Supporting Information for

The porous hollow CoInOx nanocube as a highly efficient catalyst for the catalytic combustion of toluene

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S1 Experimental details

S1.1 The calculation of Ea (Activation energy):

Reaction rate \((r)\) and activation energy \((Ea)\) is evaluated according to the equation (3), (4), (5) and (6):

\[
r = \frac{F0}{mcat} \times \{- \ln (1 - x)\} \tag{3}
\]

\[
r = kC0 \tag{4}
\]

\[
k = A \exp\left(-\frac{Ea}{RT}\right) \tag{5}
\]

\[
\ln r = \frac{Ea}{RT} + B \tag{6}
\]

\(r\), \(A\) and \(Ea\) is the reaction rate \((\text{mol s}^{-1})\), pre-exponential factor, and apparent activation energy \(Ea\) \((\text{kJ mol}^{-1})\), respectively. \(B\) is kinetic constant.

S1.2 Stability test

The stability was tested at the different reaction temperature with 3000 ppm toluene for 64 h (160 °C for 32 h and 200 °C for 32 h). Before this test, the catalyst had been treated at 300 °C for 4 h under reaction conditions (3000 ppm Toluene, 400mg catalysts, 30 000 ml g\(^{-1}\) h\(^{-1}\)).
Figure S1 The photos of (a) C-CoInOOx precursor, (b) HC-CoInOx precursor, (c) HC-CoOx precursor and (d) InOx precursor
Figure S2. SEM images of a) CoIn-PBA preferesor, and b) the C-CoInOx sample (fired at 450 °C)

Figure S3. SEM images of a) SiO$_2$@CoIn-PBA@SiO$_2$ (unfired), b) SiO$_2$@CoInOx@SiO$_2$ (fired at 450 °C)
**Figure S4.** SEM images of a) the HC-CoInOx sample, b) C-CoInOx sample; TEM images of c) the CoIn-PBA cubes (unfired), d and e) C-CoInOx sample (fired at 450 °C), f) the HC-CoInOx sample (fired at 450 °C)
Figure S5. N 1s XPS of the CoInOx catalysts
<table>
<thead>
<tr>
<th>Table S1 Co chemical states of the CoInOx catalysts with different morphology</th>
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<th>Table S2 The content of each element in the CoInOx catalysts with different morphology</th>
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\*a the element content was determined by continuous light source atomic absorption spectrometer and ICP-OES (Inductively coupled plasma optical emission spectrometry) analysis.\*
Figure S6. Raman spectrum of the CoInOx catalysts
Figure S7. SEM images of hollow porous (a) CoOx and (b) InOx catalysts through the same SiO$_2$ template method