

Supplementary data

An efficient bifunctional electrocatalyst based on nickel iron layered double hydroxide functionalized Co₃O₄ core shell structure in alkaline media

Aneela Tahira^{a*}, Zafar Hussain Ibupoto^b, Mikhail Vagin^c, Umair Aftab^d, Muhammad Ishaq Abro^d, Magnus Willander^a, Omer Nur^a

^aDepartment of Science and Technology, Campus Norrköping, Linköping University, SE-60174 Norrköping, Sweden

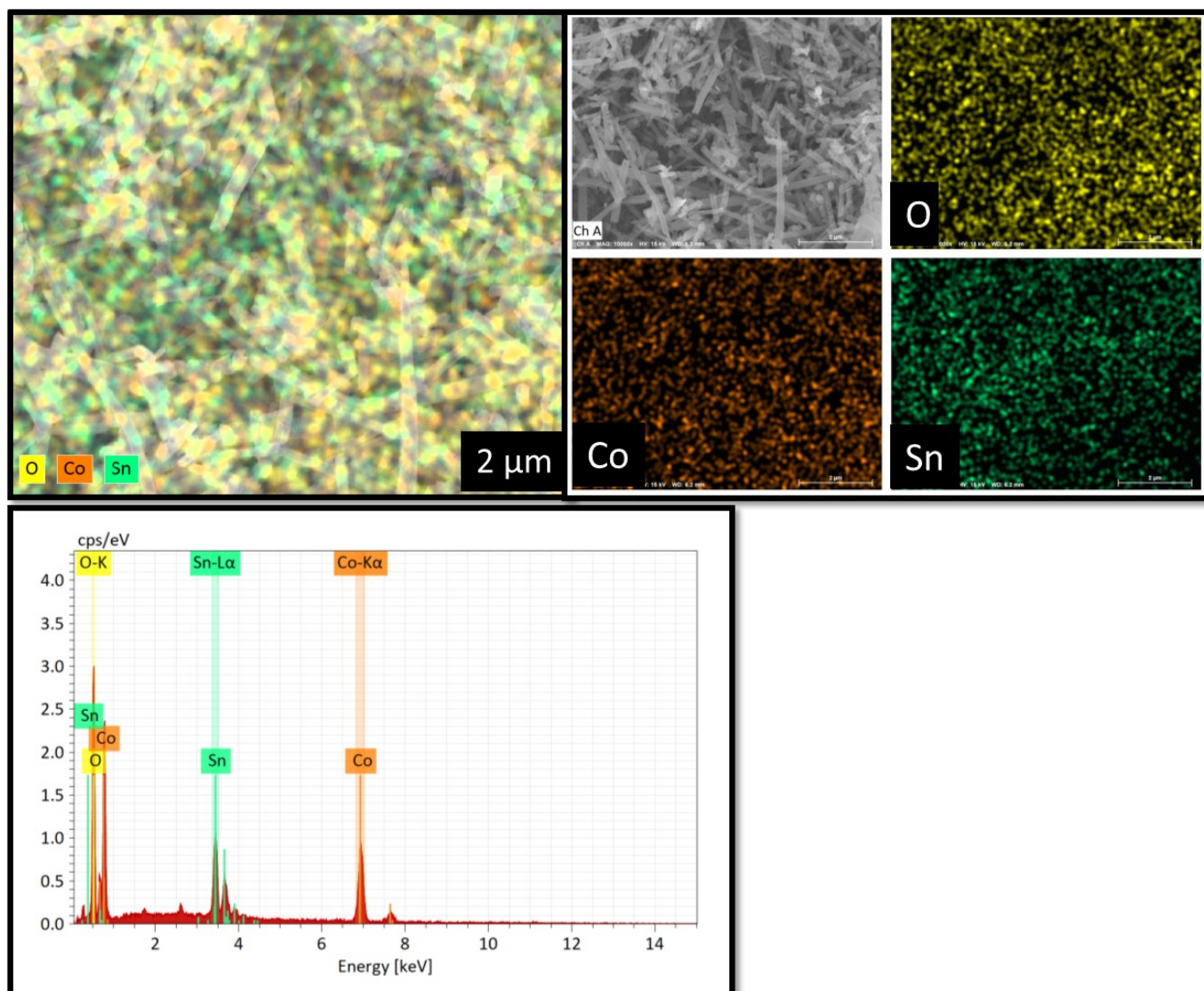
^bDr. M.A Kazi Institute of Chemistry University of Sindh Jamshoro, 76080, Sindh Pakistan

^c Department of Physics, Chemistry and Biology, Linköping University, 58183 Linköping, Sweden

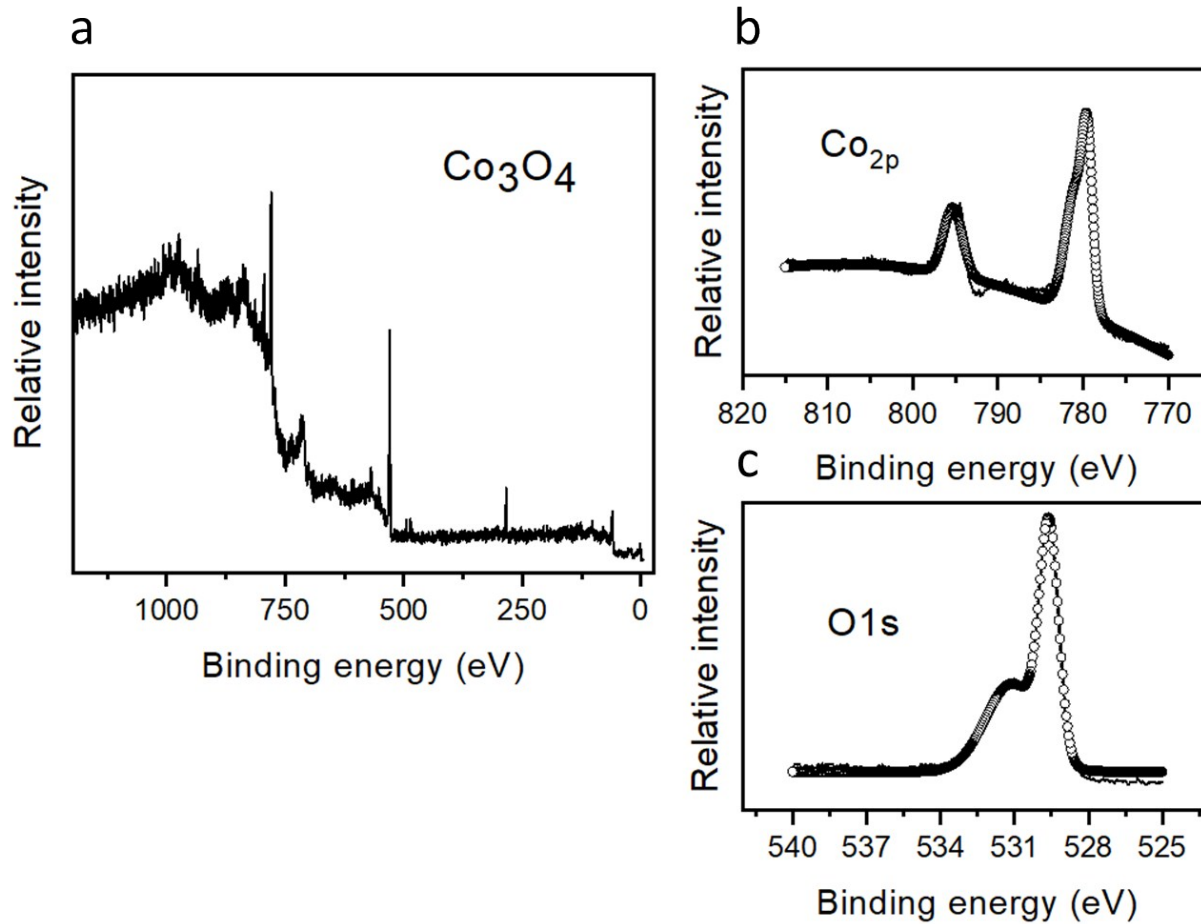
^dMehran University of Engineering and Technology, 7680 Jamshoro, Sindh Pakistan

Corresponding author: Aneela Tahira*

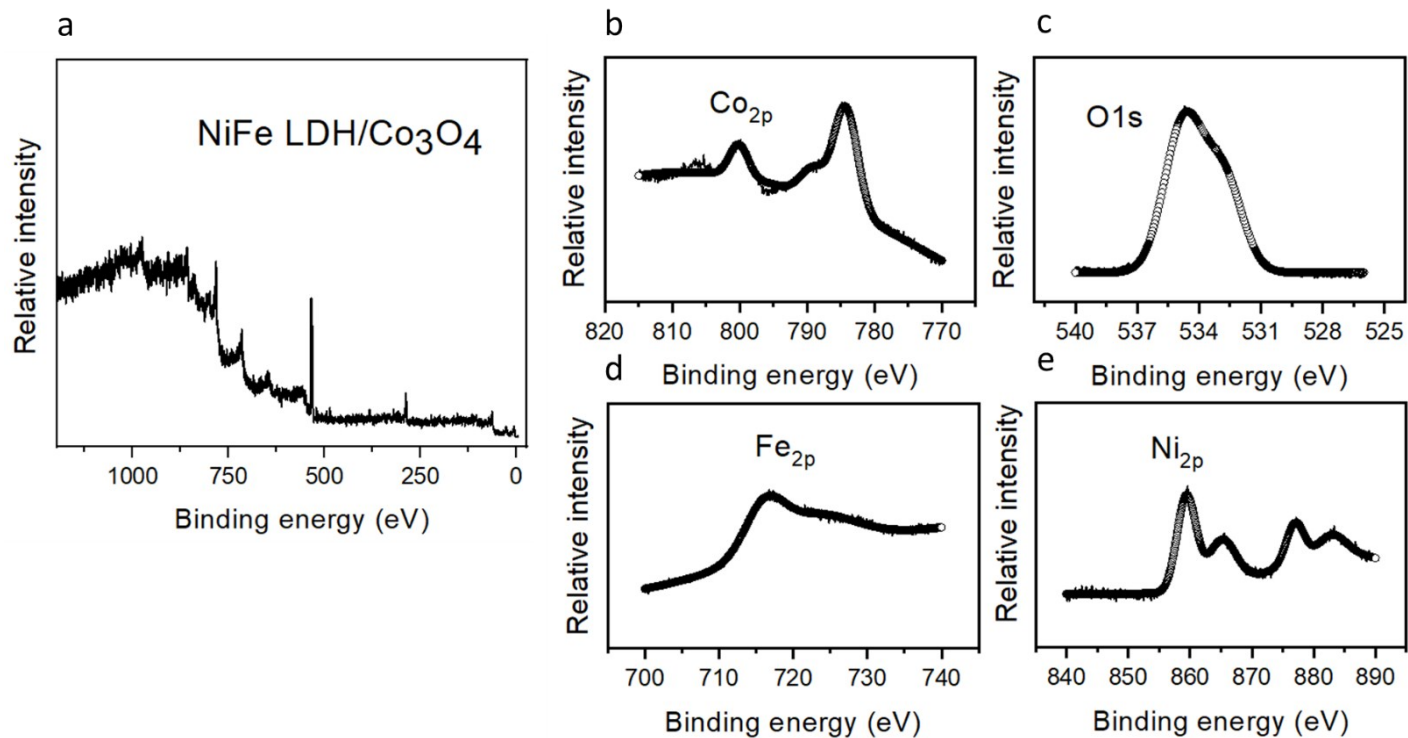
Email address: aneela.tahira@liu.se



S1. EDS mapping for the elemental distribution in pristine Co_3O_4



S2. a. wide scan survey spectra of pristine Co_3O_4 , b. Co 2p XPS spectra of pristine Co_3O_4 , c. O 1s for pristine Co_3O_4



S3. a. XPS survey spectrum of NiFeLDH functionalized Co₃O₄, **4b.** Co 2p XPS spectra of Co₃O₄ functionalized with NiFeLDH, **4c.** O 1s of Co₃O₄, **4d.** Fe 2p in the NiFe LDH, **4e.** high-resolution XPS of Ni 2p of NiFeLDH functionalized Co₃O₄.

Table S1 Comparison of OER activities of the NiFeLDH functionalized Co₃O₄ core shell structure with efficient previously reported electrocatalysts in 1M KOH

Catalyst	Tafel slope mVdec ⁻¹	Overpotential @ 10 mA/cm ²	Reference
CoCo LDH	59	393	1
CoO _x @CN		~385	2
Co-P films	47	345	3
MnCo ₂ O _x	84	> 410	4
Co ₃ O ₄ /N-rmGO	67	310	5
NiCoO _x		420	6
N-G-CoO	71	340	7
Ni _x Co _{3-x} O	64	370	8
NiFe LDH-NS @ DG10 hybrid Free-Standing	52	210	9
Exfoliated NiFe LDHs	40	300	10
NiFe LDH/NF	52.8	224	11
NiFe LDH/NF		240	12
Co ₉ S ₈ /CNS/CNT	48	267	13
FeCoW alloy		232	14
Co ₃ O ₄	84	290	15
N-Co ₃ O ₄	59	310	16
RuO ₂		366	17
IrO ₂ /NF	46	285	18
Co ₃ O ₄ hollow polyhedrons		536	19
Co (OH) ₂ @g-C ₃ N ₄ -5		320	20
CoP@PNC		330	21

SOA-Co ₄ N NW/CC		257	22
CoP ₃ NSs/CC		291	23
CoNPs@C		270	24
NiFeLDH/Co ₃ O ₄ NWs	120	1.49 V vs RHE @ 40 mA/cm ²	This work

Table S2 Comparison of HER activities of the NiFeLDH functionalized Co₃O₄ core shell structure with efficient previously reported electrocatalysts in 1M KOH

Catalyst	Tafel slope mVdec⁻¹	Overpotential @ 10 mA/cm²	References
CoP/CC, 500	129	500	25
N, P-G	145	700	26
MoS _x		540	27
Co-S/FTO		480	28
Co-NRCNTs		450	29
Co-N-C		270	30
CoO _x @CN		235	31
Ni ₃ FeN-NPs		238	32
Ni ₂ P on Ni foam		221	33
NiFeLDH/Co ₃ O ₄ NWs	79	-303 mV vs RHE @ 10 mA/cm ²	This work

References

1. F. Song and X. Hu, *Nature communications*, 2014, **5**, 4477.
2. H. Jin, J. Wang, D. Su, Z. Wei, Z. Pang and Y. Wang, *Journal of the American Chemical Society*, 2015, **137**, 2688-2694.
3. N. Jiang, B. You, M. Sheng and Y. Sun, *Angewandte Chemie*, 2015, **127**, 6349-6352.
4. F. Song and X. Hu, *Journal of the American Chemical Society*, 2014, **136**, 16481-16484.
5. Y. Liang, Y. Li, H. Wang, J. Zhou, J. Wang, T. Regier and H. Dai, *Nature materials*, 2011, **10**, 780.
6. C. C. McCrory, S. Jung, J. C. Peters and T. F. Jaramillo, *Journal of the American Chemical Society*, 2013, **135**, 16977-16987.
7. S. Mao, Z. Wen, T. Huang, Y. Hou and J. Chen, *Energy & Environmental Science*, 2014, **7**, 609-616.
8. Y. Li, P. Hasin and Y. Wu, *Advanced materials*, 2010, **22**, 1926-1929.
9. Y. Jia, L. Zhang, G. Gao, H. Chen, B. Wang, J. Zhou, M. T. Soo, M. Hong, X. Yan and G. Qian, *Advanced materials*, 2017, **29**, 1700017.
10. X. Long, J. Li, S. Xiao, K. Yan, Z. Wang, H. Chen and S. Yang, *Angewandte Chemie*, 2014, **126**, 7714-7718.
11. Z. Li, M. Shao, H. An, Z. Wang, S. Xu, M. Wei, D. G. Evans and X. Duan, *Chemical science*, 2015, **6**, 6624-6631.
12. J. Luo, J.-H. Im, M. T. Mayer, M. Schreier, M. K. Nazeeruddin, N.-G. Park, S. D. Tilley, H. J. Fan and M. Grätzel, *Science*, 2014, **345**, 1593-1596.
13. M. Al-Mamun, Y. Wang, P. Liu, Y. L. Zhong, H. Yin, X. Su, H. Zhang, H. Yang, D. Wang and Z. Tang, *Journal of Materials Chemistry A*, 2016, **4**, 18314-18321.
14. L. C. Seitz, C. F. Dickens, K. Nishio, Y. Hikita, J. Montoya, A. Doyle, C. Kirk, A. Vojvodic, H. Y. Hwang and J. K. Nørskov, *Science*, 2016, **353**, 1011-1014.
15. Y. P. Zhu, T. Y. Ma, M. Jaroniec and S. Z. Qiao, *Angewandte Chemie International Edition*, 2017, **56**, 1324-1328.
16. L. Xu, Z. Wang, J. Wang, Z. Xiao, X. Huang, Z. Liu and S. Wang, *Nanotechnology*, 2017, **28**, 165402.
17. M.-R. Gao, X. Cao, Q. Gao, Y.-F. Xu, Y.-R. Zheng, J. Jiang and S.-H. Yu, *Acs Nano*, 2014, **8**, 3970-3978.
18. X. Yan, K. Li, L. Lyu, F. Song, J. He, D. Niu, L. Liu, X. Hu and X. Chen, *ACS applied materials & interfaces*, 2016, **8**, 3208-3214.
19. D. Dong, Y. Liu and J. Li, *Particle & Particle Systems Characterization*, 2016, **33**, 887-895.
20. M. Tahir, N. Mahmood, L. Pan, Z.-F. Huang, Z. Lv, J. Zhang, F. K. Butt, G. Shen, X. Zhang and S. X. Dou, *Journal of Materials Chemistry A*, 2016, **4**, 12940-12946.
21. Z. Zhou, N. Mahmood, Y. Zhang, L. Pan, L. Wang, X. Zhang and J.-J. Zou, *Journal of Energy Chemistry*, 2017, **26**, 1223-1230.
22. P. Chen, K. Xu, Z. Fang, Y. Tong, J. Wu, X. Lu, X. Peng, H. Ding, C. Wu and Y. Xie, *Angewandte Chemie*, 2015, **127**, 14923-14927.
23. T. Wu, M. Pi, X. Wang, W. Guo, D. Zhang and S. Chen, *Journal of Alloys and Compounds*, 2017, **729**, 203-209.
24. Q. Jin, B. Ren, D. Li, H. Cui and C. Wang, *ACS applied materials & interfaces*, 2017, **9**, 31913-31921.
25. J. Tian, Q. Liu, A. M. Asiri, and X. Sun, *J. Am. Chem. Soc* 2014, **136**, 7587-7590.

26. Y. Zheng, Y. Jiao, L. H. Li, T. Xing, Y. Chen, M. Jaroniec and S. Z. Qiao, *Acs Nano*, 2014, **8**, 5290-5296.
27. D. Merki, S. Fierro, H. Vrubel and X. Hu, *Chemical science*, 2011, **2**, 1262-1267.
28. Y. Sun, C. Liu, D. C. Grauer, J. Yano, J. R. Long, P. Yang and C. J. Chang, *Journal of the American Chemical Society*, 2013, **135**, 17699-17702.
29. X. Zou, X. Huang, A. Goswami, R. Silva, B. R. Sathe, E. Mikmeková and T. Asefa, *Angewandte Chemie International Edition*, 2014, **53**, 4372-4376.
30. L. Zhang, W. Liu, Y. Dou, Z. Du and M. Shao, *The Journal of Physical Chemistry C*, 2016, **120**, 29047-29053.
31. H.Y. Jin, J. Wang, D.F. Su, Z.Z. Wei, Z.F. Pang, Y. Wang, *J. Am. Chem. Soc* 2015, **137**, 2688-2694.
32. Q. Chen, R. Wang, M. Yu, Y. Zeng, F. Lu, X. Kuang and X. Lu, *Electrochimica Acta*, 2017, **247**, 666-673.
33. L.-A. Stern, L. Feng, F. Song and X. Hu, *Energy & Environmental Science*, 2015, **8**, 2347-2351.