Supporting Information

Active P species in P-doped graphite carrier improving the catalytic performance of supported Pt towards the hydrogen evolution reaction

Zekun Li[a], Fei Han[b], Ziwu Liu[a,*], Qiancheng Peng[a], Quan-De Wang[a], Maomao Sun[a], Guo-Jun Kang[a,*]

[a]Jiangsu Key Laboratory of Coal-based Greenhouse Gas Control and Utilization, School of Chemical Engineering and Jiangsu Province Engineering Laboratory of High Efficient Energy Storage Technology and Equipments, China University of Mining & Technology, Xuzhou 221008, Jiangsu, China

[b]School of Mineral Processing and Bioengineering, Central South University, Changsha 410083, Hunan, China

*Corresponding author, Email address: lzwmsy@cumt.edu.cn, Fax: 86-516 83883501.

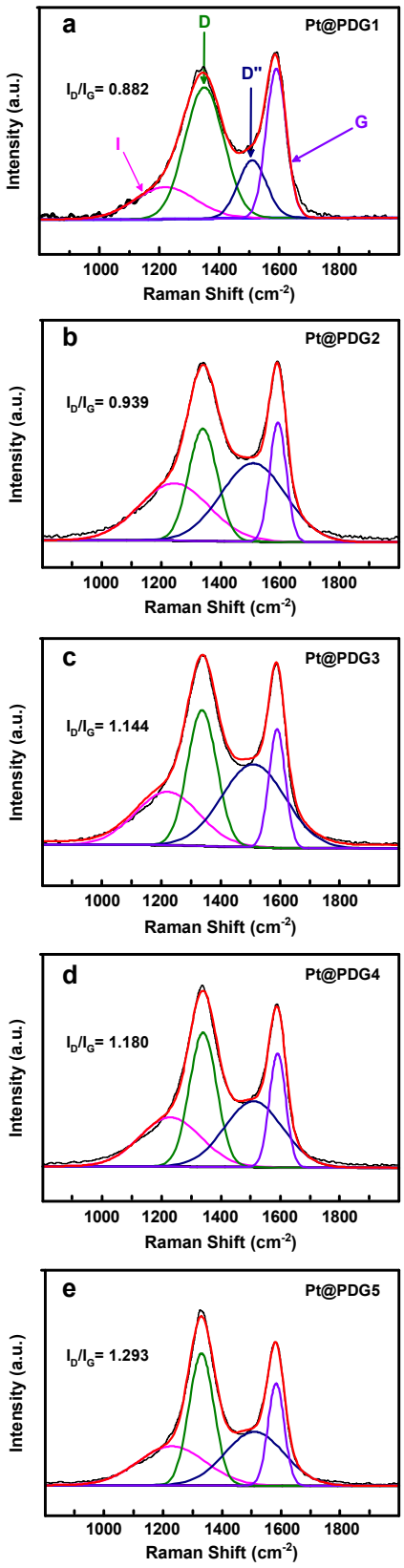

Figure S1. The detailed Raman spectrum of Pt@PDG1 (a), Pt@PDG2 (b), Pt@PDG3 (c),

Pt@PDG4 (d) and Pt@PDG5 (e).

The D band located at ~1350 cm^{-2} and the G band located at ~1580 cm^{-2} reflect the degree of lattice defects and the E_{2g} vibration of carbon atoms, respectively. The other two peaks at ~1220 cm^{-2} and ~1500 cm^{-2} can be classified as I band and D" band, respectively. The I band corresponds to the disorder in the graphitic lattice, sp^2-sp^3 bonds, or the presence of polyenes, and the D" band is generally considered to be related to the presence of amorphous carbon.

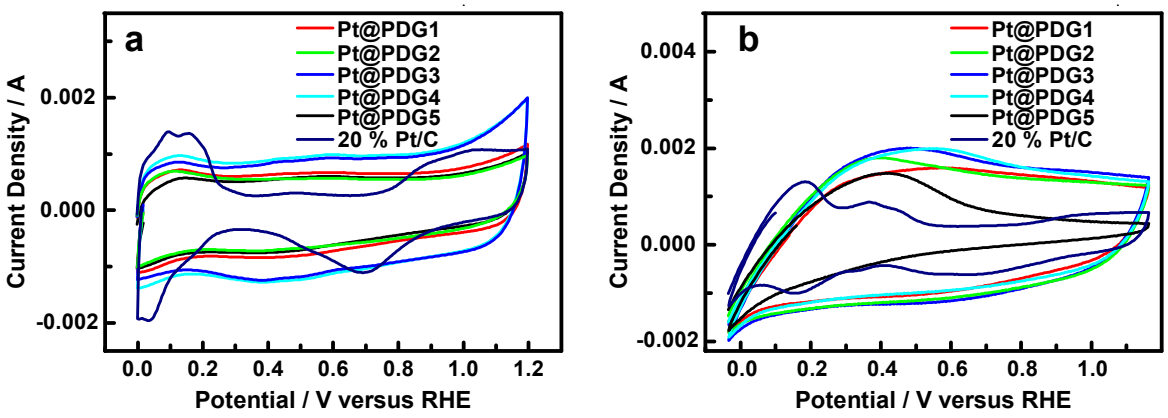

Figure S2. The CVs of Pt@PDG1, Pt@PDG2, Pt@PDG3, Pt@PDG4 and Pt@PDG5 and 20% Pt/C in N_2-saturated 0.5 M H_2SO_4 (a) and 0.1 M KOH (b) solutions.

Electrochemically active surface area (ECSA) values can be calculated from the coulombic charge for the hydrogen adsorption and desorption (Q_H) in the negative-going potential scan according to the following formula [1]: ECSA=Q_H / [Pt] (0.21), where [Pt] represents the platinum loading (g cm^{-2}) in the electrode, Q_H is the charge for hydrogen desorption (mC cm^{-2}), and 0.21 represents the charge required to oxidize a monolayer of H_2 on bright Pt (mC cm^{-2}).

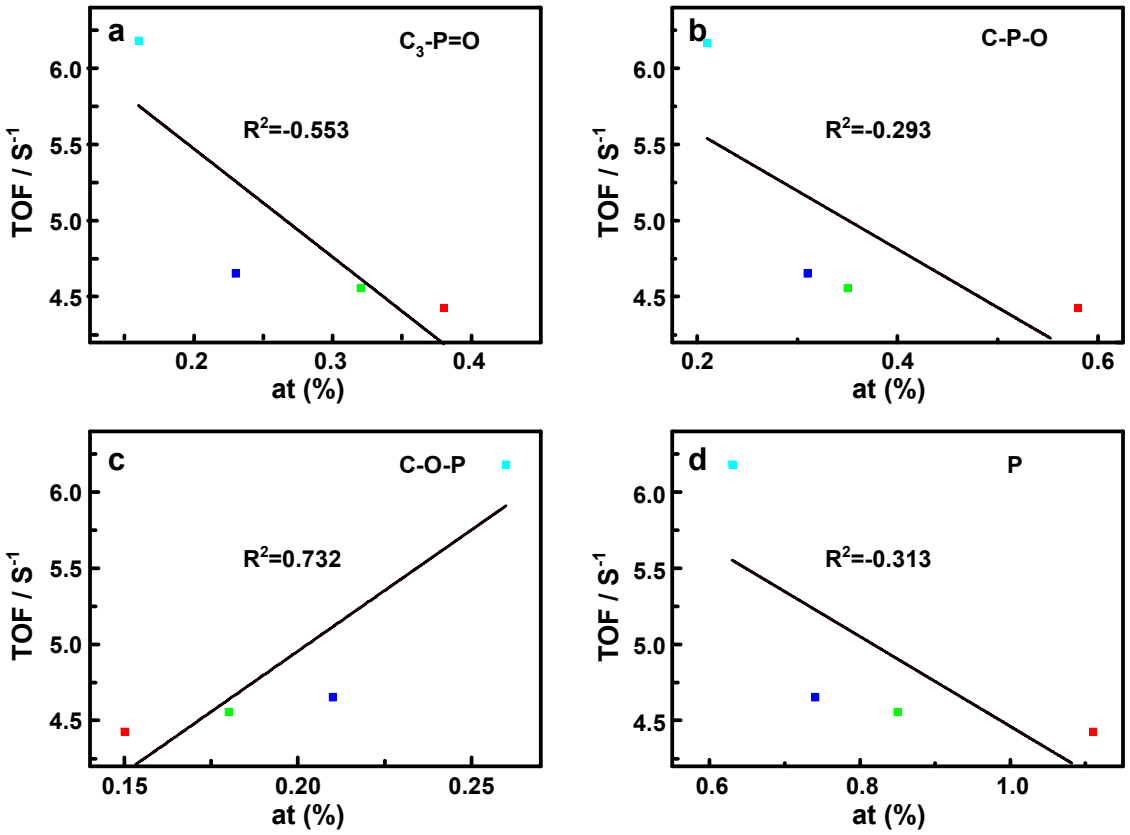

Figure S3. The relevancy between the TOF of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.2 V overpotential and the P species contents in them under acidic media.

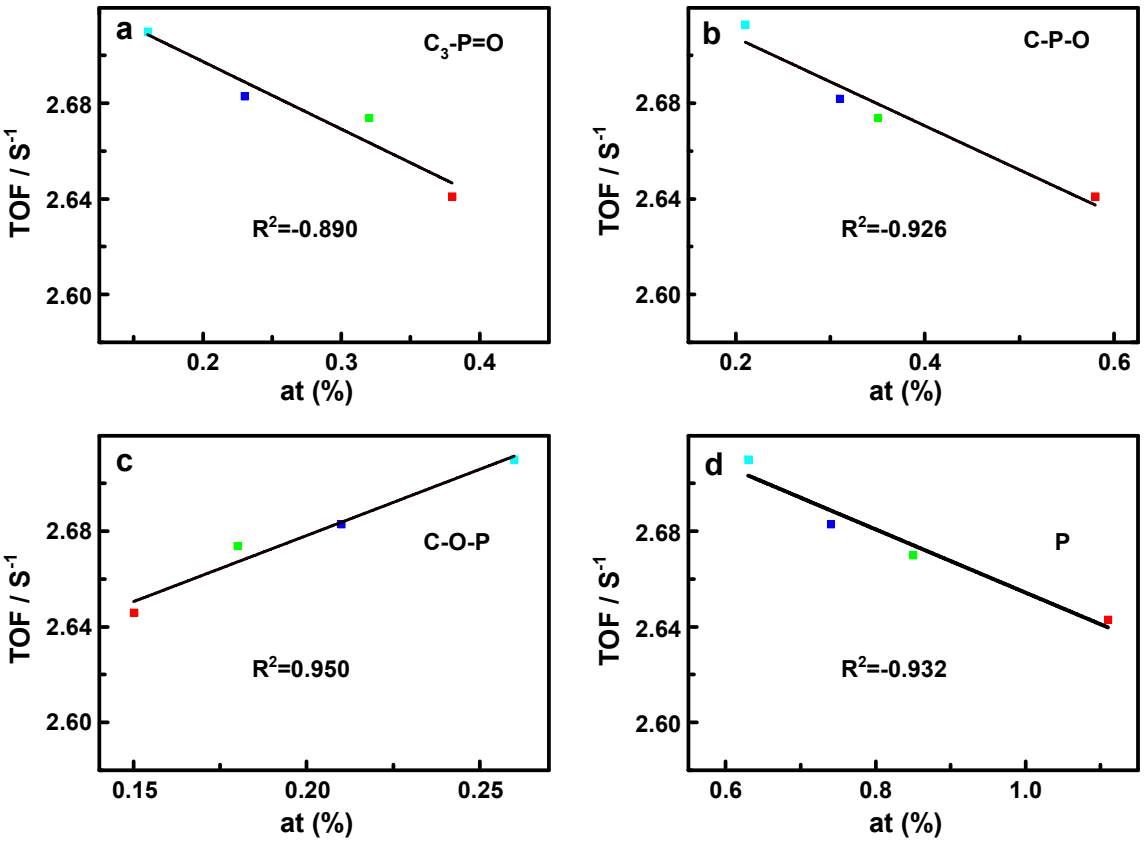

Figure S4. The relevancy between the TOF of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.335 V and the P species contents in them under alkaline media.

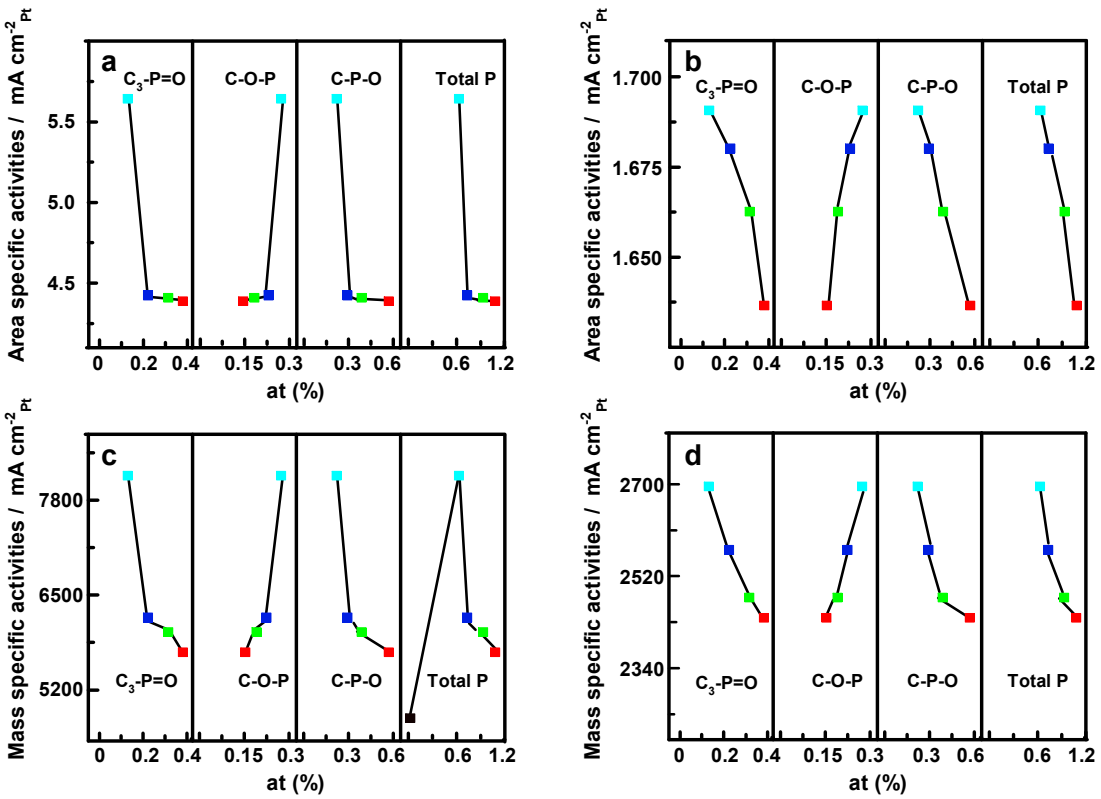

Figure S5. Dependences of area and mass specific activities of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) on total P, C_3-P=O, C-P-O and C-O-P contents under acid media (a and c) and alkaline media (b and d).

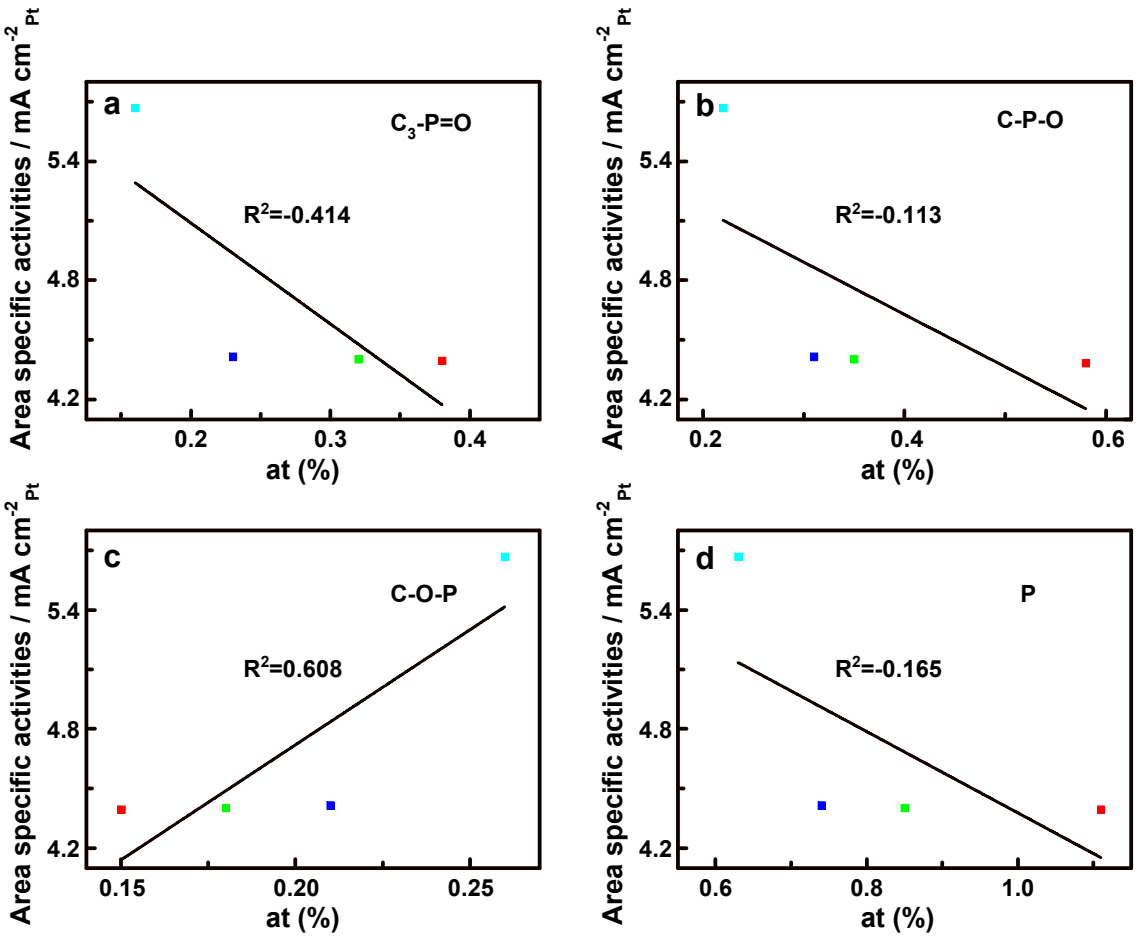

Figure S6. The relevancy between the area specific activities of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.2 V and the P species contents in them in acid medium.

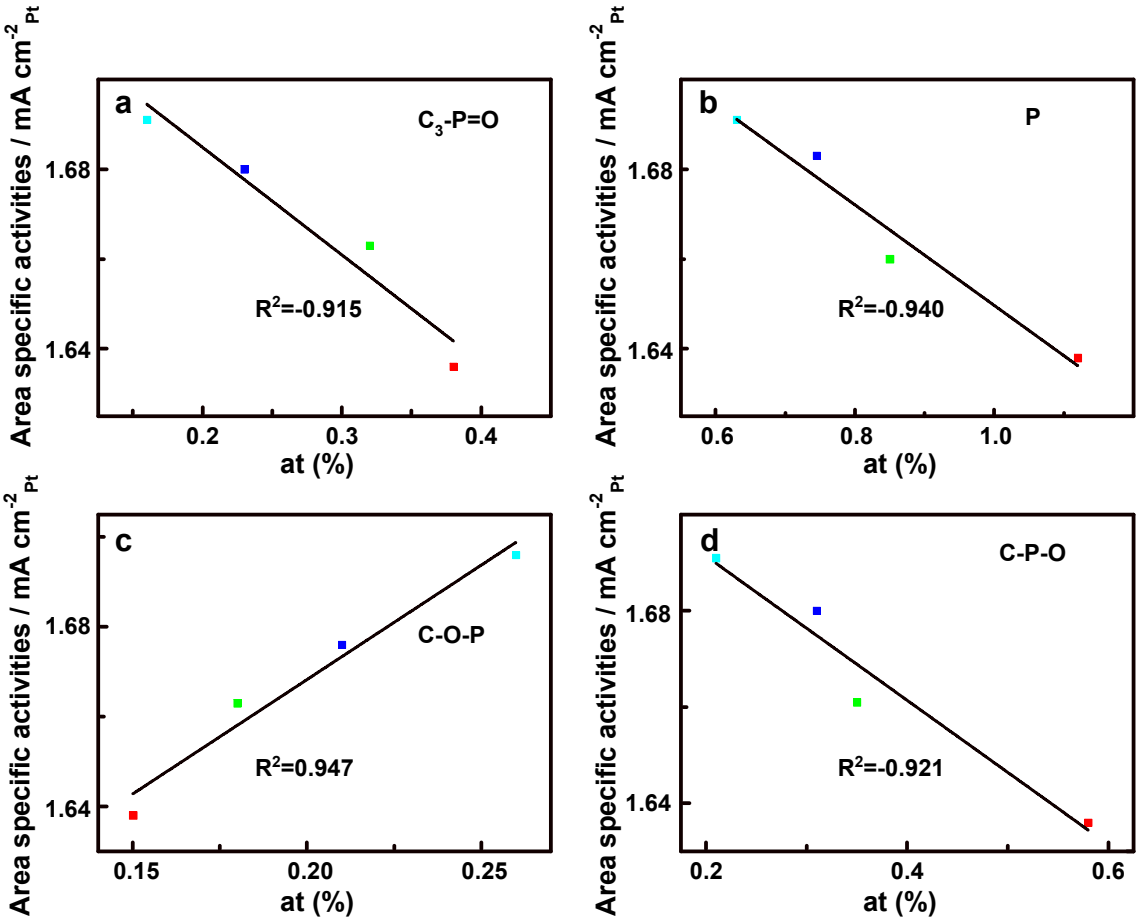

Figure S7. The relevancy between the area specific activities of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.215 V and the P species contents in them in alkaline medium.

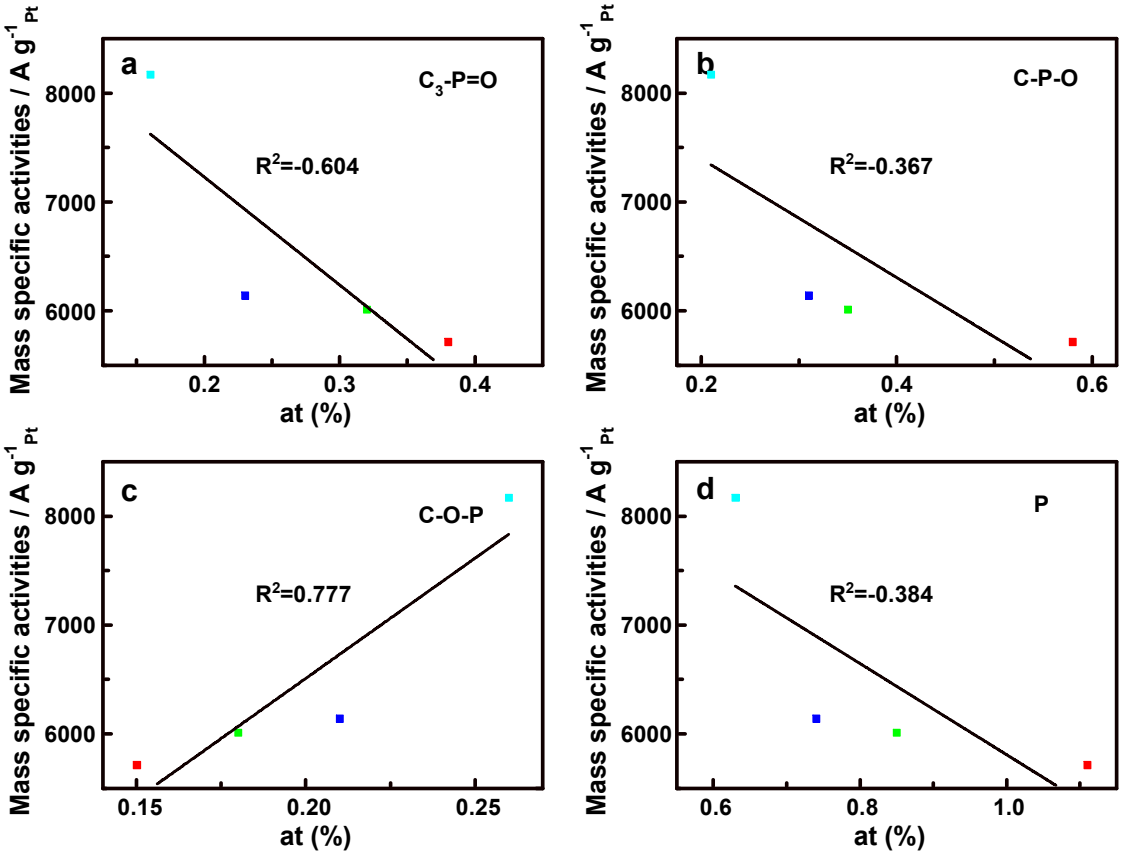

Figure S8. The relevancy between the mass specific activities of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.2 V and the P species contents in them in acid medium.

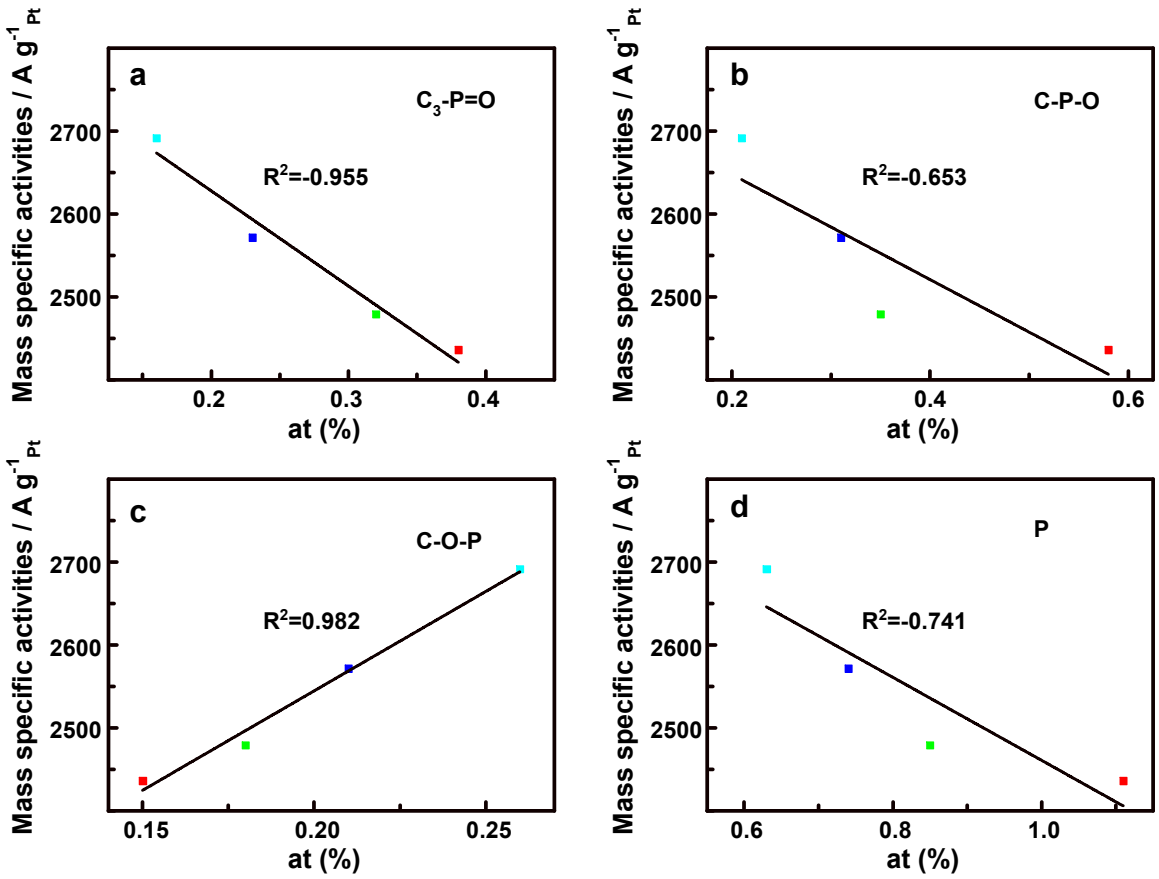

Figure S9. The relevancy between the mass specific activities of Pt@PDG1 (■), Pt@PDG2 (■), Pt@PDG3 (■) and Pt@PDG4 (■) at -0.215 V and the P species contents in them in alkaline medium.

Table S1. The ECSAs of Pt@PDG1, Pt@PDG2, Pt@PDG3, Pt@PDG4 and Pt@PDG5 and 20% Pt/C together with area and mass specific activities at -0.2 and -0.215 V in acidic and basic media.

	ECSA($m^2\ g^{-1}$)		Area specific activities ($mA\ cm^{-2}_{Pt}$)		Mass specific activities ($A\ g^{-1}_{Pt}$)	
	acidic	alkaline	acidic	alkaline	acidic	alkaline
Pt@PDG1	130.050	148.917	4.395	1.636	5715.92	2436.28
Pt@PDG2	136.547	149.061	4.403	1.663	6012.16	2478.88
Pt@PDG3	139.093	153.068	4.415	1.680	6140.96	2571.54
Pt@PDG4	144.155	159.169	5.668	1.691	8170.71	2691.55
Pt@PDG5	112.576	137.759	4.248	1.630	4782.23	2245.47
20 %Pt/C	247.797	270.833	1.262	0.375	3126.62	1015.62

Reference

[1] H.J. Huang, Y. Fan, X. Wang, Electrochim. Acta., **2012**, 80, 118-125.