Bimetallic PtAg alloyed nanoparticles and 3-D mesoporous graphene nanosheets hybrid architecture for advanced oxygen reduction reaction electrocatalysts

Zesheng Li[a,b], Yunyong Li[b], Chunyong He[b] and Pei Kang Shen[b,c,*]

[a] School of Chemical Engineering, Guangdong University of Petrochemical Technology, Maoming, 525000, (P.R. China).

[b] School of Materials Science and Engineering, Sun Yat-sen University, Guangzhou, 510275 (P.R. China).

[c] Collaborative Innovation Center of Sustainable Energy Materials, Guangxi Key Laboratory of Electrochemical Energy Materials, State Key Laboratory of Processing for Non-ferrous Metal and Featured Materials, Guangxi University, Nanning, Guangxi, 530004, (P.R. China)

*Corresponence author: E-mail: *stsspk@mail.sysu.edu.cn*

Synthesis of 3-D conductive mesoporous graphene nanosheets (3DMGS):

The 3DMGS materials were synthesized via a synchronous graphitization-activation combination method, by using an ion-exchange resin as carbon precursor, nickel acetate as catalyst precursor of graphitization and KOH as pore-forming agent. Typically, the pretreated macroporous acrylic type cation exchange resin (1 kg, Shanghai Hualing Resin Co., Ltd, China) was impregnated with targeting ions in 10 L nickel acetate (Shanghai Hebao Chemical Co., Ltd. China) solution with concentration of 0.1 mol L^{-1} for 6 h. The exchanged resin was washed with deionized water and dried at 80 ^{o}C for 12 h. Then the exchanged resin (100 g) was added into a 2 L KOH/ethanol solution containing 200 g KOH and stirred at 80 ^{o}C until the mixture solution became an 'ink-paste', followed by another 6 h of static soaking in ambient conditions. After that, the mixture solution was dried in the vacuum condition at 80 ^{o}C for 48 h and then smashed by a disintegrator. Finally, the mixture was heated at 800 ^{o}C for 2 h in N_2 atmosphere with a heating rate of 2 ^{o}C min^{-1} and an N_2 flow of 100 cc min^{-1}. After cooling down to room temperature, the resulting sample was added into 3 mol L^{-1} HCl solution with a specific volume for more than 12 h with intensive sonication. Afterwards, the sample was repeatedly washed by deionized water until a pH value of 7 was reached, dried at 80 ^{o}C in ambient for 24 h.

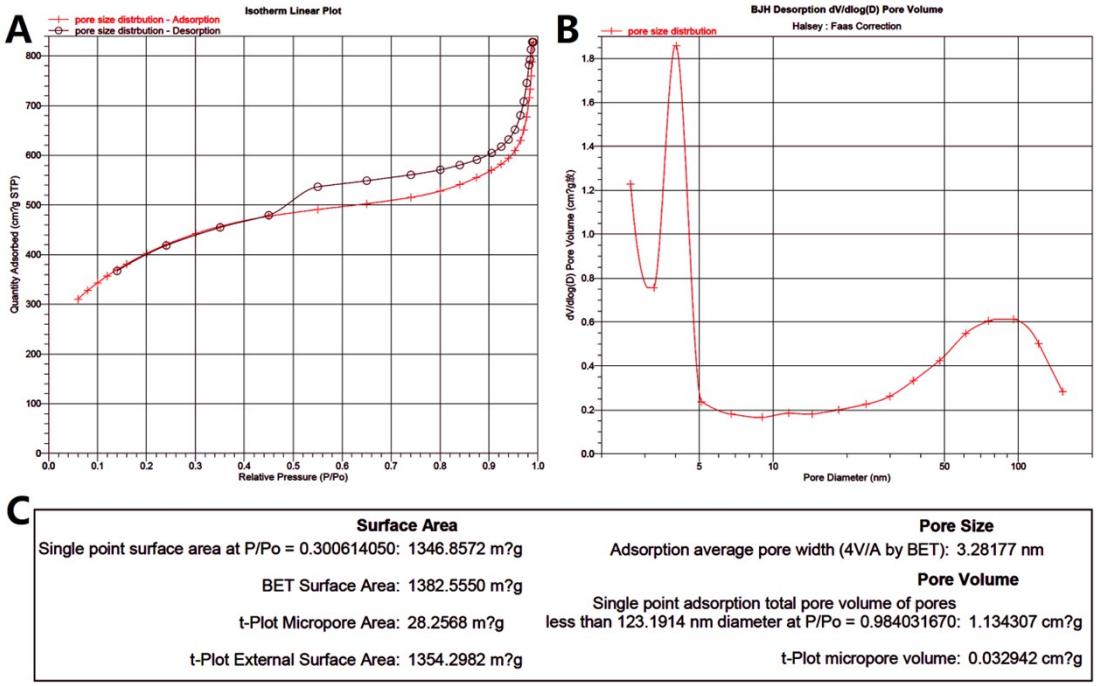

Figure S1. Nitrogen adsorption-desorption isotherm (A), pore-size distribution (B) and the summary report (C) of the 3DMGS sample.

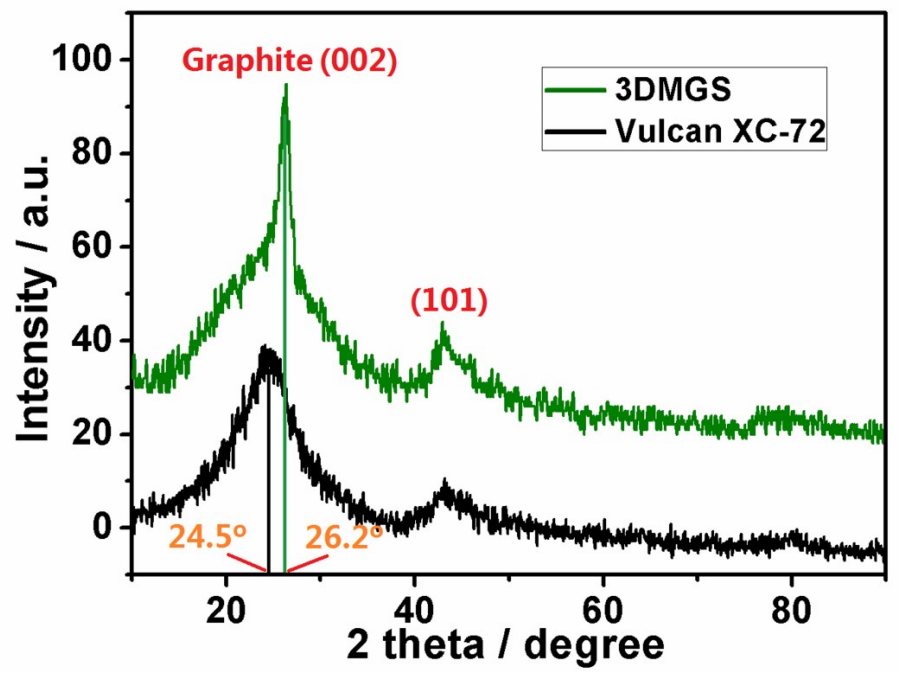

Figure S2 XRD patterns of the 3DMGS (green) and Vulcan XC-72 (black).

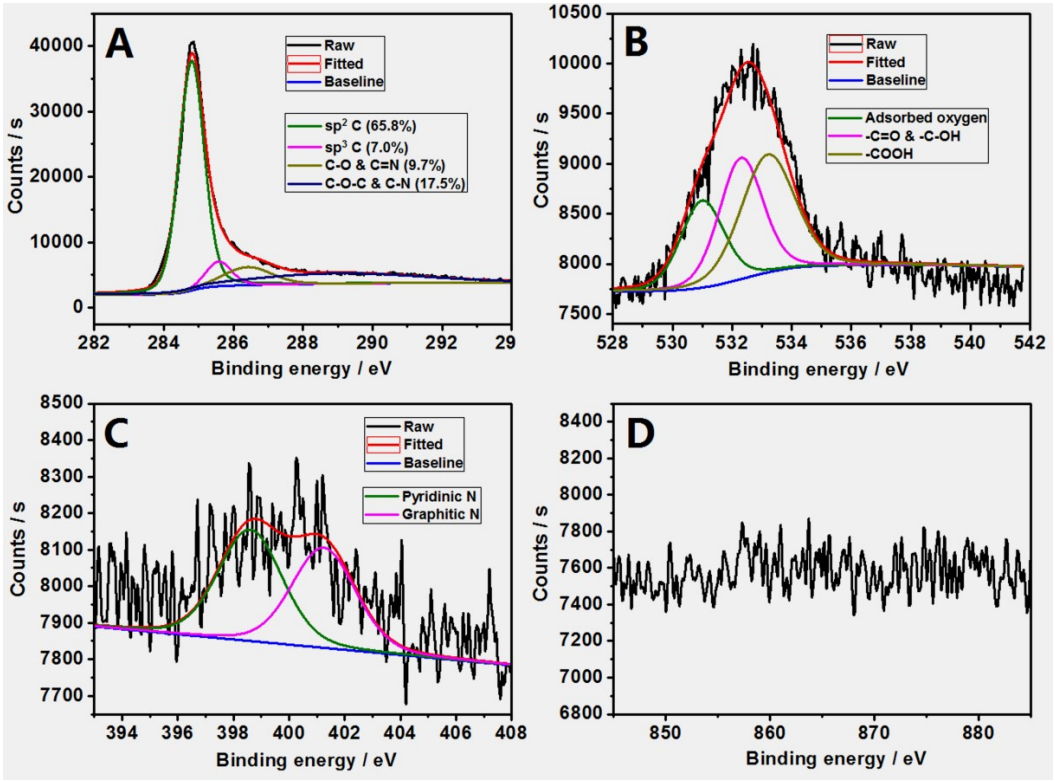

Figure S3 XPS patterns of 3DMGS: (A) C 1s, (B) O1s, (C) N 1s, (D) Ni 2p spectra.

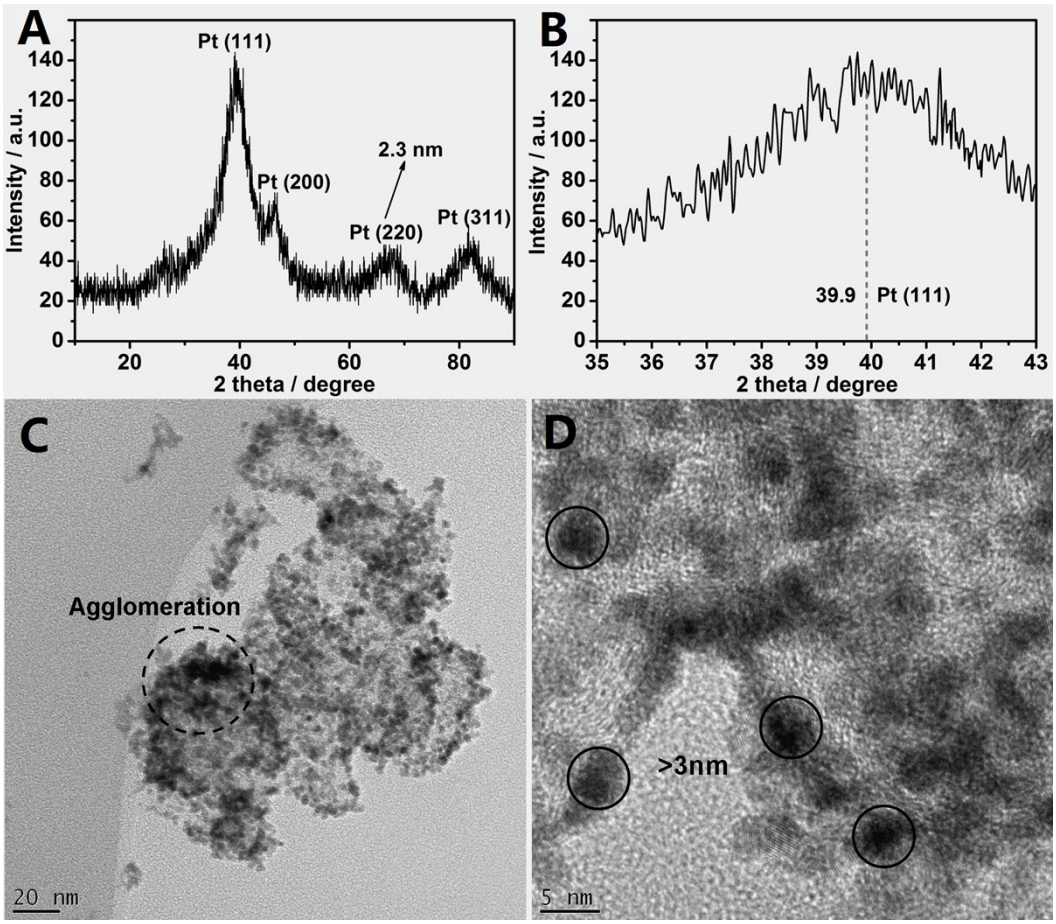

Figure S4 XRD patterns (A, B) and TEM images (C, D) of commercial Pt/C (TKK).

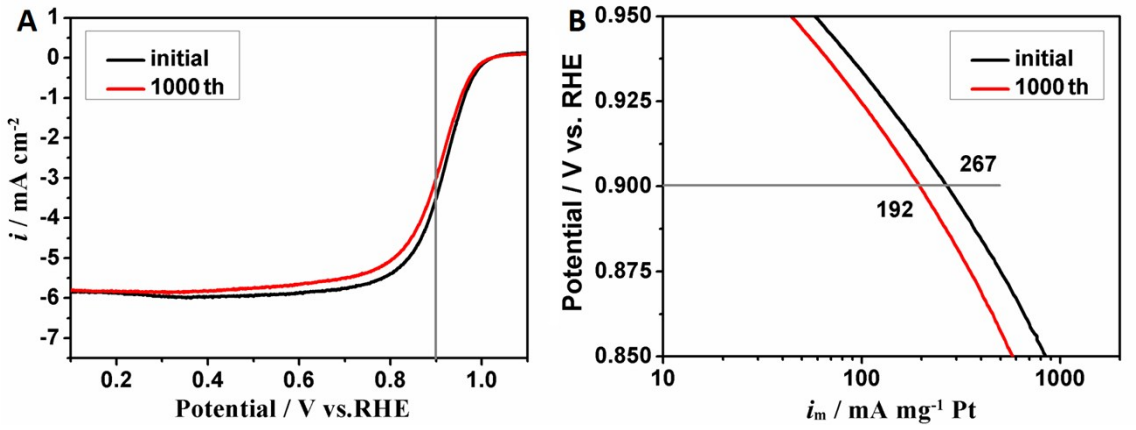

Figure S5 ORR polarization curves (A) and mass activities (B) of the PtAg/RGO (before and after 1,000 CV cycles).

Table S1 Metal content of the samples determined by ICP-AES techniques

Samples	Pt/C (TKK)	Pt/3DMGS	PtAg/3DMGS-1#	PtAg/3DMGS-2#	PtAg/3DMGS-3#
Total metal content	47.6 wt.%	46.1 wt.%	45.3 wt.%	49.6 wt.%	44.7 wt.%
Pt content	47.6 wt.%	46.1 wt.%	30.1 wt.%	24.7 wt.%	17.6 wt.%
Ag content	---	---	15.2 wt.%	24.9 wt.%	27.1 wt.%