



Synthesis of graphene nanosheets from petroleum asphalt by pulsed arc discharge in water

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HIGHLIGHTS

- ▶ Graphene is synthesized by pulsed arc discharge in water.
- ▶ Graphene nanosheets are synthesized with petroleum asphalt as carbon sources.
- ▶ The reactive hydrogen released from asphalt can benefit the formation of few-layer graphene nanosheets.

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ABSTRACT

The synthesis of graphene nanosheets has been achieved by pulsed arc discharge in water with petroleum asphalt as a carbon source. The synthesized graphene nanosheets were examined by Raman spectroscopy, transmission electron microscopy, X-ray photoelectron spectroscopy, infrared spectroscopy and atomic force microscopy. The results indicate that most of as-synthesized graphene nanosheets have 2–5 layers, and small amounts of them have sheets in the range of 5–10 layers. The optical emission spectroscopy was used to monitor the arc discharge process, which indicates that the released hydrogen from asphalt may play a key role in the formation of graphene.

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1. Introduction

Graphene is a two dimensional material consisting of a single layer of carbon atoms arranged in a honeycomb. It has been recently a subject of considerable research activities owing to their unusual and intriguing mechanical, thermal, electrical and optical properties [1–4]. For example, graphene is the thinnest material known and yet is also one of the strongest, and it conducts electricity as efficiently as copper. Literature survey shows that graphene can be prepared by a number of techniques, including the micro-mechanical cleavage of highly oriented pyrolytic graphite [5], epitaxial growth on a SiC substrate [6], chemical vapor deposition [7], reduction of graphite oxide [8], arc discharge [9–16] and solvothermal method [17]. The arc discharge method has been widely used for the preparation of fullerenes and carbon nanotubes [18], and it has been also considered as a suitable method for the synthesis of

graphene with high crystallinity. So far, the synthesis of graphene by arc discharge has been performed in various kinds of inert gas atmosphere [12–16], which usually requires an expensive vacuum system and special ambient gas to generate the arc plasma.

Up to now, much progress has been made to optimize the arcing conditions by alternating the arcing atmosphere, carbon source or discharge medium. Arc discharge in water is considered to be an efficient and cheap route for the synthesis of carbon nanomaterials compared to the same kind of process in vacuum. The arc discharge carried out in water instead of in inert gases was first reported by Sano et al. [19] for preparation of spherical carbon nano-onions from high purity graphite. In addition, other cheap carbon sources such as coal have been investigated to replace graphite during the arc discharge for the purpose of producing carbon nanomaterials in a more economical way [20,21]. In this work, we have investigated the possibility of preparing graphene with petroleum asphalt as a carbon source by pulsed arc discharge in water. The oil-derived asphalt is an inexpensive and readily available carbon source in nature, which is a bottom product that remains after the distillation of petroleum [22], such byproduct of petroleum industry, has great

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