Electronic Supplementary Information (ESI)

One-pot synthesis of molybdenum oxide nanoparticles
encapsulated in hollow silica spheres:
an efficient and reusable catalyst for epoxidation of olefins

Yasutaka Kuwahara,a,b Naoyuki Furuichi,a Hiroyuki Seki,c and Hiromi Yamashitaa,b,*

a Division of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, 2-1 Yamada-oka, Suita, Osaka 565-0871, Japan

b Unit of Elements Strategy Initiative for Catalysts & Batteries (ESICB), Kyoto University, Katsura, Kyoto 615-8520, Japan

c Central Technical Research Laboratory, JXTG Nippon Oil & Energy Corp., 8 Chidori-cho, Naka-ku, Yokohama, Kanagawa 231-0815, Japan.

* Tel: (+81) 6-6879-7457, Fax: (+81) 6-6879-7457
E-mail: yamashita@mat.eng.osaka-u.ac.jp
**Fig. S1** TEM image of MoOₓ NPs-PAA (poly(acrylic acid)) aggregates.

**Fig. S2** (above) FE-SEM and (below) TEM images of MoOₓ-SiO₂ composites prepared by using poly(vinylpyrrolidinone) (PVP, K-30; $M_w = 30,000$) and poly(ethyleneimine) (PEI; $M_w = 1,800$) as organic templates instead of PAA (poly(acrylic acid)).
Fig. S3 (above) FE-SEM and (below) TEM images of MoO$_x$@HSS-2 catalysts synthesized with varied amounts of Mo contents ((a, d) 7 (b, e) 14 and (c, f) 28 wt% as MoO$_3$ in initial synthetic solutions).

Fig. S4 Weight loss curve of as-synthesized MoO$_x$@HSS-2 catalyst. The weight loss seen below 250 °C is ascribed to the desorption of physisorbed molecules and the weight loss seen above 250 °C is ascribed to the elimination of PAA (poly(acrylic acid)) and alkyl groups of dodecyltrimethoxysilane (C$_{12}$TMS).
Fig. S5 XRD patterns of (a) MoO₂ powder, (b) MoO₃ powder, (c) MoOₓ@HSS-0, (d) MoOₓ@HSS-2 and (e) MoOₓ/SiO₂. The broad peak seen at 2θ = 15-30° is attributed to amorphous nature of silica.

Fig. S6 Correlation between the energy shift (based on Mo foil) and oxidation state of Mo atoms in the prepared samples and reference Mo compounds.