Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Facile preparation of Cu-Mn/CeO_2/SBA-15 catalysts using ceria as auxiliary for advanced oxidation processes

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Synthesis of pristine SBA-15

Ordered mesoporous silica SBA-15 was prepared according to the literature reported previously. Typically, 4.0 g of Pluronic P123 was dissolved in 150 mL 1.6 M hydrochloric acid solution at 40 °C, followed by the addition of 8.4 g of TEOS. After being stirred for 24 h, the mixture was transferred into a drying oven and aged at 100 °C for 24 h. Then, the white precipitate was collected by filtration and dried at 80 °C. The product was obtained by removing the template in a muffle furnace at 550 °C for 5 h.

Figure S1. SEM images of trimetallic oxides nanoparticles loaded SBA-15 catalysts at different calcination temperatures Cu-Mn/CeO_2/SBA-15-400 (a) and Cu-Mn/CeO_2/SBA-15-500 (b).

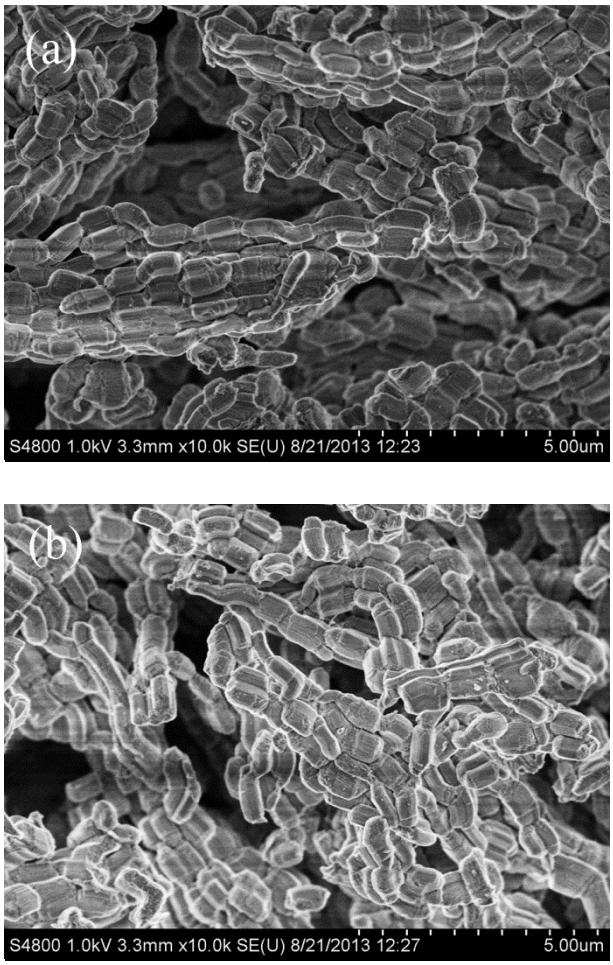

Figure S2. TEM (a, b) and HRTEM images (c, d, inset in c and d) of trimetallic oxides nanoparticles loaded SBA-15 catalysts at different calcination temperatures Cu-Mn/CeO_2/SBA-15-400 (a, c), and Cu-Mn/CeO_2/SBA-15-500 (b, d).

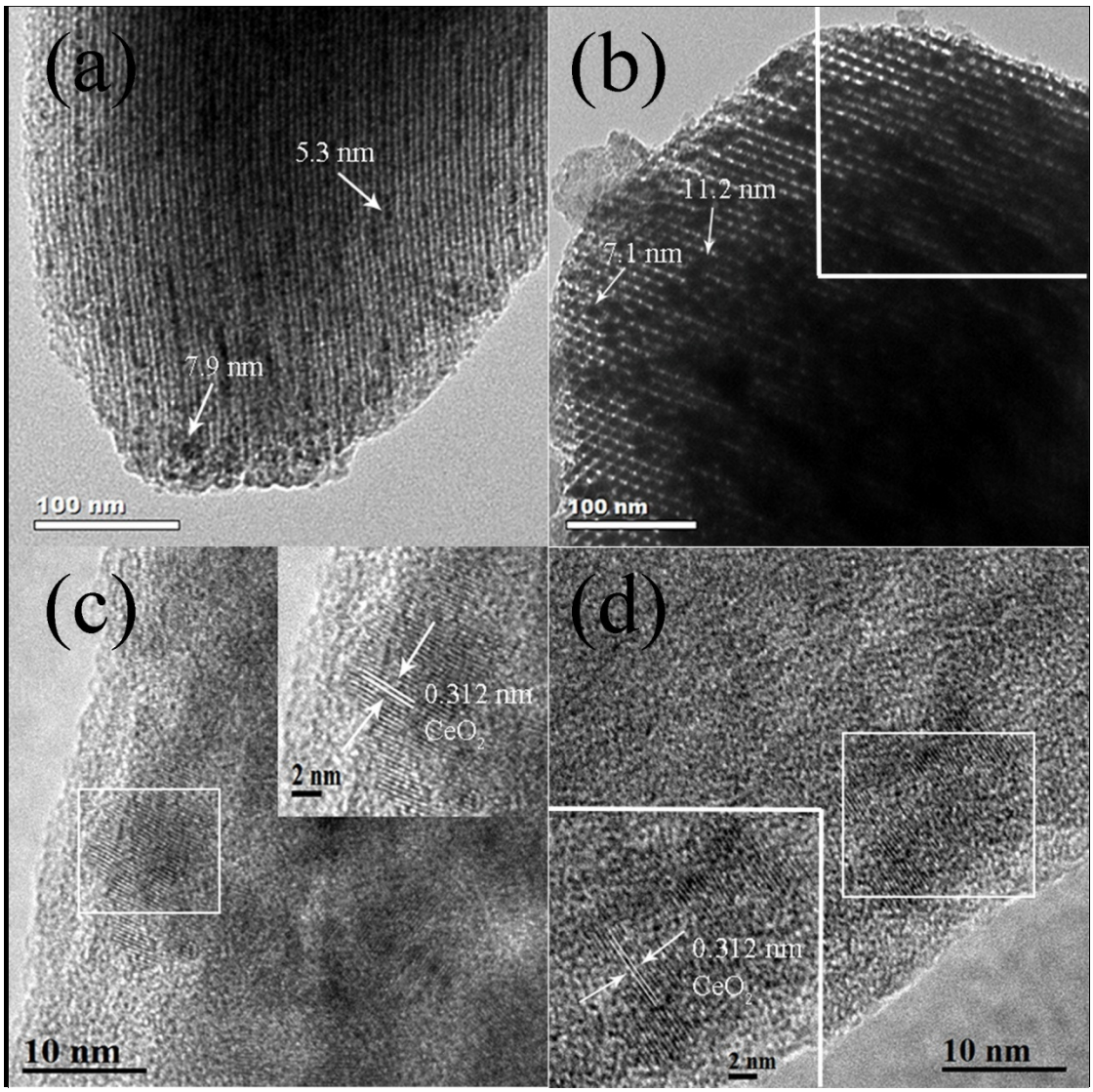

Figure S3. TEM (a) and HRTEM images (b, inset in b) of the monometallic oxide loaded CeO_2/SBA-15 sample.

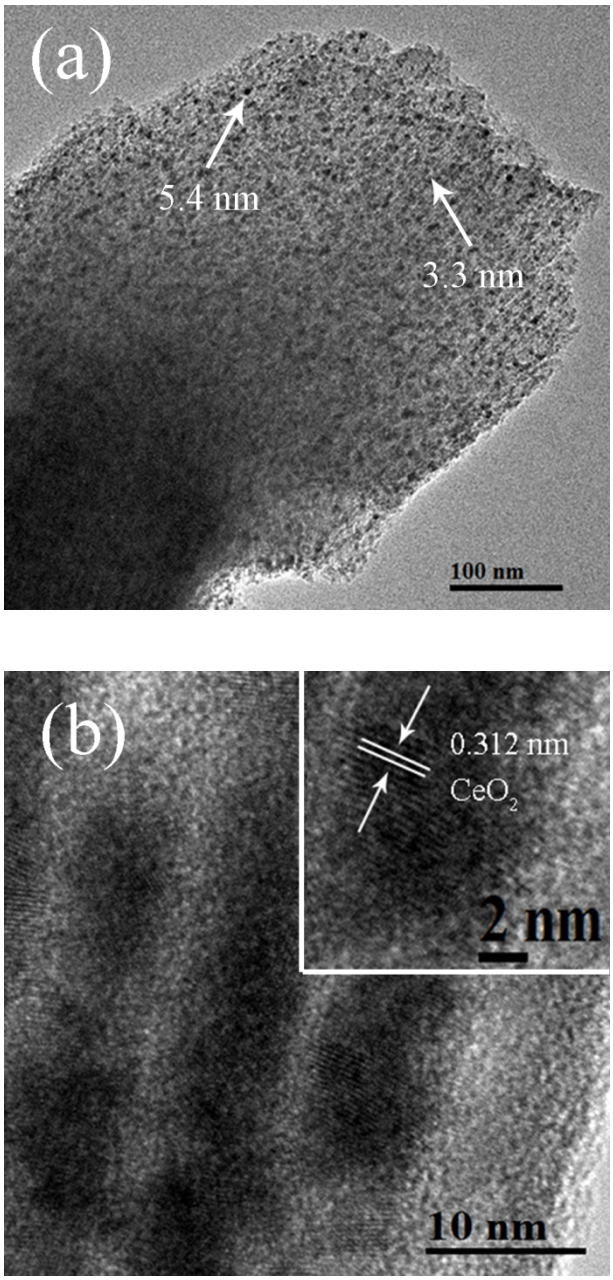

Figure S4. EDX spectra of trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C.

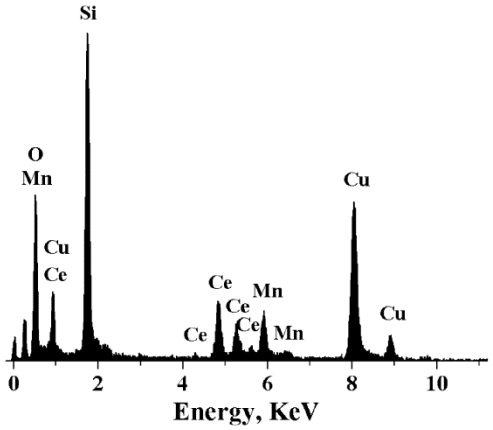

Figure S5. The STEM image (a) and mapping spectra of Cu, Mn, and Ce of trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C.

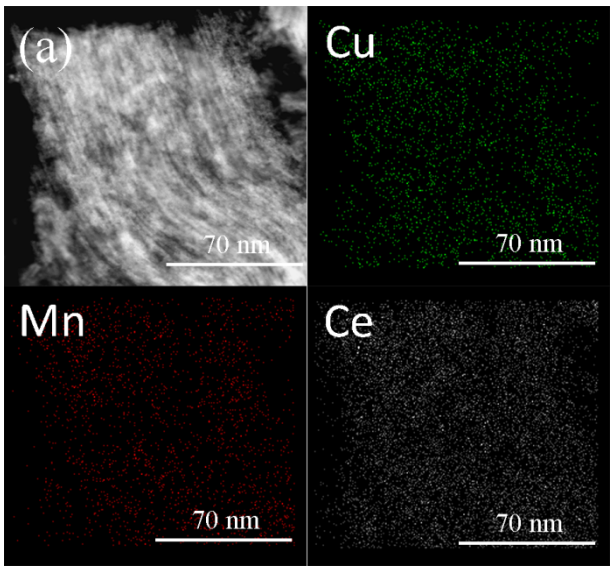

Figure S6. Wide-angle XRD patterns (A) of trimetallic oxides nanoparticles loaded SBA-15 catalysts at different calcination temperatures Cu-Mn/CeO_2/SBA-15-300 (a), Cu-Mn/CeO_2/SBA-15-400 (b), and Cu-Mn/CeO_2/SBA-15-500 (c) and (B) bimetallic oxides loaded SBA-15 catalyst Cu-Mn/SBA-15, respectively.

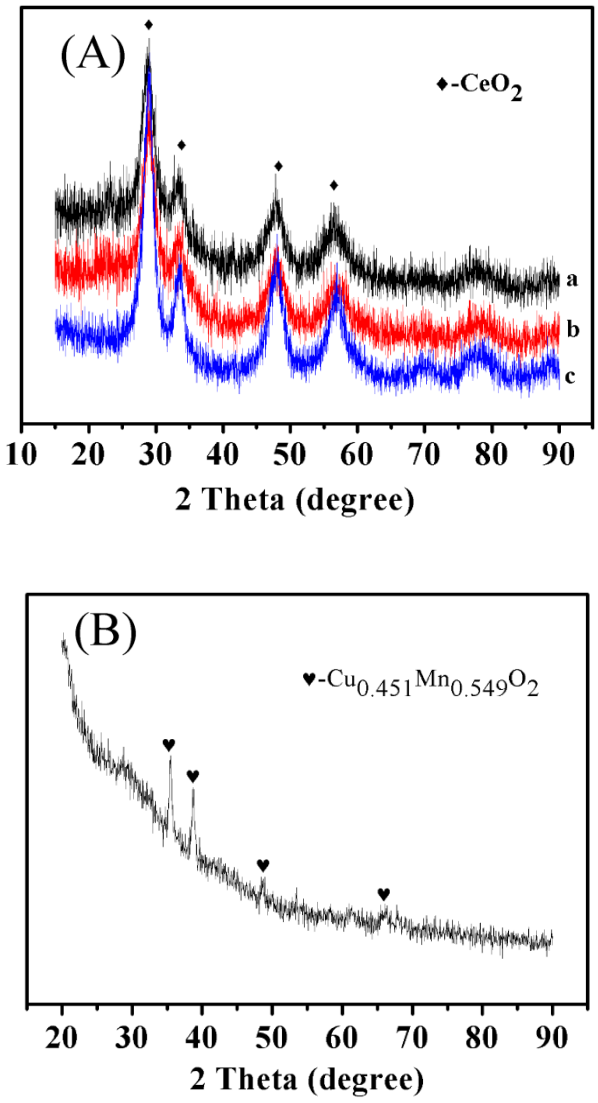

Figure S7. Effects of the different calcination temperatures of trimetallic oxides nanoparticles loaded SBA-15 catalysts Cu-Mn/CeO_2/SBA-15 at 300, 400 and 500 °C on the degradation of RhB. ($C_{catalyst}$ = 0.2 g/L, C(H_2O_2) = 0.4 moL/L, T = 70 °C, pH = 3.0)

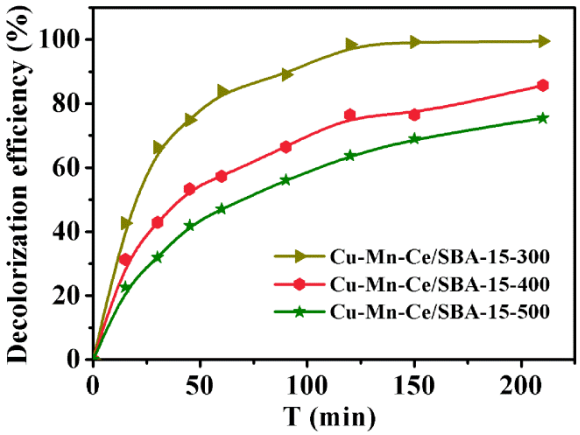

Figure S8. Effects of catalyst dosage by using trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C on the degradation of RhB ($C(H_2O_2)$ = 0.4 moL/L, T = 70 °C, pH 3.0).

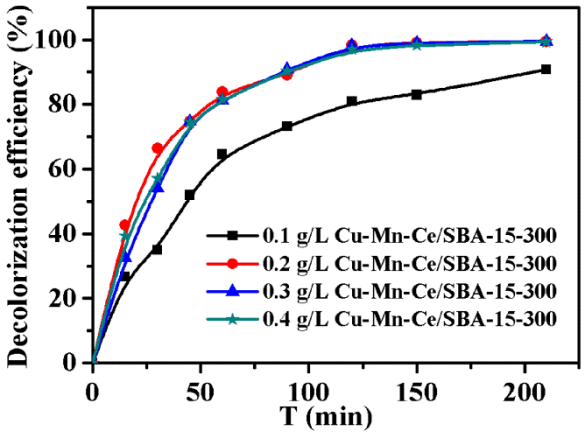

Figure S9. Effects of hydrogen peroxide concentration by using trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C on the degradation of RhB ($C_{catalyst}$ = 0.2 g/L, T = 70 °C, pH 3.0).

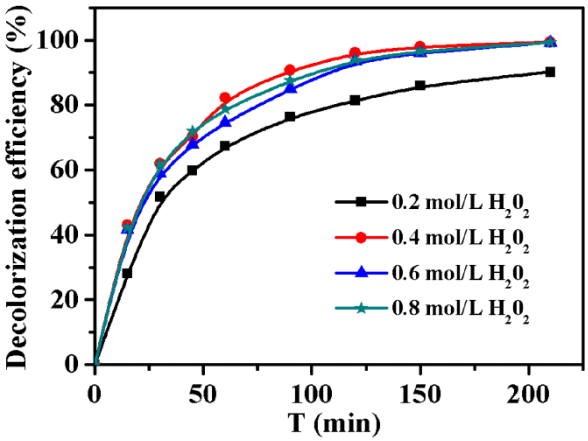

Figure S10. Effects of reaction temperature by using trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C on the degradation of RhB(C(H_2O_2) = 40 mL/L, $C_{catalyst}$ = 0.2 g/L, pH 3.0).

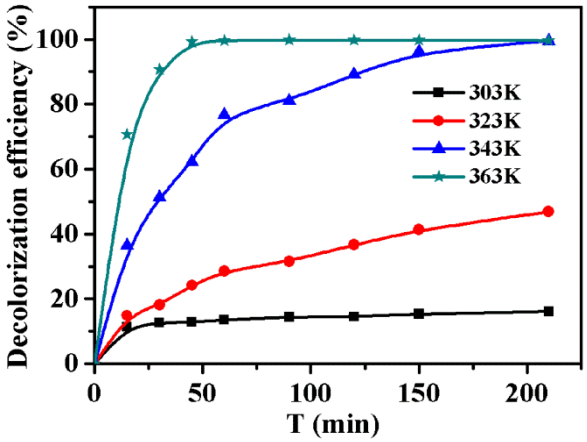

Figure S11. Effects of initial pH values by using trimetallic oxides loaded SBA-15 catalyst Cu-Mn/CeO_2/SBA-15-300 calcinated at 300 °C on the degradation of RhB. ($C_{catalyst}$ = 0.2 g/L, C(H_2O_2) = 0.4 moL/L, T = 70 °C)

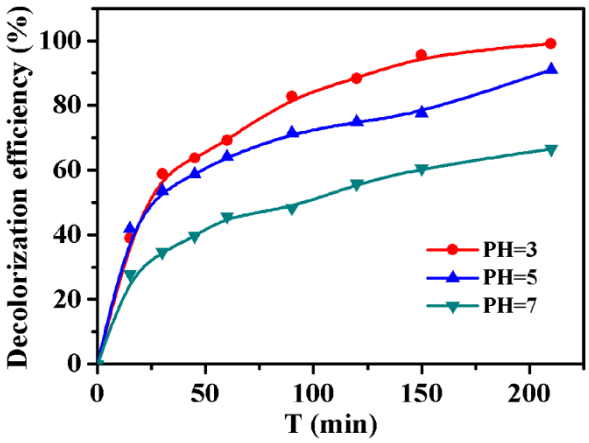

Figure S12. Time-dependant decolorization efficiency of RhB by using different reaction system: 0.2 g/L pure-silica SBA-15(a), bulk Cu-Mn-Ce oxides (b), 0.2 g/L Cu-Mn/SBA-15 (c), 0.2 g/L CeO_2/SBA-15 (d), and 0.2 g/L Cu-Mn/CeO_2/SBA-15-300(e), respectively (T = 70 °C, pH = 3.0).

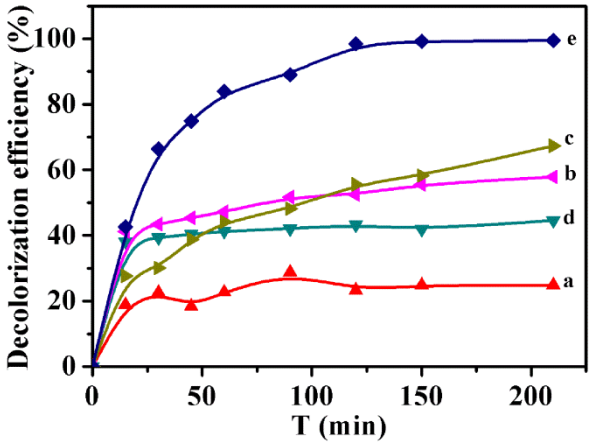

Figure S13. Reusability study of Cu-Mn/CeO_2/SBA-15-300 ($C_{catalyst}$ = 0.2 g/L, $C(H_2O_2)$ = 0.4 moL/L, T = 70 °C, pH=3).

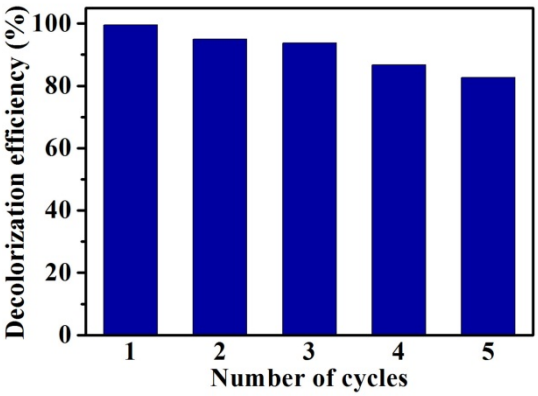

Table S1. Element contents of trimetallic oxides loaded catalyst Cu-Mn/CeO_2/SBA-15-300 obtained from EDX results.

Element	O K	Si K	Mn K	Cu K	Ce L
Weight percentage (%)	34.11	17.84	3.43	5.41	39.21
Atom percentage (%)	66.74	19.88	1.95	2.67	8.76