ELECTRONIC SUPPORTING INFORMATION

Covalently functionalized layered MoS_2 supported Pd nanoparticles as highly active oxygen reduction electrocatalyst

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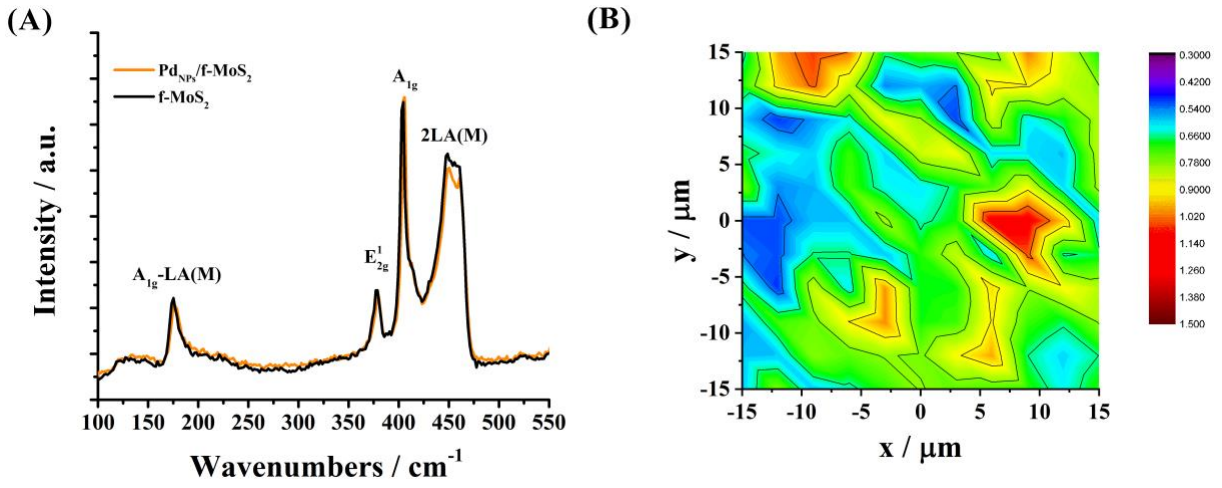

Figure S1. *(A) Raman spectra for Pd$_{NPs}$/f-MoS$_2$ (orange) and functionalized MoS$_2$ (black); (B) Raman mapping upon excitation at 633 nm of the 2LA(M)/A$_{1g}$ intensity ratio of a 30 x 30 mm^2 area (121 acquisition points in total) for Pd$_{NPs}$/f-MoS$_2$ hybrid material. In Figure S1A we present a representative Raman mapping, close to the total average of five.*

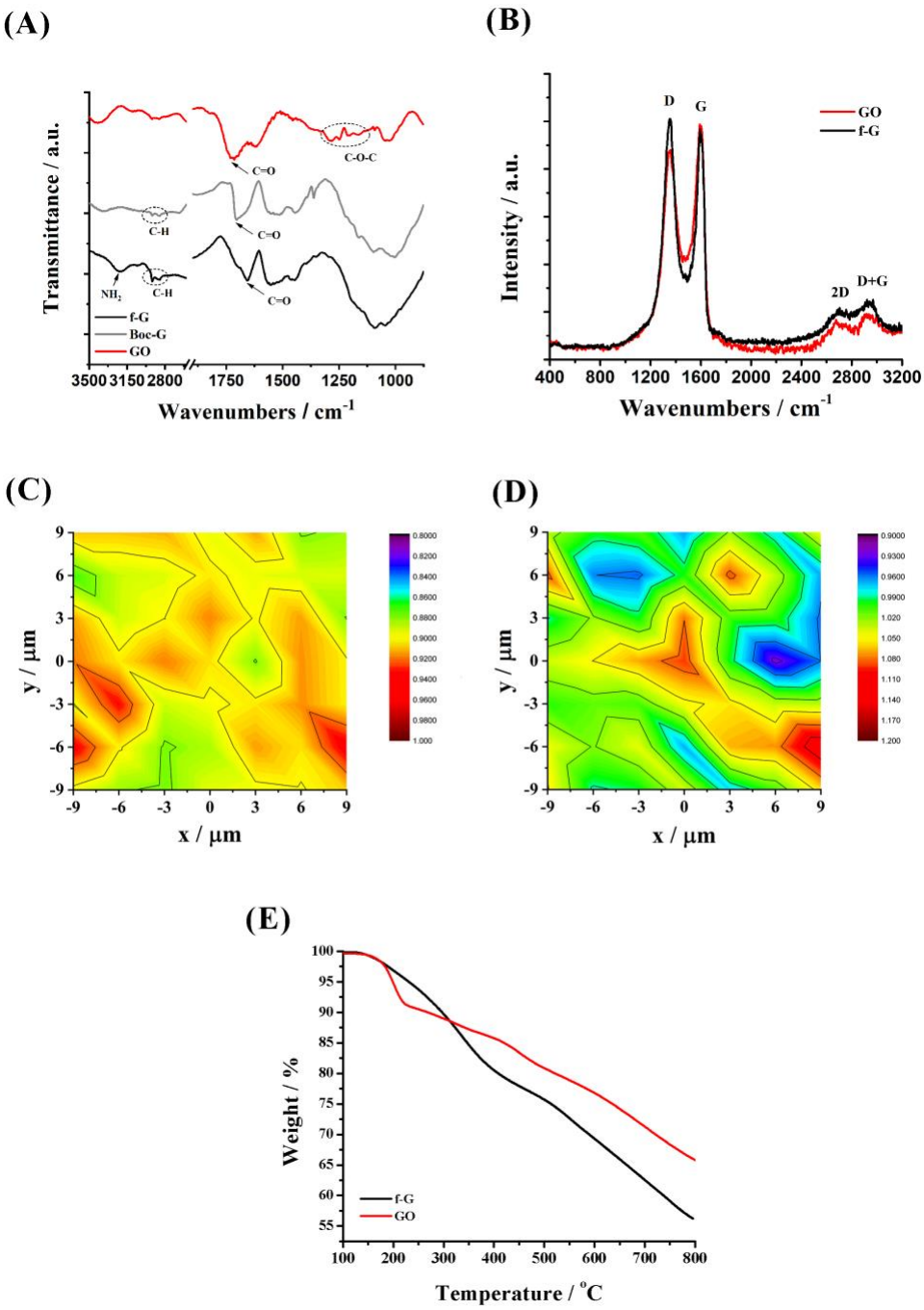

Figure S2. *(A) ATR-IR spectra for amino functionalized graphene (black), BOC modified graphene (gray) and GO (red); (B) Raman spectra for f-G (black) and GO (red) upon excitation at 514 nm; (C, D) Raman mapping upon excitation at 514 nm of the D/G intensity ratio of a 18 x 18 mm2 area (49 acquisition points in total) for GO and f-G, respectively. In Figure S2B we present a representative Raman mapping, close to the total average of five. (E) Thermographs for f-G (black) and GO (red).*

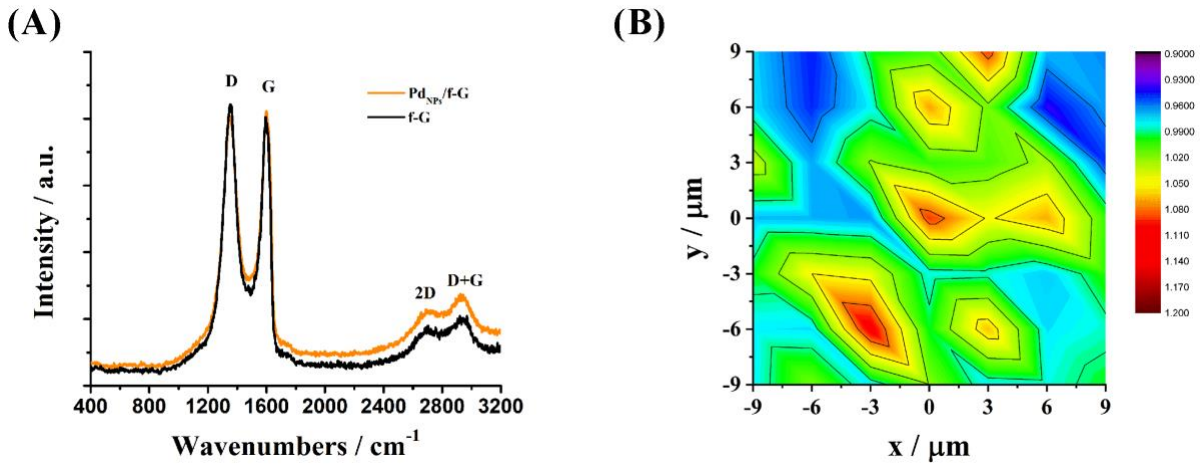

Figure S3. *(A) Raman spectra for Pd$_{NPs}$/f-G (orange) and f-G (black); (B) Raman mapping upon excitation at 514 nm of the D/G intensity ratio of a 18 x 18 mm^2 area (49 acquisition points in total) for Pd$_{NPs}$/f-G hybrid material. In Figure S3A we present a representative Raman mapping, close to the total average of five.*

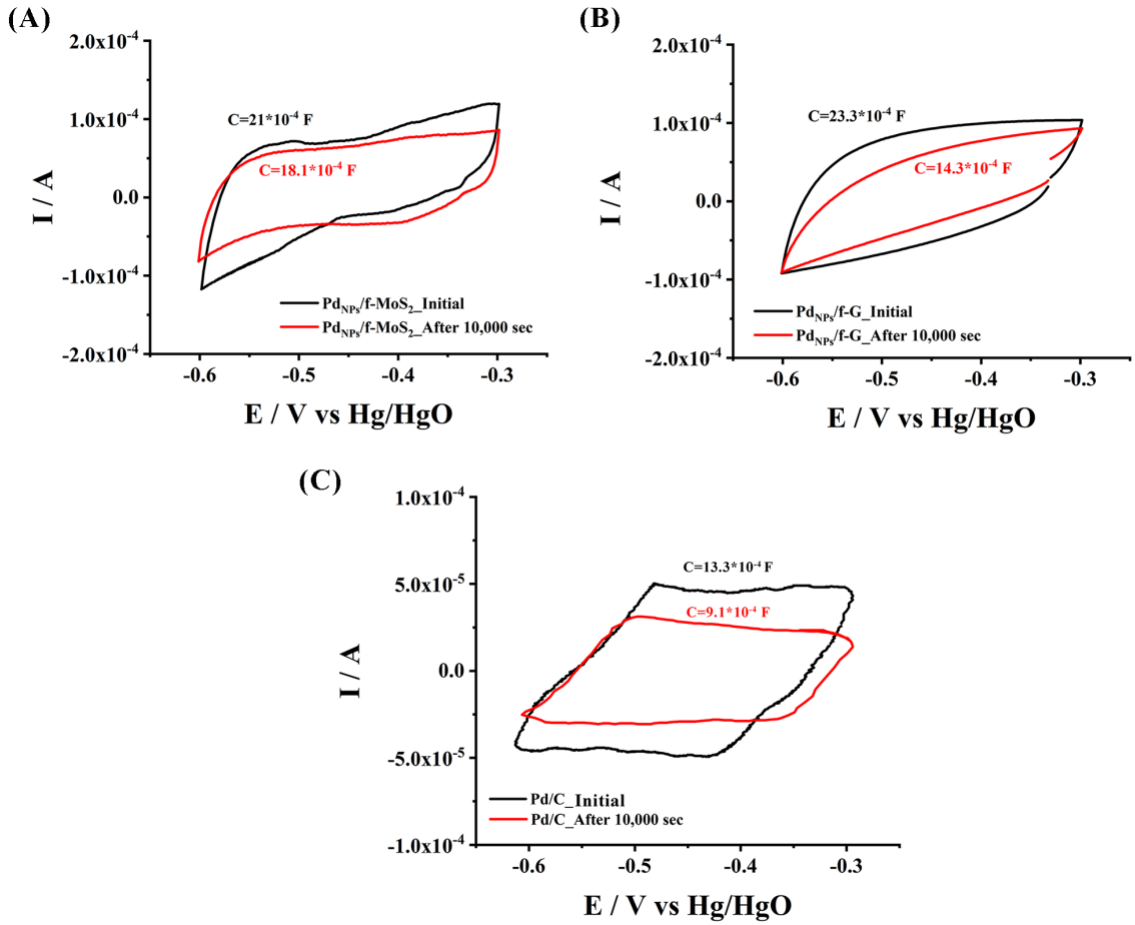

Figure S4. *Cyclic voltammetry curves for (A) Pd_{NPs}/f-MoS_2, (B) Pd_{NPs}/f-G hybrids and (C) Pd/C before and after the chronoamperometric essays. The CV curves obtained at the "double layer region" (-0.6 – 0.3 V vs Hg/HgO) recorded in N_2 saturated aqueous 0.1 M KOH solution at a scan rate 50 mV/sec. The capacitance values were calculated for each case using the Equation 6.*

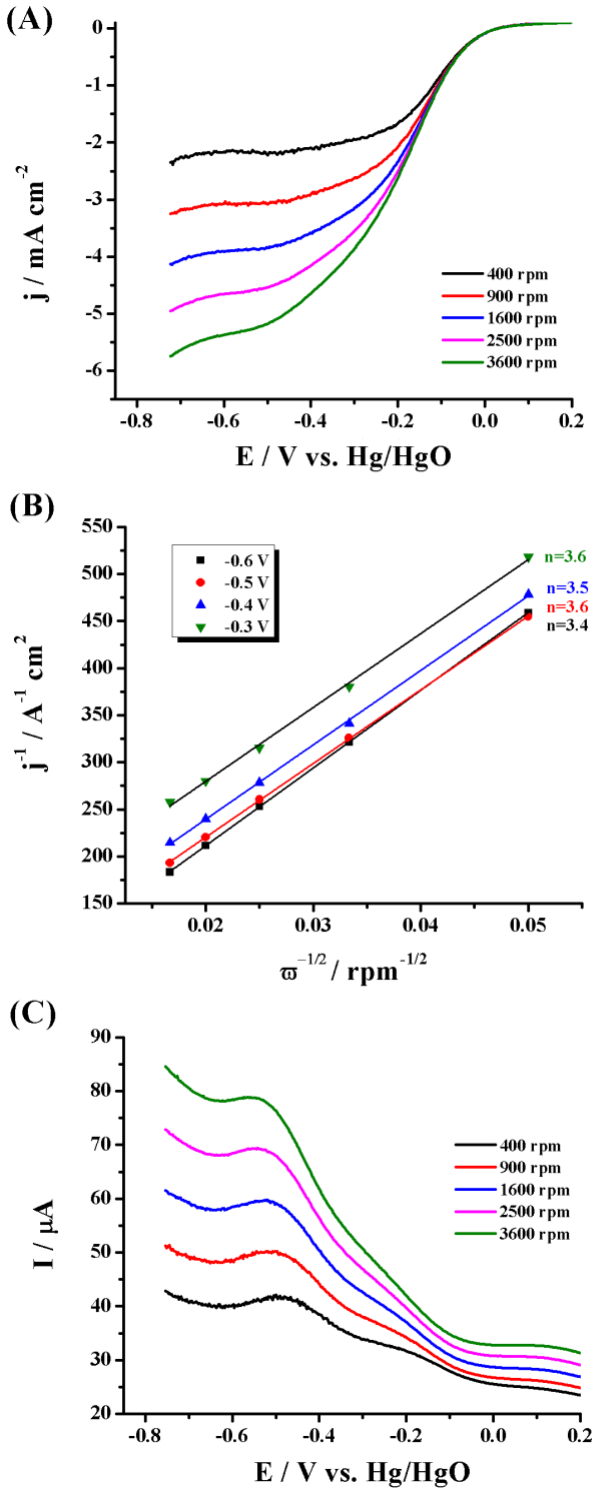

Figure S5. *(A) ORR polarization curves at different rotation rates (400-3600 rpm) for Pd_{NPs}/f-G, (B) the corresponding K-L plots and (C) ring response. All measurements were conducted in O_2-saturated aqueous 0.1M KOH electrolyte, and the corresponding LSV polarization curves were recorded at a scan rate of 5 mVs^{-1}. The ring potential was fixed at 1.0 V vs Hg/HgO. The current densities in (A) are normalized to the geometric electrode area.*

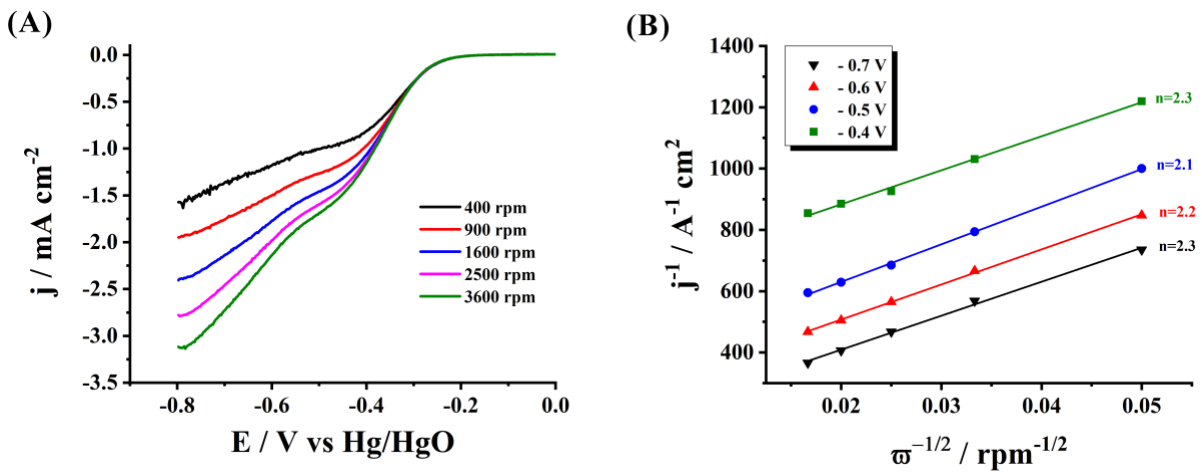

Figure S6. *(A) ORR polarization curves at different rotation rates (400-3600 rpm) for f-MoS_2 and (B) the corresponding K-L plots. All measurements were conducted in O_2-saturated aqueous 0.1 M KOH electrolyte, and the corresponding LSV polarization curves were recorded at a scan rate of 5 mV/s. The current densities are normalized to the geometric electrode area.*

Table S1. Performance analysis of recently developed hybrid MoS_2-based electrocatalysts for the ORR.

Pd_{NPs} (~9nm) on MoS_2 nanosheets	O_2-saturated 0.1 M KOH	Onset potential: -0.10 V vs. SCE Half-wave potential: -0.20 V vs. SCE Diffusion limited current density: 5.2 mA cm^{-2} at 1600 rpm Mass activity: 0.55 mA μg_{Pd}^{-1} @ -0.26 V vs. SCE Specific activity: 1.02 mA cm_{ECSA}^{-2} @ -0.26 V vs. SCE Electron transfer number: 3.6 – 4.0 Stability: after 4,000 cycles, no significant activity loss	1
PdS_{NPs} (40-50nm) on MoS_2/N-G heterostructure	O_2-saturated 0.1 M KOH	Onset potential: -0.141 V vs. SCE Half-wave potential: -0.214 V vs. SCE Diffusion limited current density: 4.1 mA cm^{-2} at 1600 rpm Electron transfer number: 3.75 – 3.82 Stability: after 1,000 cycles / 16,000 sec , no significant activity loss Methanol tolerance: up to 0.1 M CH_3OH	2
Pd_{NPs} (2-3nm) on covalently functionalized MoS_2 nanosheets	O_2-saturated 0.1 M KOH	Onset potential: +0.066 V vs. Hg/HgO Half-wave potential: -0.116 V vs. Hg/HgO Diffusion limited current density: 5.7 mA cm^{-2} at 1600 rpm Kinetic current density: 2.65 mA cm^{-2} at -60 mV vs. Hg/HgO Electron transfer number: 3.6 – 4.0 Stability: after 10,000 sec, 16.5 % loss of its initial activity	This work

1. *L.-X. Zuo, L.-P. Jiang and J.-J. Zhu, Ultrason. Sonochem., 2017, **35**, 681-688.*
2. *L. G. Bach, M. L. N. Thi, Q. B. Bui and H. T. Nhac-Vu, Synth. Met., 2019, **254**, 172-179.*