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Supplementary Information

Low-temperature Rapid Synthesis of High-quality Pristine or Boron-doped Graphene via Wurtz-type Reductive Coupling Reaction

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Estimate of Reaction Enthalpy. The reaction of graphene formation can be expressed as:

$CCl_4 + 4K \rightarrow C\ (graphene) + 4KCl$

The molar enthalpy of reaction can be roughly estimated from the difference of mlar enthalpy of formation between the products and reactants:

$$\Delta_r H_m = \Delta_f H_m(\mathrm{C}, graphene) + 4\Delta_f H_m(\mathrm{KCl}) - \Delta_f H_m(\mathrm{CCl_4}, gas) - 4\Delta_f H_m(\mathrm{K}, lipuid)$$

Whereas, the mlar enthalpy of formation of graphene is still unknow. Herein, it was estimated to be 513 *kJ/mol* from the bond enthalpy of graphene.[1]

Thus, using the thermodynamical data,[2] the molar enthalpy of reaction can be estimated as follows:

$$\Delta_r H_m = 513 + (-4*436.7) - (-96.0) - 4*\ 2.3 = -\ 1147\ kJ/mol$$

Therefore, the proposed reaction is a fiercely exothermic reaction. This contributes to the rapid preparation of graphene at low temperature in short time.

For the reaction of CCl_4 and Na, the molar enthalpy was calculated to be – 1046 *kJ/mol*, lower (around 10%) than that of the reaction of CCl_4 and K.

Figures:

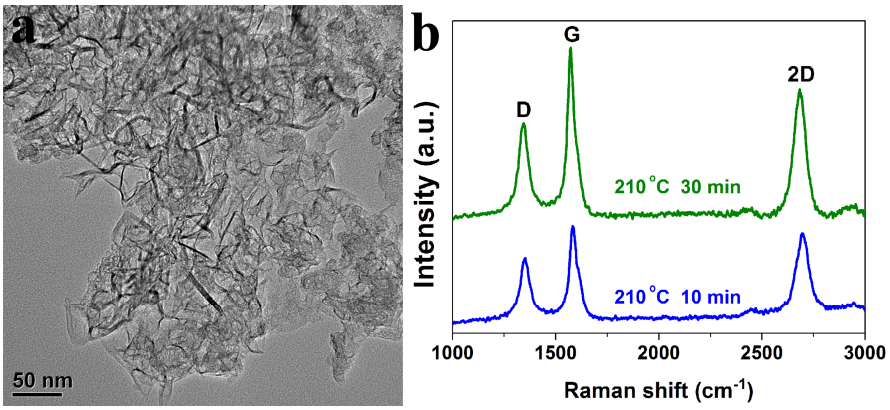

Fig. S1 (a) TEM image and (b) Raman spectrum of graphene nanosheets prepared in 10 min at 210 °C using near-stoichiometric CCl_4 (1.5 ml) and K (2.0 g), compared with the Raman spectrum of graphene prepared in 30 min as a reference.

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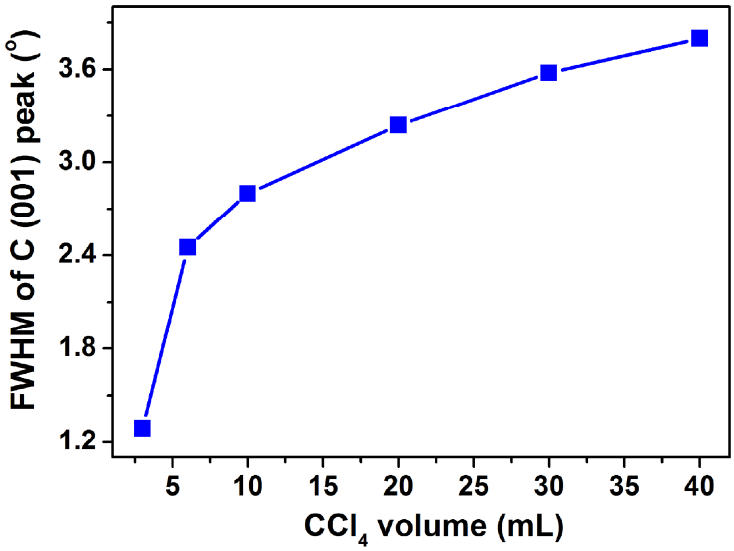

Fig. S2 The crystallinity (expressed as the FWHM of C (001) peak of XRD patterns) variation with the CCl_4 volume.

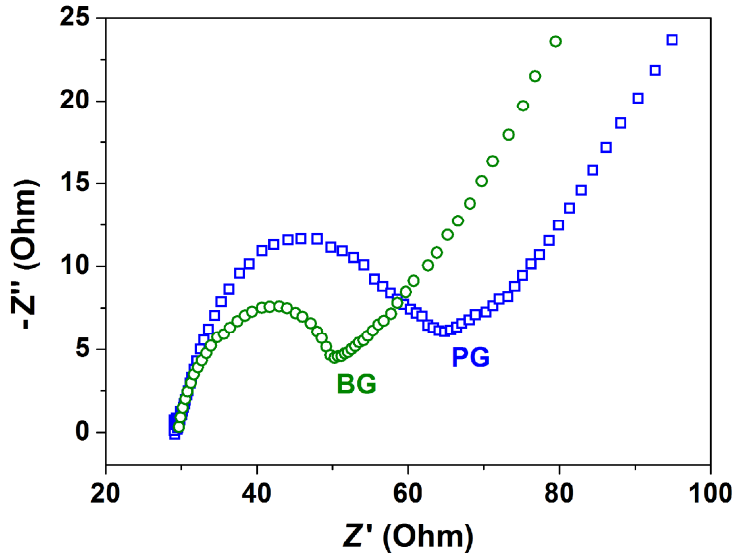

Fig. S3 The typical electrochemical Nyquist plots of pristine graphene (PG) and boron-doped graphene (BG) measured by electrochemical impedance spectra (EIS).

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Table S1. Elemental abundances determined by XPS in PG and BG samples.

	C			B		Cl	O
	Peak (eV)	Content (at. %)	BBr_3 volume (μL)	Peak (eV)	Content (at. %)	Content (at. %)	Content (at. %)
PG	284.7	89.92	/	/	/	2.60	7.18
BG	284.8	88.85	52	192.0	1.02	2.52	7.41
BG′	284.6	82.82	104	191.6	1.90	4.01	11.07
BG″	284.5	81.88	156	191.4	2.56	4.58	10.54

REFERENCES AND NOTES

1. Berry, Rice, Ross. Physical Chemistry, Part II. 1980; pp 564.

2. Barin I, Knacke O. Thermochemical Properties of Inorganic Substances. Berlin: Springer, 1973; Supplement, 1997.