Supplementary information

Gamma-rays induced strong coupling between Ru nanoparticle and cobalt-based metal organic framework nanolayer for methanol oxidation and hydrogen evolution

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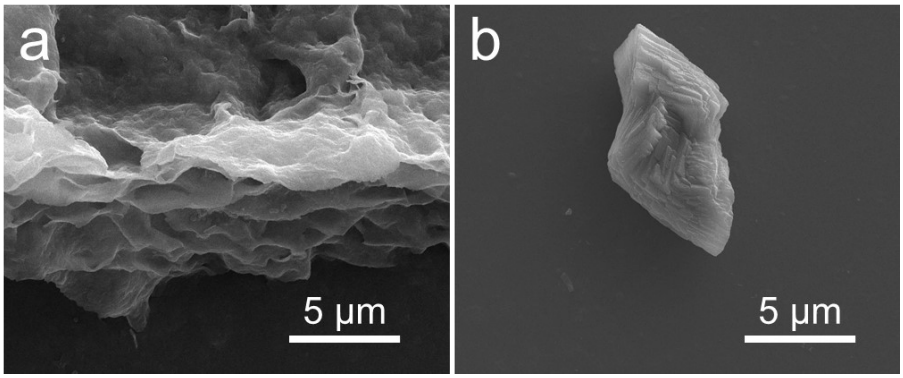

Fig. S1 The SEM image of (a) Co MOLs, (b) bulk Co MOFs.

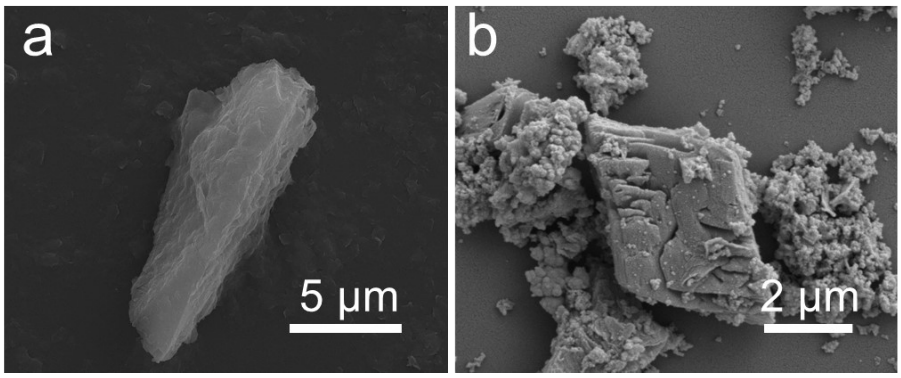

Fig. S2 The SEM image of (a) Co MOLs-20 kGy, (b) bulk Co MOFs-20 kGy.

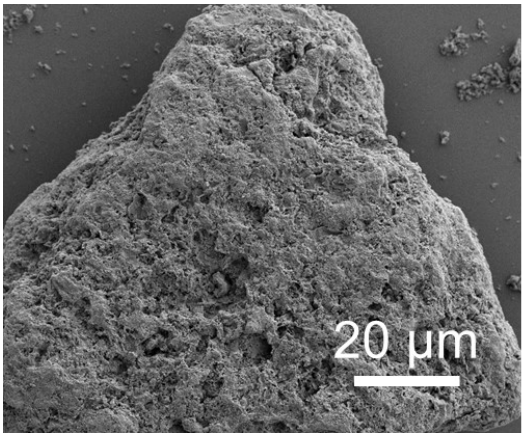

Fig. S3 The SEM image of Ru@Co MOFs.

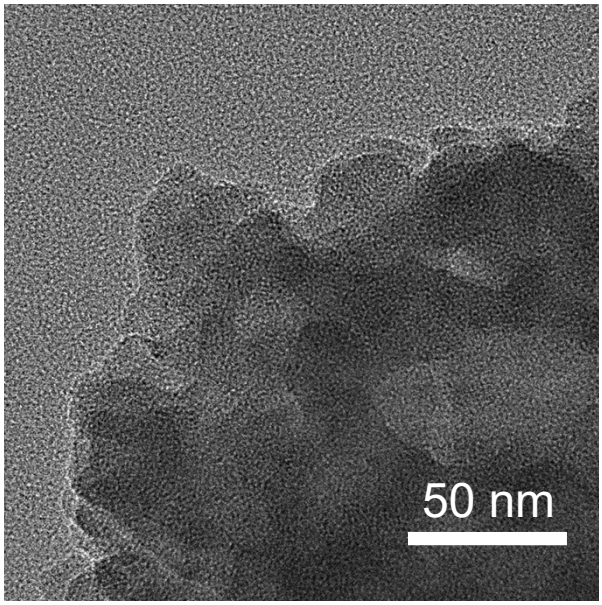

Fig. S4 The TEM image of Ru@Co MOLs.

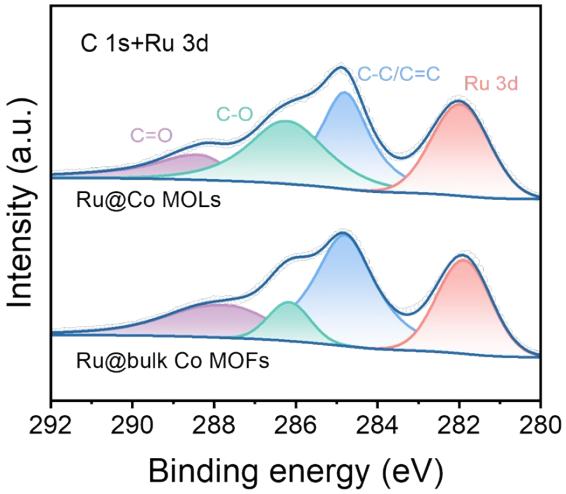

Fig. S5 High-resolution XPS spectra of C 1s+Ru 3d for Ru@Co MOLs and Ru@Co MOFs.

In the C 1s spectrum of Ru@Co MOLs in Fig. S4, three peaks correspond to C=O (288.35 eV), C-O (286.2 eV), and C-C/C=C (284.8 eV), while the peak at 281.97 eV corresponds to the Ru $3d_{5/2}$ of oxidized Ru species.

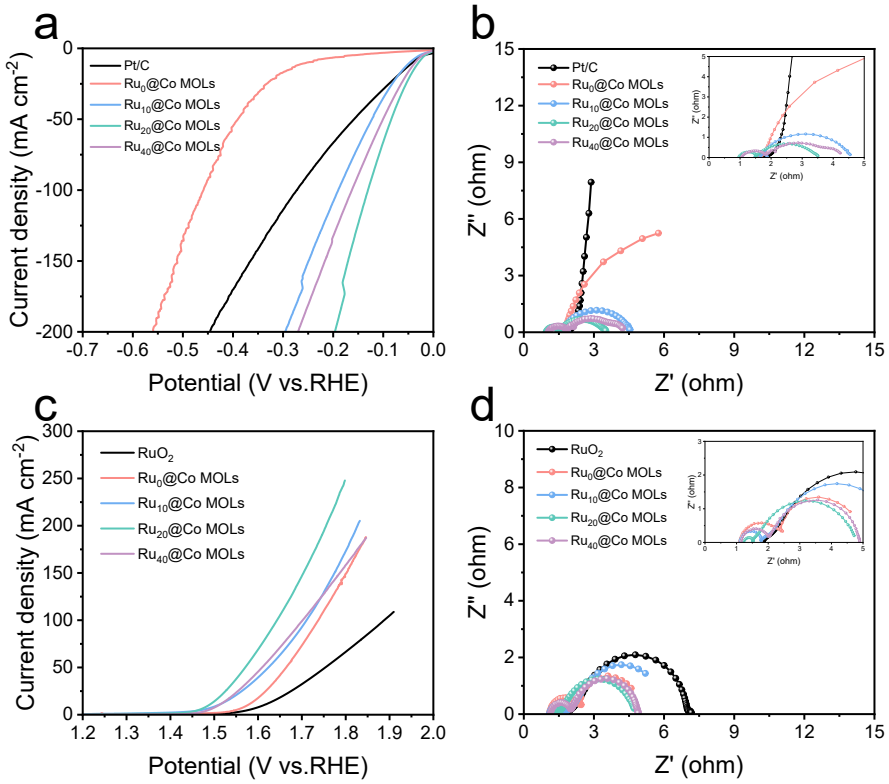

Fig. S6 The LSV and EIS curves of HER and OER of Co MOLs and Ru@Co MOLs with different Ru loading amounts.

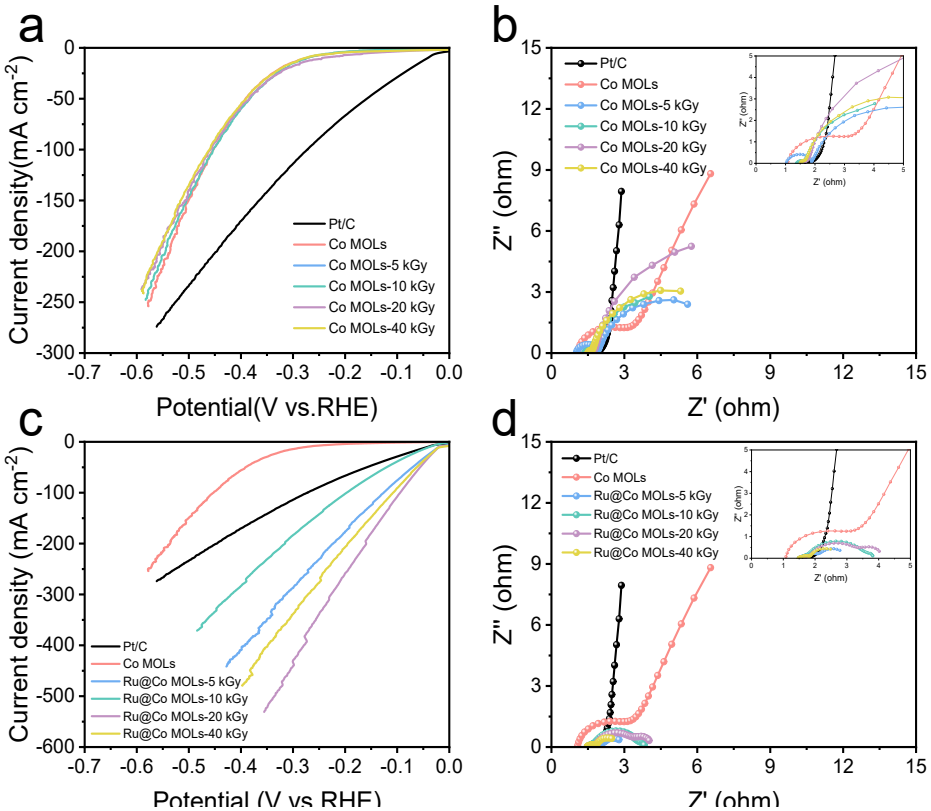

Fig. S7 The LSV and EIS curves of Co MOLs and Ru@Co MOLs with different absorbed doses.

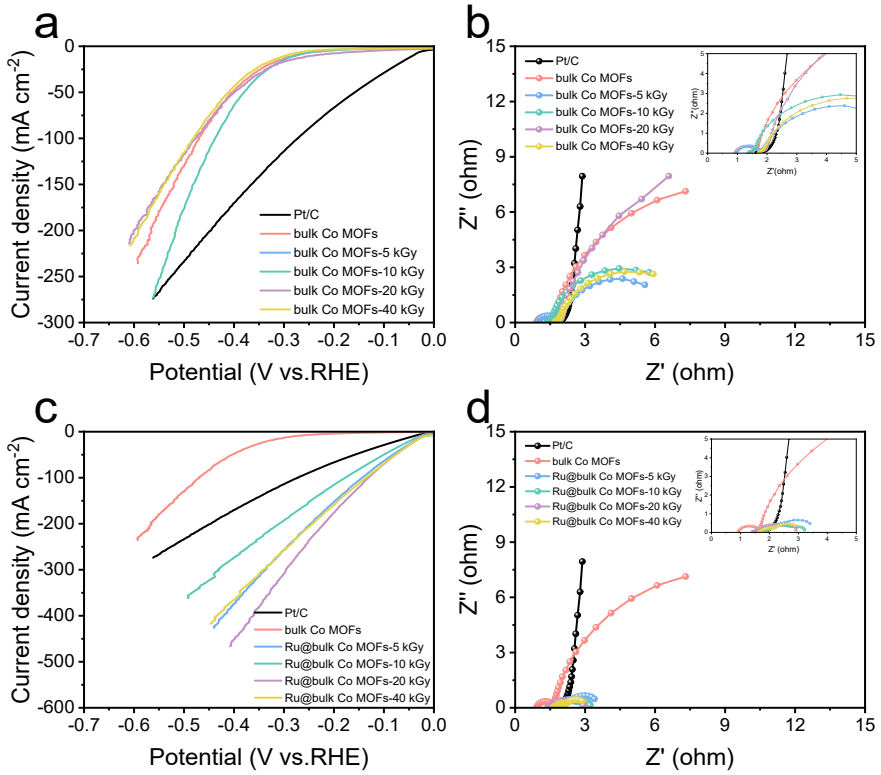

Fig. S8 The LSV and EIS curves of bulk Co MOFs and Ru@Co MOFs with different absorbed doses.

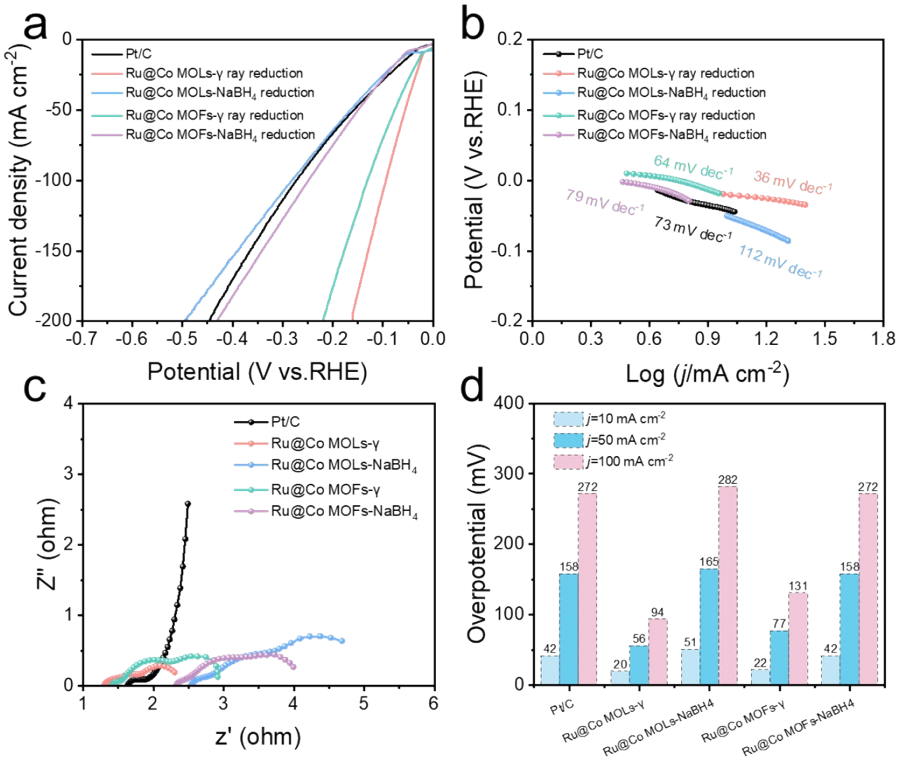

Fig. S9 (a) The LSV curves, (b) The Tafel slope and (c) The EIS curves of Ru@Co MOLs and Ru@Co MOFs synthesized by different synthetic methods for HER. (d) The overpotential values of Ru@Co MOLs and Ru@Co MOFs synthesized by different synthesis methods at 10, 50 and 100 mA cm^{-2}.

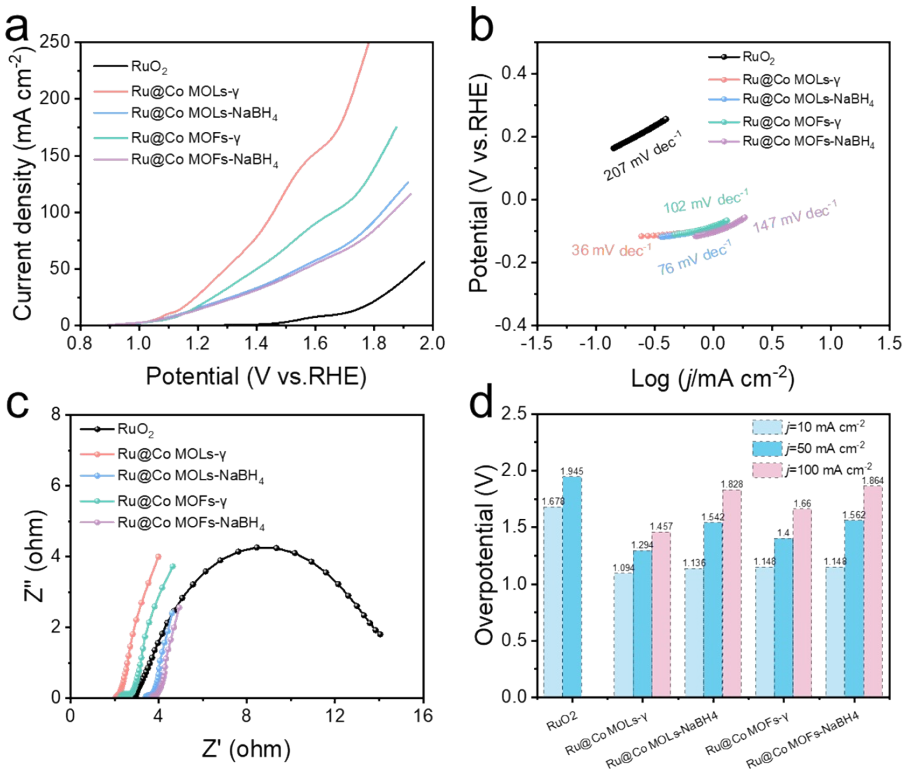

Fig. S10 (a) The LSV curves, (b) The Tafel slope and (c) The EIS curves of Ru@Co MOLs and Ru@Co MOFs synthesized by different synthetic methods for MOR. (d) The overpotential values of Ru@Co MOLs and Ru@Co MOFs synthesized by different synthesis methods at 10, 50 and 100 mA cm^{-2}.

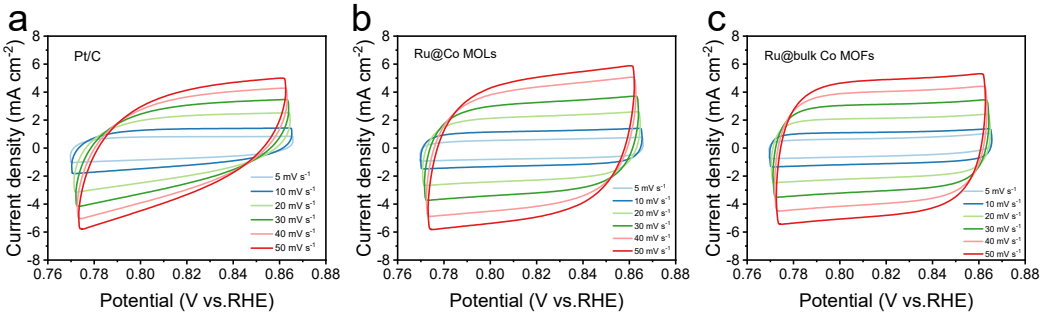

Fig. S11 The CV curves at non-Faradaic regions with various scan rates for (a) Pt/C, (b) Ru@Co MOLs and (c) Ru@Co MOFs.

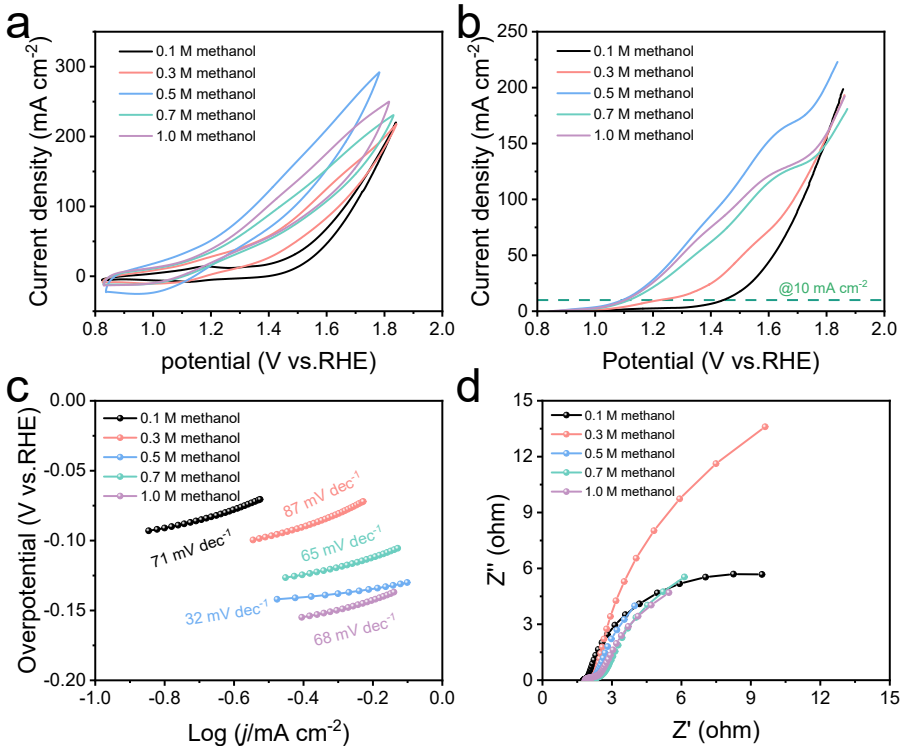

Fig. S12 (a) The CV curves, (b) The LSV curves, (c) The Tafel slope and (d) The EIS curves of different methanol concentrations for Ru@Co MOLs.

Table S1 Fitting results of EIS for different catalysts.

Samples	R_s (ohm)	R_{ct} (ohm)
Pt/C	1.510	2.284
Co MOLs	1.243	9.43
Co MOFs	1.332	18.773
Ru@Co MOLs	1.315	1.234
Ru@Co MOFs	1.523	1.797

Table S2. Comparison of the HER activity for Ru@Co MOLs with other reported catalysts in alkaline electrolyte.

Catalyst	Overpotential·(mV)·@10·mA·cm^{-2}	Tafel·slope (mV·dec^{-1})	Reference
Ru@Co MOLs	20	35	This work
Ru SAs-SnO_2/C	10	25	[1]
RuCo ANSs	10	21	[2]
β-$Ni(OH)_2$/Ni-Ru SAs NSAs	16	21	[3]
CNT-RuSx	17	35	[4]
Mo_2C-Ru/C	22	25	[5]
Ru-CoP/NC	22	50	[6]
Ru/P-TiO_2	27	28	[7]
Ru/NDC-4	29	21	[8]
Ru/MoO_{2-x}	29	22	[9]
Ru/Co_3O_4	31	70	[10]
Ru/$Ni(OH)_2$	31	30	[11]
Ru-$CoFe_2O_4$/NF	31	48	[12]
Ru_{NP}-Ru_{SA}@CFN-800	33	37	[13]
$NiRu_{0.13}$-BDC	34	32	[14]
Ru@TiO_2-V	34	35	[15]
Ru-MnFeP/NF	35	36	[16]
V_O-Ru/HfO_2-OP	39	29	[17]
Ru-G/CC	40	76	[18]

Ru@1T-MoS_2-MXene	44	47	[19]
Ru-NiFe-P	44	80	[20]
(Ru-Co)O_x	44	23	[21]
BPed-Ru-Gr	51	50	[22]
$Ru_{0.10}$@2H-MoS_2	51	65	[23]
Ni_5P_4-Ru	54	52	[24]
ECM@Ru	83	59	[25]
H-B/Ru-FeP	110	76	[26]

Table S3. The cell voltage of Ru@Co MOLs|| Ru@Co MOLs methanol electrolyzer at 10 mA cm^{-2} compared with other catalysts reported in 1 M KOH.

Catalyst	Voltage $_{MOR\|\|HER}$ at 10 mA cm^{-2}	Voltage $_{MOR\|\|HER}$ at 10 mA cm^{-2}	Reference
Ru@Co MOLs	1.54	1.18	This work
NiGd@N–C/NF	1.60	1.34	[27]
Mo-Co_4N	1.60	1.43	[28]
$NiCoSe_4$@NiCo-LDH	1.633	1.38	[29]
MoNi/DS-dNPC/NF	1.65	1.47	[30]
$Co(OH)_2$@HOS/CP	1.66	1.50	[31]
$Ni_{0.33}Co_{0.67}(OH)_2$/NF	1.66	1.50	[32]
MnSe/$Co_{0.85}$Se@NC	1.69	1.49	[33]
$Ni(OH)_2$/NF	1.70	1.52	[34]
3D Sn/NF-15	1.76	1.54	[35]

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