexible electrodes for hybrid supercapacitors, Journal of Materials Chemistry A. 7 (2019) 20778–20789. https://doi.org/10.1039/c9ta04457d.

[6] T.L. Tamang, S.G. Mohamed, G. Dhakal, J. Shim, Morphology controlling of manganese-cobalt-sulfide nanoflake arrays using polyvinylpyrrolidone capping agent to enhance the performance of hybrid, Journal of Colloid And Interface Science. (2022). https://doi.org/10.1016/j.jcis.2022.05.103.

[7] X. Hu, S. Liu, Y. Chen, J. Jiang, H. Cong, J. Tang, Y. Sun, S. Han, H. Lin, Rational design of flower-like cobalt-manganese-sulfide nanosheets for high performance supercapacitor electrode materials, New Journal of Chemistry. 44 (2020) 11786–11795. https://doi.org/10.1039/d0nj01727b.

[8] M. Li, J. Wang, F. Wang, Y. Zhai, X. Zhang, H. Lv, T. Yu, G. Lv, Construction of internal and external defect electrode materials based on hollow manganese-cobalt-nickel sulfide nanotube arrays, Applied Surface Science. 568 (2021) 150900. https://doi.org/10.1016/j.apsusc.2021.150900.

[9] L.K.A. Yew Von Lim, Shaozhuan Huang, Qingyun Wu, Dezhi Kong, Ye Wang, Yanfang Zhu, Yanxia Wang, Yun-Xiao Wang, Hua-Kun Liu, Shi-Xue Dou, and H.Y. Yang, Super Kinetically Pseudocapacitive MnCo2S4 Nanourchins toward High‐Rate and Highly Stable Sodium-Ion Storage, Advanced Functional Materials. 30 (2020) 1909702.

[10] A. Pramanik, S. Maiti, M. Sreemany, S. Mahanty, Carbon Doped MnCo2S4 Microcubes Grown on Ni foam as High Energy Density Faradaic Electrode, Electrochimica Acta. 213 (2016) 672–679. https://doi.org/10.1016/j.electacta.2016.07.159.