functions that other carbon materials cannot exhibit, for example, a catalytic function to accelerate a chemical reaction in a fuel cell battery reaction, and a catalytic function to reduce active oxygen. To make effective use of such edge or surface of graphene, it is necessary to fix three-dimensionally many very thin graphenes in nanometer order in a space and fulfill the functions sufficiently.

CITATION LIST

NON-PATENT LITERATURE

[0010]

Non-patent Document 1: 2)K.S. Novoselov, A.K. Geim, S.V. Morozov, D. Jiang, Y. Zhang, S.V. Dubons, I.V. Grigorieva and A.A. Firsov, Science, 306(2004)666

Non-patent Document 2: A.K. Geim and K.S. Novoselov, Nature Mater. 6(2007)183

Non-patent Document 3: P.Blake et al., Nano Lett., 8(2008)1704

Non-patent Document 4: X.Li et al., Science, 324(2009)1312

Non-patent Document 5: S.Bae et al., Nature Nanotech, 5(2010)574

Non-patent Document 6: C.Berger et al., Science, 312, 19912(2006)

Non-patent Document 7: S. Y. Zhou et al., Nature mat. 6, 916(2007)

Non-patent Document 8: T. Ohta et al., Science 313, 951(2006)

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0011] The present ~~invention~~ disclosure provides a carbon fiber having a novel

structure in which very thin graphenes are fixed three-dimensionally in a space and a method for producing the same.

SOLUTION TO PROBLEM

[0012] The inventors of the present ~~invention~~ disclosure have made intensive study and as a result, have found that the above problems can be solved by pre-baking a fiber of an organic compound so as to contain remaining hydrogen and then subjecting the pre-baked fiber to hot isostatic pressing treatment (HIP treatment) under predetermined conditions, and have conducted further studies to complete the present ~~invention~~disclosure.

[0013] Namely, in an aspect, the present ~~invention~~ disclosure relates to a method for producing a carbon fiber having an outermost surface composed of edges of graphenes. The production method comprises steps of pre-baking a fiber of an organic compound so as to contain remaining hydrogen, putting the pre-baked fiber of an organic compound in a closed vessel made of a heat resistant material and subjecting the pre-baked fiber together with the vessel to hot isostatic pressing treatment using a compressed gas atmosphere, wherein an aspect ratio of the fiber of an organic compound is 2.5 or more, the fiber of an organic compound is in the form of yarn, woven fabric, non-woven fabric, blended yarn with other fiber, or woven fabric or non-woven fabric made of the blended yarn, and a maximum ultimate temperature in the hot isostatic pressing treatment is 1000 to 2000°C.

[0014] In the above production method, the remaining hydrogen is preferably 500 ppm or more.

[0015] In the above production method, a pre-baking temperature is preferably 1000°C or lower.

[0016] In the above production method, the fiber of an organic compound is preferably in the form of yarn, woven fabric, non-woven

wood, waste plants, and garbage.

[0021] In the above production method, the hot isostatic pressing treatment is preferably carried out in such a state that a part or the whole around the pre-baked fiber of an organic compound charged in the closed vessel made of graphite is covered with a spacer and a sleeve.

[0022] In the above production method, the spacer and the sleeve is preferably made of one or more selected from the group consisting of glassy carbon, diamond-like carbon, and amorphous carbon.

[0023] In another aspect, ~~T~~the present ~~invention~~ disclosure further relates to a carbon fiber having an outermost surface composed of edges of graphenes in the form of yarn, woven fabric, or non-woven fabric, wherein an aspect ratio of the carbon fiber is 2.5 or more.

[0024] In yet another aspect, ~~T~~the present ~~invention~~ disclosure further relates to a method for producing a graphene dispersion comprising graphenes and a solvent, comprising:

soaking the carbon fiber having an outermost surface composed of edges of graphenes prepared by the production method of Claim 1 in the solvent, wherein an aspect ratio of the carbon fiber is 2.5 or more; and subjecting the mixture to ultrasonic wave treatment, and then filtering the mixture.

[0025] In the above production method, an aspect ratio of the carbon fiber is preferably 2.5 or more.

[0026] In the above production method, a mean diameter of the carbon fiber is preferably within a range from 0.1 to 500 μm.

[0027] In the above production method, the solvent preferably further comprises a dispersant.

CLAIMS

1. A method for producing a carbon fiber having an outermost surface composed of edges of graphenes, comprising steps of:

pre-baking a fiber of an organic compound so as to contain remaining hydrogen, and

putting the pre-baked fiber of an organic compound in a closed vessel made of a heat resistant material and subjecting the pre-baked fiber together with the vessel to hot isostatic pressing treatment using a compressed gas atmosphere,

wherein an aspect ratio of the fiber of an organic compound is 2.5 or more,

the fiber of an organic compound is in the form of yarn, woven fabric, non-woven fabric, blended yarn with other fiber, or woven fabric or non-woven fabric made of the blended yarn, and

a maximum ultimate temperature in the hot isostatic pressing treatment is 1000 to 2000°C.

2. The production method of Claim 1, wherein an amount of the remaining hydrogen is 500 ppm or more.

3. The production method of Claim 1 or 2, wherein a pre-baking temperature is 1000°C or lower.

~~4. The production method of any one of Claims 1 to 3, wherein the fiber of an organic compound is in the form of yarn, woven fabric, non-woven fabric, blended yarn with other fiber, or woven fabric or non-woven fabric made of the blended yarn.~~

~~5~~4. The production method of any one of Claims 1 to 43, wherein a mean diameter of the fiber of an organic compound before the pre-baking is 500 μm or less.

~~6~~5. The production method of any one of Claims 1 to ~~5~~4, wherein the closed vessel made of a heat resistant material is a graphite closed vessel.

~~7~~6. The production method of any one of Claims 1 to ~~6~~5, wherein the graphite closed vessel has an open pore ratio of less than 20% and is of triangular screw type.

~~8~~7. The production method of any one of Claims 1 to ~~7~~6, wherein the organic compound is one or more selected from the group consisting of starch, cellulose, protein, collagen, alginic acid, dammar, ~~kovar,~~ rosin, gutta-percha, natural rubber, cellulose resin, cellulose acetate, cellulose nitrate, cellulose acetate butyrate, casein plastic, soybean protein plastic, phenol resin, urea resin, melamine resin, benzoguanamine resin, epoxy resin, diallyl phthalate resin, unsaturated polyester resin, a bisphenol A type epoxy resin, Novolac type epoxy resin, polyfunctional epoxy resin, alicyclic epoxy resin, alkyd resin, urethane resin, polyester resin, vinyl chloride resin, polyethylene, polypropylene, polystyrene, polyisoprene, butadiene, nylon, vinylon, acrylic fiber, rayon, polyvinyl acetate, ABS resin, AS resin, acrylic resin, polyacetal, polyimide, polycarbonate, modified polyphenylene ether, polyarylate, polysulfone, polyphenylene sulfide, polyether ether ketone, fluorine-contained resin, polyamide imide, silicon resin, petroleum pitch~~,~~ and coal pitch~~, petroleum coke, coal coke, carbon black, activated carbon, waste plastic, waste PET bottle, waste wood, waste plants, and garbage~~.

~~9~~8. The production method of any one of Claims 1 to ~~8~~7, wherein the hot isostatic pressing treatment is carried out in such a state that a part or the whole around the pre-baked fiber of the organic compound charged in the closed vessel made of graphite is covered with a spacer and a sleeve.

~~10~~9. The production method of Claim ~~9~~8, wherein the spacer and the sleeve are made of one or more selected from the group consisting of glassy carbon, diamond-like carbon, and amorphous carbon.

~~11~~10. A carbon fiber in the form of yarn, woven fabric, or non-woven fabric having an outermost surface composed of edges of graphenes, wherein an aspect ratio of the carbon fiber is 2.5 or more.

~~12~~11. A method for producing a graphene dispersion comprising graphenes and a solvent, comprising:
soaking the carbon fiber having an outermost surface composed of edges of graphenes and prepared by the production method of Claim 1 in the solvent, wherein an aspect ratio of the carbon fiber is 2.5 or more; and
subjecting the mixture to ultrasonic wave treatment, and then filtering the mixture.

~~13. The method for producing a graphene dispersion of Claim 12, wherein an aspect ratio of the carbon fiber is 2.5 or more.~~

~~14~~12. The method for producing a graphene dispersion of

Claim ~~12 or 13~~11, wherein a mean diameter of the carbon fiber is within a range from 0.1 to 500 μm.

~~15~~13. The method for producing a graphene dispersion of ~~any one of~~ Claim~~s 12 to 14~~11 or 12, wherein the solvent further comprises a dispersant.