Electronic Supplementary Information

A high-performance catalyst support for methanol oxidation with graphene and vanadium carbonitride

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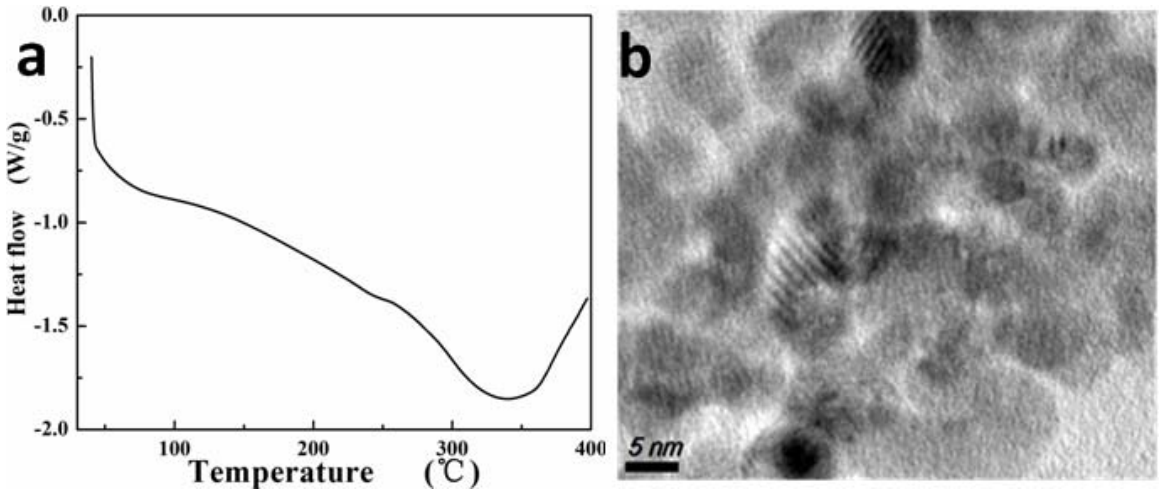

Figure S1. (a) DSC result of Pt/G-V(C, N) at a heating rate of 5°C/min. The DSC result of Pt/G-V(C, N) clearly shows that the curve decrease with the increase of temperature, which is aroused by the endothermic changes of materials. To this curve, the endothermic process should be attributed the structure changes of Pt loaded on G-V(C, N). The crystalline structure of Pt was improved during the heating. The curve reaches the lowest point at around 350 °C, which indicates that the structure change reaches the fastest speed. Considering the heating speed and the temperature for the lowest point, the annealing temperature for Pt/G-V(C, N) was determined at 400 °C. (b) TEM image of Pt/G-V(C, N) catalyst.

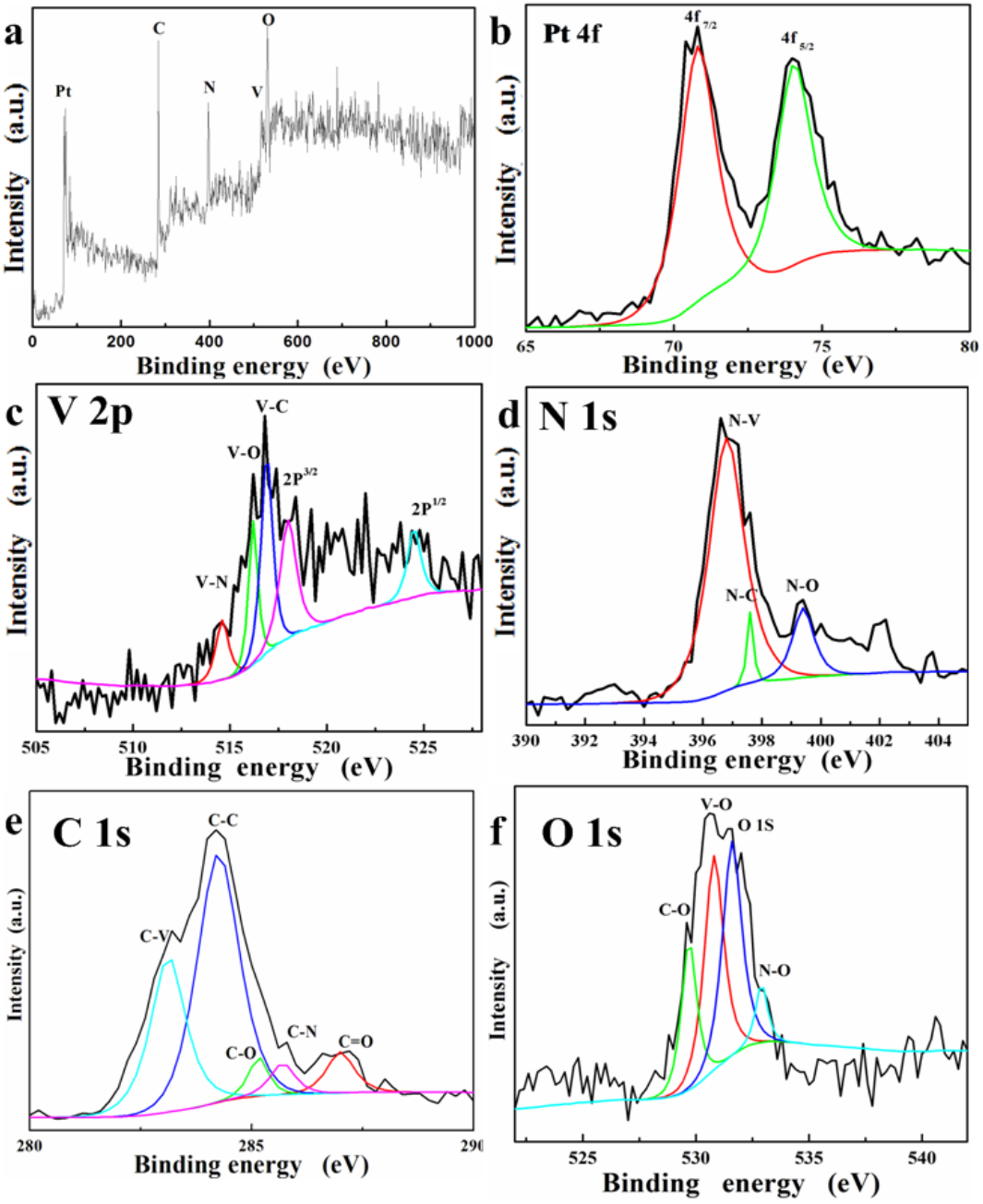

Figure S2. (a) XPS spectrum of Pt/G-V(C, N); (b), (c), (d), (e), and (f) are high-resolution XPS spectra of Pt4f, V2p, N1s, C1s, and O1s, respectively.

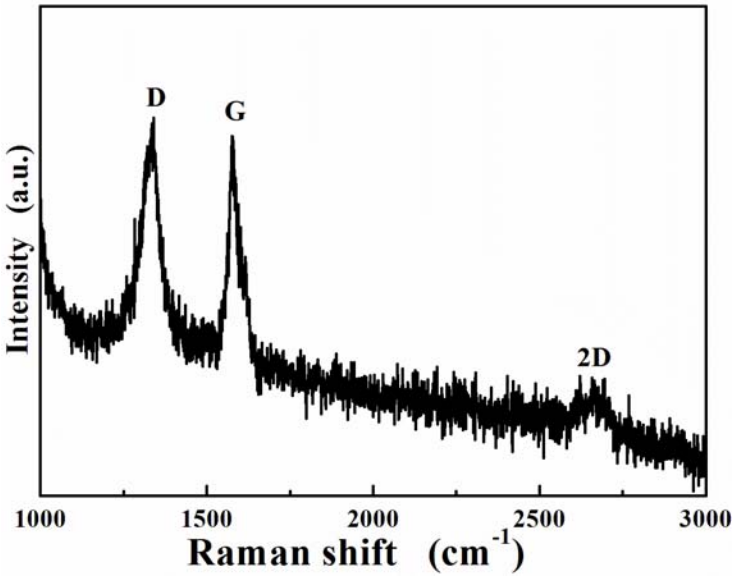

Figure S3. Raman spectrum of Pt/G-V(C,N).

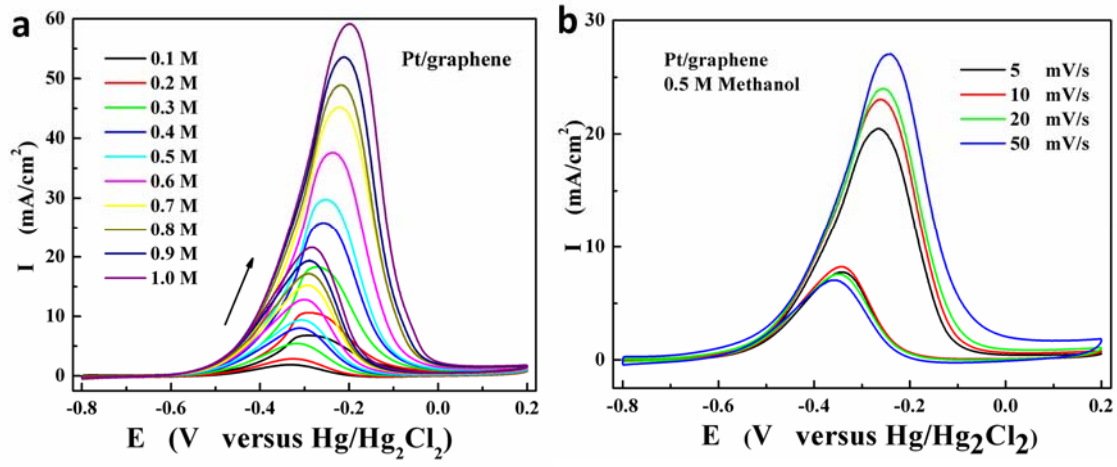

Figure S4. (a) CV curves of methanol oxidation at a scan rate of 50 mV/s with Pt/graphene in 1.0 M KOH solution with different methanol concentrations; (b) CV curves of methanol oxidation with Pt/graphene at different scan rates in 1.0 M KOH and 0.5 M methanol.

Electrochemical surface area calculation:

The methanol oxidation performance of the catalyst was also evaluated by measuring the electrochemical surface area (ECSA). The ECSA is an important factor in electrochemical measurements, which is often calculated using hydrogen adsorption/desorption isotherms and the following equation:[1]

$$ECSA = \frac{Q_H}{q_H},$$

where Q_H is the average charge integrated from the hydrogen desorption region in a cyclic voltammogram and q_H is the charge of a monolayer of hydrogen on Pt surface (210 μC cm^{-2}).[2] Using the CV curve in Figure 3a to calculate the Q_H (between -0.7 V and -0.3 V versus Hg/Hg_2Cl_2), the ECSA was obtained as 2.93 cm^2. Considering the loading of Pt in the catalyst layer (0.005 mg), the effective surface area (ESA) could be calculated as 58.7 m^2 g^{-1}.

References:

1 J.-M. Yang, S.-A. Wang, C.-L. Sun and M.-D. Ger, *J. Power Sources*, 2014, **254**, 298-305.

2 W. Sheng, M. Myint, J. G. Chen and Y. Yan, *Energy Environ. Sci.*, 2013, **6**, 1509-1512.