Supporting information

Low density magnetic silicate-nickel alloy composite hollow structures: seeds induced direct assembly fabrication and catalytic property

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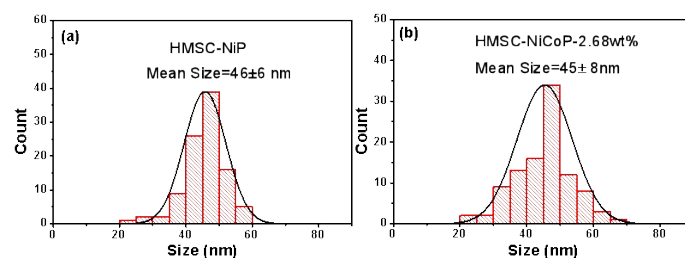100190, P. R. China；2. University of Chinese Academy of Sciences, Beijing 100049,

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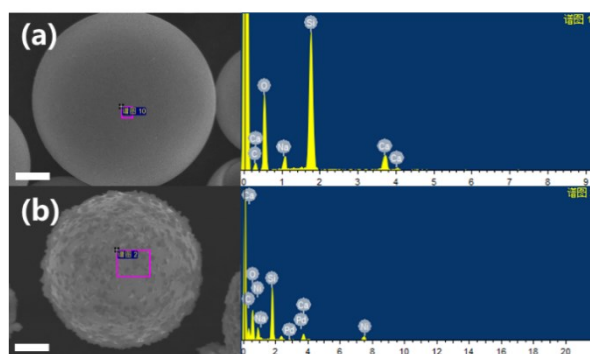*E-mail: zgan@mail.ipc.ac.cn (ZG An); jjzhang@mail.ipc.ac.cn (JJ Zhang).*

Table S1. Summary of the physical parameters of HGMs.

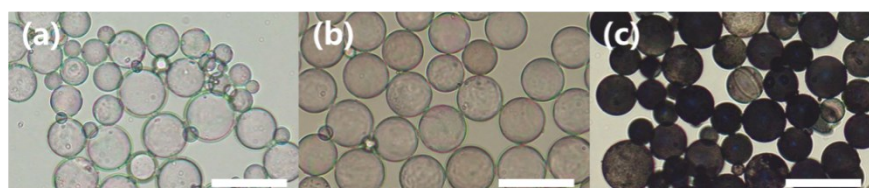| Sample	d_m (μ m)	ρ_t (g/cm³)
HGMs	50	0.38

Where d_m presents the mean particle size, ρ_t presents true density.

Fig.S1 The size distribution of NPs in (a) HMSC-NiP, (b) HMSC-NiCoP-2.68wt%.

Fig.S2 The SEM images of the (a) HGMs, (b) HMSC-Ni. The EDX results of (c) HGMs (d)
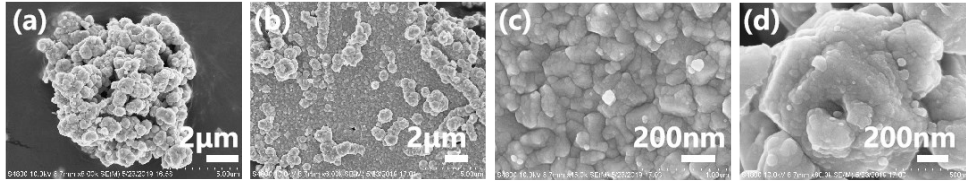
HMSC-Ni. Scale bars, 10 μm.

Fig.S3 The Optical Microscopy images of (a) HGMs, (b) AHGMs, (c) HMSC-NiCoP-
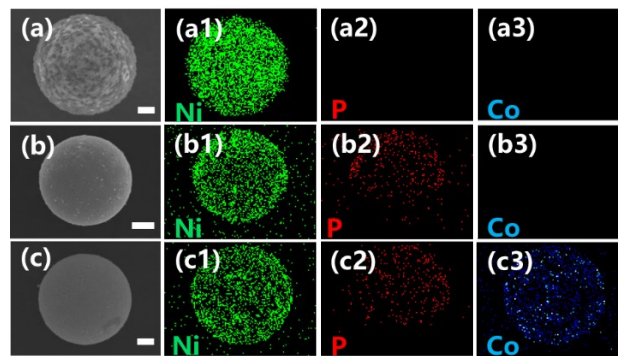
2.68wt%. Scale bars, 100μm.

Table S2. Loading amounts measured by XRF and the rate constant of different loading amounts of HMSC-NiCoP. Where k_A refers to apparent rate constant, k_N presents mass normalized rate constant.

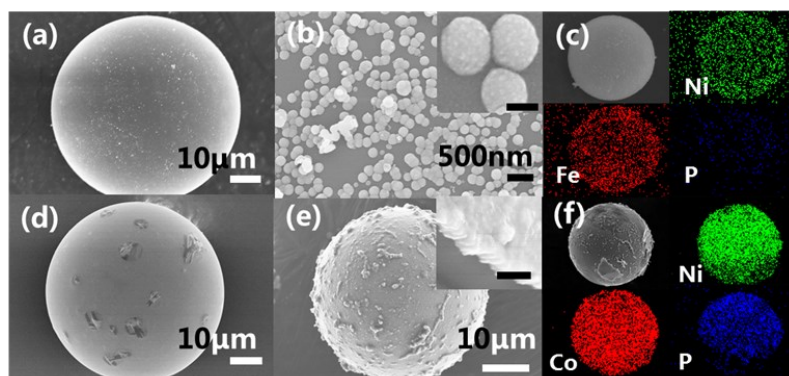| Samples	Loading (wt%)	k_A ($10^{-3}s^{-1}$)	k_N ($s^{-1}g^{-1}$)
HMSC-NiCoP-0.314%	0.314	4.08	12.9
HMSC-NiCoP-0.586%	0.586	4.08	6.96
HMSC-NiCoP-1.34%	1.34	7.00	5.22
HMSC-NiCoP-2.14%	2.14	33.5	15.6
HMSC-NiCoP-2.68%	2.68	37.4	14.0
HMSC-NiCoP-2.93%	2.93	27.7	9.45
HMSC-NiCoP-3.14%	3.14	16.6	5.29
HMSC-NiCoP-3.48%	3.48	14.8	4.25
HMSC-NiCoP-6.00%	6.00	9.08	1.51

Fig.S4 SEM images of pure NiCoP without HGMs.

As is shown in Fig.S4, the coalescence of NiCoP without HGMs support is obviously serious. It is further illustrated that HGMs support is necessary for active NPs to improve its stability.
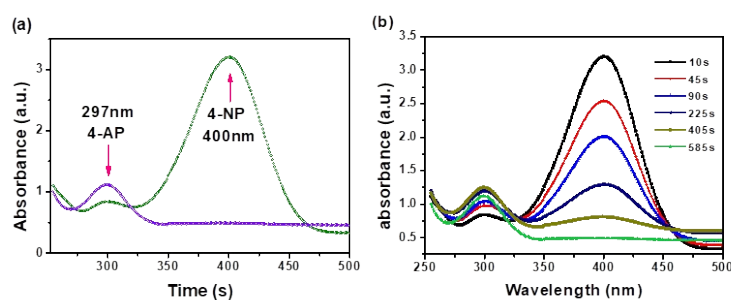

Fig.S5 The energy dispersive spectrometer X-ray (EDX) element mapping patterns of (a) HMSC-Ni, (b) HMSC-NiP, (c) HMSC-NiCoP-2.68wt%；Scale bars, 10 μm.
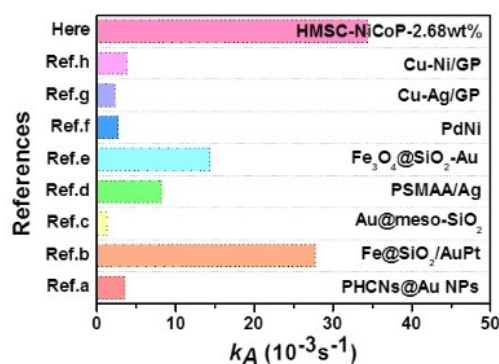

Fig.S6 SEM images of depositing other metallic alloy on different supported spheres, (a) HGMs, (b) HMSC-NiFeP, inset of panel is the enlargement of superfacial alloy particles. Scale bars, 100nm.   (c) the elemental mapping of HMSC-NiFeP, (d) hollow phenolic resin

microspheres (HPRMs), (e) HPRM-NiCoP, inset of panel is the enlargement of the shell cross section. Scale bars, 500nm. (f) the elemental mapping of HPRM-NiCoP.

The seeds induced direct assembly approaches reported here holds the potential to be extended to the directed formation of other metallic NPs on various supports. As shown in Fig.S6, we have successfully realized the directed assembly of NiFeP NPs on AHGMs, and the nickel-based NPs on hollow phenolic resin microspheres. The elemental mapping by EDX illustrates the successful fabrication of diverse alloy materials on different supports. It is further certified that our seeds induced direct assembly fabrication is highly universal.
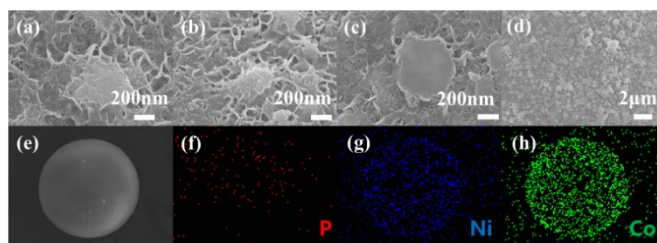

Fig.S7 Typical time-dependent UV-Vis spectra, showing (a) the change in absorbance before and after the catalytic reaction of *p*-nitrophenol (4-NP) to *p*-aminophenol (4-AP) and (b) the absorbance evolutions by $NaBH_4$ using HMSC-NiCoP-2.68wt%.
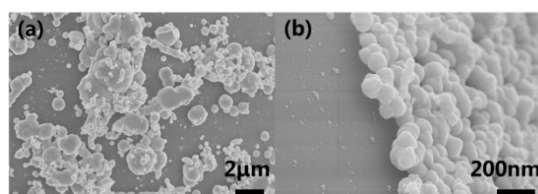

Fig.S8 The k_A of HMSC-NiCoP-2.68wt% and the reported supported noble metal catalysts

and alloy catalysts used in catalyzing the 4-NP conversion. (Ref.a[7], Ref.b[30], Ref.c[31], Ref. d[32], Ref.e[2], Ref.f[33], Ref.g[34], Ref.h[34])

Fig.S9 The SEM and EDX elemental mapping images of the synthesized catalytic materials after cyclic catalysis.

Fig.S10 SEM images of (a) re-deposit the alloy species on HMSC-NiCoP-2.68wt% used after 7 cycles, (b) re-deposit the alloy species on HMSC-NiCoP-2.68wt% used after 1 cycle.

Table S3. XPS peak parameters of HMSC-Ni.

Peaks (Ni 2p)	Position(eV)	Area	FWHM(eV)

	Position(eV)	Area	FWHM(eV)
λ_1	880.49	3300.00	6.80
μ_1	873.83	2457.00	3.43
v_1	869.50	213.59	1.40
λ_2	862.15	3068.80	4.36
μ_2	856.20	4992.82	3.25
v_2	852.49	547.07	1.92

Table S4. XPS peak parameters of HMSC-NiP

Peaks (Ni 2p)	Position(eV)	Area	FWHM(eV)
λ_1'	880.25	1056.00	5.30
μ_1'	874.13	1258.88	4.49
v_1'	870.03	252.37	2.47
λ_2'	861.69	1137.40	4.53
μ_2'	856.16	1721.60	3.10
v_2'	852.89	740.26	1.82

Peaks (P 2p)	Position(eV)	Area	FWHM(eV)
$\gamma_1{}'$	132.90	108.54	3.29
$\phi_1{}'$	129.56	98.90	2.12

Table S5. XPS peak parameters of HMSC-NiCoP-2.68wt%.

Peaks (Ni 2p)	Position(eV)	Area	FWHM(eV)
$\lambda_1{}''$	881.11	3500.00	1.48
$\mu_1{}''$	874.45	2500.00	3.13
$v_1{}''$	870.86	1274.22	3.10
$\lambda_2{}''$	862.28	1908.00	2.66
$\mu_2{}''$	856.83	3700.00	2.84
$v_2{}''$	853.39	1349.26	6.50

Peaks (Co 2p)	Position(eV)	Area	FWHM(eV)
$\delta_1{}''$	803.48	127.86	2.73

η_1''	798.10	300.00	3.52
δ_2''	786.49	163.91	3.31
η_2''	781.47	600.00	3.77

Peaks (P 2p)	Position(eV)	Area	FWHM(eV)
γ_1''	132.76	81.16	1.88
ϕ_1''	129.61	114.64	1.60

Fig.S11 Corresponding absorbance curves at different wavelength of (a) RhB, (b) MB, (c) ArS, (d) MO before and after by $NaBH_4$ using synthesized HMSC-NiCoP-2.68wt%

Fig.S12 Hysteresis loop of HMSC-NiCoP-2.68wt%.