# Supporting Information

## Precious Metal Free Hydrogen Evolution Catalyst Design and Application

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The data provided in this supporting information file was used to prepare Figures 18 and 19 in the main text.

**Table S1**. Transition metal phosphide hydrogen evolution reaction electrocatalyst activities.

| Date of publication | Catalyst | Electrolyte | Loading [mg cm$^{-2}$] | Overpotential to achieve TOF [mV] vs RHE | TOF [$H_2$ s$^{-1}$ site$^{-1}$] | Overpotential to achieve geometric current density and mass activity [mV] vs RHE | Geometric current density [mA cm$^{-2}$] | Mass activity [A mg$^{-1}$] | DOI |
|---|---|---|---|---|---|---|---|---|---|
| 03/06/2013 | Nanoporous FeP nanosheets | 0.5 M H2SO4 | 0.28 | | | 237 | 10 | 3.57E-02 | https://doi.org/10.1016/j.electacta.2019.134798 |
| 13/06/2013 | Nanostructured Ni2P/Ti | 0.5 M H2SO4 | 1.00 | 100.00 | 1.50E-02 | 130 | 20 | 2.00E-02 | https://doi.org/10.1021/ja403440e |
| 13/06/2013 | Nanostructured Ni2P/Ti | 0.5 M H2SO4 | 1.00 | 200.00 | 5.00E-01 | 180 | 100 | 1.00E-01 | https://doi.org/10.1021/ja403440e |
| 11/04/2014 | Nanostructured CoP | 0.5 M H2SO4 | 0.90 | 100.00 | 4.20E-02 | 95 | 20 | 2.22E-02 | https://doi.org/10.1002/anie.201402646 |
| 11/04/2014 | Nanostructured CoP | 0.5 M H2SO4 | 2.00 | | | 85 | 20 | 1.00E-02 | https://doi.org/10.1002/anie.201402646 |
| 15/05/2014 | Cobalt Phosphide Nanowire Arrays | 0.5 M H2SO4 | 0.92 | 75.00 | 7.25E-01 | 67 | 10 | 1.09E-02 | https://doi.org/10.1021/ja503372r |
| 15/05/2014 | Cobalt Phosphide Nanowire Arrays | 0.5 M H2SO4 | 0.92 | 240.00 | 4.00E+00 | 100 | 20 | 2.17E-02 | https://doi.org/10.1021/ja503372r |
| 15/05/2014 | Cobalt Phosphide Nanowire Arrays | 0.5 M H2SO4 | 0.92 | | | 204 | 100 | 1.09E-01 | https://doi.org/10.1021/ja503372r |
| 21/07/2014 | CoP nanotube | 0.5 M H2SO4 | 0.20 | 106.00 | 1.00E+00 | 72 | 2 | 1.00E-02 | https://doi.org/10.1039/C4TA02368D |

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|---|---|---|---|---|---|---|---|---|---|
| 21/07/ 2014 | CoP nanotube | 0.5 M H2SO4 | 0.20 | | | 129 | 10 | 5.00E-02 | https://doi.org/10.1039/C4TA02368D |
| 21/07/ 2014 | CoP nanoparticles | 0.5 M H2SO4 | 0.20 | 172.00 | 1.00E+00 | 200 | 2 | 1.00E-02 | https://doi.org/10.1039/C4TA02368D |
| 21/07/ 2014 | CoP nanoparticles | 0.5 M H2SO4 | 0.20 | | | 297 | 10 | 5.00E-02 | https://doi.org/10.1039/C4TA02368D |
| 23/07/ 2014 | CoP | 0.5 M H2SO4 | 2.00 | | | 90 | 10 | | https://doi.org/10.1021/acscatal.8b04291 |
| 23/07/ 2014 | CoP | 0.5 M H2SO4 | 2.00 | | | 146 | 100 | | https://doi.org/10.1021/cm501273s |
| 01/08/ 2014 | Ni2P nanoparticle films | 1.0 M H2SO4 | 2.00 | 205.00 | 7.25E-01 | 120 | 10 | 5.00E-03 | https://doi.org/10.1039/C4NR03037K |
| 01/08/ 2014 | Ni2P nanoparticle films | 1.0 M H2SO4 | 2.00 | | | 138 | 20 | 1.00E-02 | https://doi.org/10.1039/C4NR03037K |
| 01/08/ 2014 | Ni2P nanoparticle films | 1.0 M H2SO4 | 2.00 | | | 188 | 100 | 5.00E-02 | https://doi.org/10.1039/C4NR03037K |
| 11/08/ 2014 | MoP | 0.5 M H2SO4 | 0.07 | 100.00 | 4.80E-02 | 246 | 10 | 1.41E-01 | https://doi.org/10.1039/C4CC05936K |
| 11/08/ 2014 | Ni2P | 0.5 M H2SO4 | 0.07 | 100.00 | 2.50E-02 | 346 | 10 | 1.41E-01 | https://doi.org/10.1039/C4CC05936K |
| 20/08/ 2014 | FeP Nanorod array/Ti | 0.5 M H2SO4 | 0.60 | 85.00 | 2.58E+00 | 85 | 10 | 1.67E-02 | https://doi.org/10.1039/C4TA03638G |
| 20/08/ 2014 | FeP Nanorod array/Ti | 0.5 M H2SO4 | 0.60 | | | 183 | 240 | 4.00E-01 | https://doi.org/10.1039/C4TA03638G |
| 26/08/ 2014 | Co2P nanorod | 0.5 M H2SO4 | 1.00 | 143.00 | 7.25E-01 | 167 | 20 | 2.00E-02 | https://doi.org/10.1016/j.nanoen.2014.08.013 |
| 04/09/ 2014 | Amorphous W doped nickel P | 0.5 M H2SO4 | 1.50 | 100.00 | 7.25E-01 | 110 | 20 | 1.33E-02 | https://doi.org/10.1039/C4TA04434G |
| 04/09/ 2014 | Amorphous W doped nickel P | 0.5 M H2SO4 | 1.50 | | | 180 | 100 | 6.67E-02 | https://doi.org/10.1039/C4TA04434G |

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|---|---|---|---|---|---|---|---|---|---|
| 18/09/2014 | NiP2nanosheet arrays | 0.5 M H2SO4 | 4.30 | | | 75 | 10 | 2.33E-03 | https://doi.org/10.1039/C5TA02128F |
| 18/09/2014 | NiP2nanosheet arrays | 0.5 M H2SO4 | 4.30 | | | 99 | 20 | 4.65E-03 | https://doi.org/10.1039/C4NR04866K |
| 18/09/2014 | NiP2nanosheet arrays | 0.5 M H2SO4 | 4.30 | | | 204 | 100 | 2.33E-02 | https://doi.org/10.1039/C4NR04866K |
| 01/10/2014 | Nanostructured FeP/Ti | 0.5 M H2SO4 | 1.00 | 100.00 | 2.77E-01 | 50 | 10 | 1.00E-02 | https://doi.org/10.1021/nn5048553 |
| 01/10/2014 | Nanostructured FeP/Ti | 0.5 M H2SO4 | 1.00 | | | 61 | 20 | 2.00E-02 | https://doi.org/10.1021/nn5048553 |
| 17/10/2014 | FeP Nanorod Array | 0.5 M H2SO4 | 1.50 | | | 58 | 10 | 6.67E-03 | https://doi.org/10.1039/C4TA04867A |
| 30/10/2014 | MoP\|S | 0.5 M H2SO4 | 1.00 | 100.00 | 1.20E-01 | 86 | 10 | 1.00E-02 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP\|S | 0.5 M H2SO4 | 1.00 | 150.00 | 7.50E-01 | | | 0.00E+00 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP\|S | 0.5 M H2SO4 | 3.00 | | | 64 | 10 | 3.33E-03 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP\|S | 0.5 M H2SO4 | 3.00 | | | 78 | 20 | 6.67E-03 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP\|S | 0.5 M H2SO4 | 3.00 | | | 120 | 100 | 3.33E-02 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP in H2 anneal | 0.5 M H2SO4 | 1.00 | | | 90 | 10 | 1.00E-02 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP | 0.5 M H2SO4 | 1.00 | 100.00 | 2.40E-02 | 117 | 10 | 1.00E-02 | https://doi.org/10.1002/anie.201408222 |
| 30/10/2014 | MoP | 0.5 M H2SO4 | 1.00 | 150.00 | 1.90E-01 | 180 | 100 | 1.00E-01 | https://doi.org/10.1002/anie.201408222 |
| 04/11/2014 | Ni12P5 NC | 0.5 M H2SO4 | 1.99 | | | 208 | 10 | 5.03E-03 | https://doi.org/10.1039/C4NR04866K |
| 04/11/2014 | Ni2P NC | 0.5 M H2SO4 | 1.99 | | | 137 | 10 | 5.03E-03 | https://doi.org/10.1039/C4TA04867A |

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|---|---|---|---|---|---|---|---|---|---|
| 04/11/2014 | Ni5P4 NC | 0.5 M H2SO4 | 1.99 | | | 118 | 10 | 5.03E-03 | https://doi.org/10.1039/C4TA04867A |
| 09/01/2015 | Ni5P4 (pellet) | 1.0 M H2SO4 | 176.56 | 100.00 | 3.50E+00 | 23 | 10 | 5.66E-05 | https://doi.org/10.1039/C4EE02940B |
| 09/01/2015 | Ni5P4 (pellet) | 1.0 M H2SO4 | 176.56 | 200.00 | 9.80E+00 | 62 | 100 | 5.66E-04 | https://doi.org/10.1039/C4EE02940B |
| 09/01/2015 | Ni2P (pellet) | 1.0 M H2SO4 | 177.27 | 100.00 | 1.50E-02 | 42 | 10 | 5.64E-05 | https://doi.org/10.1039/C4EE02940B |
| 09/01/2015 | Ni2P (pellet) | 1.0 M H2SO4 | 177.27 | 200.00 | | 101 | 100 | 5.64E-04 | https://doi.org/10.1039/C4EE02940B |
| 12/01/2015 | CoP-OMC | 0.5 M H2SO4 | 0.29 | 200.00 | 2.70E+00 | 112 | 10 | 3.51E-02 | https://doi.org/10.1039/C4TA06630H |
| 12/01/2015 | CoP NPs | 0.5 M H2SO4 | 0.29 | 200.00 | 1.70E+00 | 212 | 10 | 3.51E-02 | https://doi.org/10.1039/C4TA06630H |
| 16/01/2015 | Highly Branched CoP/Ti | 0.5 M H2SO4 | 1.00 | 100.00 | 1.90E-02 | 117 | 20 | 2.00E-02 | https://doi.org/10.1039/C4TA06642A |
| 27/03/2015 | Ni2P nanowires | 1.0 M H2SO4 | 1.42 | | | 133 | 10 | 7.04E-03 | https://doi.org/10.1002/adma.201800140 |
| 20/04/2015 | Ni2P/CNT | 0.5 M H2SO4 | 0.18 | | | 98 | 2 | 1.09E-02 | https://doi.org/10.1021/acs.nanolett.6b02203 |
| 20/04/2015 | Ni2P/CNT | 0.5 M H2SO4 | 0.18 | | | 124 | 10 | 5.43E-02 | https://doi.org/10.1039/C5TA02128F |
| 20/04/2015 | Ni12P5/CNT | 0.5 M H2SO4 | 0.18 | | | 240 | 10 | 5.43E-02 | https://doi.org/10.1039/C5TA02128F |
| 05/02/2016 | CoP/NCNTs | 0.5 M H2SO4 | 0.20 | | | 79 | 10 | 5.03E-02 | https://doi.org/10.1039/C5CP01065A |
| 05/02/2016 | CoP/NCNTs | 0.5 M H2SO4 | 0.20 | | | 99 | 20 | 1.01E-01 | https://doi.org/10.1039/C6TA00575F |
| 05/02/2016 | Co2P/NCNTs | 0.5 M H2SO4 | 0.20 | | | 171 | 20 | 1.01E-01 | https://doi.org/10.1039/C6TA00575F |

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|---|---|---|---|---|---|---|---|---|---|
| 07/06/ 2016 | Co2P@NPG | 0.5 M H2SO4 | 0.50 | | | 45 | 1 | 2.00E-03 | https://doi.org/10.1002/smll.201602873 |
| 07/06/ 2016 | Co2P@NPG | 0.5 M H2SO4 | 0.50 | | | 103 | 10 | 2.00E-02 | https://doi.org/10.1021/acs.nanolett.6b02203 |
| 07/06/ 2016 | Co2P@NPG | 0.5 M H2SO4 | 0.50 | | | 128 | 20 | 4.00E-02 | https://doi.org/10.1021/acs.nanolett.6b02203 |
| 07/06/ 2016 | Co2P@NPG | 0.5 M H2SO4 | 0.50 | | | 220 | 100 | 2.00E-01 | https://doi.org/10.1021/acs.nanolett.6b02203 |
| 07/07/ 2016 | MoP@PC | 0.5 M H2SO4 | 0.41 | | | 153 | 10 | 2.44E-02 | https://doi.org/10.1021/acscatal.7b00555 |
| 01/02/ 2017 | CoP–CNTs | 0.5 M H2SO4 | 0.28 | | | 139 | 10 | 3.53E-02 | https://doi.org/10.1039/C6TA00575F |
| 29/03/ 2017 | MoP/SN nanoparticles | 0.5 M H2SO4 | 90.50 | | | 57 | 1 | 1.10E-05 | https://doi.org/10.1021/acscatal.7b00555 |
| 29/03/ 2017 | MoP/SN nanoparticles | 0.5 M H2SO4 | 0.50 | | | 104 | 10 | 2.00E-02 | https://doi.org/10.1021/acscatal.7b00555 |
| 17/12/ 2017 | Ni2P@NPCNFs | 0.5 M H2SO4 | 0.34 | | | 63 | 10 | 2.97E-02 | https://doi.org/10.1002/anie.201710150 |
| 17/12/ 2017 | Ni2P@NPCNFs | 0.5 M H2SO4 | 0.34 | | | 85 | 20 | 5.93E-02 | https://doi.org/10.1002/anie.201710150 |
| 17/12/ 2017 | Ni2P@NPCNFs | 0.5 M H2SO4 | 0.34 | | | 173 | 100 | 2.97E-01 | https://doi.org/10.1002/anie.201710150 |
| 26/12/ 2017 | Co2P@NPC/CC | 0.5 M H2SO4 | 5.00 | | | 116 | 10 | 2.00E-03 | https://doi.org/10.1039/C7NR08148K |
| 26/12/ 2017 | Co2P@NPC/CC | 0.5 M H2SO4 | 5.00 | | | 134 | 20 | 4.00E-03 | https://doi.org/10.1039/C7NR08148K |
| 26/12/ 2017 | Co2P@NPC/CC | 0.5 M H2SO4 | 5.00 | | | 154 | 50 | 1.00E-02 | https://doi.org/10.1039/C7NR08148K |
| 03/04/ 2018 | PANI/CoP HNWs-CF | 0.5 M H2SO4 | 0.80 | | | 57 | 10 | 1.25E-02 | https://doi.org/10.1021/jacs.7b12968 |
| 03/04/ 2018 | PANI/CoP HNWs-CF | 0.5 M H2SO4 | 0.80 | | | 82 | 20 | 2.50E-02 | https://doi.org/10.1021/jacs.7b12968 |

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|---|---|---|---|---|---|---|---|---|---|
| 03/04/2018 | PANI/CoP HNWs-CF | 0.5 M H2SO4 | 0.80 | | | 101 | 50 | 6.25E-02 | https://doi.org/10.1021/jacs.7b12968 |
| 03/04/2018 | PANI/CoP HNWs-CF | 0.5 M H2SO4 | 0.80 | | | 122 | 100 | 1.25E-01 | https://doi.org/10.1021/jacs.7b12968 |
| 16/05/2018 | Co2P@CP | 0.5 M H2SO4 | 3.20 | | | 120 | 10 | 3.13E-03 | https://doi.org/10.1021/acsenergylett.8b00514 |
| 17/05/2018 | CoP | 0.5 M H2SO4 | 1.12 | 50.00 | 3.10E-03 | 85 | 10 | 8.93E-03 | https://doi.org/10.1021/cm501273s |
| 17/05/2018 | N-doped CoP | 0.5 M H2SO4 | 1.08 | 50.00 | 1.99E-02 | 42 | 10 | 9.26E-03 | https://doi.org/10.1002/adma.201800140 |
| 05/07/2018 | MoP@HCC | 0.5 M H2SO4 | 0.26 | | | 129 | 10 | 3.85E-02 | https://doi.org/10.1002/anie.201604315 |
| 08/11/2018 | 3D-NiCoP | 0.5 M H2SO4 | | | | 80 | 10 | | https://doi.org/10.1007/s12274-018-2226-2 |
| 19/12/2018 | S-MoP NPL | 0.5 M H2SO4 | | | | 86 | 10 | | https://doi.org/10.1021/acscatal.8b04291 |
| 19/12/2018 | S-MoP NPL | 0.5 M H2SO4 | | | | 104 | 20 | | https://doi.org/10.1021/acscatal.8b04291 |
| 19/12/2018 | S-MoP NPL | 0.5 M H2SO4 | | | | 145 | 100 | | https://doi.org/10.1021/acscatal.8b04291 |
| 15/02/2019 | Ni-doped FeP | 0.5 M H2SO4 | 0.40 | | | 72 | 10 | 2.50E-02 | https://doi.org/10.1126/sciadv.aav6009 |
| 15/02/2019 | Ni-doped FeP | 0.5 M H2SO4 | 0.40 | | | 89 | 20 | 5.00E-02 | https://doi.org/10.1126/sciadv.aav6009 |
| 15/02/2019 | Ni-doped FeP | 0.5 M H2SO4 | 0.40 | | | 115 | 50 | 1.25E-01 | https://doi.org/10.1126/sciadv.aav6009 |
| 15/02/2019 | Ni-doped FeP | 0.5 M H2SO4 | 0.40 | | | 138 | 100 | 2.50E-01 | https://doi.org/10.1126/sciadv.aav6009 |
| 15/03/2019 | N-Co2P/CC | 0.5 M H2SO4 | 5.00 | | | 27 | 10 | 2.00E-03 | https://doi.org/10.1021/acscatal.9b00407 |
| 20/03/2019 | Ni5P4@Nickel hydr(oxy)oxide | 0.5 M H2SO4 | | | | 66 | 10 | | https://doi.org/10.1016/j.apcatb.2019.03.037 |

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|---|---|---|---|---|---|---|---|---|---|
| 25/03/2019 | CoP@PC-750 | 0.5 M H2SO4 | 1.00 | | | 72 | 10 | 1.00E-02 | https://doi.org/10.1002/smll.201900550 |
| 15/04/2019 | N-CoP/CC | 0.5 M H2SO4 | 5.00 | | | 25 | 10 | 2.00E-03 | https://doi.org/10.1016/j.apcatb.2019.04.038 |
| 02/09/2019 | LC-WP | 0.5 M H2SO4 | 0.21 | 200.00 | 3.60E-01 | 105 | 1 | 4.69E-03 | https://doi.org/10.1016/j.apcatb.2019.118358 |
| 02/09/2019 | LC-WP | 0.5 M H2SO4 | 0.21 | | | 170 | 10 | 4.69E-02 | https://doi.org/10.1016/j.electacta.2019.134798 |
| 02/09/2019 | LC-WP | 0.5 M H2SO4 | 0.21 | | | 300 | 81 | 3.78E-01 | https://doi.org/10.1016/j.electacta.2019.134798 |
| 02/11/2019 | MoP@NPCS | 0.5 M H2SO4 | 0.25 | | | 113 | 10 | 4.00E-02 | https://doi.org/10.1016/j.apcatb.2019.118352 |
| 08/11/2019 | MoP@NC | 0.5 M H2SO4 | 0.28 | | | 96 | 10 | 3.57E-02 | https://doi.org/10.1039/C8NR04246B |
| 25/04/2020 | CP@NCNT) | 0.5 M H2SO4 | 0.27 | | | 94 | 10 | 3.70E-02 | https://doi.org/10.1016/j.jechem.2020.04.005 |
| 25/04/2020 | CP@NCNT) | 0.5 M H2SO4 | 0.27 | | | 174 | 50 | 1.85E-01 | https://doi.org/10.1016/j.jechem.2020.04.005 |
| 06/10/2020 | hierarchical porous Ni12P5-Ni2P | 0.5 M H2SO4 | | | | 83 | 10 | | https://doi.org/10.1016/j.apcatb.2020.119609 |
| 15/10/2020 | NiCoP/NPC | 0.5 M H2SO4 | | | | 108 | 10 | | https://doi.org/10.1016/j.apcatb.2020.119635 |
| 17/11/2020 | Co2P/Ni2P nanohybrid | 0.5 M H2SO4 | | | | 46 | 20 | | https://doi.org/10.1016/j.mtphys.2020.100314 |
| 08/02/2021 | P-MoP/Mo2N | 0.5 M H2SO4 | | 100.00 | 6.50E-02 | 89 | 10 | | https://doi.org/10.1002/anie.202016102 |
| 24/02/2021 | Ni-graphene-CNTs-Ni2P–CuP2 heterostructure | 0.5 M H2SO4 | 11.25 | 100.00 | 1.00E+00 | 12 | 10 | 8.89E-04 | https://doi.org/10.1021/acsnano.1c00647 |
| 24/02/2021 | Ni-graphene-CNTs-Ni2P– | 0.5 M H2SO4 | 11.25 | 142.00 | 2.00E+00 | 124 | 100 | 8.89E-03 | https://doi.org/10.1021/acsnano.1c00647 |

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|---|---|---|---|---|---|---|---|---|---|
| | CuP2 heterostr ucture | | | | | | | | |
| 24/02/ 2021 | Ni-graphene-CNTs-Ni2P–CuP2 heterostr ucture | 0.5 M H2SO4 | 11.25 | 174.00 | 3.00E+ 00 | 174 | 200 | 1.78E- 02 | https://doi.org/10.1021/acsn ano.1c00647 |
| 27/03/ 2021 | CoP@N,S-3D-GN | 0.5 M H2SO4 | 0.20 | | | 118 | 10 | 5.00E- 02 | https://doi.org/10.1016/j.ele ctacta.2021.138262 |
| 27/03/ 2021 | CoP@3D-GN | 0.5 M H2SO4 | 0.20 | | | 198 | 10 | 5.00E- 02 | https://doi.org/10.1016/j.ele ctacta.2021.138262 |

**Table S2**. Transition metal sulfide hydrogen evolution reaction electrocatalyst activities.

| **Date of publica tion** | **Catalyst** | **Electrolyte** | **Loading [mg cm$^{-2}$]** | **Overpotenti al for TOF [mV] vs RHE** | **TOF [$H_2$ $s^{-1}$ $site^{-1}$]** | **Overpotential to achieve geometric current density and mass activity [mV] vs RHE** | **Geometric current density [mA cm$^{-2}$]** | **Mass activity [A mg$^{-1}$]** | **DOI** |
|---|---|---|---|---|---|---|---|---|---|
| 06/07/ 2007 | UHV MoS2 - edges | 0.5 M H2SO4 | 0.00 | 150 | 9.37E+ 00 | 150 | 0 | 3.30E+0 0 | https://doi.org/10.1126/scien ce.1141483 |
| 06/07/ 2007 | UHV MoS2 - all sites | 0.5 M H2SO4 | | 150 | 2.70E+ 00 | | | | https://doi.org/10.1126/scien ce.1141483 |
| 14/04/ 2011 | Amorphous molybdenum sulfide | 0.5 M H2SO4 | | | | 242 | 10 | | https://doi.org/10.1039/C1SC 00117E |
| 21/04/ 2011 | MoS2 RGO | 0.5 M H2SO4 | 0.28 | 200 | 1.00E- 01 | 200 | 33 | 1.18E- 01 | https://doi.org/10.1021/ja20 1269b |
| 21/04/ 2011 | MoS2 RGO | 0.5 M H2SO4 | 0.28 | 250 | 3.00E- 01 | 250 | 101 | 3.60E- 01 | https://doi.org/10.1021/ja20 1269b |

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|---|---|---|---|---|---|---|---|---|---|
| 14/09/2011 | Core–shell MoO3–MoS2 Nanowires | 0.5 M H2SO4 | | | | 254 | 10 | | https://doi.org/10.1021/nl2020476 |
| 14/09/2011 | Core–shell MoO3–MoS2 Nanowires | 0.5 M H2SO4 | | 272 | 4.00E+00 | 272 | 20 | | https://doi.org/10.1021/nl2020476 |
| 10/08/2012 | Amorphous Molybdenum Sulfide | 0.5 M H2SO4 | | 200 | 3.00E-01 | 200 | 10 | | https://doi.org/10.1021/cs300451q |
| 07/10/2012 | DG MoS2 | 0.5 M H2SO4 | | | | 206 | 10 | | https://doi.org/10.1038/nmat3439 |
| 12/02/2013 | MoS2 | 0.5 M H2SO4 | 0.01 | 0 | 1.30E-02 | 300 | 1 | 7.06E-02 | https://doi.org/10.1021/nl400258t |
| 11/04/2013 | MoSx/GP | 0.5 M H2SO4 | | | | 194 | 10 | | https://doi.org/10.1039/C3CC41945B |
| 11/04/2013 | MoS2/piranha GP | 0.5 M H2SO4 | | | | 175 | 6 | | https://doi.org/10.1039/C3CC41945B |
| 11/04/2013 | MoS2/piranha GP | 0.5 M H2SO4 | | | | 154 | 10 | | https://doi.org/10.1039/C3CC41945B |
| 06/08/2013 | Electro deposited MoS2+x | 1.0 M H2SO4 | 0.02 | 200 | 7.60E-01 | 200 | 12 | 7.67E-01 | https://doi.org/10.1021/cs400441u |
| 06/08/2013 | Electro deposited MoS2+x | 1.0 M H2SO4 | 0.02 | 250 | 1.30E+01 | 250 | 196 | 1.31E+01 | https://doi.org/10.1021/cs400441u |
| 21/11/2013 | 1T basal plane | 0.5 M H2SO4 | 0.05 | 150 | 1.55E+00 | 201 | 10 | 2.00E-01 | https://doi.org/10.1021/nl403661s |
| 21/11/2013 | 1T basal plane | 0.5 M H2SO4 | 0.05 | 180 | 8.72E+00 | 217 | 20 | 4.00E-01 | https://doi.org/10.1021/nl403661s |
| 03/12/2013 | Lithiated ALDMoS2t | 0.5 M H2SO4 | 0.12 | | | 168 | 10 | 8.33E-02 | https://doi.org/10.1073/pnas.1316792110 |

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|---|---|---|---|---|---|---|---|---|---|
| 03/12/2013 | Lithiated ALDMoS2t | 0.5 M H2SO4 | 0.12 | | | 216 | 100 | 8.33E-01 | https://doi.org/10.1073/pnas.1316792110 |
| 03/12/2013 | lithiated MoS2on MPGC | 0.5 M H2SO4 | 0.02 | | | 200 | 7 | 3.06E-01 | https://doi.org/10.1073/pnas.1316792110 |
| 03/12/2013 | lithiated MoS2on MPGC | 0.5 M H2SO4 | 0.02 | | | 113 | 0 | 4.55E-03 | https://doi.org/10.1073/pnas.1316792110 |
| 26/01/2014 | Mo3S13\|HOPG | 0.5 M H2SO4 | 0.00 | 200 | 3.12E+00 | 200 | 0 | 2.58E+00 | https://doi.org/10.1038/nchem.1853 |
| 26/01/2014 | Mo3S13\|HOPG | 0.5 M H2SO4 | 0.00 | 250 | 2.15E+01 | 250 | 0 | 1.77E+01 | https://doi.org/10.1038/nchem.1853 |
| 26/01/2014 | Mo3S13\|GP | 0.5 M H2SO4 | 0.01 | 214 | 1.21E+00 | 214 | 10 | 1.00E+00 | https://doi.org/10.1038/nchem.1853 |
| 26/01/2014 | Mo3S13\|GP | 0.5 M H2SO4 | 0.02 | 196 | 6.08E-01 | 196 | 10 | 5.00E-01 | https://doi.org/10.1038/nchem.1853 |
| 26/01/2014 | Mo3S13\|GP | 0.5 M H2SO4 | 0.05 | 183 | 2.44E-01 | 183 | 10 | 2.00E-01 | https://doi.org/10.1038/nchem.1853 |
| 26/01/2014 | Mo3S13\|GP | 0.5 M H2SO4 | 0.10 | 176 | 1.21E-01 | 176 | 10 | 1.00E-01 | https://doi.org/10.1038/nchem.1853 |
| 06/02/2014 | MoSx /N-CNT | 0.5 M H2SO4 | 0.10 | 200 | 3.50E+00 | 110 | 10 | 9.80E-02 | https://doi.org/10.1021/nl404108a |
| 09/04/2014 | 1T MoS2 | 0.5 M H2SO4 | 3.40 | | | 118 | 10 | 2.94E-03 | https://doi.org/10.1021/nn500959v |
| 09/04/2014 | 1T MoS2 | 0.5 M H2SO4 | 3.40 | | | 200 | 200 | 5.88E-02 | https://doi.org/10.1021/nn500959v |
| 08/10/2014 | Mo3S13 anodized GP | 0.5 M H2SO4 | | | | 149 | 10 | | ttps://doi.org/10.1021/cs500923c |
| 09/01/2015 | ALD MoS2 film | 0.5 M H2SO4 | | 200 | 1.45E+00 | 200 | 1 | | https://doi.org/10.1021/la504162u |
| 09/01/2015 | ALD MoS2 film | 0.5 M H2SO4 | | 215 | 3.00E+00 | | | | https://doi.org/10.1021/la504162u |
| 03/11/2015 | 1T@2H-MoS2 | 0.5 M H2SO4 | 0.32 | | | 64 | 10 | 3.13E-02 | https://doi.org/10.1039/C5TA08520A |

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|---|---|---|---|---|---|---|---|---|---|
| 09/11/2015 | SV-MoS2 | 0.5 M H2SO4 | | 0 | 3.10E-01 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | SV-MoS2 | 0.5 M H2SO4 | | 50 | 9.88E-01 | 170 | 10 | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | SV-MoS2 | 0.5 M H2SO4 | | 100 | 5.42E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | SV-MoS2 | 0.5 M H2SO4 | | 150 | 1.79E+01 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | V-MoS2 | 0.5 M H2SO4 | | 50 | 2.78E-01 | 250 | 10 | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | V-MoS2 | 0.5 M H2SO4 | | 100 | 9.03E-01 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | V-MoS2 | 0.5 M H2SO4 | | 150 | 3.32E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | S-MoS2 | 0.5 M H2SO4 | | 237 | 1.01E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | S-MoS2 | 0.5 M H2SO4 | | 297 | 5.00E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | MoS2 | 0.5 M H2SO4 | | 248 | 1.00E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 09/11/2015 | MoS2 | 0.5 M H2SO4 | | 316 | 5.01E+00 | | | | https://doi.org/10.1038/nmat4465 |
| 25/04/2016 | MoS2/N-RGO-180 | 0.5 M H2SO4 | 0.14 | | | 56 | 10 | 7.14E-02 | https://doi.org/10.1002/aenm.201600116 |
| 15/12/2016 | MoS2 - edge sites | 0.5 M H2SO4 | | 0 | 7.50E+00 | | | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | MoS2 - sulfur vacancies | 0.5 M H2SO4 | | 0 | 3.20E+00 | | | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | MoS2 - grain boundaries | 0.5 M H2SO4 | | 0 | 1.00E-01 | | | | https://doi.org/10.1021/jacs.6b05940 |

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|---|---|---|---|---|---|---|---|---|---|
| 15/12/2016 | 7% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 163 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | 10% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 187 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | 12% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 261 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | 14% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 304 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | 4% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 325 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 15/12/2016 | 2% densities of sulfur vacancies | 0.5 M H2SO4 | | | | 366 | 10 | | https://doi.org/10.1021/jacs.6b05940 |
| 02/03/2017 | P-doped MoS2 (P3) | 0.5 M H2SO4 | 0.32 | 100 | 1.40E+00 | 43 | 10 | 3.13E-02 | https://doi.org/10.1021/acsenergylett.7b00111 |
| 07/03/2017 | MoS2 nanowall | 0.5 M H2SO4 | 0.88 | | | 95 | 10 | 1.14E-02 | https://doi.org/10.1007/s12274-017-1421-x |
| 07/03/2017 | MoS2 nanowall | 0.5 M H2SO4 | 0.88 | | | 300 | 311 | 3.53E-01 | https://doi.org/10.1007/s12274-017-1421-x |
| 12/04/2017 | MoS2 foam | 0.5 M H2SO4 | 0.50 | | | 210 | 10 | 2.00E-02 | https://doi.org/10.1038/ncomms14430 |
| 12/04/2017 | Co-MoS2 foam | 0.5 M H2SO4 | 0.50 | | | 156 | 10 | 2.00E-02 | https://doi.org/10.1038/ncomms14430 |
| 24/04/2017 | MoS2/Ti3C2-MXene@C | 0.5 M H2SO4 | 0.40 | | | 135 | 10 | | https://doi.org/10.1002/adma.201607017 |
| 08/05/2017 | 1TMoS2/SWNT | 0.5 M H2SO4 | | | | 108 | 10 | | https://doi.org/10.1021/acs.chemmater.7b00446 |

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|---|---|---|---|---|---|---|---|---|---|
| 03/08/2017 | NiS2/MoS2 HNW | 0.5 M H2SO4 | 0.20 | | | 235 | 10 | 5.00E-02 | https://doi.org/10.1021/acscatal.7b02225 |
| 18/01/2018 | MoS2/HG | 0.5 M H2SO4 | 0.13 | 220 | 7.80E+00 | 124 | 10 | 7.87E-02 | https://doi.org/10.1021/acscatal.7b03316 |
| 07/02/2018 | MoSx polymer brush composite | 1.0 M H2SO4 | 0.04 | 200 | 1.30E+00 | 211 | 1 | 1.43E-02 | https://doi.org/10.1021/acsami.7b16679 |
| 07/02/2018 | MoSx polymer brush composite | 1.0 M H2SO4 | 0.04 | 250 | 4.90E+00 | | | | https://doi.org/10.1021/acsami.7b16679 |
| 18/03/2018 | Co-MoS2-0.5 | 0.5 M H2SO4 | 2.00 | | | 60 | 10 | 5.00E-03 | https://doi.org/10.1039/C8CC00766G |
| 20/03/2018 | 1T-MoS2 | 0.5 M H2SO4 | 0.29 | 200 | 2.50E-01 | 76 | 10 | 3.51E-02 | https://doi.org/10.1007/s12274-018-2026-8 |
| 20/03/2018 | 1T-MoS2 | 0.5 M H2SO4 | 0.29 | | | 164 | 100 | 3.51E-01 | https://doi.org/10.1007/s12274-018-2026-8 |
| 02/04/2018 | 1T'-MoS2 | 0.5 M H2SO4 | | | | 400 | 607 | | https://doi.org/10.1038/s41557-018-0035-6 |
| 02/04/2018 | 2H-MoS2 | 0.5 M H2SO4 | | | | 400 | 43 | | https://doi.org/10.1038/s41557-018-0035-6 |
| 02/04/2018 | 1T'-MoS2 | 0.5 M H2SO4 | | | | 175 | 10 | | https://doi.org/10.1038/s41557-018-0035-6 |
| 02/04/2018 | 1T'-MoS2 | 0.5 M H2SO4 | | | | 400 | 607 | | https://doi.org/10.1038/s41557-018-0035-6 |
| 17/01/2019 | MoS2/Mo2C | 0.5 M H2SO4 | 0.30 | | | 227 | 1000 | 3.33E+00 | https://doi.org/10.1038/s41467-018-07792-9 |
| 23/01/2019 | 1T-MoS2 | 0.5 M H2SO4 | 1.70 | | | 151 | 10 | 5.88E-03 | https://doi.org/10.1016/j.apcatb.2019.01.062 |
| 01/03/2019 | L-MoS2 | 0.5 M H2SO4 | 0.20 | 250 | 7.67E+00 | 178 | 10 | 5.00E-02 | https://doi.org/10.1021/acssuschemeng.8b06717 |
| 01/03/2019 | P-MoS2 | 0.5 M H2SO4 | 0.20 | 250 | 4.19E-01 | 256 | 10 | 5.00E-02 | https://doi.org/10.1021/acssuschemeng.8b06717 |

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|---|---|---|---|---|---|---|---|---|---|
| 05/10/2019 | V-doped MoS2 | 0.5 M H2SO4 | 0.50 | | | 194 | 10 | 2.00E-02 | https://doi.org/10.1016/j.apcatb.2019.04.028 |
| 02/11/2019 | MoS2@NSCS | 0.5 M H2SO4 | 0.25 | | | 158 | 10 | 4.00E-02 | https://doi.org/10.1016/j.apcatb.2019.118352 |
| 06/11/2019 | N-MoS2/CN | 0.5 M H2SO4 | 0.29 | 114 | 3.62E-01 | 114 | 10 | | https://doi.org/10.1021/jacs.9b09932 |
| 19/11/2019 | Co1\|1T-MoS2 | 0.5 M H2SO4 | 0.07 | 100 | 7.82E+00 | 42 | 10 | 1.43E-01 | https://doi.org/10.1038/s41467-019-12997-7 |
| 01/12/2020 | 1T-2H MoS2 | 0.5 M H2SO4 | 0.29 | | | 79 | 1 | 3.51E-03 | https://doi.org/10.1021/acsami.0c16537 |
| 01/12/2020 | 1T-2H MoS2 | 0.5 M H2SO4 | 0.29 | 150 | 1.51E+02 | 157 | 10 | 3.51E-02 | https://doi.org/10.1021/acsami.0c16537 |
| 01/12/2020 | 1T-2H MoS2 | 0.5 M H2SO4 | 0.29 | | | 211 | 100 | 3.51E-01 | https://doi.org/10.1021/acsami.0c16537 |
| 01/04/2021 | V0.05Mo0.95S2 | 0.5 M H2SO4 | 0.26 | | | 156 | 10 | 3.85E-02 | https://doi.org/10.1016/j.cej.2020.128158 |
| 05/05/2021 | MoS2-Ti3C2 MXene | 0.5 M H2SO4 | 0.38 | 150 | 1.28E+00 | 98 | 10 | 2.67E-02 | https://doi.org/10.1016/j.apcatb.2019.04.028 |
| 05/05/2021 | MoS2-Ti3C2 MXene | 0.5 M H2SO4 | 0.38 | 200 | 2.60E+00 | | | | https://doi.org/10.1016/j.apcatb.2019.04.028 |
| 12/11/2021 | 1T-MoS2@Ti | 0.5 M H2SO4 | 0.10 | | | 230 | 10 | 1.00E-01 | https://doi.org/10.1016/j.jechem.2021.10.031 |
| 12/11/2021 | 1T-MoS2/TiO2−x@Ti | 0.5 M H2SO4 | 0.30 | | | 146 | 10 | 3.33E-02 | https://doi.org/10.1016/j.jechem.2021.10.031 |
| 22/04/2022 | Frenkel-defected monolayer MoS2 | 0.5 M H2SO4 | | | | 164 | 10 | | https://doi.org/10.1038/s41467-022-29929-7 |
| 22/04/2022 | pristine MoS2 | 0.5 M H2SO4 | | | | 358 | 10 | | https://doi.org/10.1038/s41467-022-29929-7 |

**Table S3**. Transition metal carbide hydrogen evolution reaction electrocatalyst activities.

| Date of publication | Catalyst | Electrolyte | Loading [mg $cm^{-2}$] | Overpotential for TOF [mV] vs RHE | TOF [$H_2$ $s^{-1}$ $site^{-1}$] | Overpotential to achieve geometric current density and mass activity [mV] vs RHE | Geometric current density [mA $cm^{-2}$] | Mass activity [A $mg^{-1}$] | DOI |
|---|---|---|---|---|---|---|---|---|---|
| 09/11/2012 | Mo2C | 1 M H2SO4 | 1.40 | | | 210 | 10 | 7.14E-03 | https://doi.org/10.1002/anie.201207111 |
| 31/01/2013 | Mo2C/CNT | 1 M HClO4 | 2.00 | | | 152 | 10 | 5.00E-03 | https://doi.org/10.1039/C2EE23891H |
| 17/10/2013 | np-Mo2C NW | 0.5 M H2SO4 | 0.21 | | | 200 | 60 | 2.86E-01 | https://doi.org/10.1039/C3EE42441C |
| 23/05/2014 | MoxC/Ni-30-725-5 | 0.5 M H2SO4 | 38.40 | 250 | 8.60E-01 | 250 | 35 | 9.04E-04 | https://doi.org/10.1002/cctc.201402000 |
| 08/07/2014 | Mo2C/GCSs | 0.5 M H2SO4 | 0.36 | | | 200 | 10 | 2.78E-02 | https://doi.org/10.1021/cs5005294 |
| 08/07/2014 | Mo2C/GCSs | 0.5 M H2SO4 | 0.36 | | | 150 | 2 | 5.56E-03 | https://doi.org/10.1021/cs5005294 |
| 30/07/2014 | WP/Ti | 0.5 M H2SO4 | 1.00 | | | 120 | 10 | 1.00E-02 | https://doi.org/10.1039/C4CC04709E |
| 30/07/2014 | WP/Ti | 0.5 M H2SO4 | 1.00 | | | 149 | 20 | 2.00E-02 | https://doi.org/10.1039/C4CC04709E |
| 11/03/2015 | MoCx nano-octahedrons | 0.5 M H2SO4 | 0.80 | | | 87 | 1 | 1.25E-03 | https://doi.org/10.1038/ncomms7512 |
| 11/03/2015 | MoCx nano-octahedrons | 0.5 M H2SO4 | 0.80 | | | 142 | 10 | 1.25E-02 | https://doi.org/10.1038/ncomms7512 |
| 20/03/2015 | a-Mo2C | 0.5 M H2SO4 | 0.10 | 200 | 5.00E-01 | 198 | 10 | 9.80E-02 | https://doi.org/10.1039/C5TA00139K |
| 30/06/2015 | Fe3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 49 | 10 | 7.09E-02 | https://doi.org/10.1021/acsnano.5b02420 |

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|---|---|---|---|---|---|---|---|---|---|
| 30/06/2015 | Co3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 91 | 10 | 7.09E-02 | https://doi.org/10.1021/acsnano.5b02420 |
| 30/06/2015 | Ni3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 48 | 10 | 7.09E-02 | https://doi.org/10.1021/acsnano.5b02420 |
| 30/06/2015 | Fe3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 200 | 167 | 1.18E+00 | https://doi.org/10.1021/acsnano.5b02420 |
| 30/06/2015 | Co3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 200 | 80 | 5.65E-01 | https://doi.org/10.1021/acsnano.5b02420 |
| 30/06/2015 | Ni3C-GNRs | 0.5 M H2SO4 | 0.14 | | | 200 | 116 | 8.26E-01 | https://doi.org/10.1021/acsnano.5b02420 |
| 16/10/2015 | Mo2C NP | 0.5 M H2SO4 | 0.25 | | | 78 | 10 | 4.00E-02 | https://doi.org/10.1002/anie.201506727 |
| 22/10/2015 | MoSx@Mo2C | 0.5 M H2SO4 | 0.21 | 400 | 1.10E+00 | 400 | 146 | 6.85E-01 | https://doi.org/10.1021/acscatal.5b01803 |
| 22/10/2015 | pure Mo2C | 0.5 M H2SO4 | 0.21 | 400 | 3.70E-01 | 400 | 178 | 8.36E-01 | https://doi.org/10.1021/acscatal.5b01803 |
| 05/11/2015 | β-Mo2C Nanotubes | 0.5 M H2SO4 | 0.75 | | | 172 | 10 | 1.33E-02 | https://doi.org/10.1002/anie.201508715 |
| 05/11/2015 | β-Mo2C Nanotubes | 0.5 M H2SO4 | 0.75 | | | 197 | 20 | 2.67E-02 | https://doi.org/10.1002/anie.201508715 |
| 01/12/2015 | 0.27Mo2.4Ni@900 | 0.5 M H2SO4 | 1.10 | | | 75 | 10 | 9.09E-03 | https://doi.org/10.1021/jacs.5b07924 |
| 01/04/2016 | Mo2C@NPC/NPRGO | 0.5 M H2SO4 | 0.14 | | | 34 | 10 | 7.14E-02 | https://doi.org/10.1038/ncomms11204 |
| 22/11/2016 | Mo2C/NCF | 0.5 M H2SO4 | 0.28 | | | 85 | 1 | 3.57E-03 | https://doi.org/10.1021/acsnano.6b06580 |
| 22/11/2016 | Mo2C/NCF | 0.5 M H2SO4 | 0.28 | | | 144 | 10 | 3.57E-02 | https://doi.org/10.1021/acsnano.6b06580 |
| 19/04/2017 | P-Mo2C@C nanowires | 0.5 M H2SO4 | 1.30 | | | 89 | 10 | 7.69E-03 | https://doi.org/10.1039/C7EE00388A |
| 13/10/2017 | Mo2C nanobelts | 0.5M H2SO4 | 16.00 | | | 140 | 10 | 6.25E-04 | https://doi.org/10.1016/j.apcatb.2017.10.025 |

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|---|---|---|---|---|---|---|---|---|---|
| 31/10/2017 | Ni2PMo2C | 0.5 M H2SO4 | 0.20 | 200 | 2.78E+00 | 154 | 10 | 5.00E-02 | https://doi.org/10.1021/acs.chemmater.7b03377 |
| 31/10/2017 | CoPMo2C | 0.5 M H2SO4 | 0.20 | 200 | 1.61E+00 | 158 | 10 | 5.00E-02 | https://doi.org/10.1021/acs.chemmater.7b03377 |
| 31/10/2017 | FePMo2C | 0.5 M H2SO4 | 0.20 | 200 | 1.30E+00 | 169 | 10 | 5.00E-02 | https://doi.org/10.1021/acs.chemmater.7b03377 |
| 31/10/2017 | Mo2C | 0.5 M H2SO4 | 0.20 | 200 | 4.30E-01 | 206 | 10 | 5.00E-02 | https://doi.org/10.1021/acs.chemmater.7b03377 |
| 22/11/2017 | Mo2N-Mo2C | 0.5M H2SO4 | 0.34 | 100 | 8.60E-02 | 157 | 10 | 2.97E-02 | https://doi.org/10.1002/adma.201704156 |
| 03/01/2018 | Mo2C-carbon | 0.5M H2SO4 | 0.57 | | | 70 | 10 | 1.75E-02 | https://doi.org/10.1002/advs.201700733 |
| 02/03/2018 | N-doped WC | 0.5M H2SO4 | 16.00 | | | 89 | 10 | 6.25E-04 | https://doi.org/10.1038/s41467-018-03429-z |
| 02/03/2018 | N-WC nanoarray | 0.5 M H2SO4 | 10.00 | | | 113 | 10 | 1.00E-03 | https://doi.org/10.1038/s41467-018-03429-z |
| 02/03/2018 | N-WC nanoarray | 0.5 M H2SO4 | 10.00 | | | 310 | 200 | 2.00E-02 | https://doi.org/10.1038/s41467-018-03429-z |
| 05/03/2018 | N-Mo2C@C | 0.5M H2SO4 | 0.53 | | | 72 | 10 | 1.88E-02 | https://doi.org/10.1016/j.apcatb.2017.10.025 |
| 05/03/2018 | Co-Mo2C@C | 0.5M H2SO4 | 0.53 | | | 122 | 10 | 1.88E-02 | https://doi.org/10.1016/j.apcatb.2017.10.025 |
| 05/03/2018 | Fe-Mo2C@C | 0.5M H2SO4 | 0.53 | | | 129 | 10 | 1.88E-02 | https://doi.org/10.1016/j.apcatb.2017.10.025 |
| 05/03/2018 | Cr-Mo2C@C | 0.5M H2SO4 | 0.53 | | | 147 | 10 | 1.88E-02 | https://doi.org/10.1016/j.apcatb.2017.10.025 |
| 24/05/2018 | Ni/WC | 0.5M H2SO4 | 0.70 | | | 52 | 10 | 1.43E-02 | https://doi.org/10.1039/C8EE01129J |
| 10/06/2018 | W-C single atom catalyst | 0.5M H2SO4 | 0.41 | 52 | 1.00E+00 | 105 | 10 | 2.45E-02 | https://doi.org/10.1002/adma.201800396 |
| 01/09/2018 | MoS2/Ti3C2Tx | 0.5M H2SO4 | 0.28 | | | 152 | 10 | 3.53E-02 | https://doi.org/10.1016/j.apcatb.2018.08.083 |

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|---|---|---|---|---|---|---|---|---|---|
| 20/12/2018 | Mo2C-basal functionalized | 0.5M H2SO4 | 1.00 | 250 | 3.00E-03 | 189 | 10 | 1.00E-02 | https://doi.org/10.1021/acsaem.7b00054 |
| 21/12/2018 | Co-carbon@Mo2C | 0.5M H2SO4 | 0.83 | | | 143 | 10 | 1.20E-02 | https://doi.org/10.1016/j.nanoen.2018.12.060 |
| 17/01/2019 | MoS2/Mo2C | 0.5M H2SO4 | 0.30 | | | 220 | 1000 | 3.33E+00 | https://doi.org/10.1038/s41467-018-07792-9 |
| 26/01/2019 | Ti3C2Ox | 0.5M H2SO4 | 0.40 | | | 190 | 10 | 2.50E-02 | https://doi.org/10.1002/cssc.201803032 |
| 06/05/2019 | Fe3W3C NRs/RGO | 0.5 M H2SO4 | 0.82 | 100 | 2.30E-01 | 57 | 10 | 1.22E-02 | https://doi.org/10.1016/j.nanoen.2019.05.009 |
| 06/05/2019 | WC NRs/RGO | 0.5 M H2SO4 | 0.82 | 100 | 2.00E-02 | 151 | 10 | 1.22E-02 | https://doi.org/10.1016/j.nanoen.2019.05.009 |
| 20/09/2019 | Mo2C-Co | 1M H2SO4 | 0.10 | 250 | 1.00E-01 | 250 | 10 | 1.00E-01 | https://doi.org/10.1021/jacs.9b08897 |
| 02/11/2019 | Mo2C | 0.5M H2SO4 | 0.25 | | | 132 | 10 | 4.00E-02 | https://doi.org/10.1016/j.apcatb.2019.118352 |
| 02/11/2019 | Mo2C@NPCS | 0.5 M H2SO4 | 0.25 | | | 132 | 10 | 4.00E-02 | https://doi.org/10.1016/j.apcatb.2019.118352 |
| 13/12/2019 | MoSe2 –Mo2C | 0.5M H2SO4 | | | | 73 | 10 | | https://doi.org/10.1016/j.apcatb.2019.118531 |
| 27/12/2019 | Mo2C-MoOx/CC | 1M HClO4 | 1.80 | | | 60 | 10 | 5.56E-03 | https://doi.org/10.1002/anie.201914752 |
| 25/02/2020 | Co-doped Mo2C | 1M HClO4 | 0.39 | | | 125 | 10 | 2.55E-02 | https://doi.org/10.1002/adfm.202000561 |
| 02/08/2020 | Ni/vanadium carbide | 0.5 M H2SO4 | 2.11 | 150 | 2.40E-01 | 111 | 10 | 4.74E-03 | https://doi.org/10.1002/aenm.202002260 |
| 02/08/2020 | Ni/Fe3C | 0.5 M H2SO4 | 2.53 | | | 112 | 10 | 3.95E-03 | https://doi.org/10.1002/aenm.202002260 |
| 02/08/2020 | Ni/vanadium carbide | 0.5 M H2SO4 | 2.11 | | | 270 | 150 | 7.11E-02 | https://doi.org/10.1002/aenm.202002260 |
| 02/08/2020 | Ni/Fe3C | 0.5 M H2SO4 | 2.53 | | | 291 | 150 | 5.93E-02 | https://doi.org/10.1002/aenm.202002260 |

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|---|---|---|---|---|---|---|---|---|---|
| 02/08/2020 | Ni/VC | 0.5M H2SO4 | 2.11 | 150 | 2.40E-01 | 111 | 10 | 4.74E-03 | https://doi.org/10.1002/aenm.202002260 |
| 02/08/2020 | Ni/Fe3C | 0.5M H2SO4 | 2.53 | | | 112 | 10 | 3.95E-03 | https://doi.org/10.1002/aenm.202002260 |
| 24/11/2020 | Co-Mo2C/N-doped carbon | 0.5M H2SO4 | 1.13 | | | 116 | 10 | 8.83E-03 | https://doi.org/10.1016/j.apcatb.2020.119738 |
| 29/03/2021 | Mo2C/CFP | 0.5M H2SO4 | 2.00 | | | 56 | 10 | 5.00E-03 | https://doi.org/10.1039/D1NR00169H |
| 07/04/2021 | WC650 | 0.5 M H2SO4 | 0.53 | | | 120 | 10 | 1.89E-02 | https://doi.org/10.1088/2632-959X/abf2ad |
| 13/11/2021 | β-Mo2C | 0.5 M H2SO4 | 0.41 | 200 | 3.09E+00 | 156 | 100 | 2.46E-01 | https://doi.org/10.1021/acsanm.1c02770 |
| 22/11/2021 | MoC-Mo2C-790 oC | 0.5M H2SO4 | | 250 | 1.30E+00 | 114 | 10 | | https://doi.org/10.1038/s41467-021-27118-6 |
| 18/07/2022 | Ni-doped Mo2C@CFP | 0.5M H2SO4 | 2.00 | | | 56 | 10 | 5.00E-03 | https://doi.org/10.1007/s40145-022-0610-6 |

**Table S4**. Platinum-based hydrogen evolution reaction electrocatalyst activities.

| **Date of publication** | **Catalyst** | **Electrolyte** | **Loading [mg cm$^{-2}$]** | **Overpotential for TOF [mV] vs RHE** | **TOF [H2 s$^{-1}$ site$^{-1}$]** | **Overpotential to achieve geometric current density and mass activity [mV] vs RHE** | **Geometric current density [mA cm$^{-2}$]** | **Mass activity [A mg$^{-1}$]** | **TOF [$H_2$ s$^{-1}$ site$^{-1}$] at j = 10mA cm$^{-2}$** | **DOI** |
|---|---|---|---|---|---|---|---|---|---|---|
| 05/07/1905 | Pt on Floating electrode | 4 M HClO4 | 8.40E-04 | 1.00E-01 | 3.01E+03 | 0.10 | 1260 | 1.29E+03 | | https://doi.org/10.1149/05801.0039ecst |
| 05/07/1905 | Pt on Floating electrode | 4 M HClO4 | 8.40E-04 | 2.00E-01 | 7.43E+03 | 0.20 | 3040 | 3.18E+03 | | https://doi.org/10.1149/05801.0039ecst |

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|---|---|---|---|---|---|---|---|---|---|---|
| 27/08/2015 | Pt-TiO2–Ti-pn+Si | 1 M HClO4 | 1.00E-03 | | | 32.00 | 10 | 1.00E+01 | | https://doi.org/10.1039/C5EE02188J |
| 17/03/2017 | 400-SWNT/Pt | 0.5 M H2SO4 | 5.70E-04 | | | 27.00 | 10 | 1.75E+01 | | https://doi.org/10.1021/acscatal.7b00199 |
| 30/07/2018 | Pt-GT-1 | 0.5 M H2SO4 | 1.40E-03 | | | 18.00 | 10 | 7.14E+00 | 7.20E+00 | https://doi.org/10.1038/s41560-018-0209-x |
| 22/11/2018 | PtNP/OMC | 0.5 M H2SO4 | 1.10E-03 | | | 33.00 | 10 | 9.09E+00 | | https://doi.org/10.1016/j.jcat.2018.11.006 |
| 12/12/2018 | $Mo_2TiC_2T_x$–$Pt_{SA}$ | 0.5 M H2SO4 | 1.20E-02 | | | 30.00 | 10 | 8.33E-01 | | https://doi.org/10.1038/s41929-018-0195-1 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.30E-05 | 1.50E-02 | 3.10E+02 | 133.00 | 10 | 7.69E+02 | 6.60E+03 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.90E-05 | 1.50E-02 | 2.60E+02 | 115.00 | 10 | 5.26E+02 | 4.20E+03 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 5.00E-05 | 1.50E-02 | 1.10E+02 | 85.00 | 10 | 2.00E+02 | 1.40E+03 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.00E-04 | 1.50E-02 | 7.90E+01 | 61.00 | 10 | 1.00E+02 | 7.50E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.70E-05 | 1.50E-02 | 2.40E+02 | 120.00 | 10 | 5.88E+02 | 4.60E+03 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 5.00E-05 | 1.50E-02 | 9.80E+01 | 83.00 | 10 | 2.00E+02 | 1.20E+03 | https://doi.org/10.1021/acsenergylett.1c00246 |

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|---|---|---|---|---|---|---|---|---|---|---|
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.00E-04 | 1.50E-02 | 7.30E+01 | 54.00 | 10 | 1.00E+02 | 6.30E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 2.00E-04 | 1.50E-02 | 4.80E+01 | 41.00 | 10 | 5.00E+01 | 3.00E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 2.00E-04 | 1.50E-02 | 5.80E+01 | 48.00 | 10 | 5.00E+01 | 3.90E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 5.00E-04 | 1.50E-02 | 2.80E+01 | 35.00 | 10 | 2.00E+01 | 1.20E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 5.00E-04 | 1.50E-02 | 3.60E+01 | 34.00 | 10 | 2.00E+01 | 1.30E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 1.00E-03 | 1.50E-02 | 2.20E+01 | 29.00 | 10 | 1.00E+01 | 7.10E+01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Small raster | 0.5 M H2SO4 | 5.00E-03 | 1.50E-02 | 9.00E+00 | 20.00 | 10 | 2.00E+00 | 1.80E+01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Large raster | 0.5 M H2SO4 | 5.65E-04 | 1.50E-02 | 4.70E+01 | 24.00 | 10 | 1.77E+01 | 1.00E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Large raster | 0.5 M H2SO4 | 1.00E-03 | 1.50E-02 | 2.40E+01 | 21.00 | 10 | 1.00E+01 | 4.40E+01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | UHV Pt NP - Large raster | 0.5 M H2SO4 | 5.00E-03 | 1.50E-02 | 1.30E+01 | 16.00 | 10 | 2.00E+00 | 1.30E+01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | Commercial Pt/C | 0.5 M H2SO4 | 5.00E-04 | 1.50E-02 | 4.00E+01 | 30.00 | 10 | 2.00E+01 | 1.30E+02 | https://doi.org/10.1021/acsenergylett.1c00246 |

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|---|---|---|---|---|---|---|---|---|---|---|
| 19/03/2021 | Commercial Pt/C | 0.5 M H2SO4 | 1.00E-03 | 1.50E-02 | 1.70E+01 | 30.00 | 10 | 1.00E+01 | 5.50E+01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | Commercial Pt/C | 0.5 M H2SO4 | 5.00E-03 | 1.50E-02 | 5.00E+00 | 21.00 | 10 | 2.00E+00 | 8.80E+00 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | Commercial Pt/C | 0.5 M H2SO4 | 5.00E-02 | 1.50E-02 | 3.00E-01 | 21.00 | 10 | 2.00E-01 | 6.90E-01 | https://doi.org/10.1021/acsenergylett.1c00246 |
| 19/03/2021 | Commercial Pt/C | 0.5 M H2SO4 | 1.00E-01 | 1.50E-02 | 4.00E-01 | 18.00 | 10 | 1.00E-01 | 6.00E-01 | https://doi.org/10.1021/acsenergylett.1c00246 |