Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

MoO_x-modified bimetallic alloy nanoparticles for highly efficient hydrogen production from hydrous hydrazine

Qilu Yao, Meng He, Xiaoling Hong, Xiaoliang Zhang, Zhang-Hui Lu*

Institute of Advanced Materials (IAM), College of Chemistry and Chemical Engineering, Jiangxi Normal University, Nanchang 330022, P.R. China.

E-mail: luzh@jxnu.edu.cn

Table S1 Catalysts composition determined by inductively coupled plasma atomic emission spectroscopic (ICP-AES).

Catalysts	Ni/Pt (molar ratio)	Mo (mol%)
$Ni_{0.2}Pt_{0.8}$-MoO_x (16.7mol% Mo)	0.23/0.77	16.3
$Ni_{0.4}Pt_{0.6}$-MoO_x (16.7mol% Mo)	0.38/0.62	16.2
$Ni_{0.6}Pt_{0.4}$-MoO_x (16.7mol% Mo)	0.61/0.39	16.5
$Ni_{0.8}Pt_{0.2}$-MoO_x (16.7mol% Mo)	0.82/0.18	16.8
Ni-MoO_x (16.7mol% Mo)	~	16.6
Pt-MoO_x (16.7mol% Mo)	~	16.3

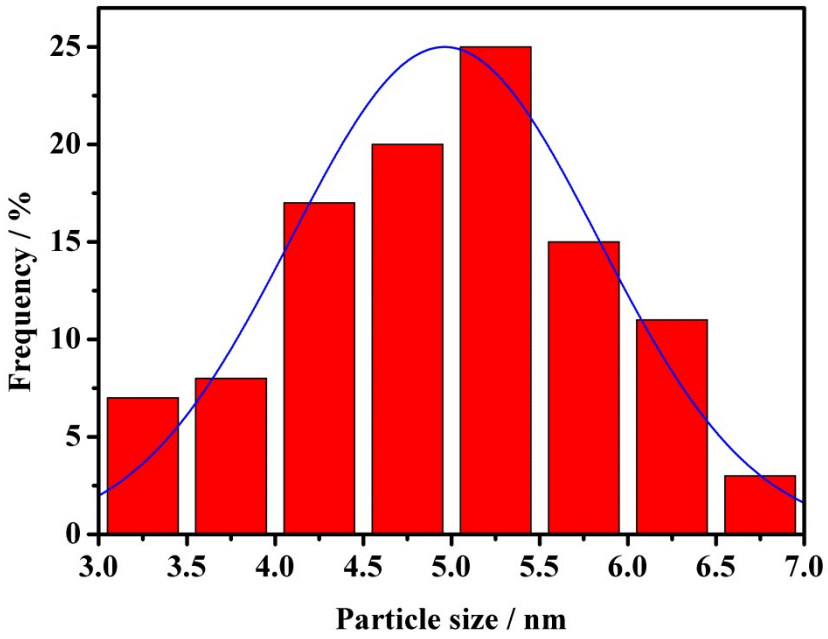

Fig. S1 Particle size distribution of NiPt-MoO_x catalyst.

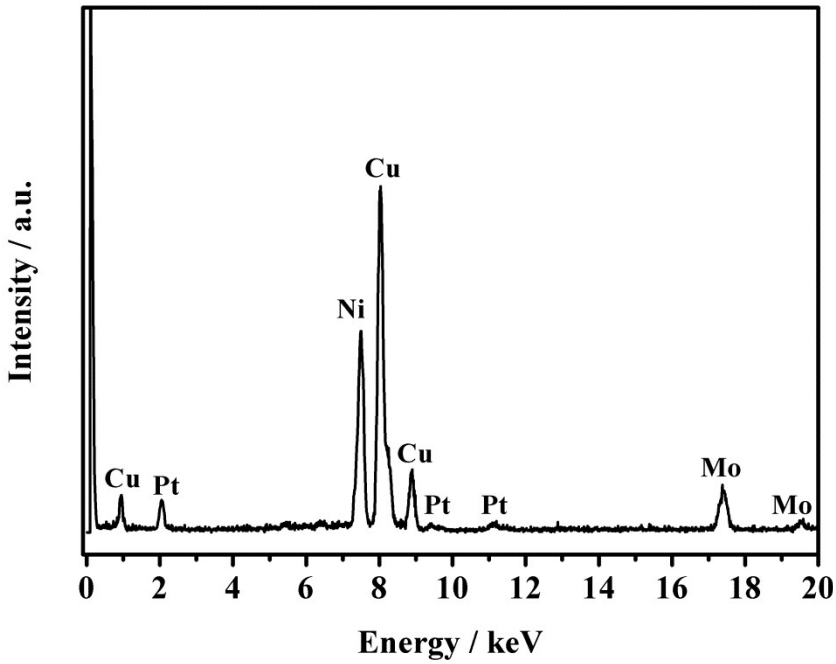

Fig. S2 The corresponding EDX spectrum of the NiPt-MoO_x catalyst. The Cu signal originates from Cu grid.

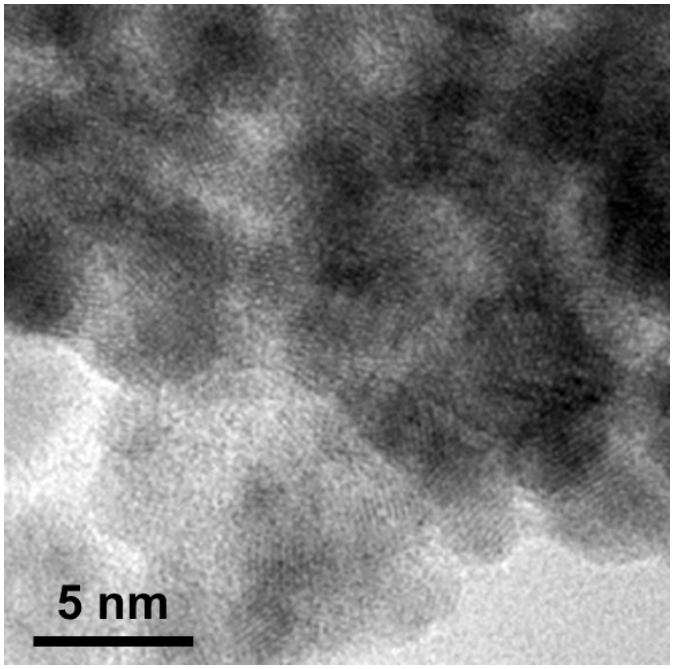

Fig. S3 HRTEM image of the NiPt-MoO_x catalyst.

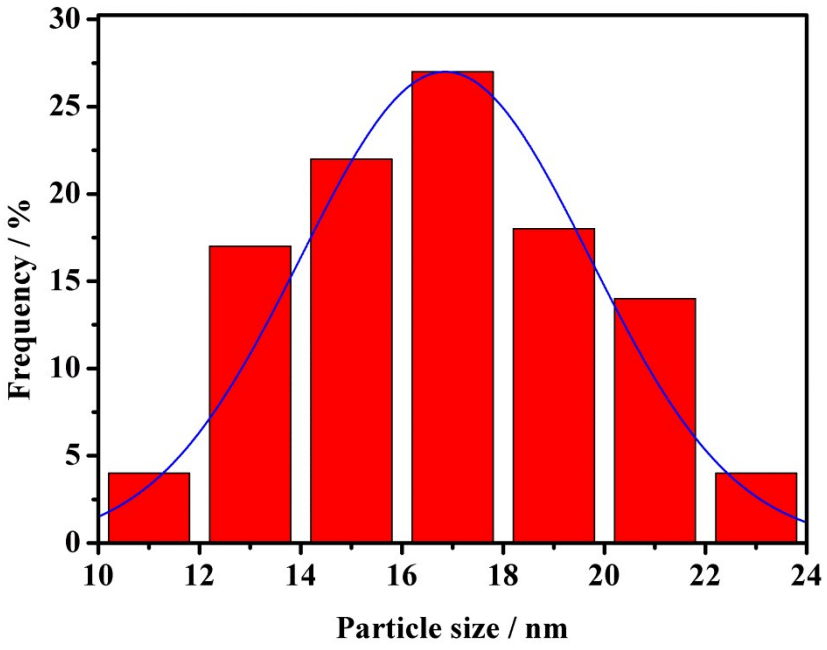

Fig. S4 Particle size distribution of NiPt catalyst.

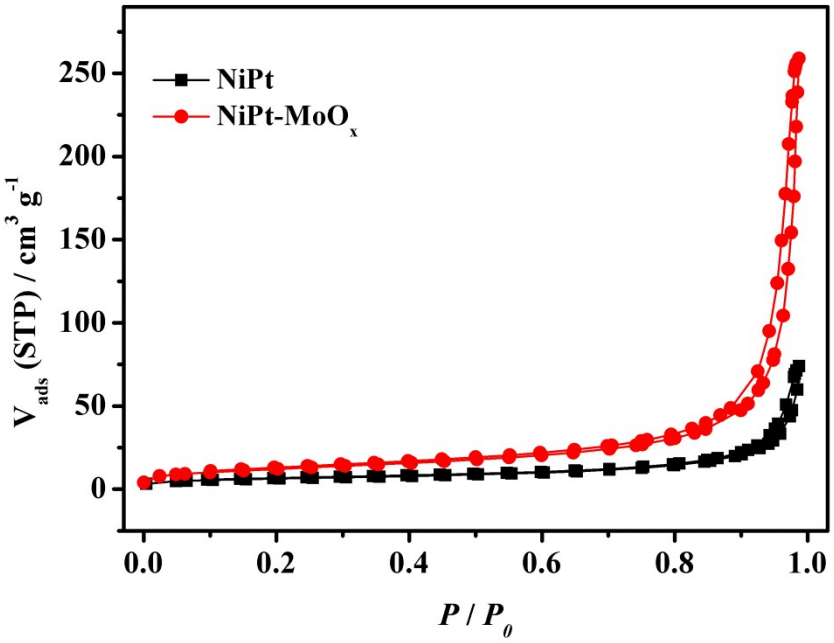

Fig. S5 N_2 adsorption-desorption isotherms for NiPt-MoO_x and NiPt catalyst.

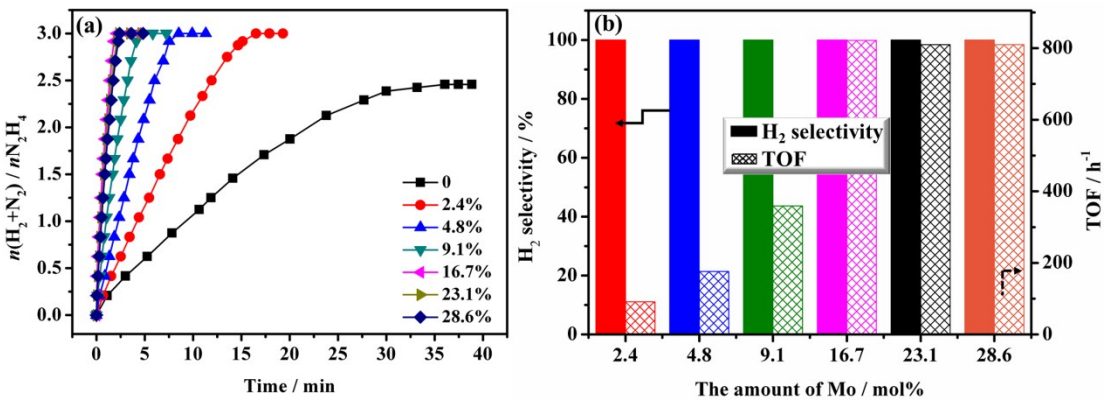

Fig. S6 (a) Time course plots and (b) the related hydrogen selectivity and TOF values for H_2 evolution from $N_2H_4 \cdot H_2O$ (200 mM, 5 mL) decomposition over $Ni_{0.6}Pt_{0.4}$-MoO_x catalysts with different Mo contents in the presence of NaOH (1.0 M) at 323 K.

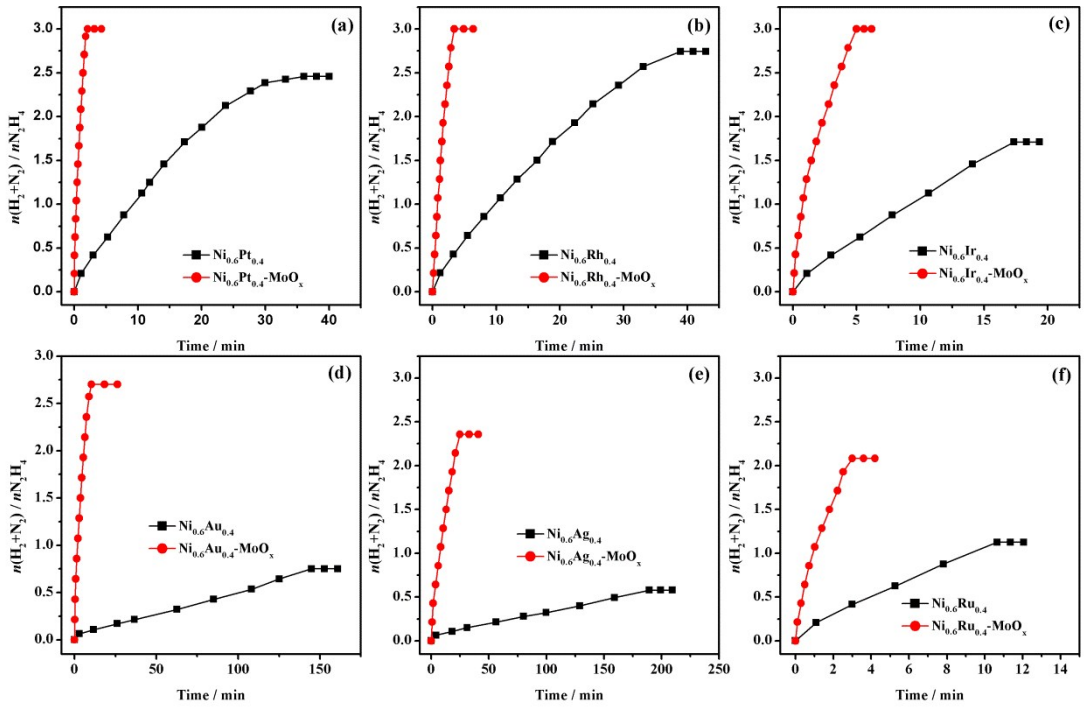

Fig. S7 Time course plots for H_2 evolution from $N_2H_4 \cdot H_2O$ (200 mM, 5 mL) decomposition over $Ni_{0.6}M_{0.4}$-MoO_x and $Ni_{0.6}M_{0.4}$ (M = Pt, Rh, Ir, Au, Ag, and Ru) catalysts in the presence of NaOH (1.0 M) at 323 K.

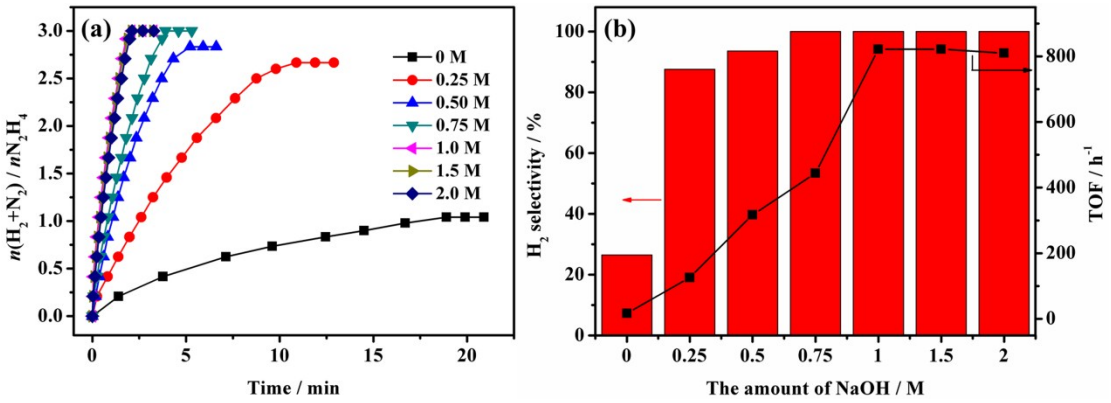

Fig. S8. (a) Time course plots and (b) the related hydrogen selectivity and TOF values for H_2 evolution from $N_2H_4 \cdot H_2O$ (200 mM, 5 mL) decomposition over NiPt-MoO_x catalysts with different concentrations of NaOH at 323 K.

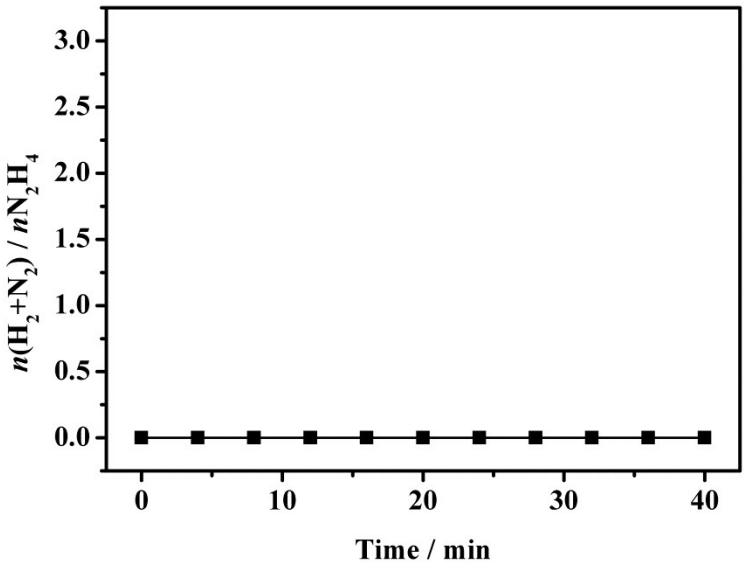

Fig. S9 Time course plots for H_2 evolution from $N_2H_4 \cdot H_2O$ (200 mM, 5 mL) decomposition in the presence of NaOH (1.0 M) at 323 K.

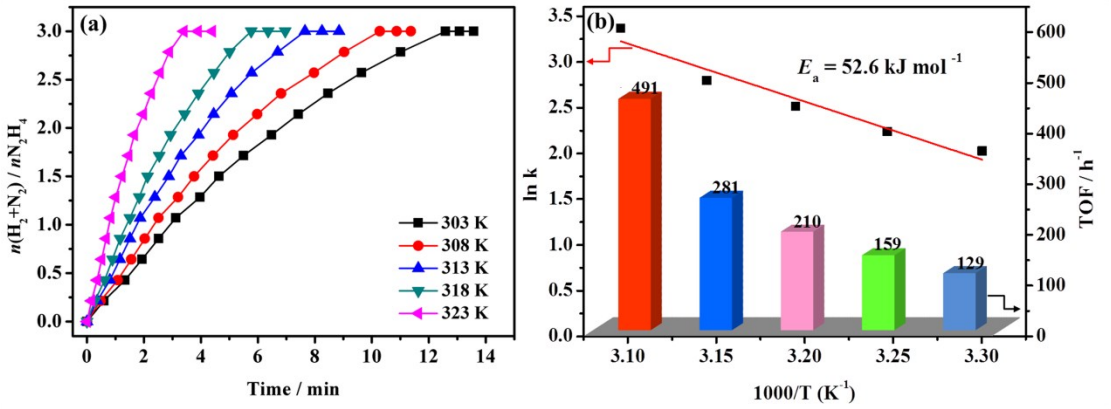

Fig. S10 (a) Time course plots for H_2 evolution from N_2H_4 aqueous solution (200 mM, 5 mL) over $Ni_{0.6}Rh_{0.4}$-MoO_x catalyst at different temperatures. (b) The corresponding TOF values and Arrhenius plots (ln k versus 1/T) for H_2 evolution from N_2H_4 aqueous solution.

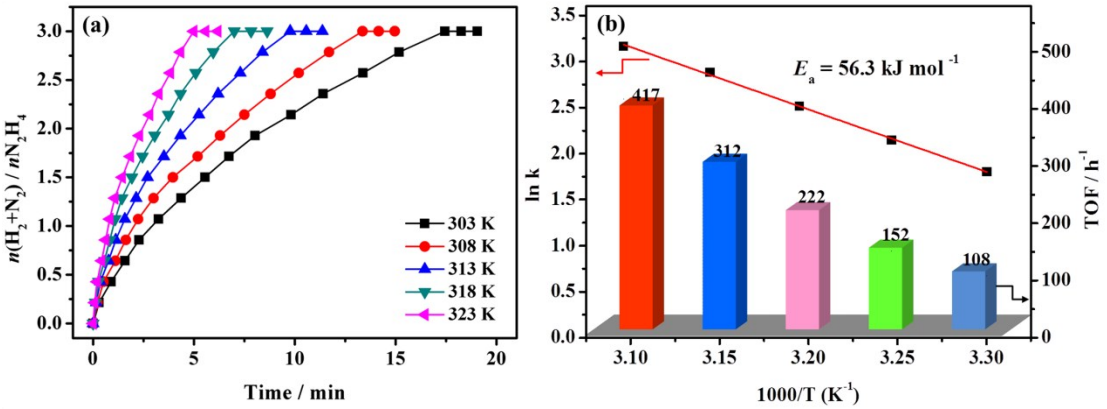

Fig. S11 (a) Time course plots for H_2 evolution from N_2H_4 aqueous solution (200 mM, 5 mL) over $Ni_{0.6}Ir_{0.4}$-MoO_x catalyst at different temperatures. (b) The corresponding TOF values and Arrhenius plots (ln k versus 1/T) for H_2 evolution from N_2H_4 aqueous solution.

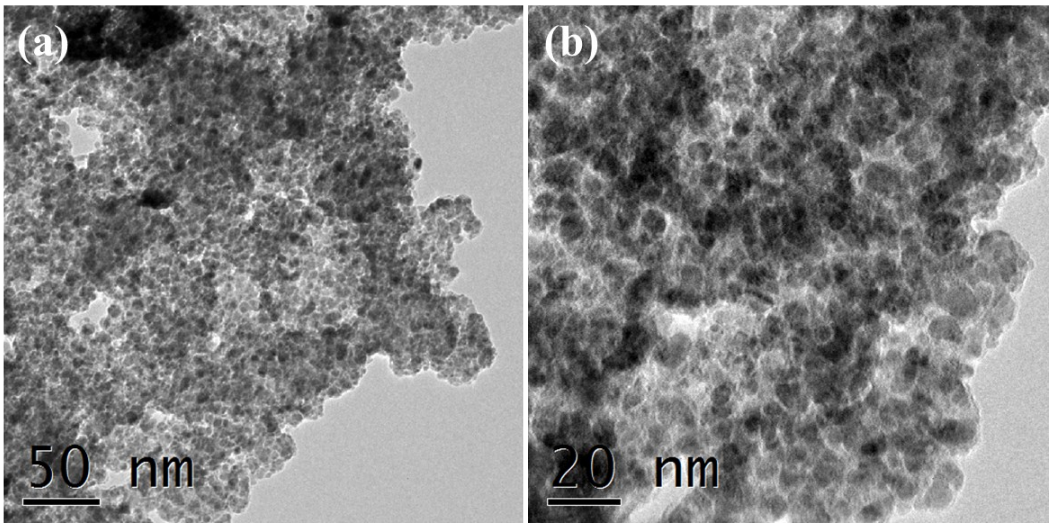

Fig. S12 TEM images of $Ni_{0.6}Pt_{0.4}$-MoO_x after the durability test.

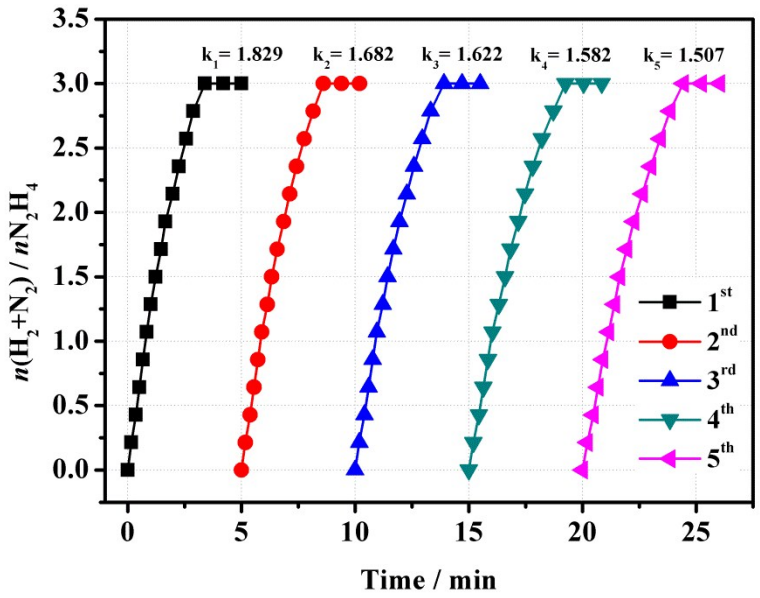

Fig. S13 Stability test for H_2 evolution from N_2H_4 aqueous solution (200 mM, 5 mL) over $Ni_{0.6}Rh_{0.4}$-MoO_x NPs at 323 K.

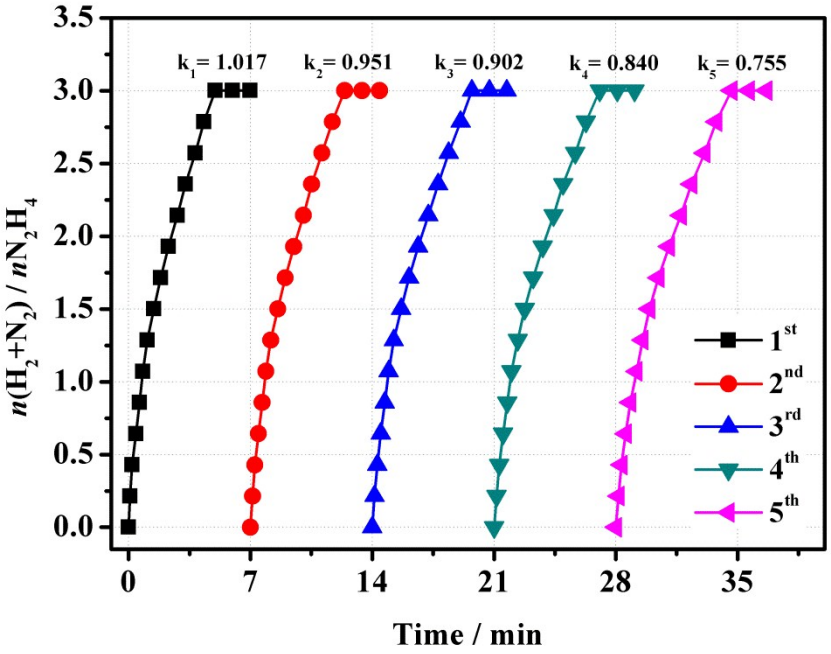

Fig. S14 Stability test for H_2 evolution from N_2H_4 aqueous solution (200 mM, 5 mL) over $Ni_{0.6}Ir_{0.4}$-MoO_x NPs at 323 K.

Table S2 Comparison of activities of different catalysts for hydrogen evolution from $N_2H_4 \cdot H_2O$ aqueous solution.

Catalysts	T (K)	H_2 Selectivity (%)	TOF (h^{-1})	Ea (kJ mol^{-1})	Ref.
$Pt_{0.6}Ni_{0.4}$/PDA-rGO	30	100	903	33.39	S1
$Ni_{0.6}Pt_{0.4}$-MoO_x	50	100	822	49.6	This work
$(Ni_3Pt_7)_{0.5}$-$(MnO_x)_{0.5}$/NPC-900	50	100	706	50.15	S2
$Ni_{0.8}Pt_{0.2}$/MIL-101-NH_2	50	100	676	53.2	S3
$Ni_{40}Pt_{60}$-CNDs	50	100	594	43.9	S4
$Ni_{84}Pt_{16}$/graphene	50	100	415	40	S5
Ni_3Pt_7/graphene	50	100	416	49.36	S6
$Ni_{88}Pt_{12}$/MIL-101	50	100	350	55.5	S7
Ni@Ni-Pt/La_2O_3	50	100	312	56.20	S8
G_4-OH($Pt_{12}Ni_{48}$)	70	100	240	-	S9
PtNi/C	50	100	210	55.3	S10
Ni_3Pt_7/BNG-1000	25	100	199.4	28.4	S11
$Ni_{87}Pt_{13}$/meso-Al_2O_3	50	100	160	55.7	S12
Ni_6Pt_4-SF	25	100	150	-	S13
$Ni_{80}Pt_{20}$@ZIF-8	50	100	90	-	S14
$Ni_{0.90}Pt_{0.05}Rh_{0.05}$/$La_2O_3$	25	100	45.9	-	S15
$Ni_{0.9}Pt_{0.1}$/Ce_2O_3	25	100	28.1	42.3	S16
$NiPt_{0.057}$/Al_2O_3	30	99	16.5	34.0	S17

Calculation method for TOF

The turn over frequency (*TOF*) reported in this work is an apparent *TOF* value based on the number of metal (Ni + Pt) atoms in catalysts, which is calculated from the equation as follows:

$$\mathrm{TOF} = \frac{2P_{atm}V_{H_2+N_2}/RT}{3n_{\mathrm{Ni+Pt}} \times t} \qquad \text{(S1)}$$

Where P_{atm} is the atmospheric pressure, $V_{H_2+N_2}$ is the volume of generated gas when the conversion reached 50%, R is the universal gas constant, T is the room temperature, $n_{\mathrm{Ni+Pt}}$ is the total number of moles of (Ni + Pt) atoms in the catalyst and t is the time in hour when the conversion reached 50%.

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