

1 **Supplementary Information**

2 **Bioelectrochemical Nitrogen Fixation Towards Sustainable Hydroponics**

3 Panpan Zhang<sup>1, #</sup>, Jie Cheng<sup>2, #</sup>, Jinghui Deng<sup>3</sup>, Wei Hao Loh<sup>3,4</sup>, Muhammad Yusof B Mad

4 Dali<sup>5</sup>, Yukun Hu<sup>1</sup>, Fei Yu<sup>5</sup>, Chaolong Wei<sup>5</sup>, Olivier Lefebvre<sup>3,4</sup>, Andrew Barnabas Wong<sup>1,5\*</sup>

5 <sup>1</sup> Department of Chemical and Biomolecular Engineering, National University of Singapore,

6 Engineering Drive 4, Singapore 117585

7 <sup>2</sup> Institute for Functional Intelligent Materials (I-FIM), National University of Singapore, 4

8 Science Drive 2, Singapore 117544

9 <sup>3</sup> Centre for Water Research, Department of Civil and Environmental Engineering, National

10 University of Singapore, Engineering Drive 2, Singapore 117576

11 <sup>4</sup> NUS Environmental Research Institute, National University of Singapore, #02-03, T-Lab

12 Building 5A Engineering Drive 1, Singapore 117411

13 <sup>5</sup> Department of Materials Science and Engineering, National University of Singapore,

14 Engineering Drive 1, Singapore 117575

15 Email: [mseabw@nus.edu.sg](mailto:mseabw@nus.edu.sg)

16 # The authors share equal contributions.

17 \* Corresponding author

18 **Author information**

19 **Corresponding Author**

20 Andrew Barnabas. Wong —Assistant Professor, Department of Materials Science and  
21 Engineering, Department of Chemical and Biomolecular Engineering, National University of  
22 Singapore, Singapore. Email: [mseabw@nus.edu.sg](mailto:mseabw@nus.edu.sg)

23 **Authors**

24 Panpan Zhang — Department of Chemical and Biomolecular Engineering, National University  
25 of Singapore. Email: [e0787951@u.nus.edu](mailto:e0787951@u.nus.edu)

26 Jie Cheng — Institute for Functional Intelligent Materials (I-FIM), National University of  
27 Singapore. Email: [jcheng23@nus.edu.sg](mailto:jcheng23@nus.edu.sg)

28 Jinghui Deng —Department of Civil and Environmental Engineering, National University of  
29 Singapore. Email: [e0511896@u.nus.edu](mailto:e0511896@u.nus.edu)

30 Wei Hao Loh — NUS Environmental Research Institute, Department of Civil and  
31 Environmental Engineering, National University of Singapore. Email: [weihao.loh@u.nus.sg](mailto:weihao.loh@u.nus.sg)

32 Muhammad Yusof B Mad Dali — Department of Materials Science and Engineering, National  
33 University of Singapore. Email: [yusofdali@u.nus.edu](mailto:yusofdali@u.nus.edu)

34 Yukun Hu — Department of Chemical and Biomolecular Engineering, National University of  
35 Singapore, Singapore. Email: [huyukun@u.nus.edu](mailto:huyukun@u.nus.edu)

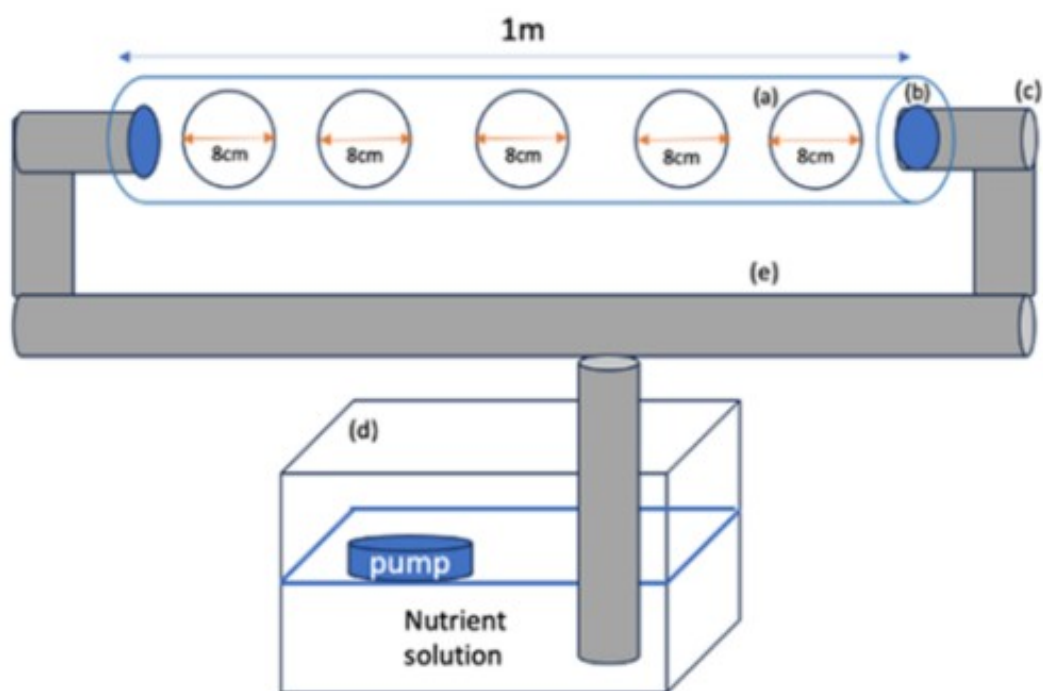
36 Fei Yu — Department of Materials Science and Engineering, National University of Singapore.  
37 Email: [feiyu@u.nus.edu](mailto:feiyu@u.nus.edu)

38 Chaolong Wei — Department of Materials Science and Engineering, National University of

39 Singapore. Email: [chaolongwei@u.nus.edu](mailto:chaolongwei@u.nus.edu)

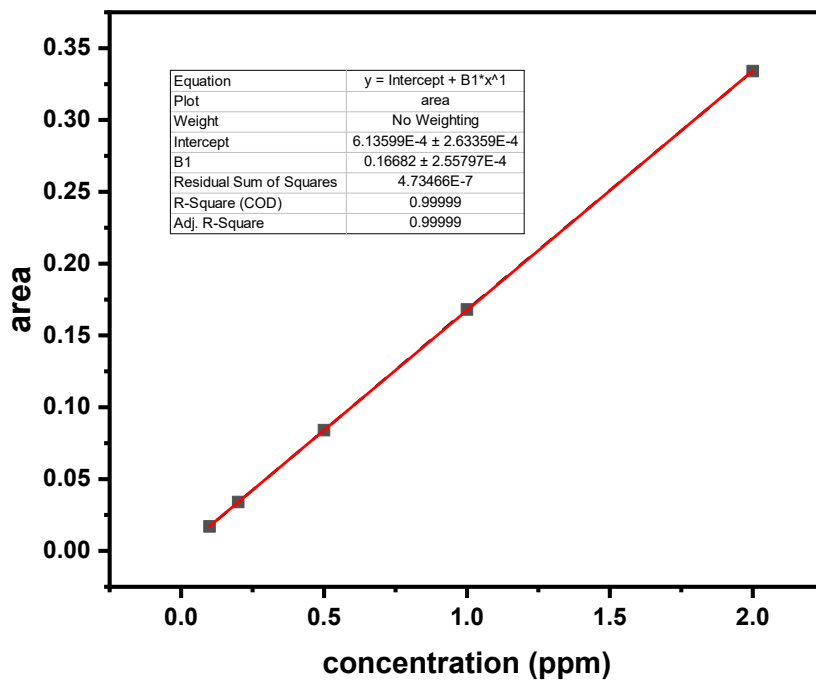
40 Olivier Lefebvre — NUS Environmental Research Institute, Department of Civil and

41 Environmental Engineering, National University of Singapore. Email: [ceelop@nus.edu.sg](mailto:ceelop@nus.edu.sg)



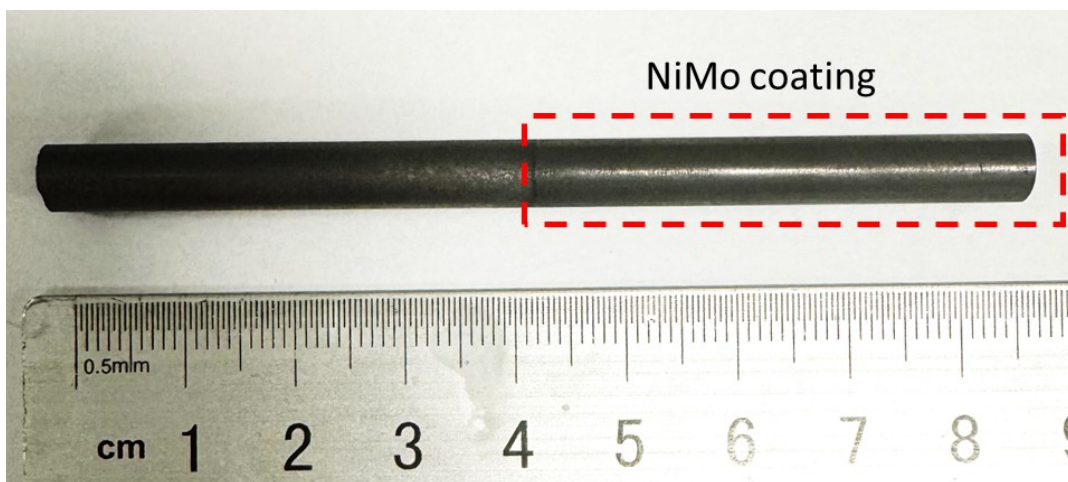
42

43 Fig. S1 The configuration of the long-term hydroponic cultivation.



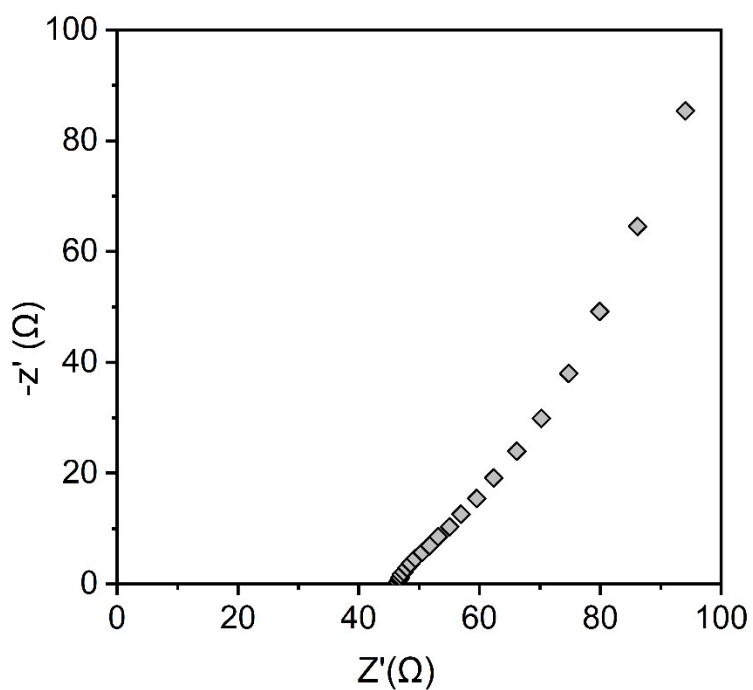
44

45 Fig.S2 Ammonia standard curve for IC detection.  $R^2$  is 0.99999.



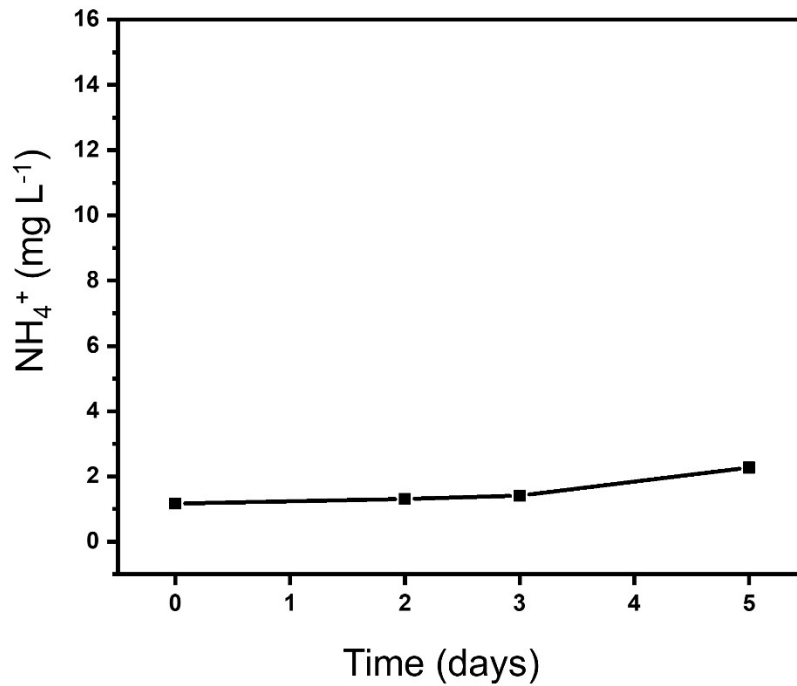
46

47 **Fig. S3 Photo of NiMo@CR.** The right side of the red dash box was a carbon rod coated with  
 48 a NiMo catalyst.



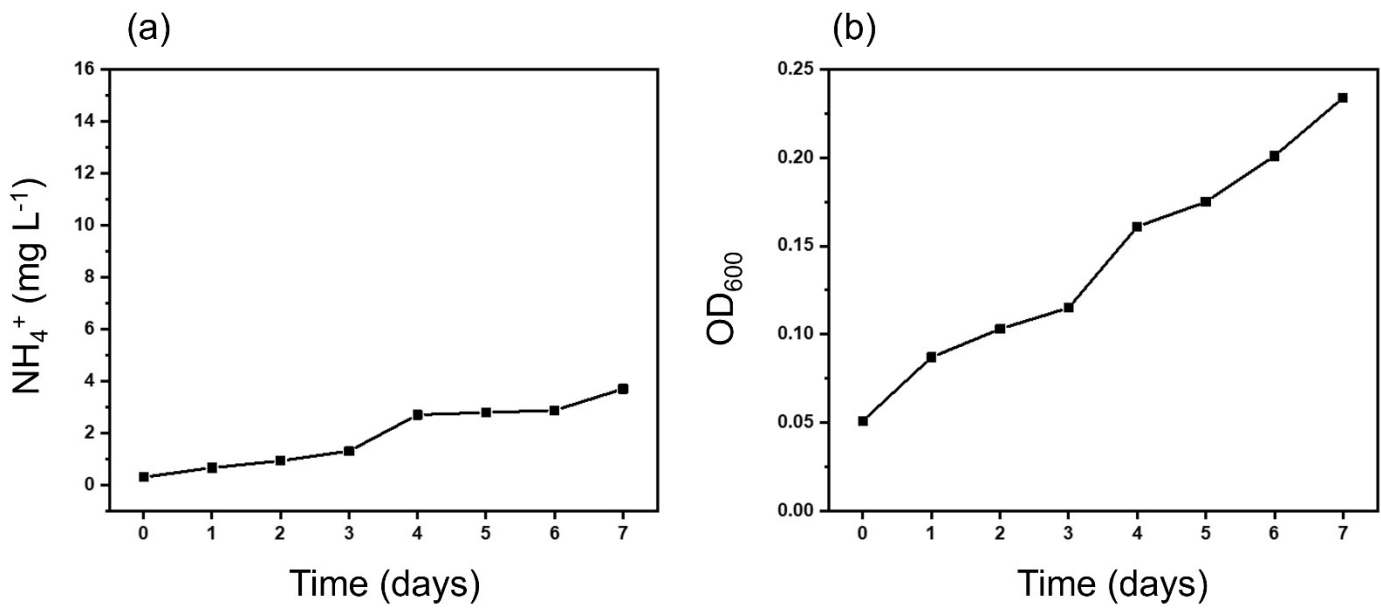
49

50 **Fig. S4 EIS spectra of pristine carbon rod as the cathode.** Note: the Nyquist curves of the  
 51 system, with the equivalent circuit inserted,  $Z'$  and  $-Z''$  are the real and imaginary parts  
 52 of the impedance, respectively.



53

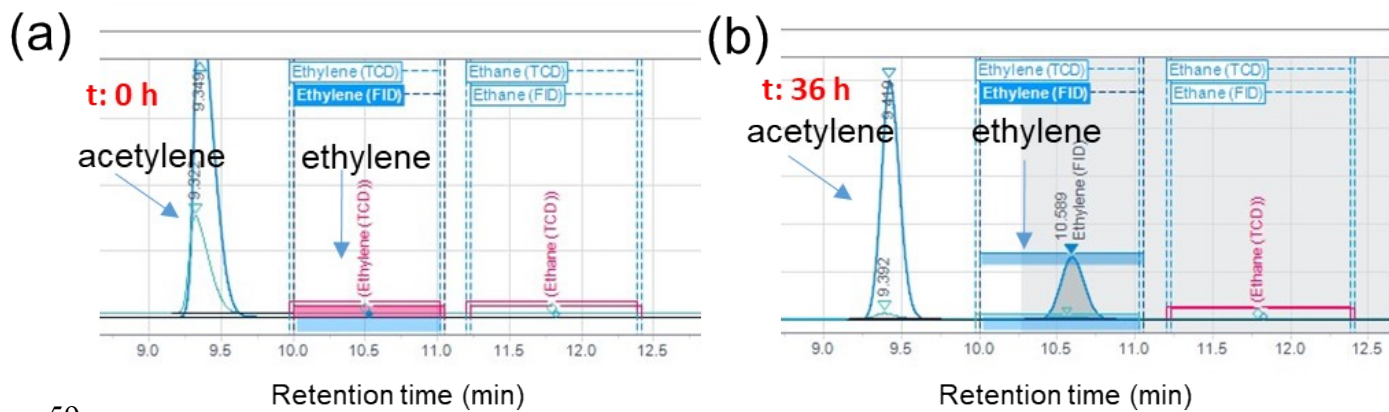
54 **Fig.S5 Ammonium concentration in the abiotic system with NiMo@CR as the cathode.**



56 **Fig.S6 N<sub>2</sub> reduction performance on the NiMo-X. *autotrophicus* hybrid system without**

57 **the addition of phosphinothricin. (a) ammonia concentration, (b) OD<sub>600</sub> in 7-d**

58 **experiments.**

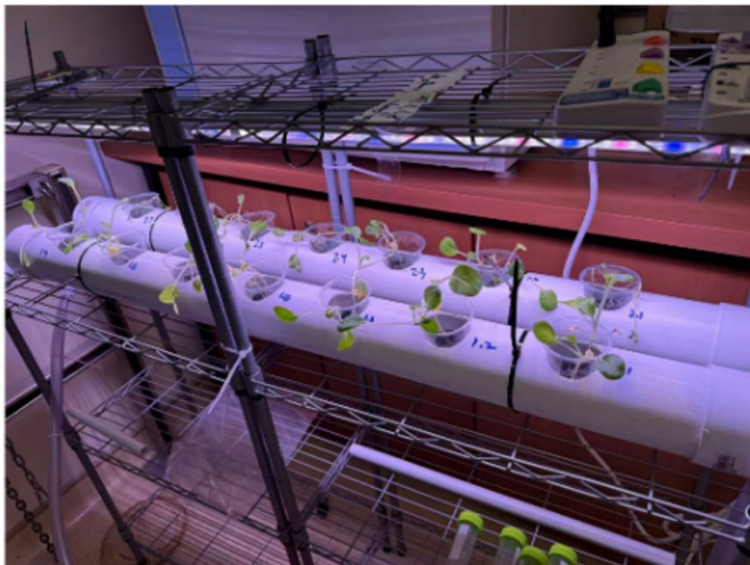


59

60 **Fig S7 A qualitative gas chromatography (GC) comparison of the whole-cell acetylene**

61 **reduction.** (a) and (b) represent the GC spectra at incubation times of  $t = 0$  h and  $t = 36$

62 h after  $C_2H_2$  injection, respectively.  $t$  is incubation time after  $C_2H_2$  injection.



63

64 **Fig.S8 Hydroponic setup of a 27 L water system for Pak-Choy.** Note: there are two parallel

65 hydroponic groups, each line has 7 holes for planting.