Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A

Supporting Information

Highly Efficient Hydrogen Generation from Hydrous Hydrazine over Amorphous $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ Nanocatalyst at Room Temperature

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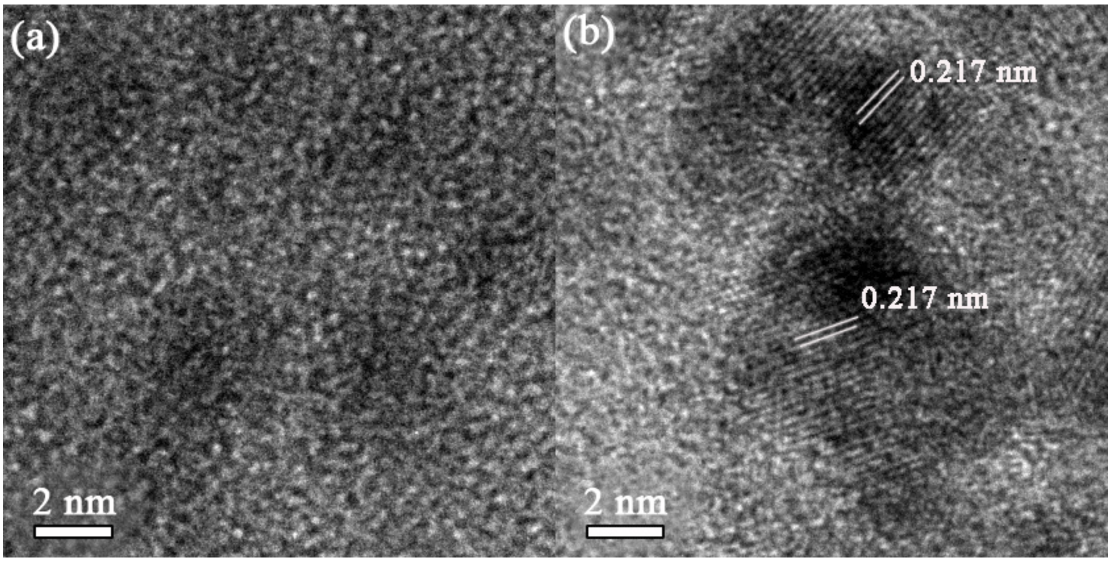

Fig. S1 HRTEM images of the as-synthesized a) $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ and b) $Ni_{0.9}Pt_{0.1}$ NPs.

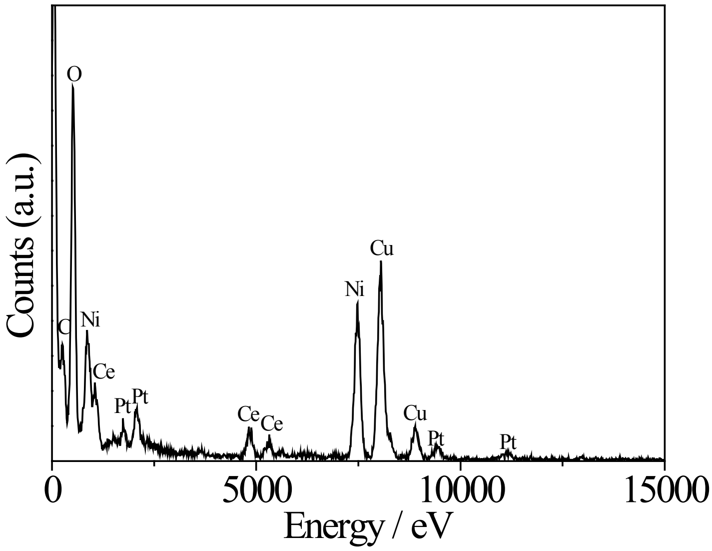

Fig. S2 EDS spectra for the $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ NPs.

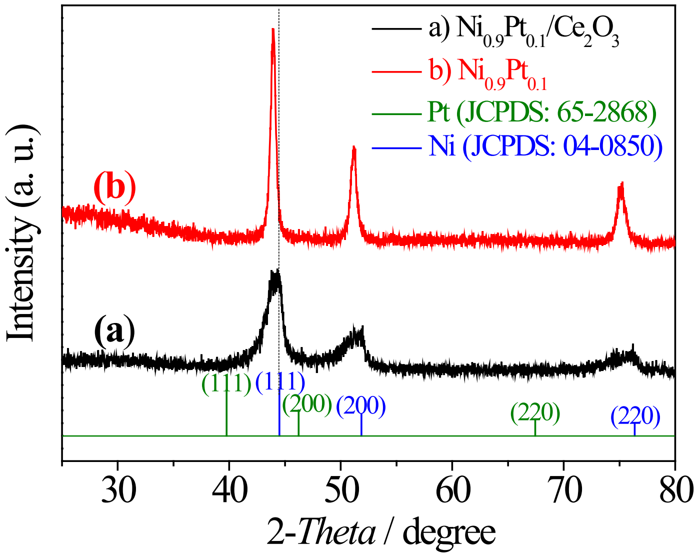

Fig. S3 X-ray diffraction patterns of a) the $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ NPs and b) the $Ni_{0.9}Pt_{0.1}$ NPs after heat treatment at 823K for 3 h in argon atmosphere.

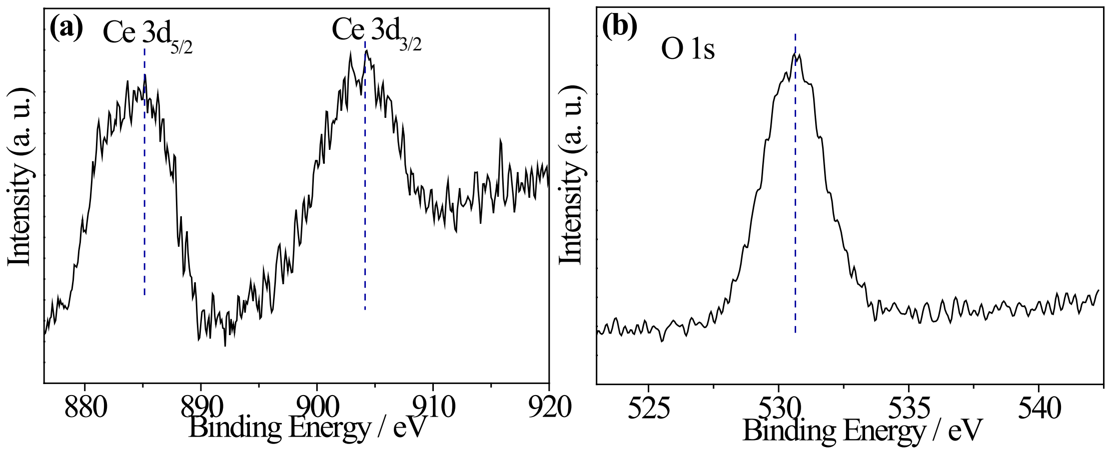

Fig. S4 XPS spectra of (a) Ce 3d and (b) O 1s for the $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ catalyst.

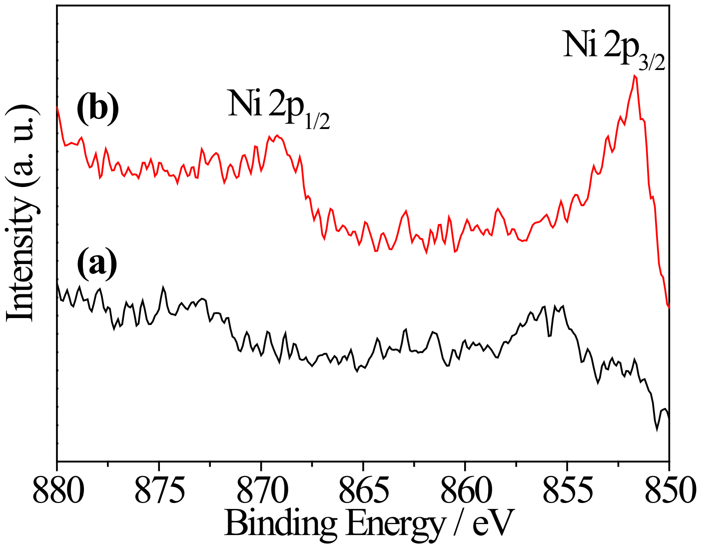

Fig. S5 The XPS spectra of the electron binding energies for Ni 2p in the $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ catalyst before (a) and after (b) argon sputtering of 20 min.

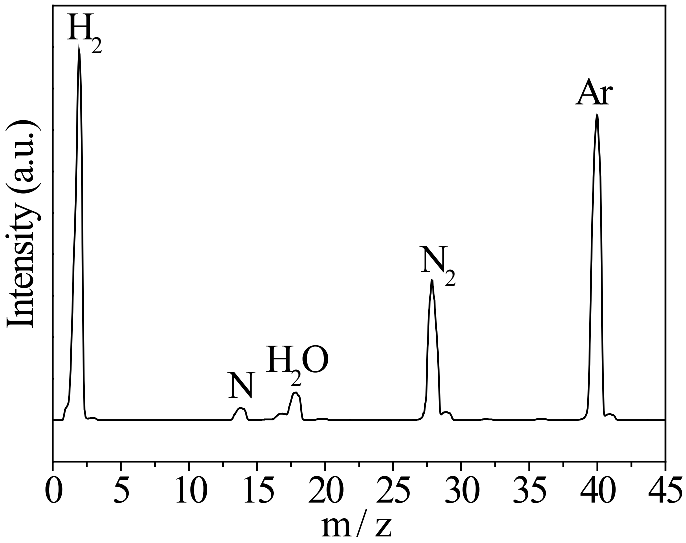

Fig. S6 Mass spectra of released gases from the complete decomposition of hydrazine catalyzed $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ NPs in argon at room temperature.

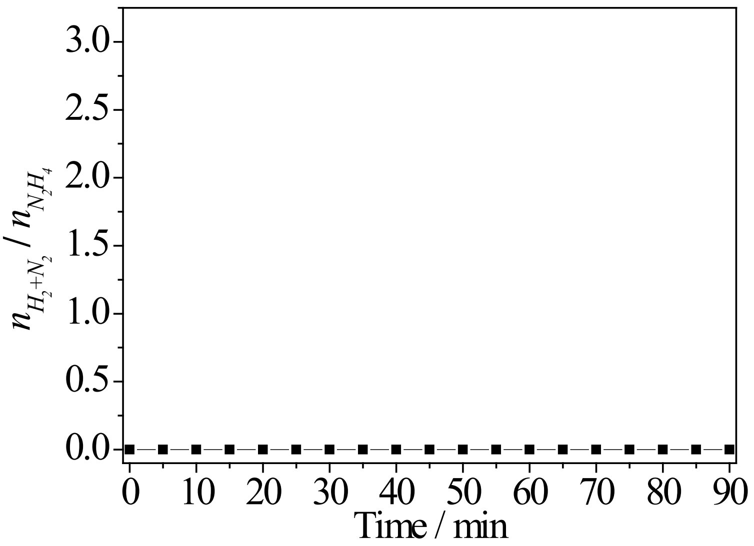

Fig. S7 Time course plots for the decomposition of hydrous hydrazine (0.5 M, 5 mL) in the presence of Ce_2O_3 (Ce_2O_3/H_2NNH_2 = 1:10) nanocatalysts with NaOH (0.5 M, 5 mL) at room temperature under ambient atmosphere.

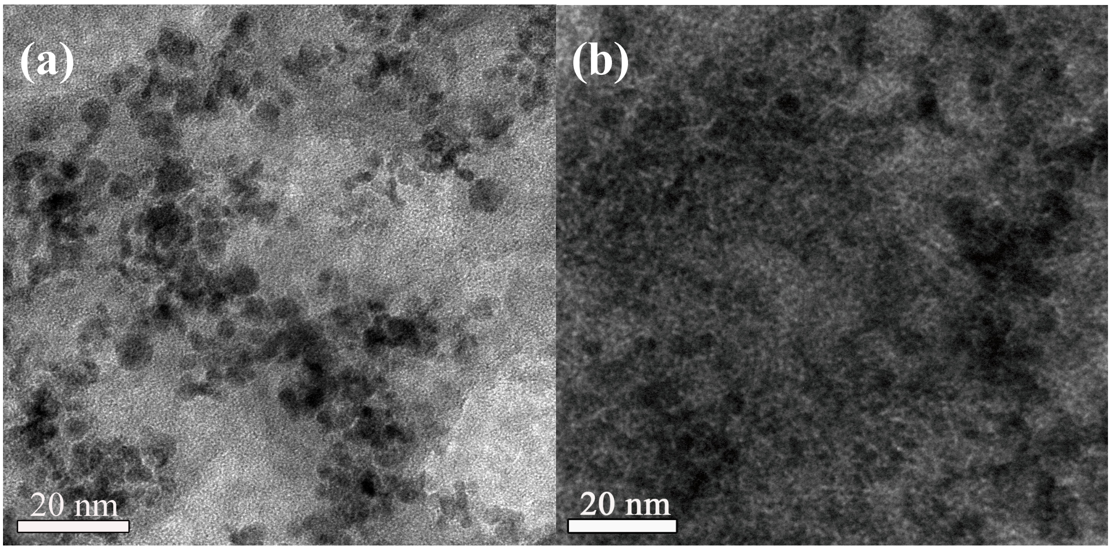

Fig. S8 TEM images of $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ nanocatalysts before (a) and after (b) four catalytic runs.

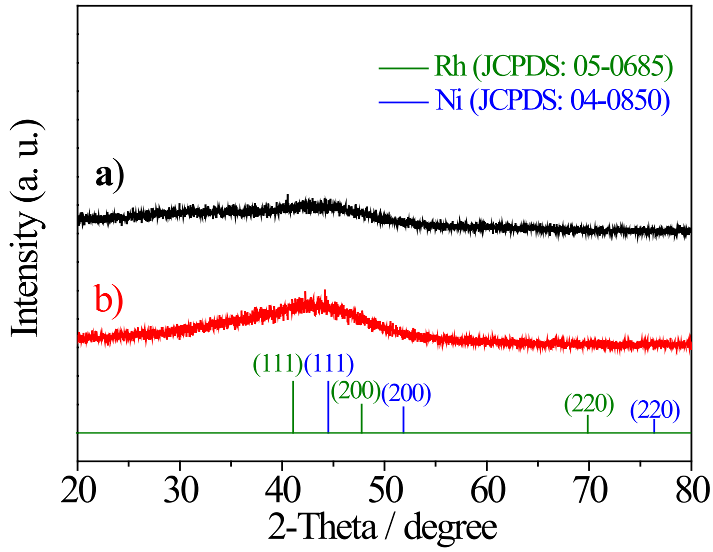

Fig. S9 X-ray diffraction patterns for a) $Ni_{0.9}Rh_{0.1}/Ce_2O_3$ NPs and b) $Ni_{0.9}Rh_{0.1}$ NPs.

Table S1. Activities in terms of TOF values of recycle test (4 times) of hydrogen generation from the decomposition of N_2H_4 (0.5 M, 5 mL) aqueous solution with $Ni_{0.9}Pt_{0.1}/Ce_2O_3$ nanocatalysts ($NiPt/H_2NNH_2$ = 1:10, 14 mol% Ce).

Catalyst	The number of run	Temp. (℃)	Reaction time (h)	Volume of gas (mL)	$n_{catalyst}$ (mmol)	Selectivity for H_2 (%)	$TOF_{initial}$ (h^{-1})
$Ni_{0.9}Pt_{0.1}/Ce_2O_3$	1st	25	0.717	172	0.250	100	28.1
$Ni_{0.9}Pt_{0.1}/Ce_2O_3$	2nd	25	0.740	172	0.250	100	19.7
$Ni_{0.9}Pt_{0.1}/Ce_2O_3$	3rd	25	0.913	172	0.250	100	13.5
$Ni_{0.9}Pt_{0.1}/Ce_2O_3$	4th	25	0.994	172	0.250	100	11.9

Calculation methods:

$$\mathrm{TOF}_{\mathrm{initial}} = \frac{P_{atm}V_{H_2+N_2}/\mathrm{R}T}{3n_{metal}t} \tag{S1}$$

Where $\mathrm{TOF}_{\mathrm{initial}}$ is the initial turnover frenquency, P_{atm} is the atmospheric pressure, $V_{H_2+N_2}$ is the volume of the generated gas (H_2+N_2) when the conversion reaches 50%, R is the universal gas constant, T is the room temperature (298 K), n_{metal} is the mole number of metal catalyst, and t is the reaction time when the conversion reaches 50%.

The relationship of the temperature and the initial rate (conversion <50%)[S1] was followed Arrhenius behavior. The Arrhenius' reaction rate equation can be written as follows:

$$\ln \mathrm{TOF} = \ln \mathrm{A} - E_a/\mathrm{R}T \tag{S2}$$

Where A is the reaction constant.

References:

S1. A. Boddien, D. Mellmann, F. Gärtner, R. Jackstell, H. Junge, P. J. Dyson, G. Laurenczy, R. Ludwig and M. Beller, *Science*, 2011, **333**, 1733.