Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Electronic Supplementary Information (ESI)

Crumpled reduced graphene oxide by flame-induced reduction of graphite oxide for supercapacitive energy storage

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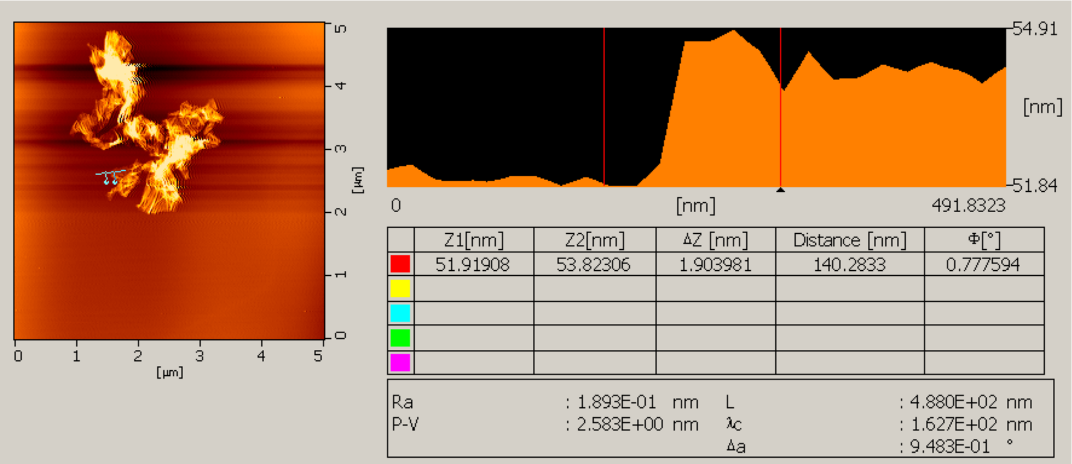
Electrochemical measurements in two-electrode system

The electrochemical performances of the as-prepared graphene materials were further measured in a symmetrical two-electrode cell. 10 wt% of PTFE was added to 90 wt% of the as-prepared graphene as a binder. The mixtures were dispersed in ethanol and drop casted on nickel foam current collectors. The as-prepared electrodes were subsequently constructed into supercapacitors using standard stainless steel button cell case (CR 2032), with a 6 M KOH aqueous solution as the electrolyte, and a cellulose filter paper as the separator. All the electrochemical measurements were carried out on a CHI760D electrochemical workstation.

From charge-discharge measurements, the specific capacitances of samples were obtained from the acquired data using following equation: $C=4I\times\Delta t/(m\times\Delta V)$. Where C represents the specific capacitances of graphene, I for the constant charge current, Δt for the discharging period, m for the mass of graphene used as electrodes, ΔV for the voltage of capacitor after constant current charging. The energy (E) and power (P) densities were calculated from charge-discharge curves at different current densities using following equations: $E=0.5*C*\Delta V^2$, where "ΔV" is the potential window of discharge process; $P=E/\Delta t$, where Δt is the discharge time.

Measurement of the electrical conductivity

Electrical conductivity of the rGO samples was evaluated by a four point probe method at room temperature. Prior to measurement, 8 mg of each sample was placed in a hollow cylinder with inner diameter (D) of 8 mm. The powder was compressed between two brass pistons at pressure varied from 5 to 20 MPa in air, forming the series of sample pellets. The electrical resistance of each pellet (R) was measured by a four point probe tester, while the thickness of which (L) was measured by a thickness gauge. The Ohmic electrical conductivity (σ) was calculated by the following formula: $\sigma=L/R.A$, where A is the area of the pellet surface.



	Z1[nm]	Z2[nm]	ΔZ [nm]	Distance [nm]	Φ[°]
🟥	51.91908	53.82306	1.903981	140.2833	0.777594
🟨					
🟦					
🟩					
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Ra : 1.893E-01 nm
P-V : 2.583E+00 nm
L : 4.880E+02 nm
λc : 1.627E+02 nm
Δa : 9.483E-01 °

Fig. S1. AFM image of ethanol-rGO.

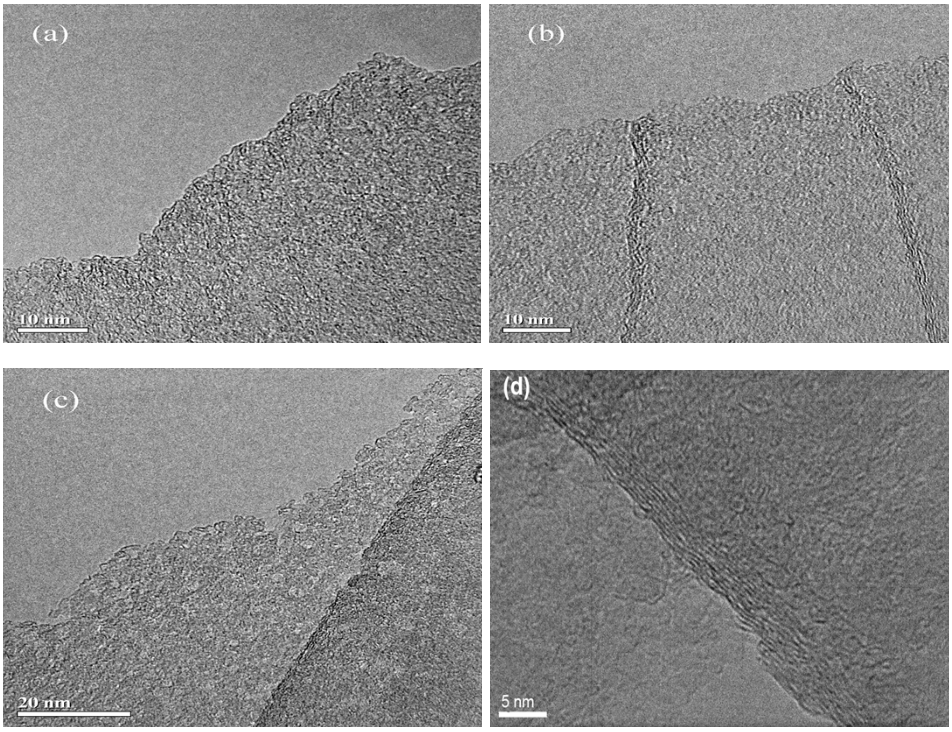

Fig. S2. HRTEM images of ethanol-rGO.

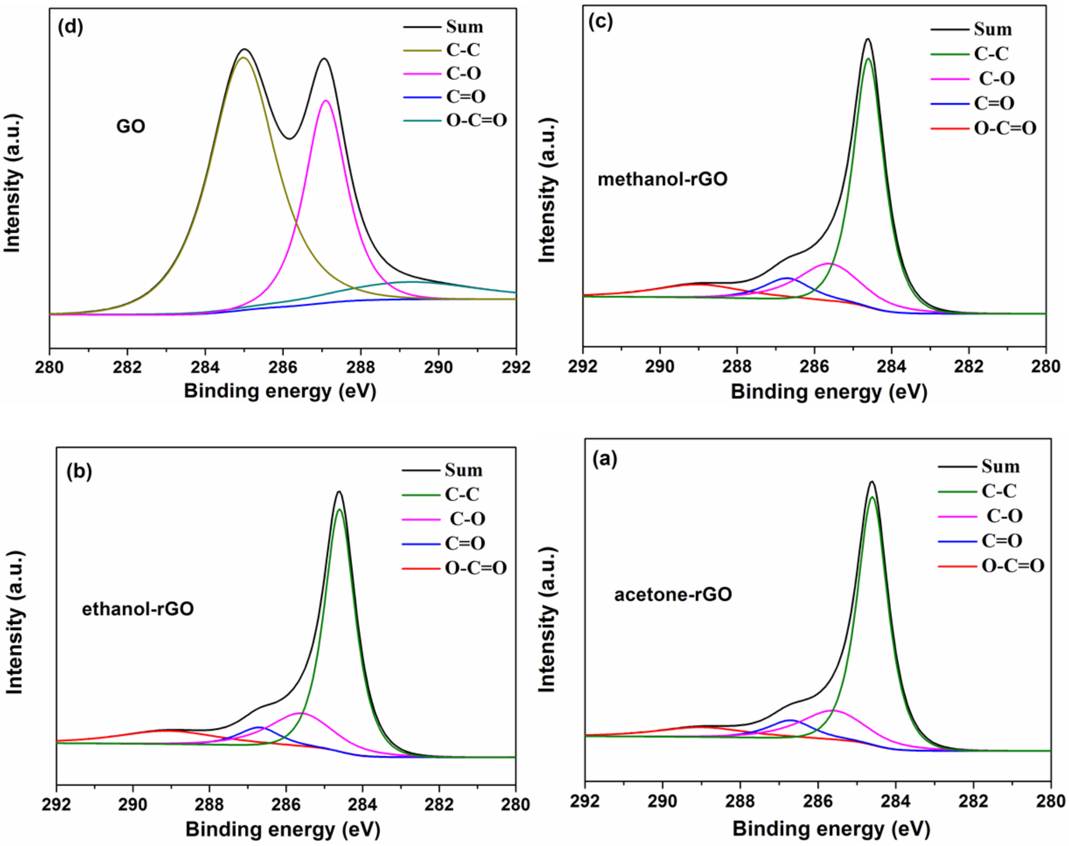

Fig. S3. C1s XPS spectra of acetone-rGO, methanol-rGO and ethanol-rGO.

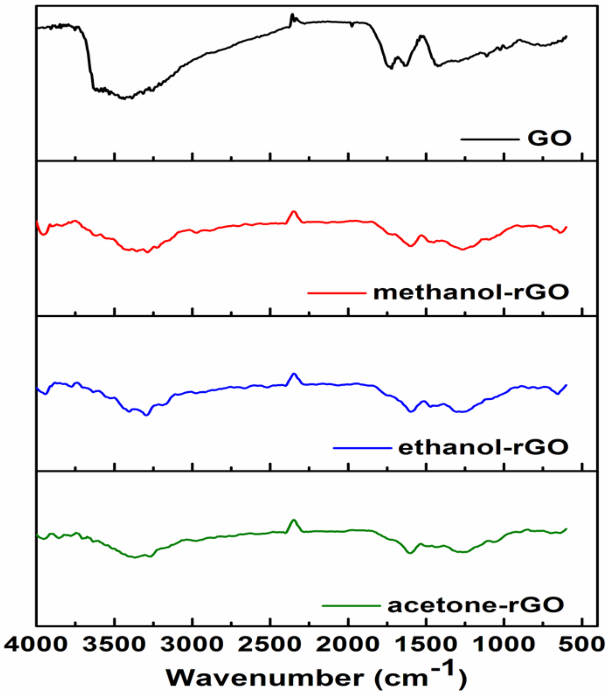

Fig. S4. FT-IR spectra of GO, acetone-rGO, methanol-rGO and ethanol-rGO.

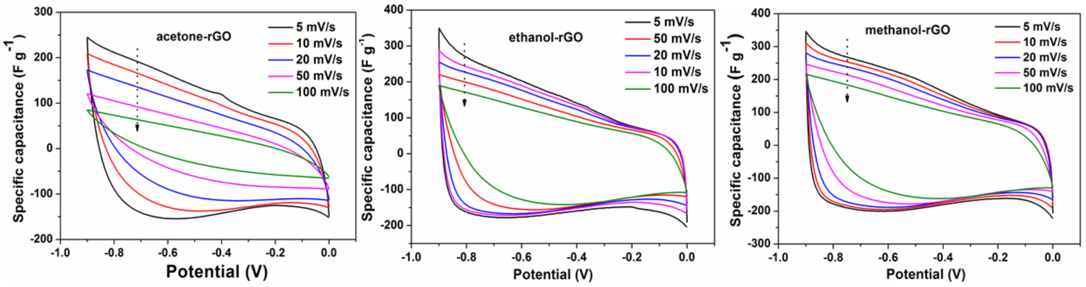

Fig. S5. CV curves of acetone-rGO, methanol-rGO and ethanol-rGO at different scan rates.

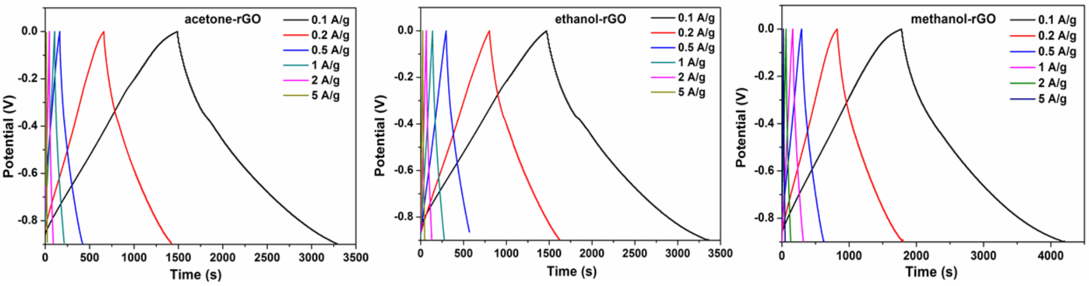

Fig. S6. Galvanostatic charging-discharging curves of acetone-rGO, methanol-rGO and ethanol-rGO measured with different current densities.

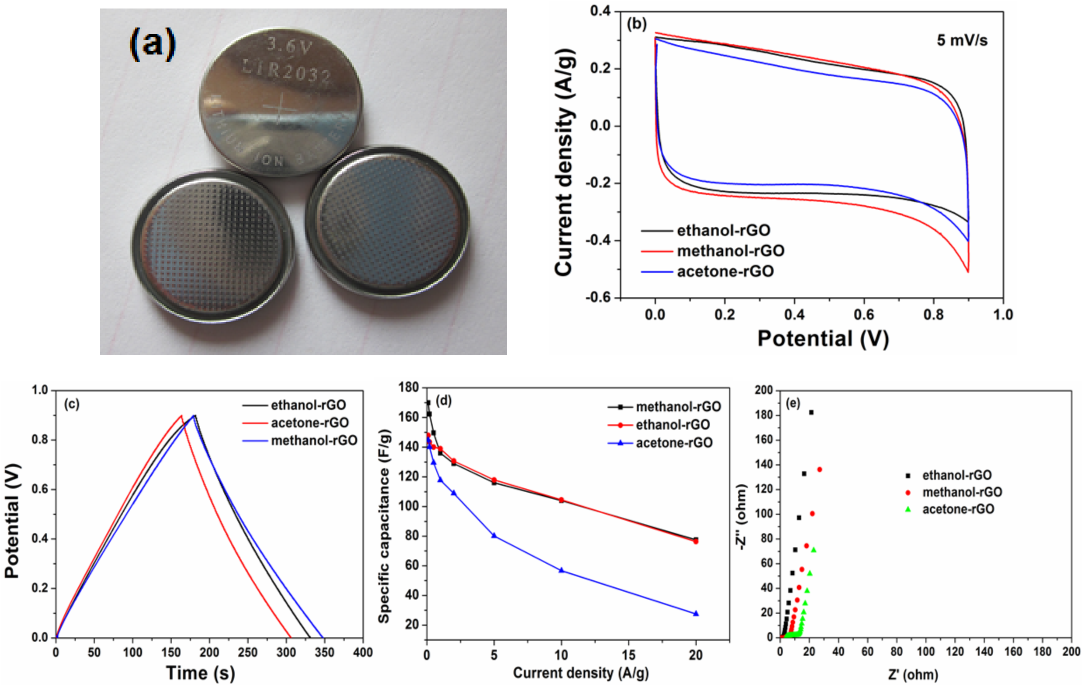

Fig. S7. (a) A digital photograph of a test cell for a two-electrode system electrochemical measurement; (b) CV curves at a scan rate of 5 mV/s, (c) galvanostatic charging-discharging curves at a constant current density of 0.2 A/g, (d) specific capacitance of samples at various current densities; and (e) EIS of samples. The results show that the specific capacitance obtained from two-electrode system is lower than that obtained from three-electrode system.

This phenomenon is very normal for electrode materials.

Table S1 Comparison of electrode performance of graphene-based materials in the literatures

Active materials	**C_{high} (F/g)**	**Electrolyte**	**Current collector**	**Cell**	**Ref.**
$Ni(OH)_2$/G	1335(2.8 A/g)	1M KOH	Ni foam	3E	[1]
GO	189(0.05A/g)	6M KOH	-	2E	[2]
G(chemical reduced)	164(10mV/s)	6M KOH	Ni foam	3E	[3]
G (hydrogen gas reduction)	110(10mV/s)	6M KOH	Ni foam	2E	[4]
G/β-$Ni(OH)_2$ sphere	1551.8(2.67A/g)	6M KOH	Ni foam	3E	[5]
G (thermal reduced at 200^{o}C)	260(0.4A/g)	6M KOH	Copper mesh	3E	[6]
G(chemical reduction)	135(0.01A/g)	5.5M KOH	Conductive vinyl film	2E	[7]
Nitrogen-doped G	207(3mV/s)	6M KOH	Ni foam	3E	[8]
Methanol-rGO	260(0.1A/g)	6M KOH	Ni foam	3E	In this work
	170(0.1A/g)	6M KOH	Ni foam	2E	

Note: 2E: Two-electrode cell, 3E: Three-electrode cell, C_{high}: Specific capacitance, G: Graphene, GO: Graphene oxide, rGO: Reduced graphene oxide.

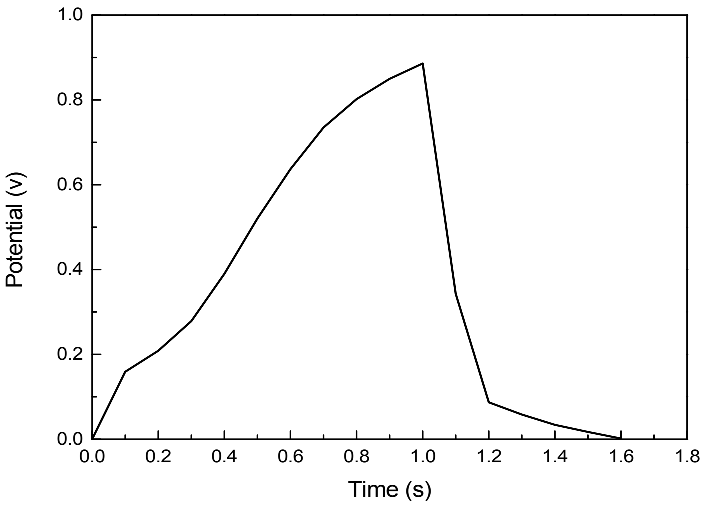

Fig. S8. Galvanostatic charging-discharging curves of nickel foam at a constant current density of 0.1 A/g

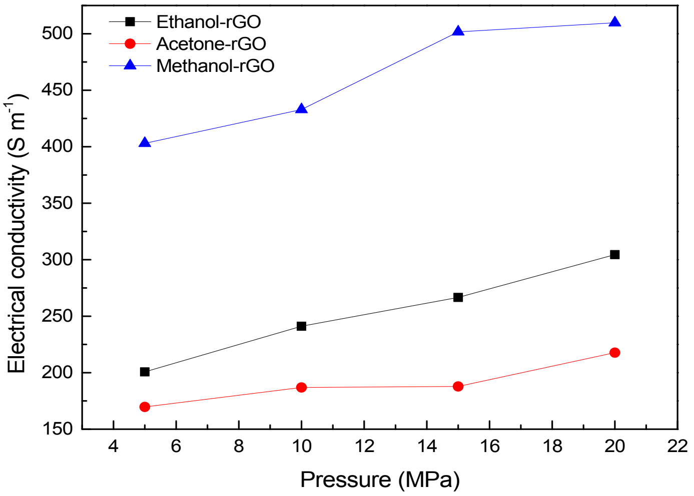

Fig. S9. Electrical conductivity of acetone-rGO, methanol-rGO and ethanol-rGO pellets compressed under different pressure.

References

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