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研　究　主　論　文　抄　録

論文題目

Photoreaction and Proton Conduction of Graphene Oxide

（酸化グラフェンの光反応とプロトン伝導）

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主論文要旨

Graphene is a monolayer of graphite structure and has excellent mechanical electrical optical properties. Because of these properties, Geim and Novoselov *et al.* got the Novel price in 2010. Graphene is produced by various methods such as epitaxial growth and chemical vapor deposition. In these methods, reduction of graphene oxide (GO) produced by exfoliation of graphite oxide is most inexpensive and easy route for mass production graphene. However, it is impossible to produce graphene with a perfect structure from GO.

GO, which is composed of hydrophobic π–conjugated sp^2 domains and sp^3 domains with hydrophilic oxygen functional groups, is not only a precursor for graphene but also one of the most promising materials because of its excellent properties such as high surface area, water solubility and tunable band gap. GO can be also produced very easily and cheaply from natural graphite as raw material. Therefore, GO has the potential to be key material for industrial applications in the future. In this study, we report the photoreaction and proton conductivity of GO.

This thesis is composed of 7 chapters.

Chapter 1

Introduction

The general background, physical and chemical properties, synthesis of GO are described as introduction.

Chapter 2

Simple Photoreduction of Graphene Oxide Nanosheet under Mild Conditions

The photoreduction technique is demonstrated as new reduction method of GO. This method is very simple, easy and safety. It is investigated that the electron conductivity of GO rapidly increased through photoreduction. Moreover, it is possible to produce

photopatterning a conducting section of micrometer size on insulating GO.

Chapter 3

Photoreaction of Graphene Oxide Nanosheets in Water

The photoreaction of GO in water is demonstrated. It is investigated that GO is reduced and H_2 and CO_2 are evolved from GO under UV irradiation in water. In addition, production of nanopores in GO through photoreaction process is observed. The mechanism of photoreaction of GO in water is also described.

Chapter 4

Photochemical Engineering of Graphene Oxide Nanosheets

Simple production of nanopores in GO via photoreaction in O_2 under UV irradiation at room temperature is reported. The total area of the nanopores can be controlled by irradiation time using this approach. The photoreaction mechanism in N2 and O2 is also described.

Chapter 5

Proton Conduction of Graphene Oxide

Proton conductivity of GO is described. It is demonstrated that GO is electronic insulator but, by contrast, has high proton conductivity. Optimization of proton conductivity in GO by filling sulfate ions is also presented. The mechanism of proton conductivity is discussed.

Chapter 6

Tunable Graphene Oxide Proton / Electron Mixed Conductor that Function at Room Temperature

The successful control of the proton and electron conductivities of GO using the photoirradiation and thermal reduction is presented. Both the electron and proton conduction mechanisms for GO are also discussed based on the concentrations of various functional groups and defects, changes in the interlayer distance, and the activation energy associated with proton conduction.

Chapter 7

Conclusions

In this chapter, the general conclusions of the thesis are described.