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# Effect of graphene surface functionalization on the oxygen reduction reaction in alkaline media

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## 1. Size distribution of FLGS particles

The size distribution of FLGS particles was obtained using an LS 13 320 XR laser particle size analyzer (Beckman Coulter, USA).

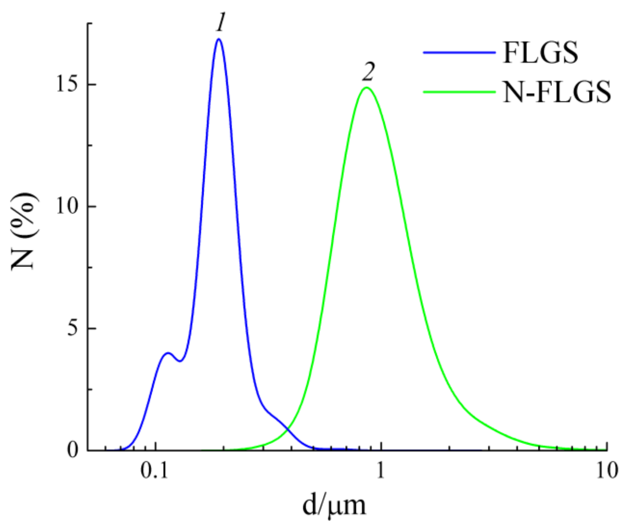


**Figure S1** Size distribution of FLGS (*1*) and N-FLGS (*2*) particles.

## 2. XPS analysis of FLGS surface

The XPS spectra were obtained using a Specs PHOIBOS 150 MCD spectrometer (Specs, Germany) with Mg *K*α radiation (1253.6 eV). Pressure in a working chamber of a spectrometer was within $4\cdot10^{-8}$ Pa. The probed area was 300–700 μm$^2$, depth of analysis was 1–2 nm.

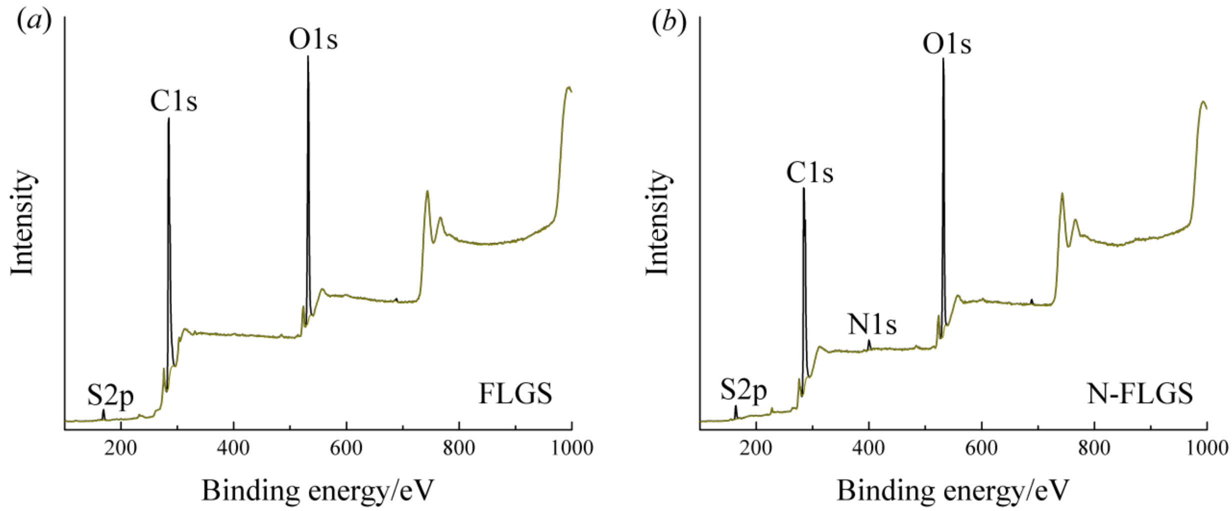


**Figure S2** Survey XPS spectra of FLGS (*a*) and N-FLGS (*b*).

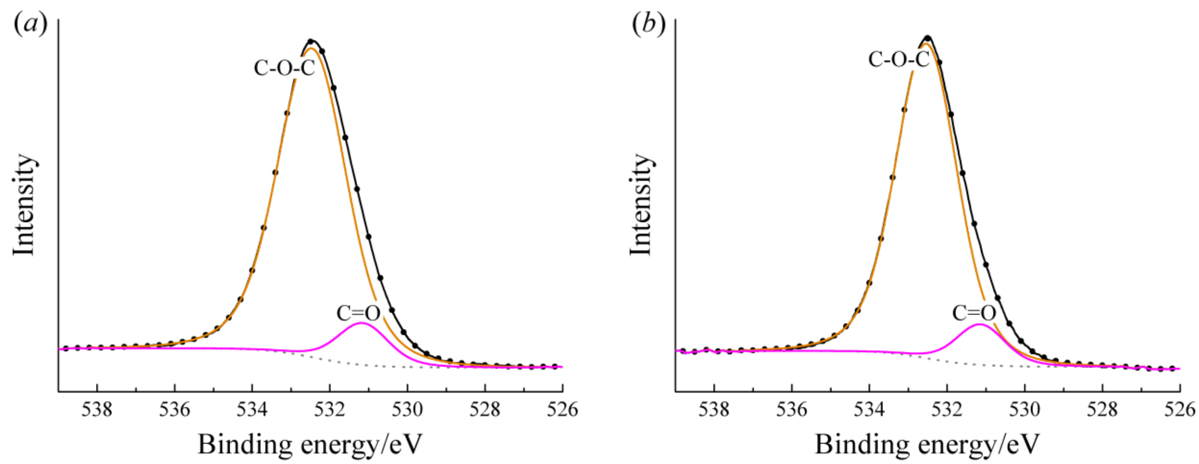


**Figure S3** O1s high resolution XPS spectra of FLGS (*a*) and N-FLGS (*b*)

**Table S1** Surface elemental composition of FLGS and N-FLGS samples.

| sample | C 1s, % (284 eV) | O 1s, % (532 eV) | N 1s, % (400 eV) | S 2p, % (169 eV) |
|---|---|---|---|---|
| FLGS | 79.9 | 18.8 | - | 1.3 |
| N-FLGS | 75.4 | 20.7 | 1.4 | 2.5 |
| | | | | |
| sample | C=O, % (531.4 eV) | C–O–C, % (532.3 eV) | pirrolic-N, % (399.0 eV) | pyridinic-N, % (400.0 eV) |
| FLGS | 1.7 | 17.1 | - | - |
| N-FLGS | 1.9 | 18.8 | 0.7 | 0.7 |

**3. Oxygen reduction reaction on GC, FLGS and N-FLGS in air-saturated 0.1 M KOH solution**

To determine the number of electrons participating in ORR at the covered with FLGS and the pristine GC electrodes, the *j*,*E*-dependencies were measured for various ω [Figures S4(*a*), S4(*b*) and S4(*c*)]. The values *of n* were calculated from the *j*,*E*-curves analysis with the Koutecký-Levich equation:[S1]

$$\frac{1}{j} = \frac{1}{j_\mathrm{k}} + \frac{1}{j_\mathrm{d}} \qquad (1)$$

$$j_\mathrm{k} = n\mathrm{F}kc^0 \qquad (2)$$

$$j_\mathrm{d} = 0.62n\mathrm{F}\mathrm{D}^{2/3}\omega^{1/2}\upsilon^{-1/6}c^0, \qquad (3)$$

where $j_\mathrm{k}$ and $j_\mathrm{d}$ are densities of the kinetic and the limiting diffusion current, respectively, $[j]$ = mA·cm$^{-2}$; $k$ is a rate constant of oxygen reduction reaction, $[k]$ = cm·s$^{-1}$; ω is an angular velocity of electrode rotation, [ω] = rad·s$^{-1}$; F is Faraday constant, F = 96485 C·mol$^{-1}$; D is a coefficient of oxygen diffusion in a 0.1 M KOH solution, D = $1.9\cdot10^{-5}$ cm$^2$·s$^{-1}$; $\upsilon$ is kinematic viscosity of the 0.1 M KOH, $\upsilon$ = 0.01 cm$^2$·s$^{-1}$; $c^0$ is bulk concentration of dissolved oxygen, $c^0 = 0.24\cdot10^{-3}$ mol·L$^{-1}$ in the 0.1 M KOH solution.[S2,S3]

The values of the limiting diffusion current density were evaluated according to the Levich equation[S1] (equation 3).

**References**

S1 A. J. Bard and L. R. Faulkner, *Electrochemical Methods: Fundamentals and Applications,* 2nd edn., Wiley, New York, 2001.

S2 L. T. Qu, Y. Liu, J. B. Baek and L. M. Dai, *ACS Nano*, 2010, **4**, 1321.

S3 G. Jürmann and K. Tammeveski, *J. Electroanal. Chem.*, 2006, **597**, 119.

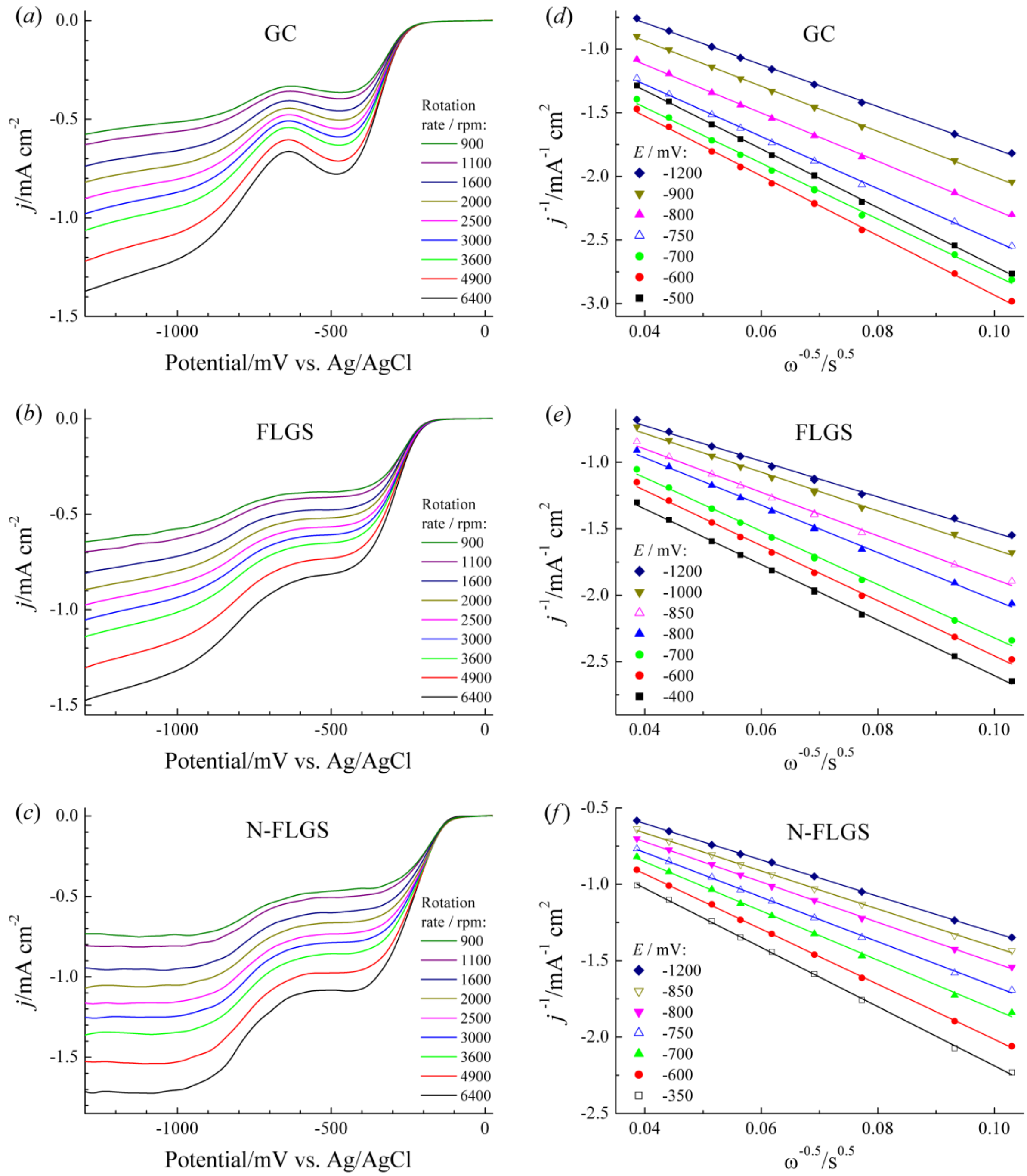


**Figure S4** (*a*) (*b*) and (*c*) are *j*,*E*-curves for pristine GC and GC electrodes covered with FLGS and N-FLGS, respectively, at various electrode rotation rates; (*d*), (*e*) and (*f*) are the corresponding *j*,ω-dependencies in the Koutecký-Levich coordinates at selected potentials.