Electronic Supplementary Information

Single Phase of Spinel Co_2RhO_4 Nanotubes with Remarkably Enhanced Catalytic Performance for Oxygen Evolution Reaction

So Yeon Kim[a, c], Areum Yu [a, c], Yejung Lee[a], Ha Yeon Kim[a], Nam-Suk Lee[b], Yeon Jae Kim[a]

Chongmok Lee[a], Youngmi Lee[a,*], and Myung Hwa Kim[a,*]

[a]*Department of Chemistry & Nanoscience, Ewha Womans University, Seoul, 13760, Korea*

[b]*National Institute for Nanomaterials Technology (NINT), Pohang University of Science and Technology (POSTECH), Pohang, 790-784, Korea*

[c]*Authors contributed equally to this work.*

[*]To whom all correspondence should be addressed: myungkim@ewha.ac.kr, youngmilee@ewha.ac.kr

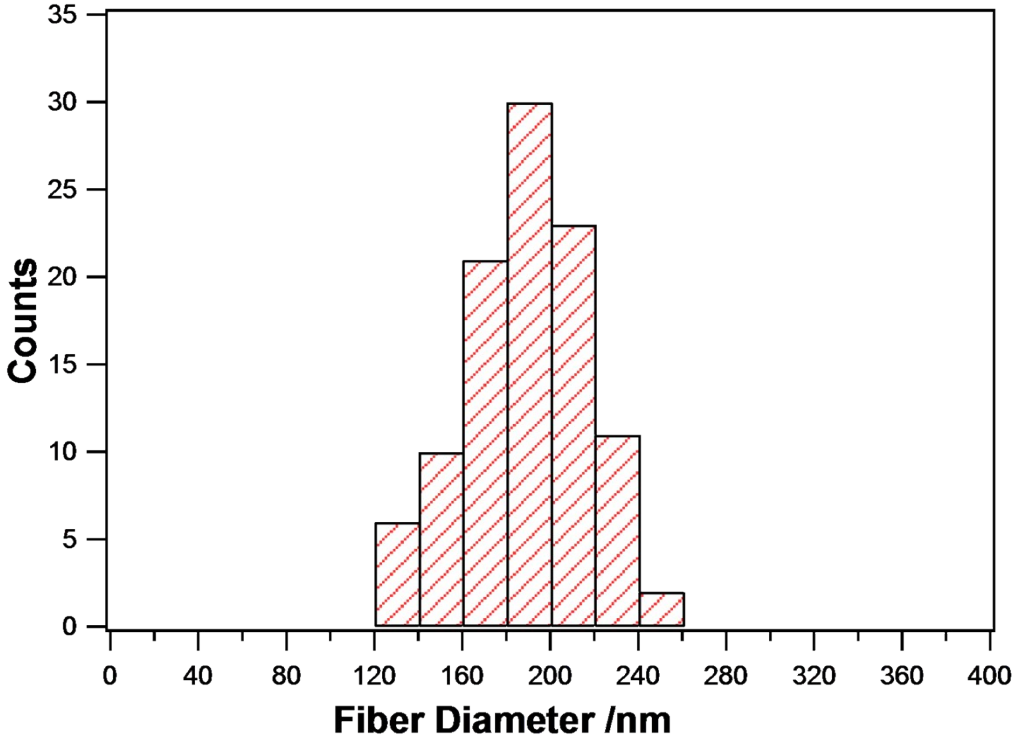

Fig. S1 Size distribution of Co_2RhO_4 obtained from SEM images.

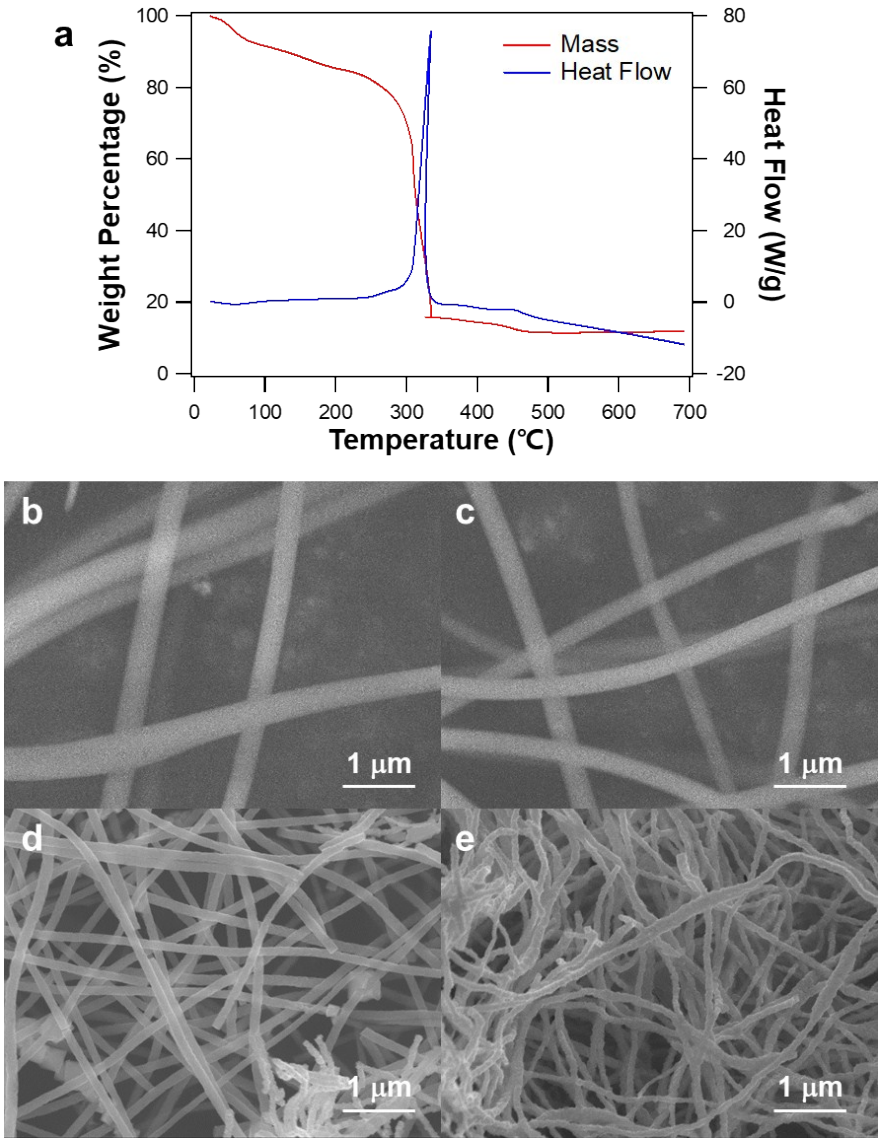

Fig. S2 DSC/TGA curves obtained in air with 10 ℃ /min of as spun $RhCl_3/Co(NO_3)_2$/PVP composite nanofibers. SEM images of as spun $RhCl_3/Co(NO_3)_2$/PVP composite nanofibers after thermally treated until reaching different temperature of (b) 200 ℃, (c) 330 ℃, (d) 450 ℃ and (e) 500 ℃ with increasing rate of 10 ℃ /min.

The first weight loss occurs with 14.83% in the range of 22.6°C to 206°C accompanied by a small endothermic peak near 58°C in the DSC curve. We believe that it is mainly due to the

loss of the surface absorbed water or the residual water molecules in the composite fibers. The second weight loss with 46.24% is positioned between 206^{o}C and 320^{o}C accompanied by two exothermic peaks including a small satellite peak near 280^{o}C and 311^{o}C in the DSC curve. In this region, the dramatic weight loss is attributed to the decomposition of the nitrate, chlorine and side-chain of PVP. The third weight loss with 24.37% is achieved in the temperature range from 320^{o}C to 400^{o}C. The sharp exothermic peak at 330^{o}C is likely originated from the oxidation of the main chain of PVP. The last weight loss with 2.56% occurs between 400^{o}C and 480^{o}C and there exists a small exothermic peak centered at about 450^{o}C. On the other hand, the weight loss is negligible above 480^{o}C so that all other components except Co, Rh, and O are completely removed to form mixed metal oxide nanofibers. The total weight loss was 12.00% at 700^{o}C. The following SEM images were taken at the same condition with a DSC/TGA measurement for a comparison of the measured weight loss with the estimated volume reduction during the thermal annealing process. The diameter of nanofibers at various temperatures were estimated by 341(±41) at 200^{o}C, 289(±26) at 330^{o}C, 118(±14) at 450^{o}C, and 92(±7) at 500^{o}C, respectively. The dramatic change of the nanofiber diameter is closely associated up to the completion of a few exotherms between 200^{o}C and 450^{o}C. Above 450°C, the fiber diameter remains relatively constant while the weight loss continues. Below 450 °C the surface of nanofibers is relatively smooth, but the surface texture at 500^{o}C becomes quite rough, suggesting the formation of the metal oxide crystalline phases begins to develop and becomes increasingly prominent at higher temperatures. Thus, DSC/TGA result suggests that it is necessary for the formation of mixed metal oxide crystalline phases to increase the annealing temperature up to higher than 500^{o}C, consistent with our structural analysis.

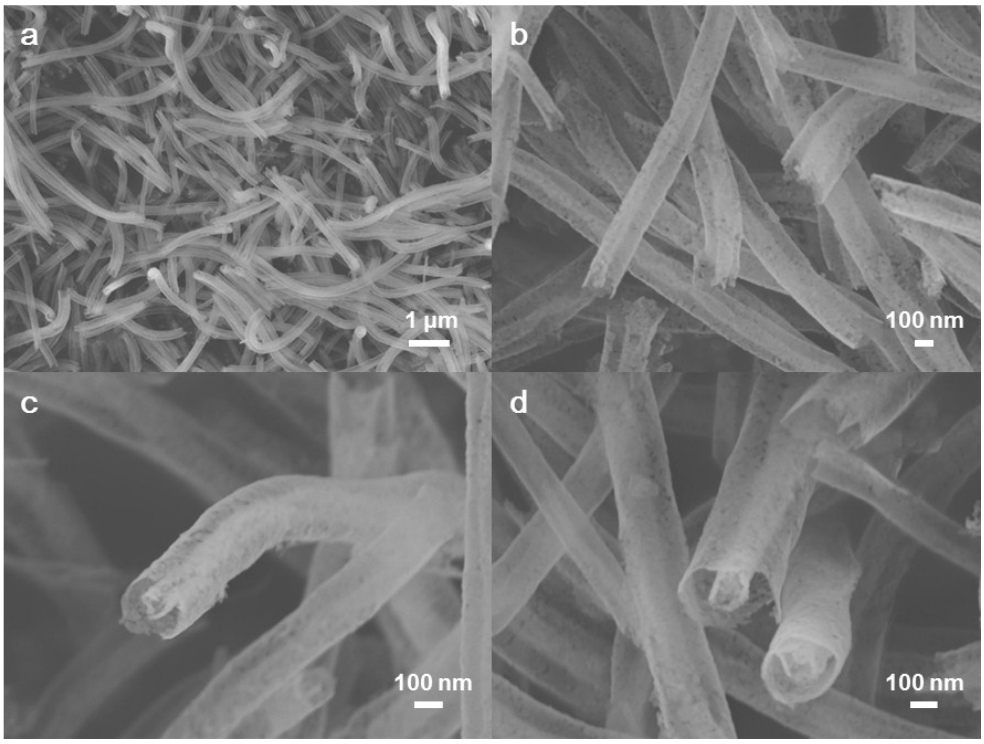

Fig. S3 SEM images of Co_3O_4 nanofiber

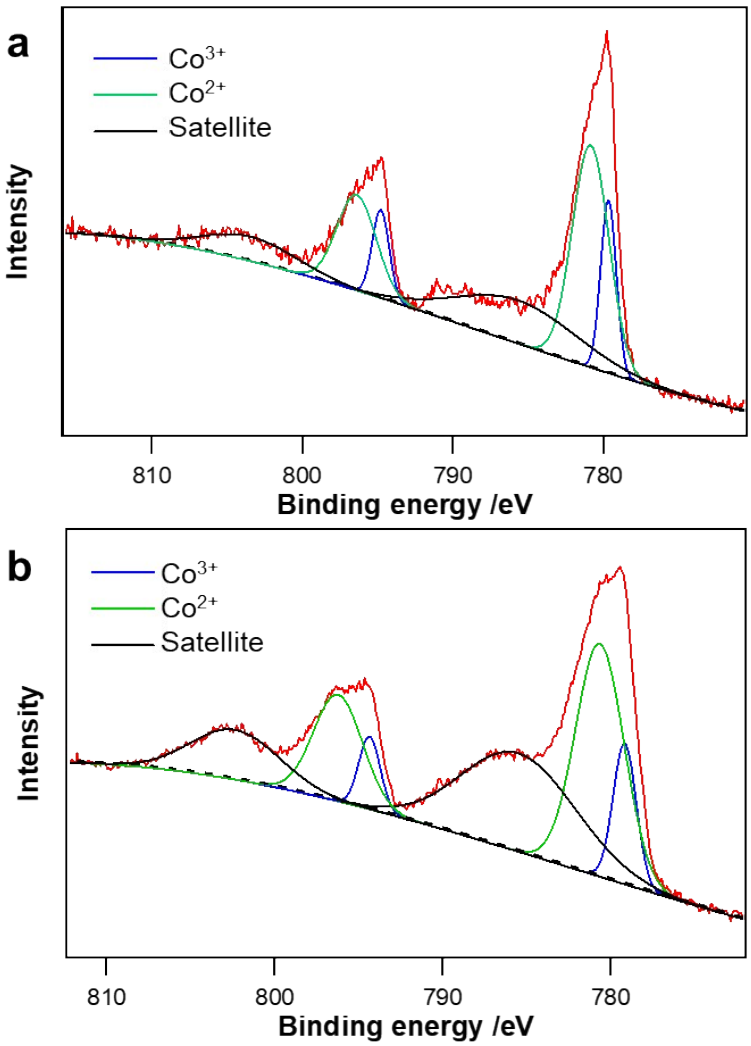

Fig. S4 High resolution Co 2p spectra of (a) electrospun Co_3O_4 nanotubes and (b) electrospun Co_2RhO_4 nanotubes. The atomic ratios of Co^{2+} to Co^{3+} are 3.34 for $2p_{1/2}$ and 3.46 for $2p_{3/2}$ in Co_2RhO_4, while those values are 2.05 for $2p_{1/2}$ and 3.02 for $2p_{3/2}$ in pure Co_3O_4.