## **Supporting Information**

## Crystallization of transitional metal oxides within 12 seconds

Kunfeng Chen, Dongfeng Xue\*

State Key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, China.

\*E-mail: dongfeng@ciac.ac.cn

## **Burning of methanol**



**Burning of filter paper** 



**Burning without flame** 



Figure S1. Digital photographs show the burning process with  $0.1M Cu(NO_3)_2$  as copper salt.



Figure S2. XRD pattern of pure filter paper showing characteristic peaks of cellulose (JCPDS # 3-289).



Figure S3. XRD patterns of burned products using different concentrations of  $Cu(NO_3)_2$ methanol solution: (a) 3 M, (b) 1.5 M, (c) 0.7 M, and (b) 0.5 M. When the initial concentrations of  $Cu(NO_3)_2$  in methanol solution were 0.5 and 0.7M, peaks corresponding to  $Cu_2O$ , CuO and Cu could be seen in these XRD patterns. When the concentrations of  $Cu(NO_3)_2$  increased to 1.5 and 3M, peaks of Cu phase disappeared and only  $Cu_2O$  and CuO phases could be detected in the burned products.



Figure S4. Morphologies and microstructures of Cu<sub>2</sub>O/CuO/Cu composites after burning Cu(NO<sub>3</sub>)<sub>2</sub>-methanol-filter-paper in air for 12s. (a) SEM image shows the formation of chain-like structures with granular surface. (b) TEM image shows that chain-like structures are composed of many nanoparticles. (c) HRTEM image confirms the formation of CuO and Cu<sub>2</sub>O phases. (d) Smaller size nanoparticles were formed at the surface of chain-like structures. (e) HRTEM image confirms the formation of CuO and Cu<sub>2</sub>O phases. (f) HRTEM image confirms the formation of Cu phase. (f) HRTEM image confirms the formation of CuO and Cu<sub>2</sub>O/CuO/Cu composites have the chain-like structures consisting of overlapped CuO, Cu<sub>2</sub>O and Cu nanoparticles. HRTEM images shown in 'c' were obtained from the black rectangle in (b), while (e) and (f) images were taken from the black rectangle in (d).



Figure S5. TEM images of intermediate products during burning process with 0.1M Cu(NO<sub>3</sub>)<sub>2</sub> as copper salt at different time intervals.



Figure S6. XRD pattern of as-burned CoO product by burning Co(NO<sub>3</sub>)<sub>2</sub>-filter-paper.



Figure S7. SEM images of binary rare earth metal oxides formed by burning  $M(NO_3)_x$ -filter paper.



Figure S8 TEM and HRTEM images of  $CeO_2$  obtained by burning  $Ce(NO_3)_3$ -filter paper.



Figure S9. SEM images of iron oxides formed by burning  $Fe(NO_3)_3$ -cotton.



Figure S10 (a) Cycling performances of various binary and ternary transition metal oxides anodes at rate of 100 mA/g. (b)Voltage profiles of the as-obtained CuO/Cu<sub>2</sub>O/Cu copperbased materials.



Figure S11 Cycling performances of various binary rare earth metal oxides as anodes at rate of 100 mA/g.