Supplementary Information

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

Xujie Lü, Jianjun Wu, Tianquan Lin, Fuqiang Huang, Xiaoming Xie and Mianheng Jiang

a CAS Key Laboratory of Materials for Energy Conversion, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai 200050, P.R. China;
b Graduate School of the Chinese Academy of Sciences, Beijing 100049, P.R. China;
c State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai 200050, P.R. China

E-mail: huangfq@mail.sic.ac.cn

* To whom correspondence should be addressed. E-mail: huangfq@mail.sic.ac.cn Tel: +86-21-5241-1620, Fax: +86-21-5241-6360
**Estimate of Reaction Enthalpy.** The reaction of graphene formation can be expressed as:

\[ \text{CCl}_4 + 4\text{K} \rightarrow \text{C (graphene)} + 4\text{KCl} \]

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

\[ \Delta H_m = \Delta_f H_m (\text{C, graphene}) + 4\Delta_f H_m (\text{KCl}) - \Delta_f H_m (\text{CCl}_4, \text{gas}) - 4\Delta_f H_m (\text{K, liquid}) \]

Whereas, the molar enthalpy of formation of graphene is still unknown. Herein, it was estimated to be 513 kJ/mol from the bond enthalpy of graphene.  

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

\[ \Delta H_m = 513 + (-4 \times 436.7) - (-96.0) - 4 \times 2.3 = -1147 \text{ kJ/mol} \]

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\textsubscript{4} and Na, the molar enthalpy was calculated to be –1046 kJ/mol, lower (around 10%) than that of the reaction of CCl\textsubscript{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\textsubscript{4} (1.5 ml) and K (2.0 g), compared with the Raman spectrum of graphene prepared in 30 min as a reference.
Fig. S2 The crystallinity (expressed as the FWHM of C (001) peak of XRD patterns) variation with the CCl₄ volume.

Fig. S3 The typical electrochemical Nyquist plots of pristine graphene (PG) and boron-doped graphene (BG) measured by electrochemical impedance spectra (EIS).
Table S1. Elemental abundances determined by XPS in PG and BG samples.

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>B</th>
<th>Cl</th>
<th>O</th>
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<tr>
<td></td>
<td>Peak (eV)</td>
<td>Content (at. %)</td>
<td>BBr3 volume (μL)</td>
<td>Peak (eV)</td>
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<tr>
<td>PG</td>
<td>284.7</td>
<td>89.92</td>
<td>/</td>
<td>/</td>
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REFERENCES AND NOTES
