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Instantaneous reduction of graphene oxide at room temperature

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Characterization technique:

The phase purity and crystal structure of the graphene oxide (GO) and reduced graphene (RGO) were analyzed by X-ray diffraction (XRD) using PANalytical X'Pert Pro equipped with Cu Ka radiation (λ = 1.5406 Å). The Raman scattering measurements were recorded on a Raman system (WITec) with confocal microscopy at room temperature. A Nd:YAG laser (532 nm) was used as an excitation source. UV-vis spectra was carried out on a Hitachi UV-vis spectrophotometer. The microstructures of the sample were characterized with field emission scanning electron microscopy (FE-SEM, FEI-INSPECTF50) and Energy dispersion X-ray (EDS) spectra were used to investigate the composition. The layer structure and crystalline nature of the sample ware characterized by using transmission electron microscopy (TEM, JEOL- JEM-2100F) and cross sectional high resolution transmission electron microscopy (HRTEM) images and selected-area electron diffraction (SAED) pattern operated a 200kV accelerating voltage. The TEM sample was prepared by dispersing the sample in DMF solution by ultrasonic bath and drop casted on carbon coated cupper grid, and then dried for TEM measurments. Thermogravimetric analysis (TGA) of sample was carried out in platinum cell using the TG/DTA thermogravimetric analyzer (TA Instruments SDT Q600). The sample was heated under nitrogen flow from room temperature to 700 ^{0}C at 10 ^{0}C min^{-1}. The FTIR spectra both the solid sample was carried out in Bruker Alpha FTIR Spectrometer. For the conductivity measurement, we prepared a thin film of RGO on the SiO_2/Si substrate and used a four probe system (in ECOPIA HMS-5000).

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Hydrogen sensing measurements:

The evolution of the hydrogen gas from the reaction was measured by our home-built Ag-gurgum nanocomposite based sensor. For these measurements, we fixed the amount of the Zn metal as well as Mg (.02 mg each) with fixed volume of acids concentration (4 ml of 2M HCl solution). When the metal is dipped in acids solution, the evolution of the [H] starts and is monitored by current measurements.

Table I: Price comparison of few metals that are used as catalysts for the reduction of graphene oxide.

Metal	Price (US$/lb)
Zn	0.9
Ni	7.72
Al	0.94
Cu	3.61
Fe	3.4
Mg	<2

ESI-1

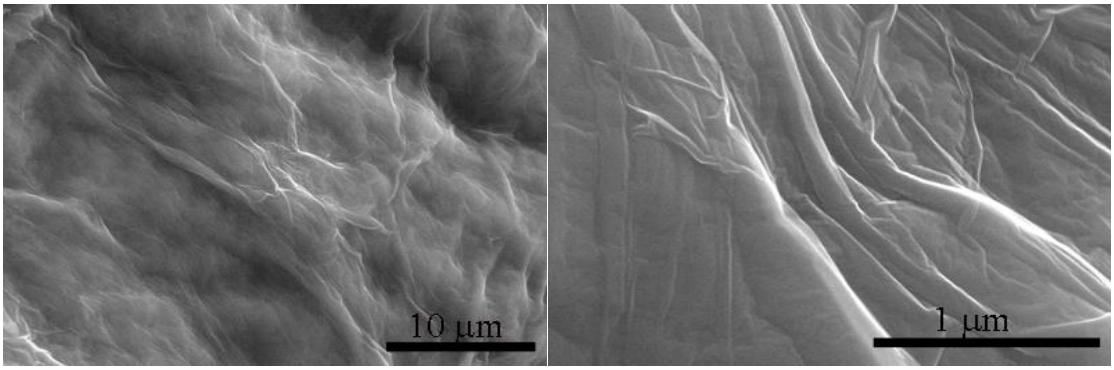

Fig. S1 SEM images of GO

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ESI-2

TEM images of crumpled, wrinkle RGO. The cross sectional HRTEM images show few layers of RGO.

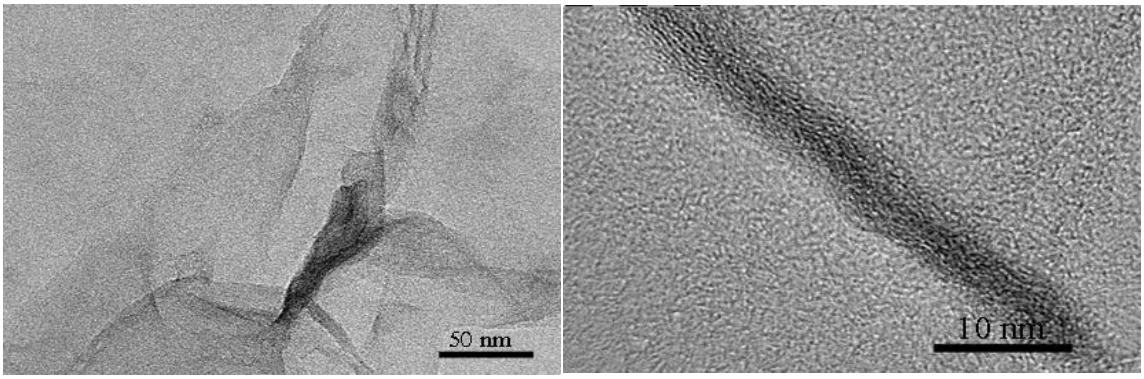

Fig. S2 TEM images of RGO

ESI-3

XPS spectra of GO and RGO after deconvolution and peak fitting

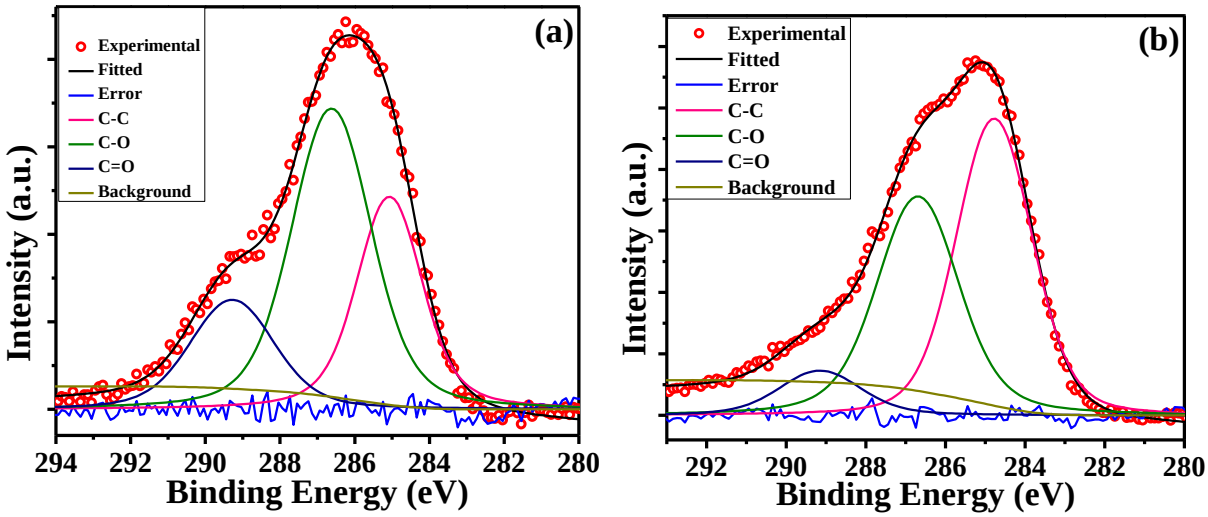

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Fig.S4 The XPS core level spectra of C1s (a) GO and (b) RGO.

ESI-4

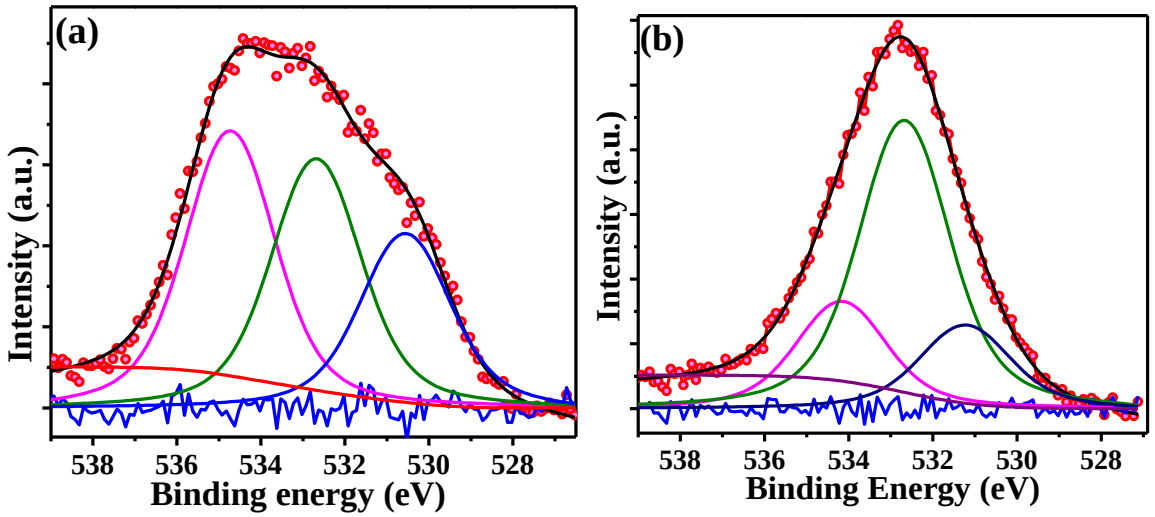
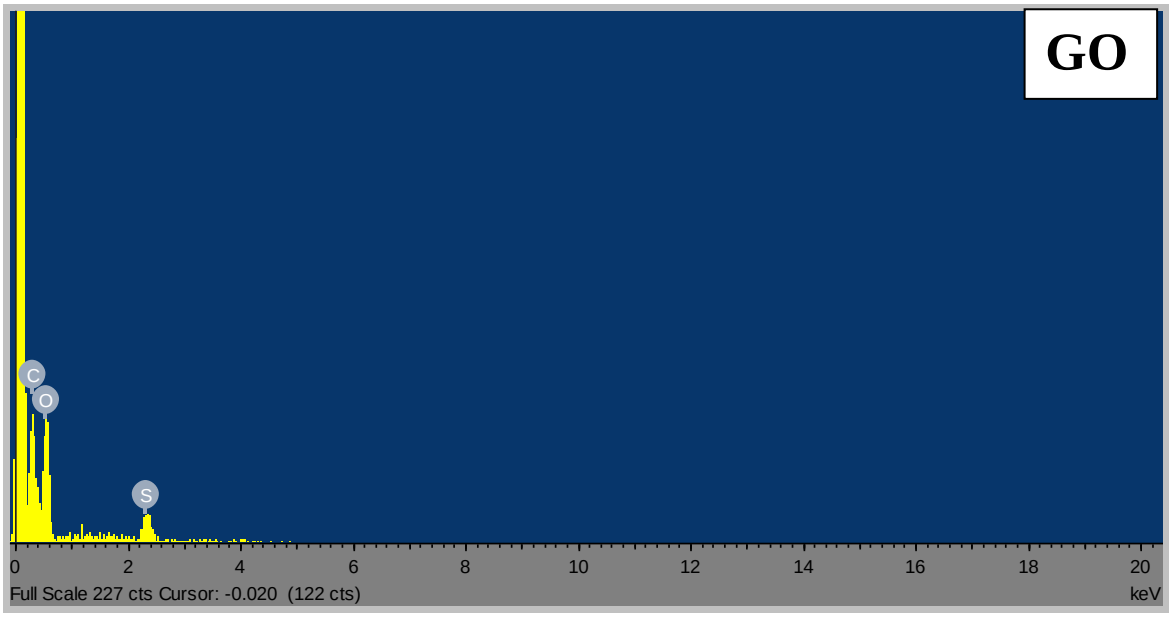


Fig.S5 The XPS core level spectra of O1s of (a) GO and (b) RGO and its deconvolution into three components centered at 530.6 eV, 532.7 eV and 534.7 eV.

ESI-5



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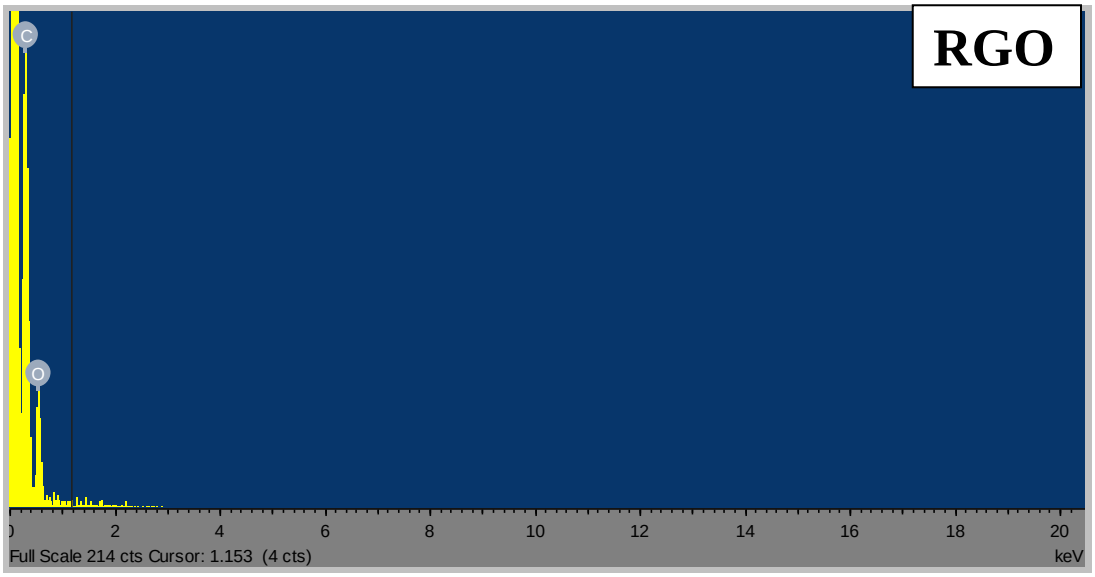

Fig. S3 The EDS spectra of GO and RGO. The S in the GO is believed to be due to the H_2SO_4 treatment that is required for oxidizing of the graphite**.**

ESI-6

FTIR spectral of GO and RGO reduced by Mg-dil. HCl (2M) within the 5 minutes.

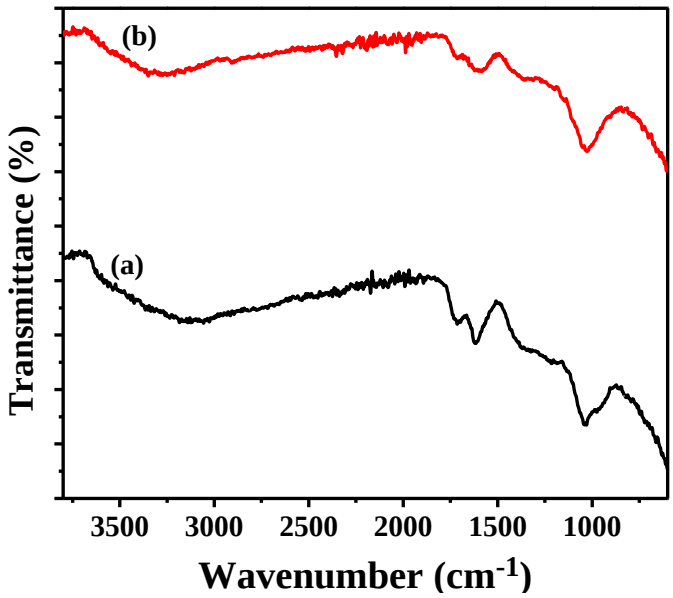

Fig. S6 FTIR spectra of the GO (a)and (b) RGO.

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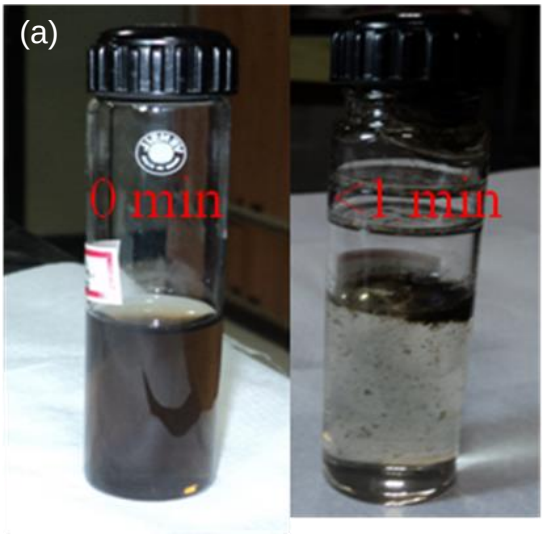
ESI-7

Table SI: Comparison of the reduction of GO by different metal

Metal	E^0 (V)	Metal amount (g)	Presence of acids	Amount of GO	C/O ratio	Electrical properties (S/m)	Reduction time (minutes)
Ni	-0.23	1.25	70 ml of Conc. HCl	0.075g GO in 100 ml H_2O			1440[13(e)]
Fe	-0.44	1.0	20 ml of Conc. HCl	100 ml of GO (0.005 g/ml)	7.9	2300	360[13(b)]
Zn	-0.76	5.0	4M H_2SO_4	0.05 g in 50 ml H_2O	------ 8.2	3416 (13f) 650 (13k)	120[13(f, h, k)]
Zn, Al	-0.76, -1.66	1.2	Conc. HCl/ 1M NaOH	400 ml GO (0.001g/ml)	17.96 5.36 21.11	7540 1120 12530	20, 30, 360 [13(g)]
Al	-1.66	1.0	10 ml conc. HCl	200 ml GO (.001 g/ml)		2100	30[13(a)]
Mg	-2.36	0.1	5 ml of 2M HCl	15 g GO in 15 ml		10.12	5 (present work)

ESI-8



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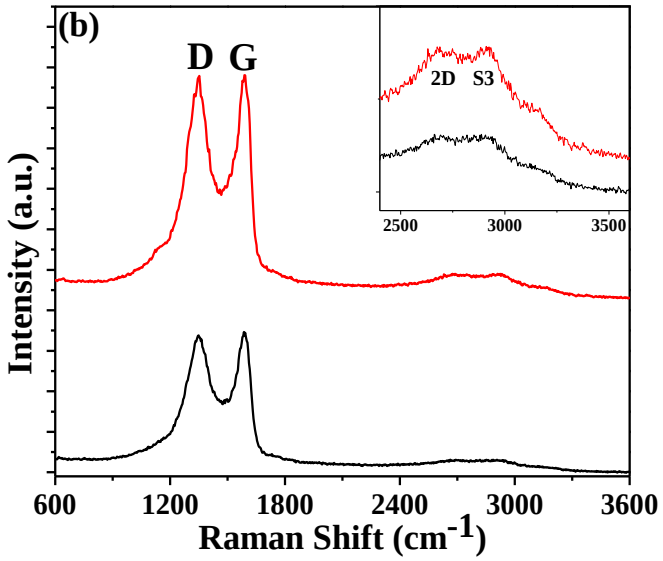

Fig. S7 (a) The digital photographs of reduction of GO in less than 1 minutes reduction in 10M HCl. (b) Raman spectra of GO (black) and RGO (red).

Raman spectra of RGO obtained by reduction of GO in 10M HCl is shown in Fig. S8. These data are comparable with reduction of GO within 5 minutes, which strongly indicate of reduction of GO less than one minutes.