Supporting Online Information

Enhanced Catalytic Properties of Rhodium Nanoparticles Deposited on Chemically Modified SiO_2 for Hydrogenation of Nitrile Butadiene Rubber

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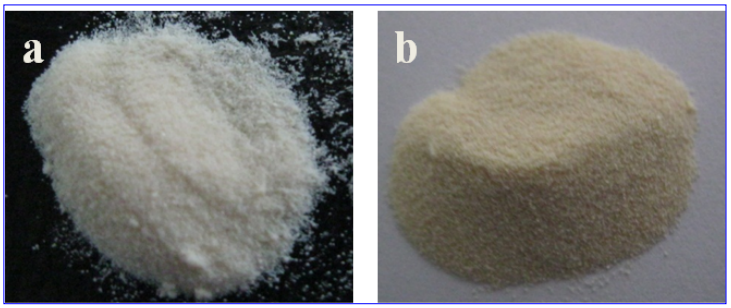

Fig. S1. Images of (a) Rh(Ⅲ)/SiO_2 **3** and (b) Rh(Ⅲ)/$MSiO_2$ **1**.

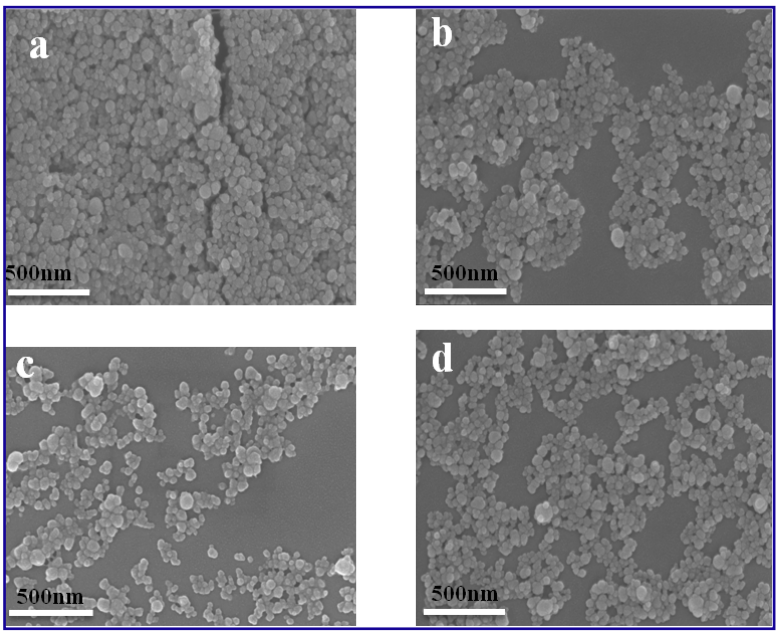

Fig. S2. SEM images of (a) SiO_2, (b) $MSiO_2$, (c) Rh(Ⅲ)/SiO_2 **3** and (d) Rh(Ⅲ)/$MSiO_2$ **1**.

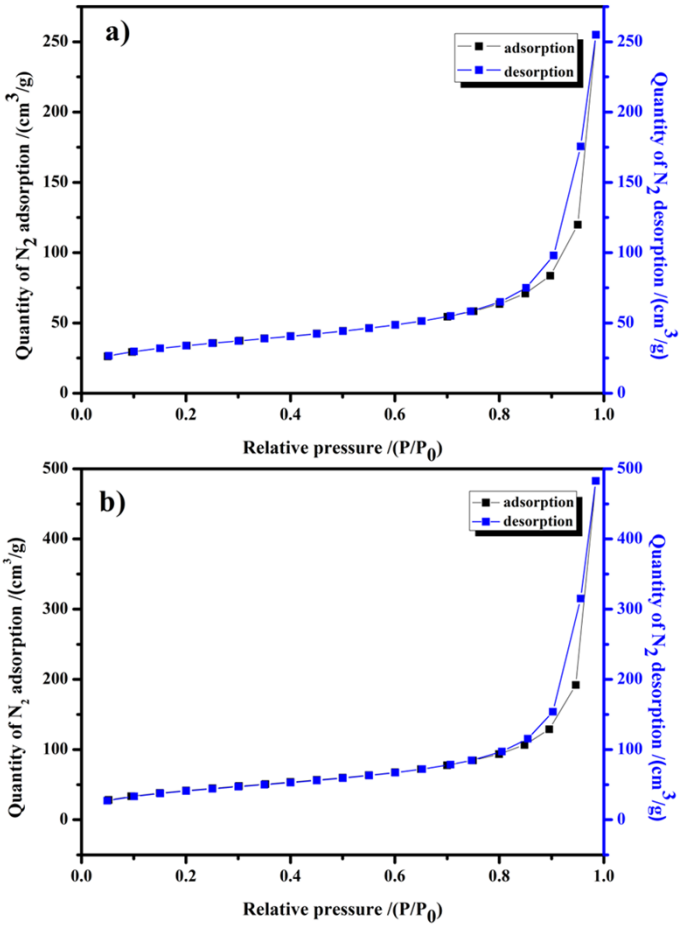

Fig. S3. Nitrogen adsorption/desorption isotherms of (a) SiO_2 and (b) $MSiO_2$.

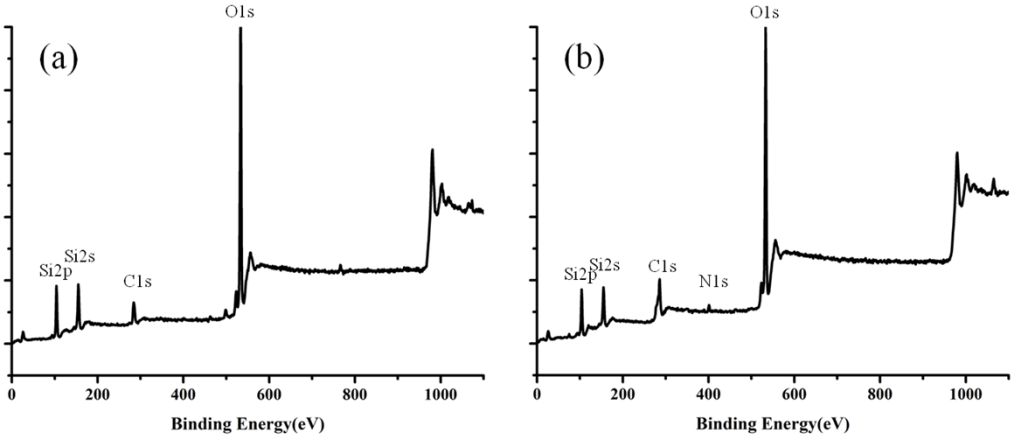

Fig. S4. XPS survey scan of (a) SiO_2 and (b) $MSiO_2$.

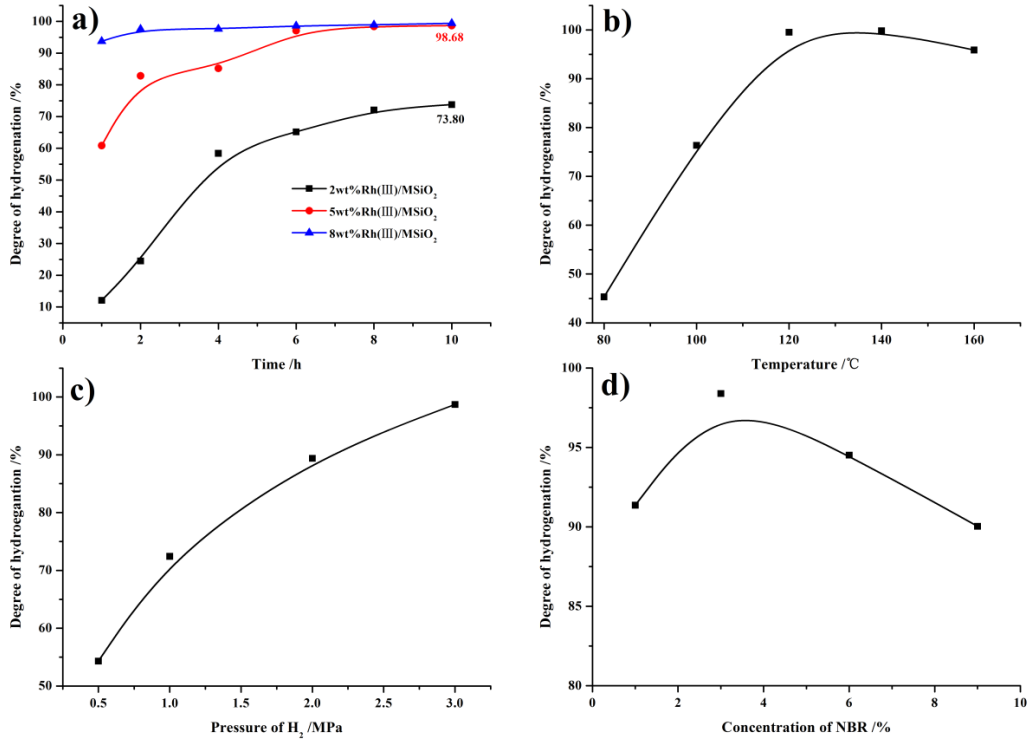

Fig. S5. Degree of hydrogenation of NBR under different reaction conditions with Rh(Ⅲ)/$MSiO_2$ **1** as catalyst. Reaction conditions: (a) concentration of NBR solution=3 wt%, $W_{PPh3}/W_{cat.}$= 0.5, P_{H2}=3.0 MPa, and T=120 ℃; (b) concentration of NBR solution=3 wt%, $W_{cat.}/W_{NBR}$=0.05, $W_{PPh3}/W_{cat.}$=0.5, P_{H2}=3.0 MPa, and t=8 h; (c) concentration of NBR solution=3 wt%, $W_{cat.}/W_{NBR}$=0.05, $W_{PPh3}/W_{cat.}$= 0.5, T=120 ℃, and t=8 h; (d) concentration of NBR solution=3 wt%, $W_{cat.}/W_{NBR}$ = 0.5, $W_{PPh3}/W_{cat.}$= 0.5, t=8 h, and T=120 ℃.

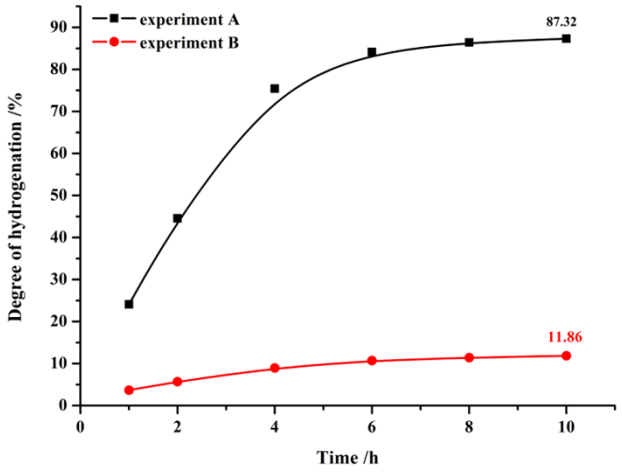

Fig. S6. Catalytic performance of recycled catalyst for hydrogenation of NBR.

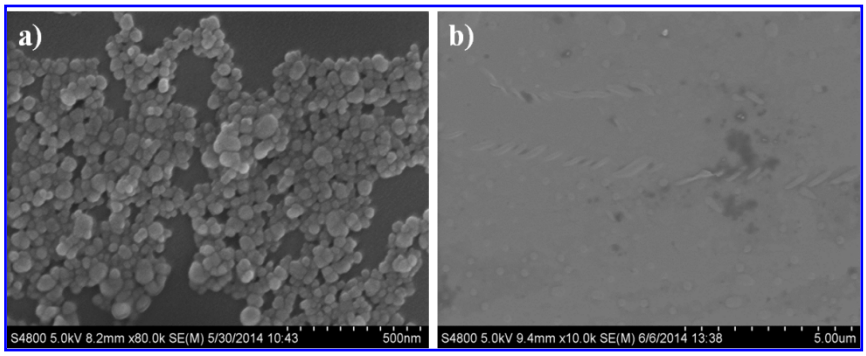

Fig. S7. SEM micrographs of Rh(Ⅲ)/$MSiO_2$ **1**: (a) before reaction and (b) after 3rd cycle.

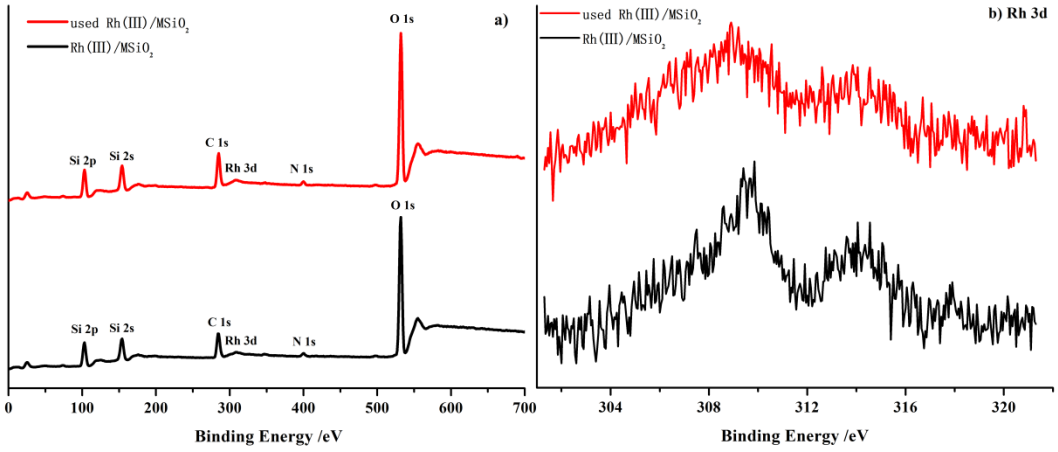

Fig. S8. (a) XPS survey spectra Rh(Ⅲ)/SiO_2 and used Rh(Ⅲ)/$MSiO_2$; (b) XPS Rh 3d spectra for Rh(Ⅲ)/SiO_2 and used Rh(Ⅲ)/$MSiO_2$ **.**

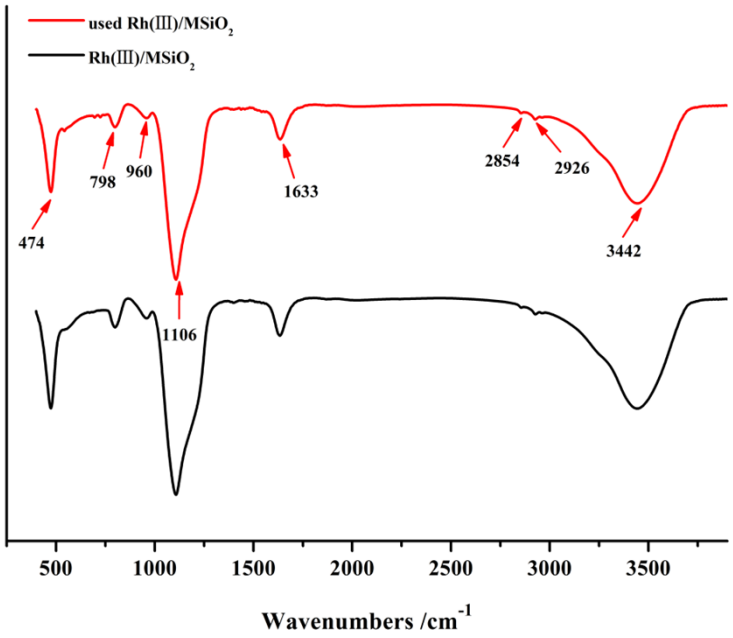

Fig. S9. FTIR spectra of Rh(Ⅲ)/SiO_2 and used Rh(Ⅲ)/$MSiO_2$.

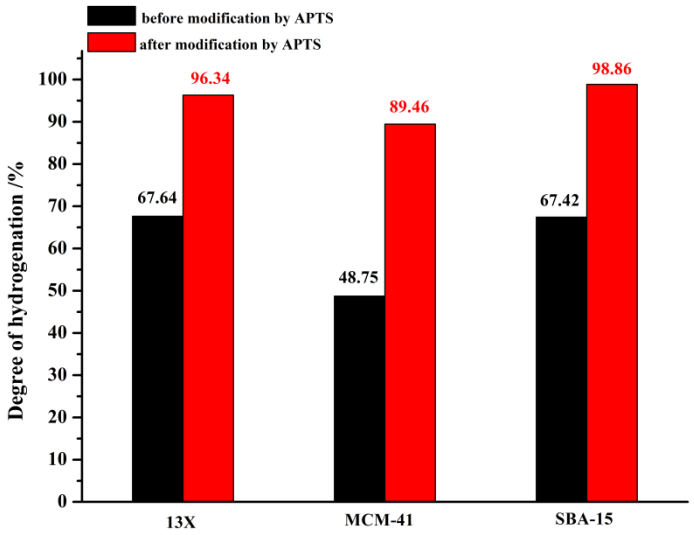

Fig. S10. Effect of various supports catalysts on degree of hydrogenation. Reaction conditions: NBR solution (200 mL, 3 wt%), supported catalyst (0.12 g, 2 wt%), and triphenylphosphine (0.06 g, 1 wt%) were heated at 120 ℃and H_2 pressure of 3.0 MPa for 6 h.

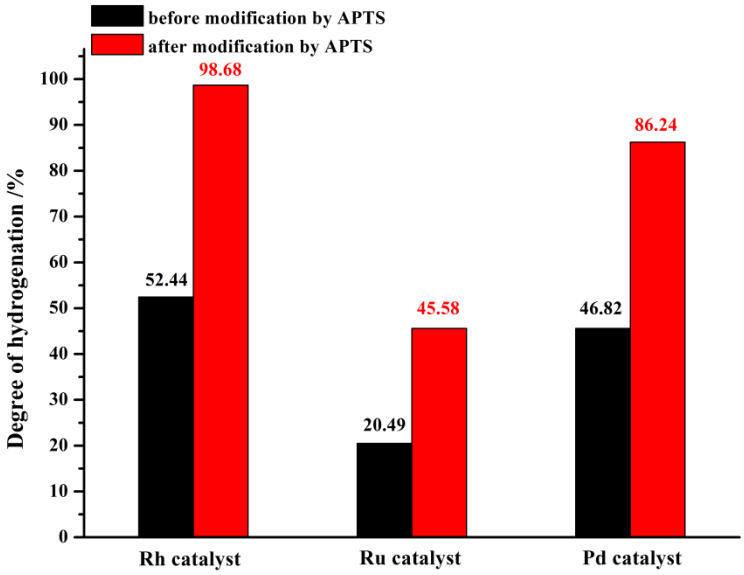

Fig. S11. Effect of different metal catalysts on degree of hydrogenation. Reaction conditions: NBR solution (200 mL, 3 wt %), supported catalyst (0.12 g, 2 wt %), and triphenylphosphine (0.06 g, 1 wt %) were heated at 120℃ and H_2 pressure of 3.0 MPa for 6 h.

Table S1. Surface area, pore volume, and average pore diameter from BJH absorption calculation

Materials	S_{BET}[a] (m^2/g)	V_P[b] (cm^3/g)	D_{BJH}[c] (nm)
SiO_2	152.44	0.73	19.40
$MSiO_2$	115.30	0.39	15.21

[a]BET surface area, [b]pore volume, and [c]average pore diameter from BJH absorption.

Table S2. Results from XPS Si 2p spectrum of SiO_2 in Fig. 4a

Species	Position (eV)	Contribution (%)
Si^{4+}	103.72±0.1	97.66±0.2
Si-OH	105.92±0.1	2.34±0.2

Table S3. Results from XPS Si 2p spectrum of $MSiO_2$ in Fig. 4b

Species	Position (eV)	Contribution (%)
Si^{4+}	103.49±0.1	99.92±0.01
Si-OH	105.69±0.1	0.08±0.01

Table S4. Results from XPS N 1s spectra of $MSiO_2$ in Fig. 4d

Species	Position (eV)	Contribution (%)
"free"-NH_2	399.8±0.2	76.73±0.3
hydrogen bonded -NH_2	401.3±0.2	23.27±0.3

Table S5. Degree of hydrogenation for Rh(Ⅲ)/$MSiO_2$ **1** prepared by using different solvents

Solvents	Water	Water/Ethanol	Ethanol
HD (%)	96.68	95.87	96.88

Reaction conditions: NBR solution (200 mL, 3 wt%), supported catalyst Rh(Ⅲ)/$MSiO_2$ **1** (0.30 g, 5 wt%), and PPh_3 (0.15 g, 0.25 wt%) were heated at of 120 ℃ under H_2 pressure of 3.0 MPa for 8 h.

Table S6. Degree of hydrogenation for Rh(Ⅲ)/$MSiO_2$ **1** with different particle sizes of SiO_2

Particle sizes of SiO_2 (μm)	**0.04**	**1**	**10**	**48**	**150**
HD (%)	72.92	77.86	76.66	65.23	62.40
Separation	No	No	Hard	Formal	Formal

Reaction conditions: NBR solution (200 mL, 3 wt %), supported catalyst (0.12 g, 2 wt %), and PPh_3 (0.06 g, 1 wt %) were heated at 120 ℃ under H_2 pressure of 3.0 MPa for 6 h.

Table S7. Comparison of degrees of hydrogenation and compositions of fresh and used catalysts

Recycle	1	2	3
HD (%)	98.53	90.35	67.61
Content of Rh (%)	1.18	1.03	0.98