Supplementary Materials: Monodispersed Pt_3Ni Nanoparticles as a Highly Efficient Electrocatalyst for PEMFCs

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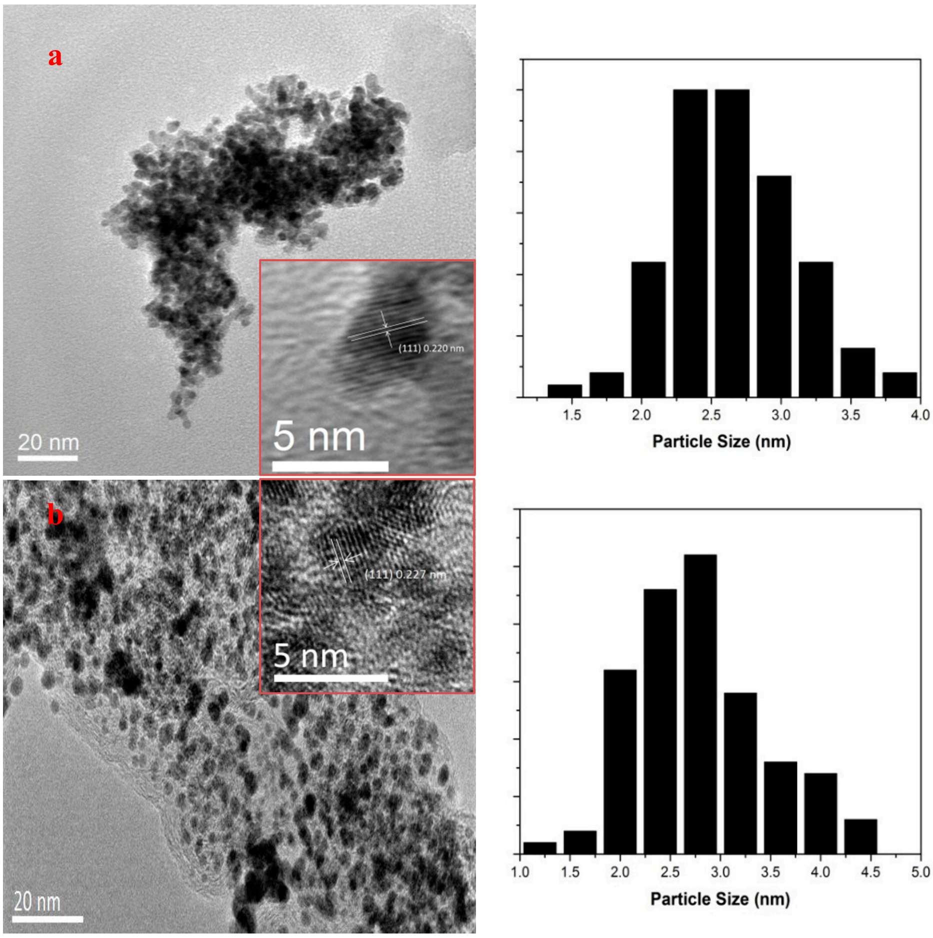
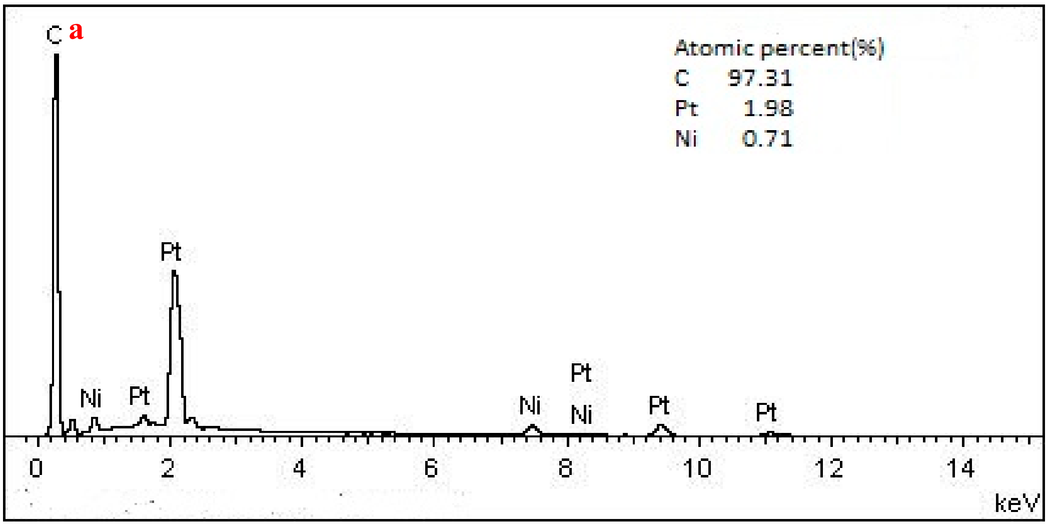


Figure S1. TEM images and size histogram of **(a)** NC-Pt_3Ni nanoparticles and **(b)** commercial Pt/C.



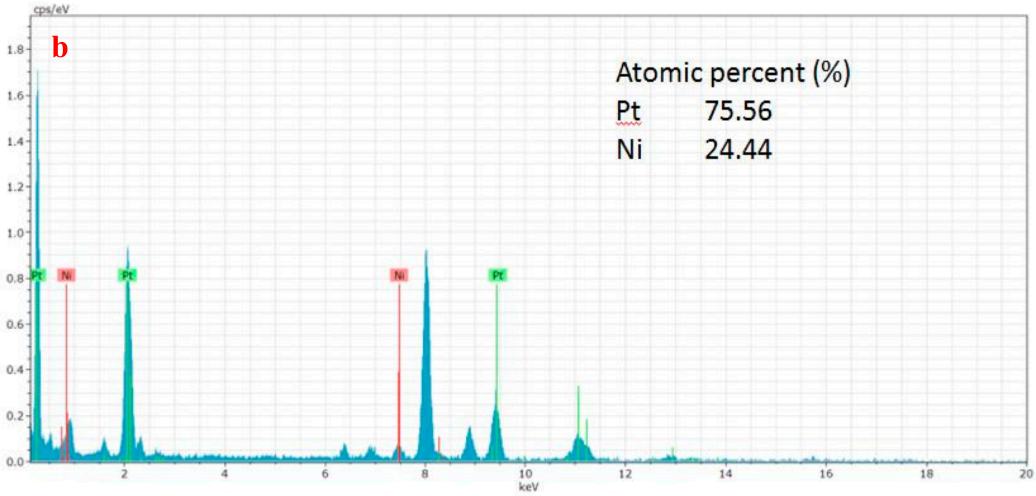


Figure S2. EDX spectra of **(a)** Pt_3Ni/EC-600 and **(b)** NC-Pt_3Ni.

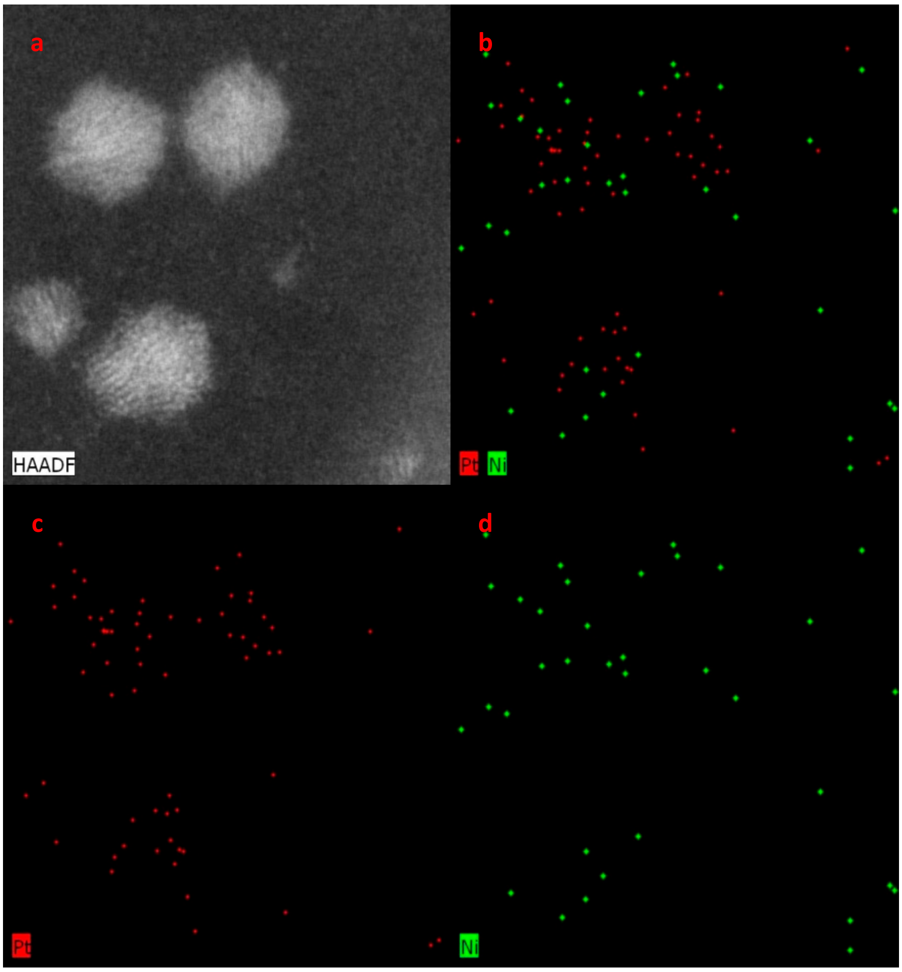


Figure S3. STEM-EDX elemental mapping of Pt_3Ni/EC-600: (**a**) HAADF-STEM image, (**b**) overall mapping of Pt and Ni, (**c**) Pt mapping in red and (**d**) the Ni mapping in green are shown.

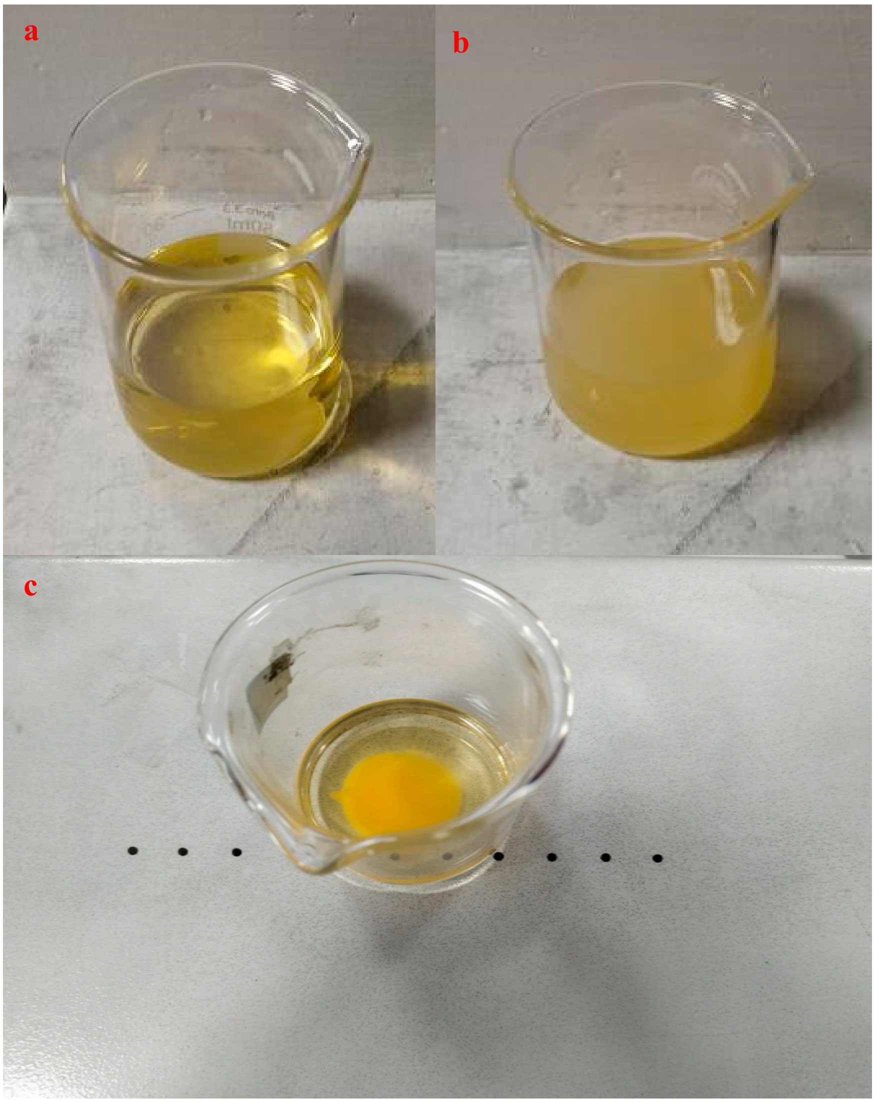


Figure S4. Optical images of precursor solution **(a)** before the addition of TEA **(b)** after the addition of TEA **(c)** 10 min after the addition of TEA without sonication.

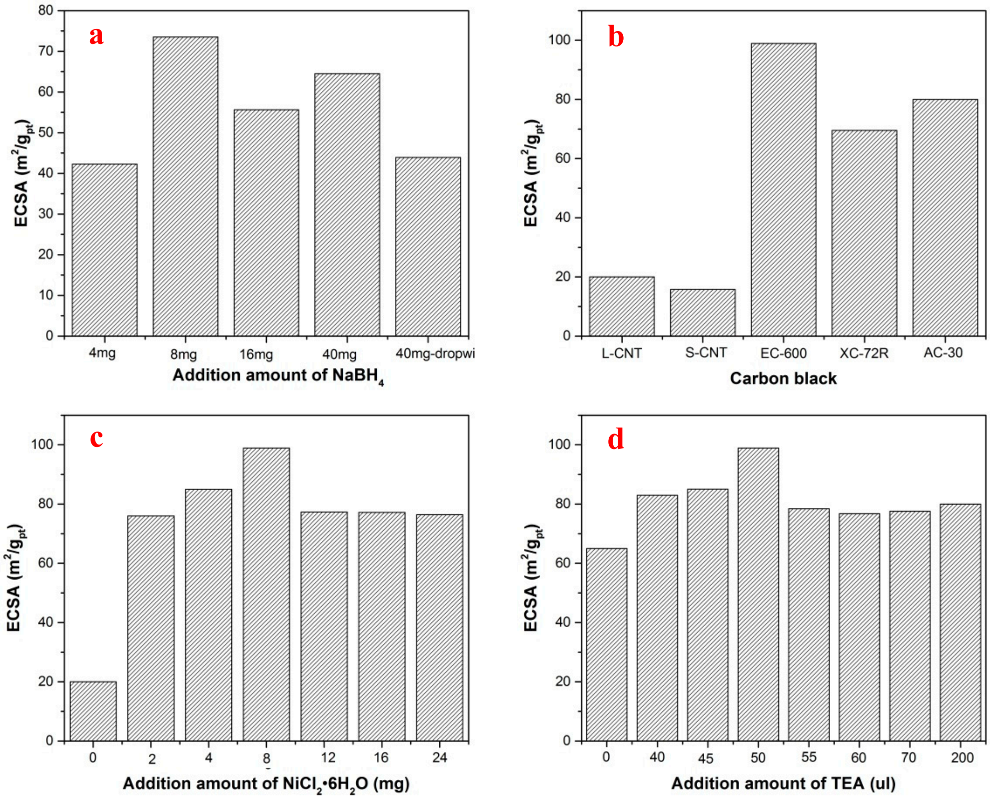


Figure S5. Changes of ECSA under various synthesis conditions. **(a)** controlling the addition rate and addition amount of NaBH4. **(b)** using different carbon black as catalyst support. **(c)** controlling the addition amount of NiCl2•6H2O. **(d)** controlling the addition amount of TEA.

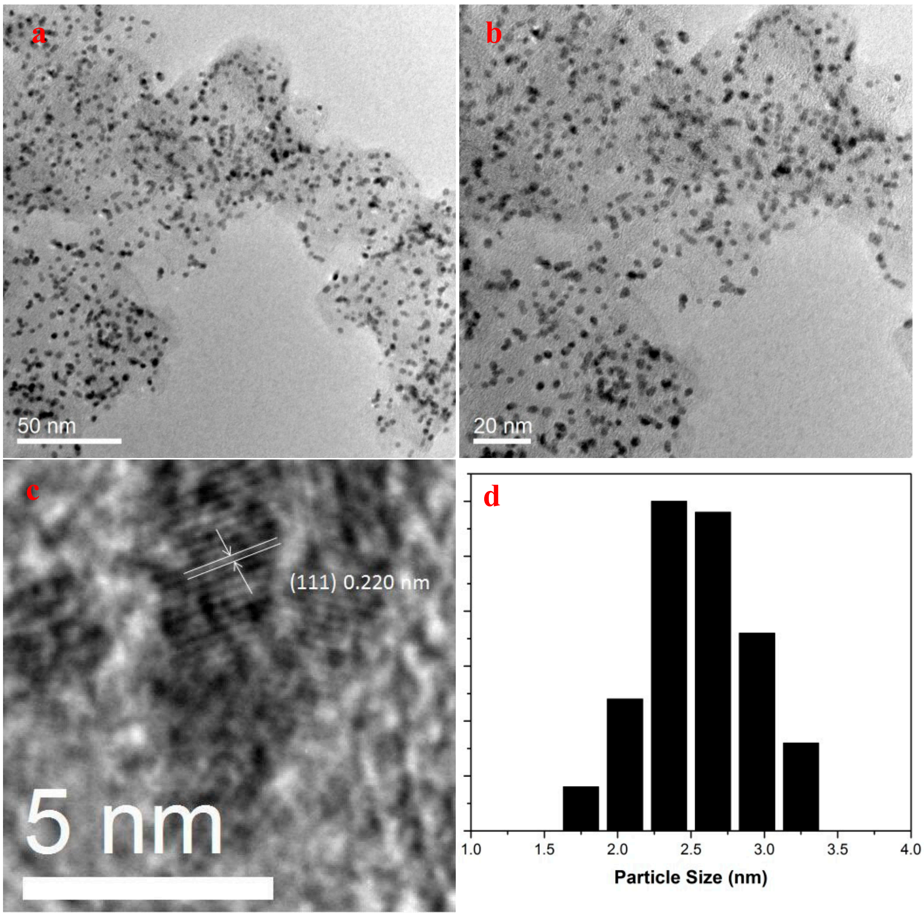


Figure S6. (a-b) TEM images, **(c)** HRTEM images and **(d)** size histogram of Pt_3Ni/EC-600 after initial electro-cycling

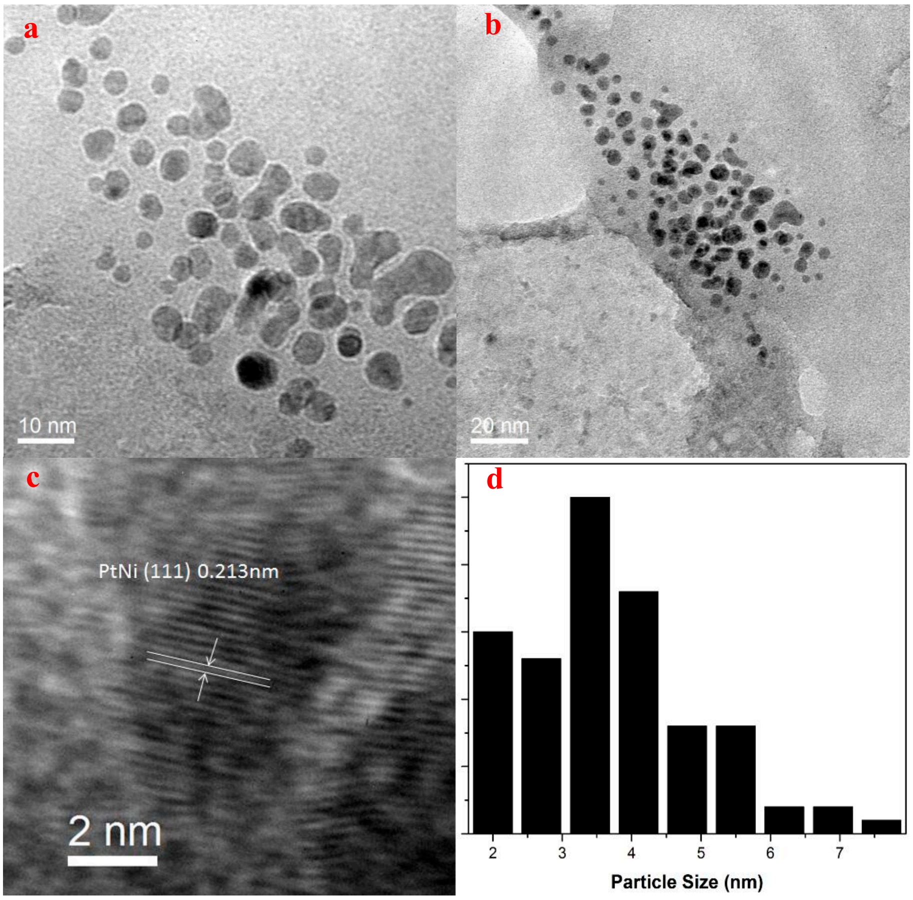


Figure S7. (a-b) TEM images, **(c)** HRTEM images and **(d)** size histogram of Pt_3Ni/EC-600 after accelerated durability tests

Table S1. Comparison of optimal as-prepared catalysts and state-of-the-art PtNi nanoparticles.

PtNi catalysts	Particle size (nm)	Dispersion and Size distribution	ECSA (m^2 g_{pt}^{-1})	MA(mA mg^{-1}_{pt}) @RDE
Pt_3Ni/EC-600	2.8±0.4	Good	98.9	0.14@0.9V
Pt_3Ni[1]	2.4~4	Bad	-----	----
PtNi/C[2]	3.87	Bad	60.9	~0@0.9V
PtNi@C[3]	5	Bad	55.4	0.84@0.9V
PtNi@MoS_2[4]	6.26±1.35	Normal	-----	----
PtNi@CNS-60[5]	3	Normal	-----	-----
PtNi core-shell[6]	6±1.7	Bad	-----	-----

[1] Varshney, M.; Sharma, A.; Shin, H.; Lee, H. H.; Jeon, T.; Lee, B.; Chae, K.; Won, S. O., Influence of Ni doping on PtNi nanoparticles: Synthesis, electronic/atomic structure and photocatalyst investigations. *JOURNAL OF PHYSICS AND CHEMISTRY OF SOLIDS* **2017**, 110, 187-194.

[2] Zhang, P.; Tao, A.; Tan, Y.; Jin, J.; Zhang, H., Performance and Durability of Pt-Ni Catalysts Supported on Polypyrrole-Carbon for Fuel Cells. *Journal of Electronic Materials* **2019**, 48, 2780-2787.

[3] Li, W.; Zou, S., PtNi Nanoparticles Encapsulated in Few Carbon Layers as High-Performance Catalysts for Oxygen Reduction Reaction. *ACS Applied Energy Materials* **2019**, 2, 2769-2778.

[4] Ma, L.; Zhang, Q.; Wu, C.; Zhang, Y.; Zeng, L., PtNi bimetallic nanoparticles loaded MoS2 nanosheets: Preparation and electrochemical sensing application for the detection of dopamine and uric acid. *Analytica Chimica Acta* **2019**, 1055, 17-25.

[5]Li, J.; Liu, L.; Ai, Y.; Hu, Z.; Xie, L.; Bao, H.; Wu, J.; Tian, H.; Guo, R.; Ren, S.; Xu, W.; Sun, H.; Zhang, G.; Liang, Q., Facile and Large-Scale Fabrication of Sub-3 nm PtNi Nanoparticles Supported on Porous Carbon Sheet: A Bifunctional Material for the Hydrogen Evolution Reaction and Hydrogenation. *Chemistry – A European Journal* **2019**, 25, 7191-7200.

[6]Glüsen, A.; Dionigi, F.; Paciok, P.; Heggen, M.; Müller, M.; Gan, L.; Strasser, P.; Dunin-Borkowski, R. E.; Stolten, D., Dealloyed PtNi-Core–Shell Nanocatalysts Enable Significant Lowering of Pt Electrode Content in Direct Methanol Fuel Cells. *ACS Catalysis* **2019**, 9, 3764-3772.