Electronic Supplementary Material (ESI) for Chemical Communications
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Supporting Information

Continuous One-Pot Synthesis of Sandwich Structured Core-Shell Particles and Transformation to Yolk-Shell Particles

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This file includes:

- Nitrogen adsorption-desorption isotherm and pore size distribution.
- Schematic diagram of ultrasonic spray pyrolysis process.
- Detailed experimental procedure
- XRD pattern of the the 20/60/20 (wt%) $Pd/V_2O_5/SiO_2$ core-shell particles.

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Nitrogen adsorption-desorption isotherm and pore size distribution:

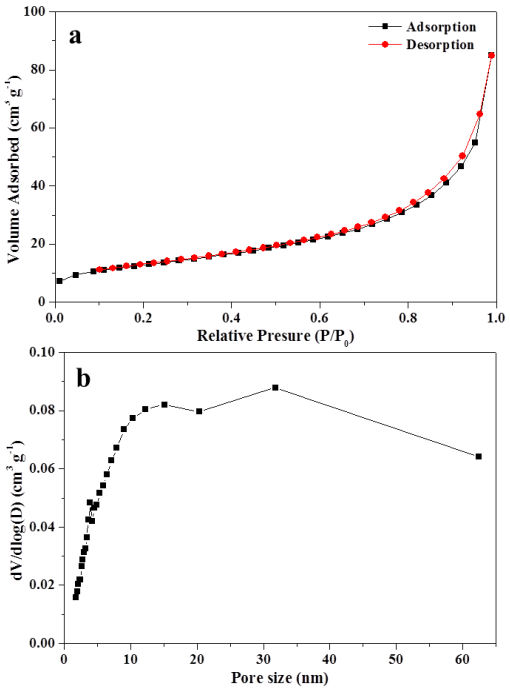

Fig. S1 (a) Nitrogen adsorption-desorption isotherms plot and (b) pore size distribution plot of the $Pd@SiO_2$ yolk-shell particles.

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Detailed experimental procedure:

The ultrasonic spray pyrolysis system shown in Fig. S1 consisted of a droplet generator, quartz reactor, and powder collector. A 1.7 MHz ultrasonic nebulizer with six vibrators was used to simultaneously generate a large quantity of droplets, which were carried into the high-temperature tubular reactor by air at a flow rate of 10 L min^{-1}. The length and diameter of the quartz reactor are 1200 and 50 mm, respectively. The tubular reactor with a heat zone of 60 cm was employed and the reactor temperature was fixed at 1000°C. The formed particles were collected by a Teflon bag filter.

V_2O_5/SiO_2 core-shell particles and sandwich structured $Pd/V_2O_5/SiO_2$ core-shell particles were directly prepared from an aqueous spray solution using ultrasonic spray pyrolysis. The precursor solutions were prepared by dissolving a weight ratio of 0:80:20, 5:75:20, and 20:60:20 palladium, vanadium, and silica precursors in distilled water and nitric acid with heating. $Pd(NO_3)_2 \cdot nH_2O$ (n=2.4, Kojima, 99%), V_2O_5 (Junsei, 99%), and tetraethyl orthosilicate (TEOS) (Samchun, 98%) were used as the source materials for Pd, V, and Si, respectively. The concentrations of the metal salts were fixed at 0.1 M. Hollow SiO_2 particles and $Pd@SiO_2$ yolk-shell particles were obtained by washing the collected particles in distilled water to eliminate V_2O_5 components and centrifugation. The core-shell powders were added into distilled water at a 1:10 weight ratio to remove V_2O_5 inner layer. After boiling, the residual product was harvested by several rinse-centrifugation cycles with distilled water.

The crystal structures of the particles were investigated using X-ray diffractometry (XRD) with CuKα radiation (λ = 1.5418 Å). Morphological characteristics were investigated via high-resolution transmission electron microscopy (HR-TEM).

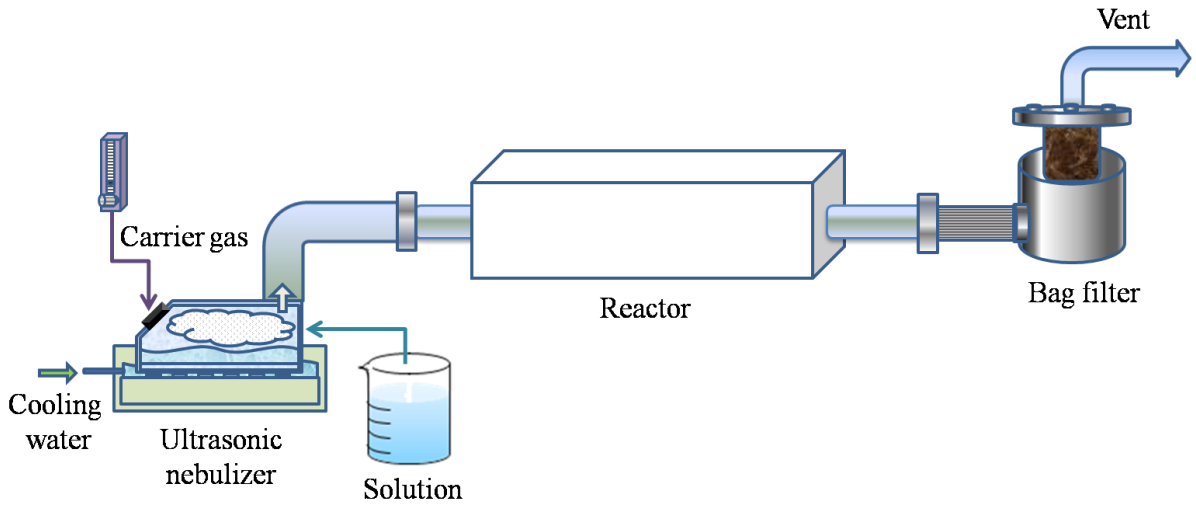

Fig. S2 Schematic diagram of the ultrasonic spray pyrolysis process.

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XRD pattern of the the 20/60/20 (wt%) $Pd/V_2O_5/SiO_2$ core-shell particles:

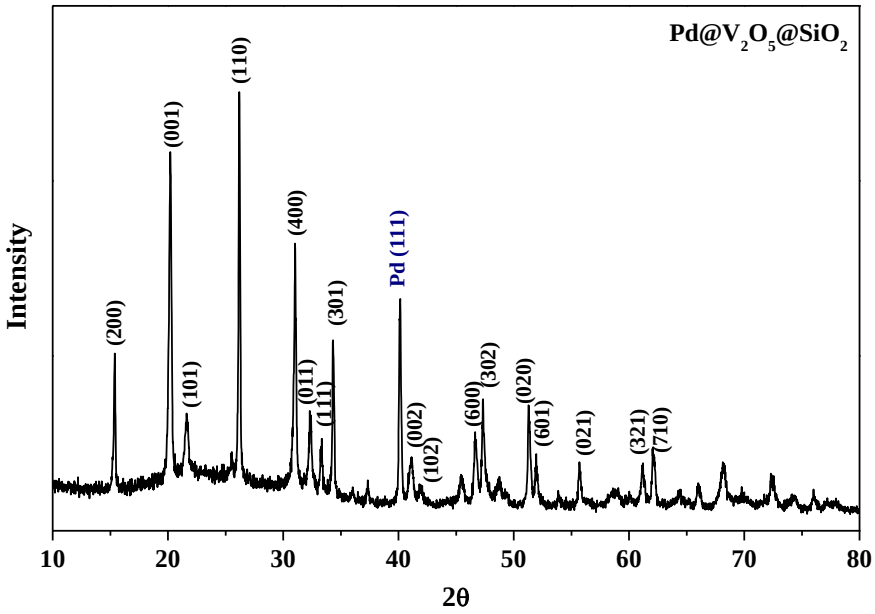

Fig. S3 XRD pattern of 20/60/20 (wt%) $Pd/V_2O_5/SiO_2$ core-shell particles.