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

Supporting Information

Carbon Thin-layer-coated Manganese-Oxide Nanocrystal as Effective Support for Highly Durable and Active Pt Electroctalyst Stabilized at Metal–Metal Oxide–Carbon Triple Junction

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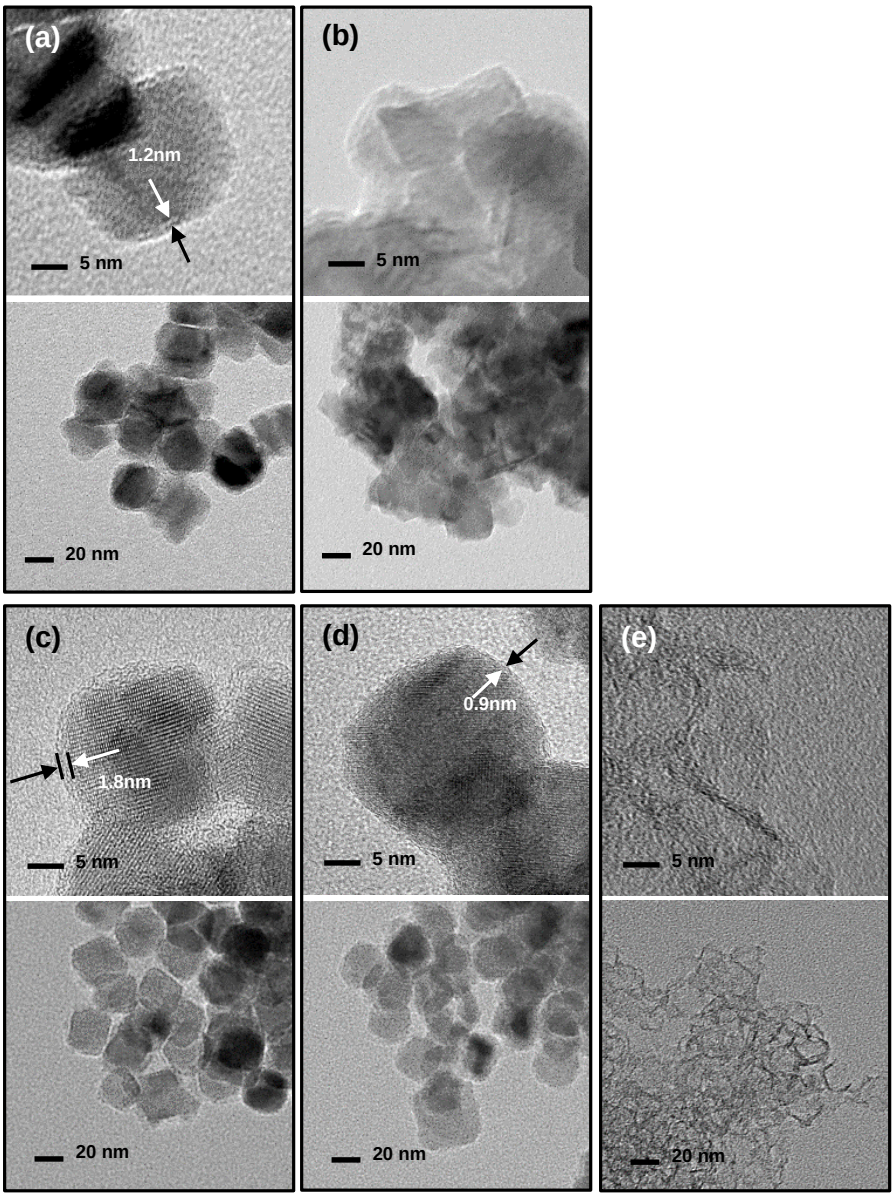

Figure S1. TEM (lower) and HRTEM (upper) images of (a) $\mathbf{Mn_3O_4@PDA_{1.2nm}}$ and (b) the resultant product of (a) after reductive annealing at 800 °C, (c) $\mathbf{Mn_3O_4@PDA_{1.8nm}}$, (d) $\mathbf{MnO@C_{0.9nm}}$ which was obtained from the $\mathbf{Mn_3O_4@PDA_{1.8nm}}$ after reductive annealing and (e) $\boldsymbol{h}\mathbf{\text{-}C_{0.9nm}}$ obtained from dissolution of MnO core of $\mathbf{MnO@C_{0.9nm}}$.

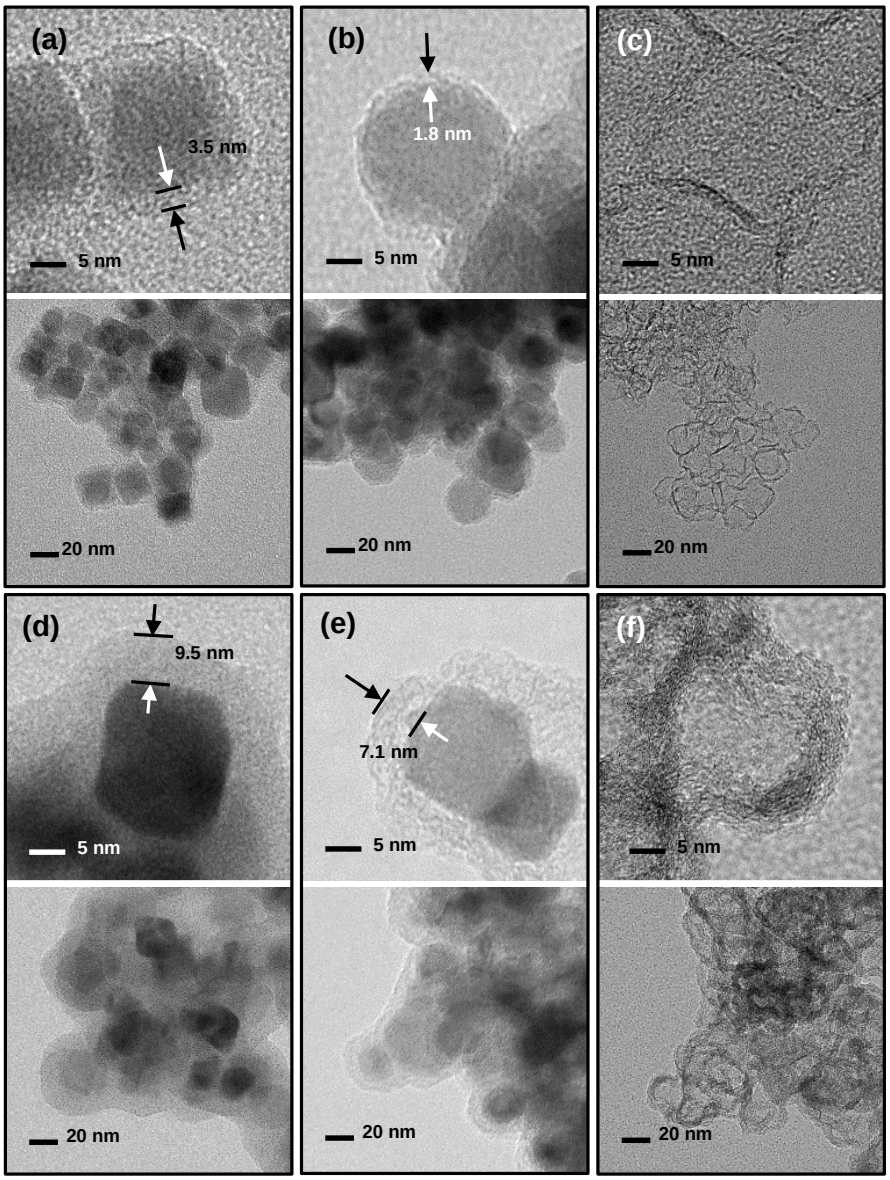

Figure S2. TEM (lower) and HRTEM (upper) images of (a) **Mn_3O_4@PDA$_{3.5nm}$**, (b) **MnO@C$_{1.8nm}$** which was obtained from reductive annealing of **Mn_3O_4@PDA$_{3.5nm}$** and (c) ***h*-C$_{1.8nm}$** by dissolving the MnO. (d) **Mn_3O_4@PDA$_{9.5nm}$**, (e) **MnO@C$_{7.1nm}$** and (f) ***h*-C$_{7.1nm}$**.

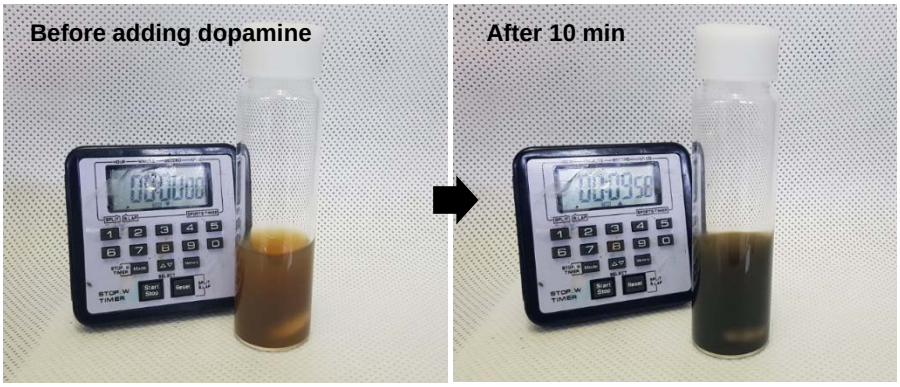

Figure S3. Photographs of the reaction suspension before and after 10 min adding the dopamine molecules to ***sf*-Mn_3O_4** dispersed suspension.

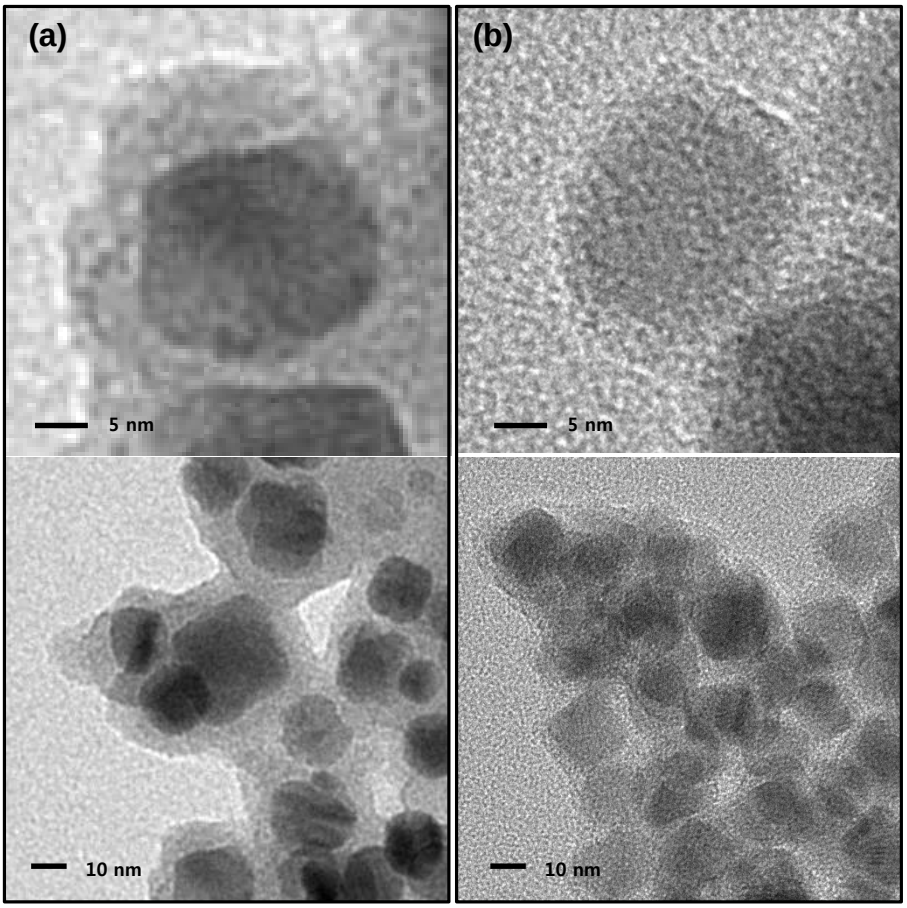

Figure S4. TEM (lower) and HRTEM (upper) images of **Mn_3O_4@PDA** prepared (a) at pH 3 in air and (b) under N_2 atmosphere at pH 8.5.

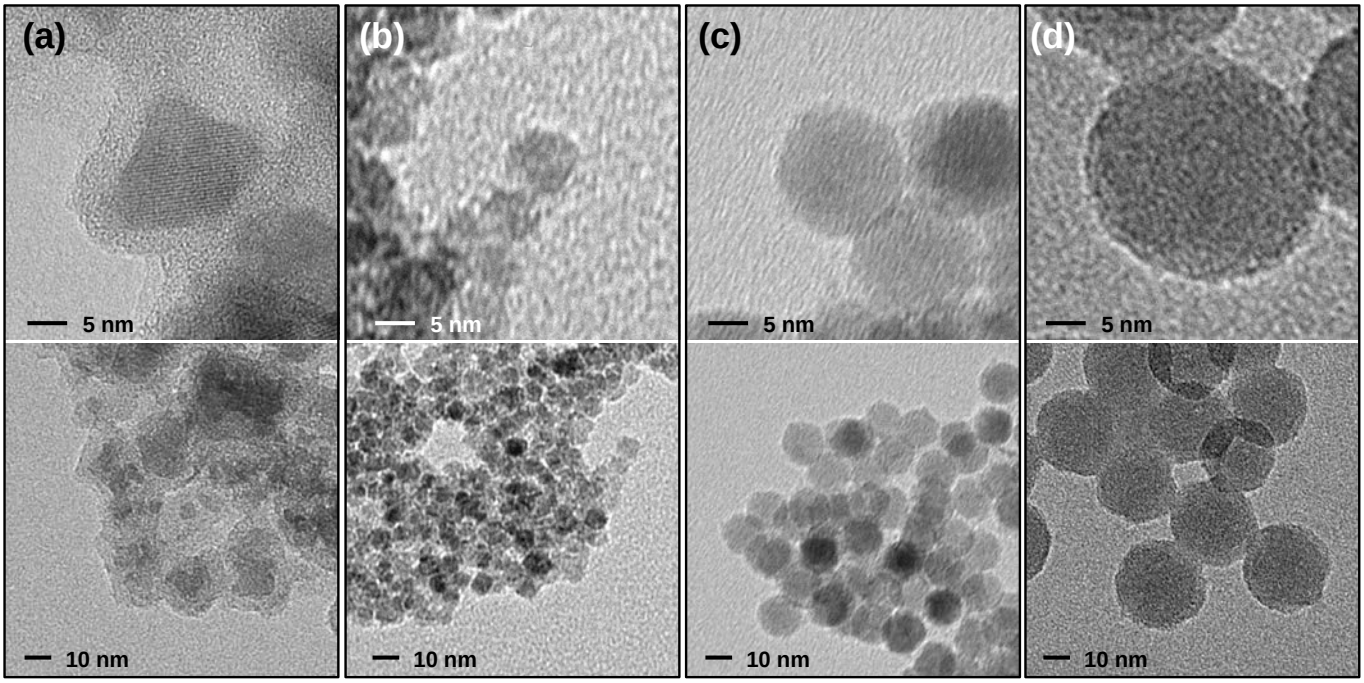

Figure S5. TEM (lower) and HRTEM (upper) images of (a) ***sf*-CoMn(III)$_2$O$_4$**, (b) ***sf*-Mn(II)Fe$_2$O$_4$**, (c) ***sf*-Fe$_3$O$_4$** and (d) SiO_2 nanoparticles after a reaction with dopamine molecules under N_2 atmosphere.

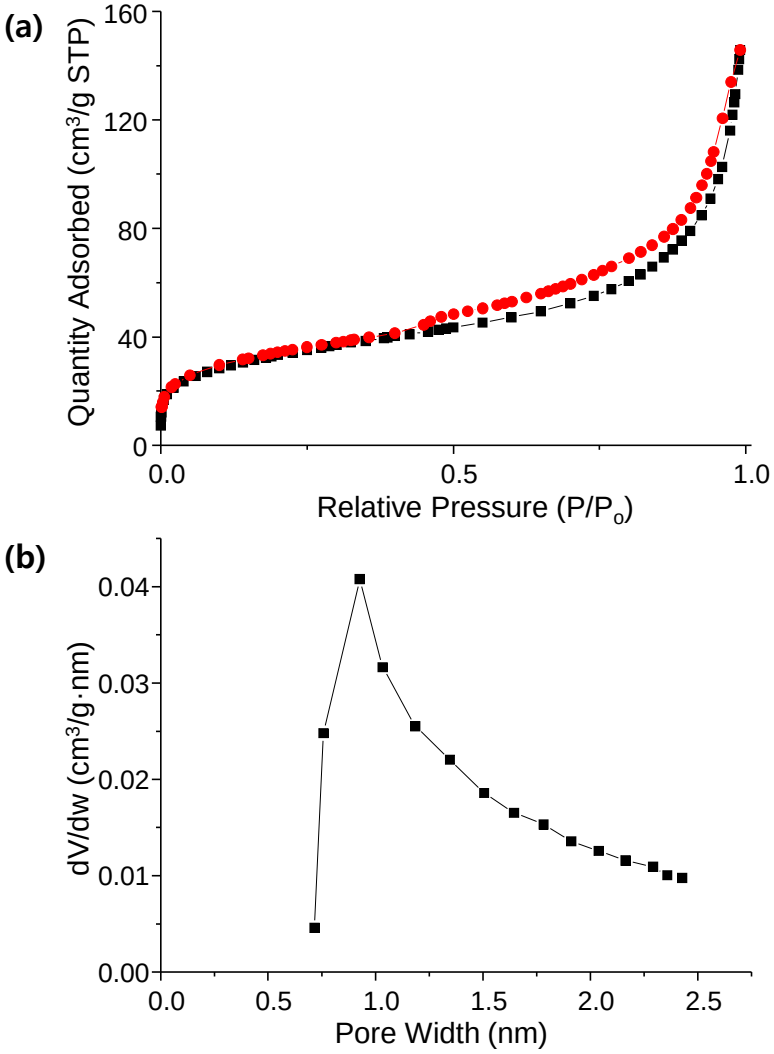

Figure S6. (a) Nitrogen adsorption/desorption isotherm at 77K of the **Mn_3O_4/Pt@$C_{1.8nm}$** and (b) pore size distribution estimated by using the H-K method.

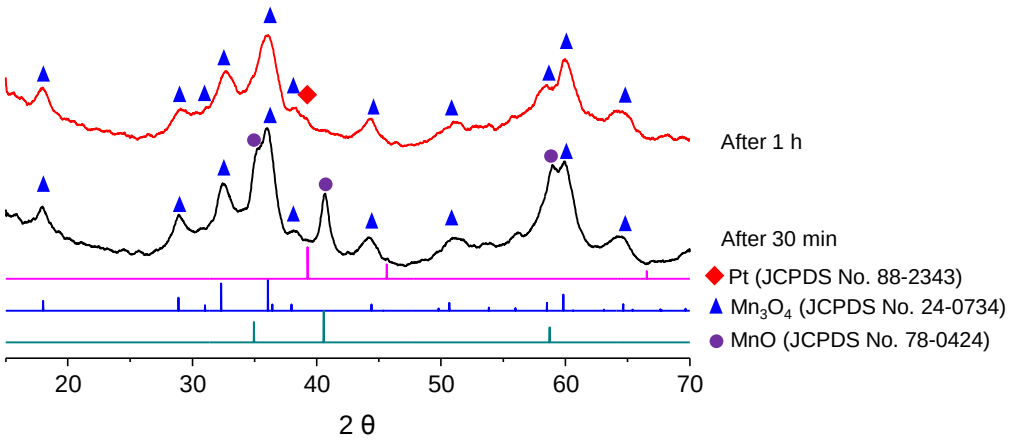

Figure S7. XRD patterns obtained after galvanic replacement reaction after 30 min and 1h.

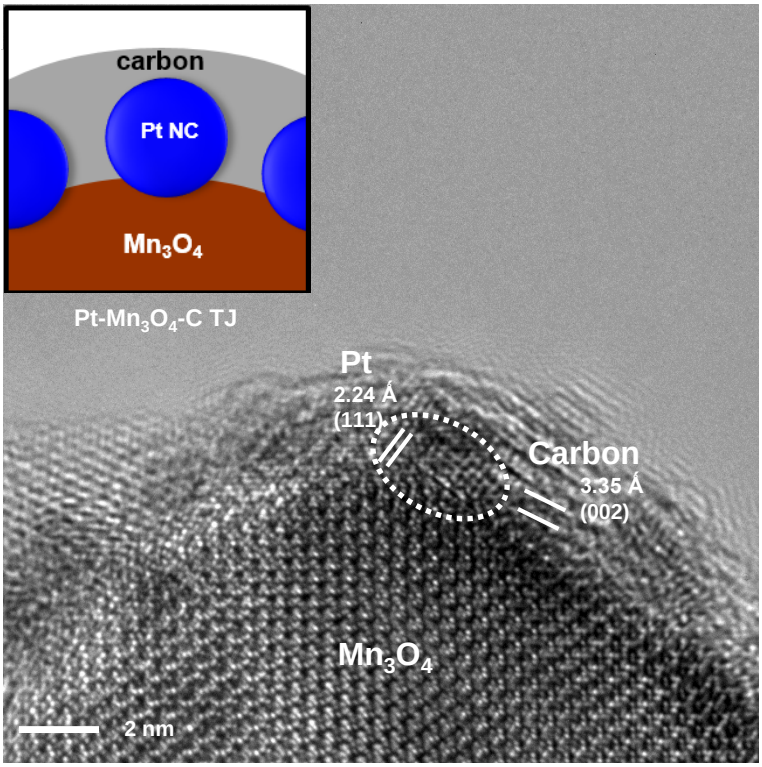

Figure S8. High resolution TEM images of surface of **Mn_3O_4/Pt@$C_{1.8nm}$**.

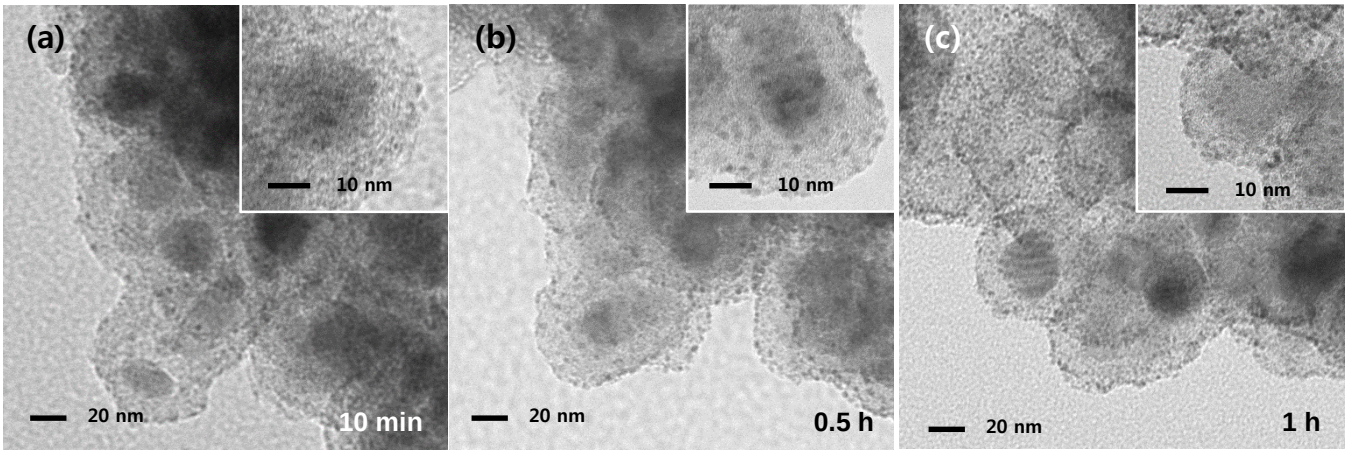

Figure S9. TEM and HRTEM images of galvanic replacement reaction of **MnO@C$_{7.1nm}$** with $PtCl_4^{2-}$ solution with different reaction time at (a) 10 min, (b) 30 min and (c) 1h.

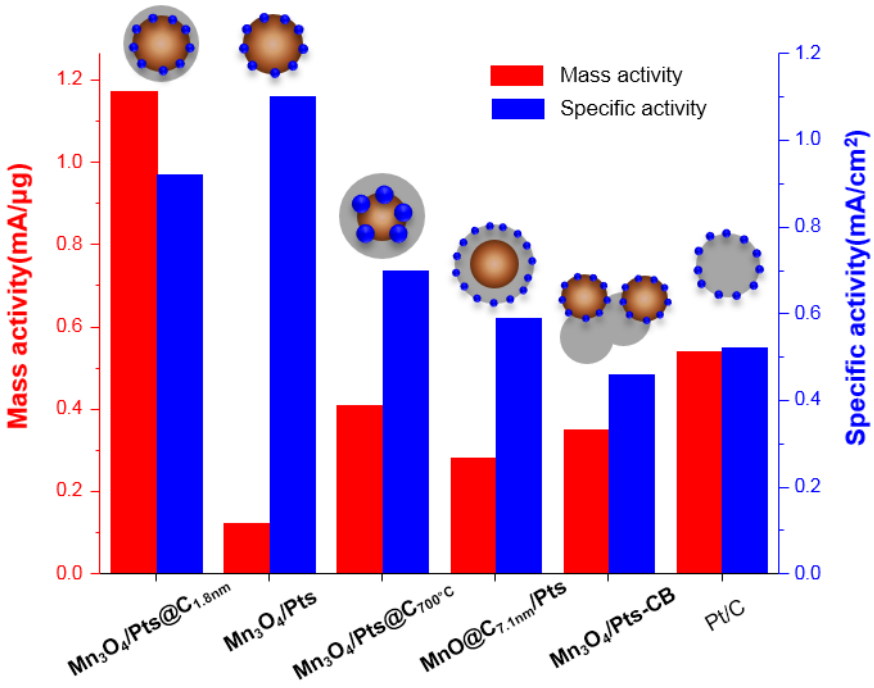

Figure S10. Comparison of electrocatalytic activities for ORR among various products of **Mn_3O_4/Pts@$C_{1.8nm}$**, **Mn_3O_4/Pts**, **Mn_3O_4/Pts@$C_{700°C}$**, **MnO@$C_{7.1nm}$/Pts** and **Mn_3O_4/Pts-CB**.

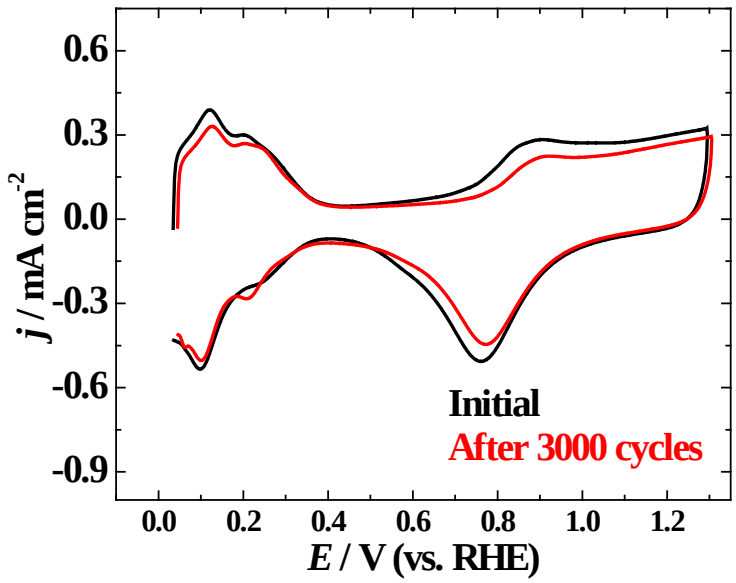

Figure S11. Cyclic voltammograms of the **Mn_3O_4/Pts@$C_{1.8nm}$** catalysts in 0.1 M $HClO_4$ obtained before (black) and after (red) 3000 potential sweeps.

Table S1. The estimated Mn ions in the supernatant solution by using ICP after the reaction of ***sf*-Mn_3O_4** with dopamine molecules under air atmosphere.

	Mn ion concentration
Supernatant solution after reaction of ***sf*-Mn_3O_4** with dopamine	20.0 mg/L
Supernatant solution without dopamine molecules (control experiment)	0.2 mg/L