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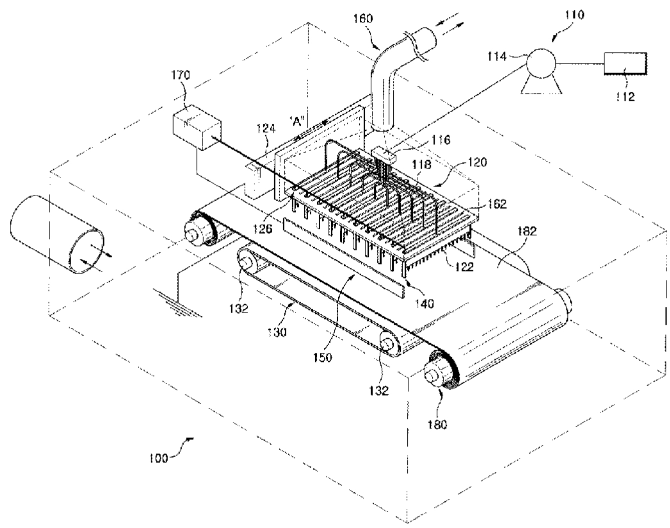
(54) Title: FILTER MATTER FOR AIR CLEANING, FILTER MADE OF THE SAME, AND METHOD FOR MAKING THE SAME



(57) Abstract: A filter matter for air cleaning, an air-cleaning filter made of the matter, and a method for making the filter are provided. The filter matter for air cleaning includes a ventilating support and a porous web laminated on one side of the ventilating support and made of ultra- fine fibers formed by electro-spinning. The ultra-fine fibers are made of any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI). Since the ultra- fine fiber web with a low adhesion characteristic is coated on a ventilating support by means of electro-spinning, the filter matter may give an excellent dust collecting efficiency with small energy consumption, so it may be effectively used for an air-cleaning filter.

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Description

FILTER MATTER FOR AIR CLEANING, FILTER MADE OF THE SAME, AND METHOD FOR MAKING THE SAME

Technical Field

[1] The present invention relates to a filter matter for air cleaning, an air-cleaning filter made of the matter, and a method for making the filter. More preferably, the present invention relates to a filter matter for air cleaning, which is suitable for air cleaning by having a low pressure drop and a high condensation efficiency, an air-cleaning filter made of the matter, and a method for making the filter.

Background Art

[2] Recently, along with the development of high-tech industries and the increase of interests on environmental pollution, air-cleaning industries are rapidly developed. In the air-cleaning industries, it is important to effectively filter dust and fine floating contaminants, and the removal of fine floating contaminants is greatly depending on a filter matter that composes a filter.

[3] In particular, as ultra-integration of memory semiconductors and nano-level ultra-precise industries are growing, it is necessarily required to remove such fine floating contaminants. In addition, as the demands of consumers for preventing viruses such as SARS (Severe Acute Respiratory Syndrome) and keeping indoor environments agreeably are increased, there is urgently needed a high-efficient filter matter. Also, according to the increased danger of biochemical wars, high performance is required for a filter matter of an anti-gas mask.

[4] Conventionally, as an air-cleaning filter matter, there were used low-efficient and low-graded filters made of fibers with a size of several ten to several hundred micrometers, obtained by a traditional non-woven fabric fabrication process such as melt-blown, spun bonding and needle punching, and high-efficient HEPA- or ULPA-level filter matters having a high pressure drop, made of single glass fibers with a size of several micrometers. In addition, an electrostatic filter matter having a minimized pressure drop by endowing electrostatic characteristics to a high-efficient non-woven material to improve an initial collecting efficiency was also used.

[5] Such conventional filter matters respectively have advantages and disadvantages, so they are limited in their usages. The traditional low-efficient non-woven fabric material has a somewhat low collecting efficiency since it is porous and has a high ventilation property, but it may minimize a pressure drop caused by a temperature difference since its resistance against air flow is low. Such kind of filter matters are mainly used as a cabin air filter of a vehicle, and it minimizes a pressure drop but shows a low

collecting efficiency.

[6] Meanwhile, the electrostatic filter, proposed as an alternative of the above filter, may minimize a pressure drop and maximize a filter efficiency since it has an excellent fine particle collecting efficiency due to electrostatic induction. However, since there arises serious losses to the initial electrostatic characteristics as it is used longer, so it may not ensure a high collecting efficiency for a long time.

[7] In addition, the filter matter using fine glass fiber with a diameter of 0.2 to 2□ is limited in its usage due to a structural feature of fine single fibers and various chemical materials put during the glass fiber making process. The single fiber has a very high packing density, so it is used as a high-efficient HEPA- or ULPA-level filter matter with a collecting efficiency of 99.97% or above. However, due to a great pressure drop over 20 mmH_2O, the filter matter using single fibers has a drawback in aspect of collecting energy. In addition, the single fibers deteriorate strength and have a life cycle, and there is serious criticism on harmfulness of fine glass fiber pieces. Thus, there are many activities to fine new dust collecting matters.

Disclosure of Invention

Technical Problem

[8] The present invention is designed to solve the problems of the prior art, and therefore it is an object of the present invention to provide a filter matter for air cleaning, which shows an excellent dust collecting efficiency even with a low energy loss such that it may be effectively used for an air-cleaning filter.

[9] In addition, an object of the present invention is to provide an air-cleaning filter made of the filter matter and a method for making the filter matter.

Technical Solution

[10] In order to accomplish the above object, the present invention provides a filter matter for air cleaning, which includes a ventilating support and a porous web laminated on one side of the ventilating support and made of ultra-fine fibers formed by electro-spinning, wherein the ultra-fine fibers are made of any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethyl-methacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI).

[11] In the filter matter for air cleaning according to the present invention, the porous web made of ultra-fine fibers laminated per a unit area of the ventilating support preferably has a mass of 0.1 to 10 g/m^2, and the ultra-fine fibers preferably have an average diameter of 200 nm to 5 □. The ventilating support is preferably a non-woven fabric made of at least one material or a mixture of at least two materials selected from

the group consisting of polyethyleneterephthalate, polyolefin and cellulose.

[12] In addition, in the filter matter for air cleaning according to the present invention, the filter matter for air cleaning preferably shows a pressure drop and a dust collecting efficiency of 0.2 to 1.2 mmH_2O and 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3 against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

[13] In another aspect of the present invention, there is also provided an air-cleaning filter, made using the filter matter for air cleaning described above.

[14] In still another aspect of the present invention, there is also provided a method for making a filter matter for air cleaning, which includes preparing a ventilating support; preparing a polymer solution containing any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide (PEI), polyimide (PI) and polyamideimide (PAI); and electro-spinning the polymer solution to one surface of the ventilating support to form a porous web of ultra-fine fibers.

Advantageous Effects

[15] According to the present invention, an ultra-fine fiber web with a low adhesion characteristic is coated on a ventilating support by means of electro-spinning, so a filter matter shows a low pressure drop and a high dust collecting efficiency. Accordingly, the filter matter of the present invention may give an excellent dust collecting efficiency with small energy consumption, so it may be effectively used for an air-cleaning filter.

Brief Description of the Drawings

[16] Other objects and aspects of the present invention will become apparent from the following description of embodiments with reference to the accompanying drawing in which:

[17] FIG. 1 is a perspective view showing an electro-spinning device used for making a filter matter according to an embodiment of the present invention;

[18] FIG. 2 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 1, which is enlarged at a magnification of 5K using an electronic microscope;

[19] FIG. 3 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 2, which is enlarged at a magnification of 3K using an electronic microscope;

[20] FIG. 4 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 3, which is enlarged at a magnification of 3K using an electronic

microscope;

[21] FIG. 5 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 4, which is enlarged at a magnification of 3K using an electronic microscope;

[22] FIG. 6 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 5, which is enlarged at a magnification of 3K using an electronic microscope;

[23] FIG. 7 is a photograph showing a porous web of an ultra-fine fiber according to an embodiment 6, which is enlarged at a magnification of 3K using an electronic microscope;

[24] FIG. 8 is a photograph showing a porous web of an ultra-fine fiber according to a comparative example 1, which is enlarged at a magnification of 3K using an electronic microscope;

[25] FIG. 9 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 1;

[26] FIG. 10 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 2;

[27] FIG. 11 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 3;

[28] FIG. 12 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 4;

[29] FIG. 13 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 5;

[30] FIG. 14 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the embodiment 6;

[31] FIG. 15 is a graph showing a dust collecting efficiency and a pressure drop of a filter matter according to the comparative example 1; and

[32] FIG. 16 is a graph in which the dust collecting efficiencies and the pressure drops according to the embodiments 1 to 6 and the comparative example 1 are compared in log-converted numerals.

Best Mode for Carrying Out the Invention

[33] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[34] In the present invention, electro-spinning is used to form a porous web made of ultra-fine fibers with a diameter of several thousand nanometers to several micrometers, and then the porous web of ultra-fine fibers with high surface area and porosity in comparison to weight is used to provide a filter matter for air cleaning with

an excellent collecting performance and a low pressure drop.

[35] An adhesion characteristic originated from physical and chemical features of polymer materials is one of important factors that determine a packing density of a porous web of ultra-fine fibers formed by electro-spinning. The filter matter for air cleaning according to the present invention selectively uses polymers that form a porous web of ultra-fine fibers, thereby giving more enhanced effects in pressure drop and dust collecting efficiency.

[36] That is to say, polymer materials in the groups of polyurethane (PU), p olyvinylacetate (PVA) and polyvinylidenefluoride (PVDF) have an excellent adhesion characteristic among the formed ultra-fine fibers, so they allows to form a web with a significantly high packing density. Meanwhile, the polymer materials such as polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI) has a very low adhesion characteristic among the formed ultra-fine fibers, thereby forming a web with a low packing density. Thus, if the porous web of ultra-fine fibers is made of one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI), the porosity of the web is increased to have a low pressure drop against air flow, thereby capable of lowering the energy loss further. As the pressure drop is decreased, the dust collecting efficiency may also be decreased, but it is insignificant. But, the ultra-fine fiber web has a great specific surface area, thereby giving a dust collecting efficiency sufficient for air cleaning.

[37] The ultra-fine fibers that forms the porous web preferably have an average diameter of 200 nm to 5 ㎛, more preferably 300 nm to 5 ㎛. If the average diameter of the ultra-fine fibers exceeds 5 ㎛, the volume and porosity of fibers are increased to lower a pressure drop, but the dust collecting efficiency is also lowered. Thus, it is required to coat a more amount of ultra-fine fibers to increase the dust collecting efficiency.

[38] The ventilating support is used for reinforcing and protecting the porous web of ultra-fine fibers and filtering coarse particles. Thus, the ventilating support should have high impact strength, high tensile strength, high bursting strength, and low thermal shrinkage rate. Any material with the above properties may be utilized as the ventilating support, representatively non-woven fabric, web, mesh, porous films and knitted goods. Among them, non-woven fabric is most preferred. For the non-woven fabric, any non-woven fabric made of one material or a mixture of at least two materials selected from polyethyleneterephthalate, polyolefin and cellulose.

[39] When the porous web of ultra-fine fibers are formed on the ventilating support, a mass of the porous web of ultra-fine fibers formed on a unit area of the ventilating support preferably has a mass of 0.1 to 10 g/m^2, more preferably 0.2 to 4.0 g/m^2. In case the mass of the porous web of ultra-fine fibers per a unit area exceeds 10 g/m^2, the pressure drop may be seriously increased. If the mass is less than 0.1 g/m^2, the dust collecting efficiency may be deteriorated.

[40] The filter for air cleaning made using the filter matter of the present invention shows an excellent dust collecting performance with even small energy consumption. In particular, it is most suitable for air cleaning to a pressure drop to 0.2 to 1.2 mmH_2O and a dust collecting efficiency to 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3[illegible] against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

[41] Hereinafter, a method for making the filter matter according to the present invention will be explained in detail.

[42] A method for making a filter matter for air cleaning according to the present invention includes the steps of preparing a ventilating support; preparing a polymer solution containing any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI); and electro-spinning the polymer solution to one surface of the ventilating support to form a porous web of ultra-fine fibers.

[43] When making the polymer solution for electro-spinning, a solvent may representative be a mixture solvent such as dimethyl acetamide (DMAc) : acetone (90:10, 80:20, 70:30, 60:40), dimethyl formamide (DMF) : acetone (90:10, 80:20, 70:30, 60:40), dimethyl acetamide (DMAc):tetrahydrofouran (THF) (90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70), and dimethyl formamide (DMF) : tetrahydrofouran (THF) (90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70), but not limitedly. The polymer solution suitably has a concentration of 10 to 40weight%.

[44] An electro-spinning device used for electro-spinning to form a porous web of ultra-fine fibers is not specially limited, if a basic mechanism of electro-spinning is applied thereto. The mechanism for electro-spinning is already well introduced in many documents ([J.M.Deitzel, J.D.Kleinmeyer, J.K.Hirvonen, N.C.Beck Tan, Polymer 42, 8163-8170(2001)], [J.M.Deitzel, J.D.Kleinmeyer, D.Harris, N.C.Beck Tan, Polymer 42, 261-272(2001)], [Y.M.Shin, M.M.Hohman, M.P.Brenner, G.C.Rutledge, Polymer 42, 9955-9967(2001)]).

[45] FIG. 1 is a perspective view showing an electro-spinning device 100 for making a filter matter according to the present invention, as an example.

[46] Referring to FIG. 1, the electro-spinning device 100 of the present invention includes a supply unit 110 for supplying polymer in a melted state as a fiber material, a spinning unit 120 having a plurality of spinning nozzles 122 for discharging the polymer solution supplied from the supply unit 110 into a charged filament form, a collector 130 spaced apart from the spinning nozzles 122 by a predetermined interval to accumulate the filaments spun from the spinning unit 120 into a predetermined thickness, control units 140 installed to at least both sides of the spinning unit 120, a guide unit 150 installed between the control unit 140 and the collector 130 to surround a filament stream S, and an air conditioning unit 160 for injecting air into a space between the spinning unit 120 and the collector 140 and evaporating the solvent in the space to be discharged out.

[47] The supply unit 110 includes a container 112 for containing a solution of polymer that becomes a fiber material, a pump 114 for pressuring the solution stored in the container 112 to be quantitatively supplied toward the spinning unit 120, and a dispenser 116 for dispensing the solution to each nozzle.

[48] The spinning unit 120 plays a role of spinning the fiber material solution supplied from the supply unit 110 toward the collector 130 in a fine filament form while the fiber material is in a charged state.

[49] A positive (+) voltage is excited by an output voltage of a high voltage unit 170. The high voltage unit 170 outputs a DC current in the range of 10 kV to 120 kV.

[50] The spinning unit 120 includes at least one spinning nozzle pack 126 in which a plurality of spinning nozzles 122 are arranged. The number of the spinning nozzles 122 composed in the spinning nozzle pack 126 or the number of spinning nozzle packs 126 composed in the spinning unit 120 is determined in consideration of size, thickness and production rate of webs to be produced.

[51] The collector 130 may be grounded to have a potential difference with respect to a voltage applied to the spinning unit 120 (see FIG. 1), or a negative (-) voltage may be applied thereto. The charged filament discharged from the spinning unit 120 may be directly integrated to the collector 130, or a ventilating support 182 may be positioned between the collector 130 and the spinning unit 120 such that the charged filament may be integrated directly on the ventilating support 182. In the present invention, as shown in FIG. 1, the ventilating support is positioned between the collector 130 and the spinning unit 120 such that an ultra-fine fiber web is formed on the ventilating support 182.

[52] The control unit 140 is used for preventing the filament streams S spun from the spinning nozzles 122 from deviating their paths, for example to prevent the filament streams S from being repelled and thus spread out from each other. The control units 140 are installed to at least both sides of the spinning nozzle pack 126 in a length

direction thereof.

[53] The guide unit 150 is applied with a voltage having the same polarity as the control unit 140. The guide unit 150 is installed around an extended charged filament stream S to guide an advancing direction of the stream. The guide unit 150 is prepared in a form of a conductor plate or a conductor rod. The guide unit 150 is charged with the same polarity as the charged filament to guide the filament being integrated in a limited region on the upper surface of the collector 130.

[54] The air conditioning unit 160 is used for volatilizing a solvent dissolved in the charged filament in a space between the spinning unit 120 and the collector 130 to exhaust the solvent out. For example, the air conditioning unit 160 includes a solvent inhaling/exhausting means such as a suction pan or an exhaust pan, and a plurality of air introduction slots 162.

[55] The solvent inhaling/exhausting means may adopt various kinds of well-known blowing devices. For example, the suction fan may be installed in an air inhaling passage to inhale a dry air from the outside and then inject the dry air into the space between the spinning unit 120 and the collector 130 through the air introduction slot 162 prepared in an upper portion of the spinning nozzle pack 126. The inhaled air volatilizes the solvent dissolved in the charged filament P spun from the spinning nozzle 122, and then it is exhausted out of the device through an air discharge passage to which the exhaust pan is installed.

[56] Now, operations of the electro-spinning device of FIG. 1 as configured above will be explained in brief.

[57] If the material solution stored in the supply unit 110 is quantitatively supplied to the spinning unit 120 through the pump 114 and the dispenser 116, the solution is charged through an electric connection unit inside each spinning nozzle pack 126. Here, the electric connection unit is installed to be included in a body of the spinning nozzle pack 126 so as to prevent direct electric reaction with the collector 130.

[58] Subsequently, the solution in a charged state is discharged toward the collector 130 in a fine filament form while passing through a capillary tube of the spinning nozzle 122. Here, due to a strong electric field formed between the collector 130 and the charged filament, the filament is extended to have a diameter of an ultra-fine level while being spun.

[59] In this spinning process, any stream that tends to spread out with departing from a set path due to a repulsive force among filaments is restored to an original position due to the control units 140 to keep its correct advancing path.

[60] Meanwhile, the guide unit 150 is installed on the collector 130 to surround the discharged stream, so any stream tending to depart from its path is guided to be directed to a limited integrating area on the collector 130 by means of the guide unit

150.

[61] The filaments guided as mentioned above are integrated on the upper surface of the ventilating support 182 to form an ultra-fine fiber web.

[62] While forming a porous web of ultra-fine fibers using the electro-spinning device, it is preferably controlled such that an applied voltage is 10 to 50 kV, a discharge rate of the spun solution is 1 to 10 ml/hole/h, and a distance from a front spinning end to the ventilating support is 10 to 40 cm.

[63] Hereinafter, the present invention will be explained in more detail based on embodiments. However, the embodiments of the present invention may be modified in various ways, and the scope of the present invention should not be interpreted to be limited to the following embodiments. The embodiments of the present invention are just for better understanding to those having ordinary skill in the art.

[64]

[65] **Embodiment 1: Coating of polysulfone ultra-fine fiber - dimethyl acetamide (DMAc) / acetone solution**

[66] 100g of polysulfon, manufactured by BASF, was put into 500 ml of dimethyl acetamide : acetone (60:40), and then stirred for 1 to 2 days at a normal temperature to make 20weight% of spinning solution. The made polysulfone solution was set and coated such that a voltage was 27.5 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 20 cm, by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 96 by using 6 packs in 16 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 30 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 40 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2, and a coating amount of porous web of polysulfone ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[67]

[68] **Embodiment 2: Coating of polysulfone ultra-fine fiber - dimethyl formamide (DMF) / tetrahydrofouran (THF) solution**

[69] 100g of polysulfon, manufactured by BASF, was put into 500 ml of dimethyl formamide (DMF) : tetrahydrofouran (THF) (60:40), and then stirred for 1 to 2 days at a normal temperature to make 20weight% of spinning solution. The made polysulfone solution was set and coated such that a voltage was 35 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 25 cm,

by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 90 by using 2 packs in 45 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 43 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 50 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2, and a coating amount of porous web of polysulfone ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[70]

[71] **Embodiment 3: Coating of polyethersulfone ultra-fine fiber**

[72] 100g of polyethersulfone was put into 500 ml of dimethyl acetamide : acetone (60:40), and then stirred for 1 to 2 days at a normal temperature to make 20weight% of spinning solution. The made polyethersulfone solution was set such that a voltage was 27.5 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 20 cm by using an electro-spinning device, and then directly coated on 100 g/m^2 of spun-bond polypropylene non-woven fabric placed on a plate. A gage used at this time was 27 gage, and the number of entire nozzles was 96 by using 6 packs in 16 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 30 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 40 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.7 to 4.2 g/m^2, and a coating amount of porous web of PES ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[73]

[74] **Embodiment 4: Coating of polycarbonate ultra-fine fiber**

[75] 100g of polycarbonate, manufactured by LG DOW PC, was put into 500 ml of dimethyl formamide (DMF) : tetrahydrofouran (THF) (40:60), and then stirred for 3 to 6 hours at a temperature of 50℃ to make 25weight% of spinning solution. The made polycarbonate solution was set and coated such that a voltage was 35 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 25 cm, by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 90 by using 2 packs in 45 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating

nozzle was 43 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 50 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2, and a coating amount of porous web of polycarbonate ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[76]

[77] **Embodiment 5: Coating of polystyrene ultra-fine fiber**

[78] 125g of polystyrene, manufactured by LG, was put into 500 ml of dimethyl formamide (DMF) : tetrahydrofouran (THF) (40:60), and then stirred for 3 to 6 hours at a temperature of 50℃ to make 25weight% of spinning solution. The made polystyrene solution was set and coated such that a voltage was 35 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 25 cm, by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 90 by using 2 packs in 45 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 43 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 50 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2, and a coating amount of porous web of polystyrene ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[79]

[80] **Embodiment 6: Coating of polymethacrylate ultra-fine fiber**

[81] 125g of polymethacrylate, manufactured by LG PMMA, was put into 500 ml of dimethyl formamide (DMF) : tetrahydrofouran (THF) (40:60), and then stirred for 3 to 6 hours at a temperature of 50℃ to make 25weight% of spinning solution. The made polymethacrylate solution was set and coated such that a voltage was 35 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 25 cm, by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 90 by using 2 packs in 45 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 43 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 50 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2,

and a coating amount of porous web of polymethacrylate ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[82]

[83] **Comparative Example 1: Coating of polyvinylidenefluoride ultra-fine fiber**

[84] 125g of Aldrich test-level plyvinylidenefluoride was put into 500 ml of dimethyl formamide (DMF) : acetone (40:60), and then stirred for 3 to 6 hours at a temperature of 50℃ to make 25weight% of spinning solution. The made polycarbonate solution was set and coated such that a voltage was 35 kV, a discharge amount per 1 hole was 2 ml/h, and a distance from the front spinning end to the support was 25 cm, by using an electro-spinning device, and the support was 100 g/m^2 of spun-bond polypropylene non-woven fabric. A gage used at this time was 27 gage, and the number of entire nozzles was 90 by using 2 packs in 45 hole / 1 pack. An interval between nozzles was 12 mm, and a distance between both ends of a coating nozzle was 43 cm. For uniform coating, a moving nozzle robot was used, and a maximum coating area was 50 cm. Thickness and amount of coating were set variously by controlling a staying speed of the support fiber passing through the coating region. The ultra-fine fiber was coated on a non-woven fabric with a mass of 0.25 to 2.5 g/m^2, and a coating amount of porous web of polyvinylidenefluoride ultra-fine fibers per a unit area (m^2) was obtained by measuring the change of weights before and after the coating.

[85]

[86] **Image Analysis using Electronic Microscope**

[87] The porous webs of ultra-fine fibers made using the filter matters according to the embodiments 1 to 4 were observed in an enlarged view using an electronic microscope, and their image-analyzed photographs are shown in FIGs. 2, 3, 4 and 5, respectively. FIG. 3 is a photograph showing a porous web of an ultra-fine fiber according to the embodiment 2, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 2, it would be understood that the porous web of ultra-fine fibers according to the embodiment 1 is composed of an aggregation of fibers with a diameter of 600 nm to 2 □. FIG. 3 is a photograph showing a porous web of an ultra-fine fiber according to the embodiment 2, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 3, it would be understood that the porous web of ultra-fine fibers according to the embodiment 2 is composed of an aggregation of fibers with a size of 600 nm to 2.5 □. FIG. 4 is a photograph showing a porous web of an ultra-fine fiber according to the embodiment 3, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 4, it would be understood that the porous web of ultra-fine fibers according to the embodiment 3 is composed of an aggregation of fibers with a size of 700 nm to 1.15 □. FIG. 5 is a photograph showing a

porous web of an ultra-fine fiber according to the embodiment 4, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 5, it would be understood that the porous web of ultra-fine fibers according to the embodiment 4 is composed of an aggregation of fibers with a size of 200 nm to 3 □. FIG. 6 is a photograph showing a porous web of an ultra-fine fiber according to the embodiment 5, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 6, it would be understood that the porous web of ultra-fine fibers according to the embodiment 5 is composed of an aggregation of fibers with a size of 200 nm to 3 □. FIG. 7 is a photograph showing a porous web of an ultra-fine fiber according to the embodiment 6, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 7, it would be understood that the porous web of ultra-fine fibers according to the embodiment 6 is composed of an aggregation of fibers with a size of 200 nm to 3 □. FIG. 8 is a photograph showing a porous web of an ultra-fine fiber according to the comparative example 1, which is enlarged at a magnification of 3K using an electronic microscope. Seeing FIG. 8, it would be understood that the porous web of ultra-fine fibers according to the comparative example 1 is composed of an aggregation of fibers with a size of 200 nm to 3 □.

[88]

[89] **<u>Dust Collecting Efficiency and Pressure Drop</u>**

[90] For the filter matter of the embodiment 1, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of $100g/m^2$ of polypropylene / porous web of polysulfone ultra-fine fibers / $30g/m^2$ of polypropylene. FIG. 9 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 1.

[91] For the filter matter of the embodiment 2, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of $100g/m^2$ of polypropylene / porous web of polysulfone ultra-fine fibers / $30g/m^2$ of polypropylene. FIG. 10 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 2.

[92] For the filter matter of the embodiment 3, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of $100g/m^2$ of polypropylene / porous web of polyethersulfone ultra-fine fibers / $30g/m^2$

of polypropylene. FIG. 11 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 3.

[93] For the filter matter of the embodiment 4, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of 100g/m^2 of polypropylene / porous web of polycarbonate ultra-fine fibers / 30g/m^2 of polypropylene. FIG. 12 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 4.

[94] For the filter matter of the embodiment 5, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of 100g/m^2 of polypropylene / porous web of polystyrene ultra-fine fibers / 30g/m^2 of polypropylene. FIG. 13 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 5.

[95] For the filter matter of the embodiment 6, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of 100g/m^2 of polypropylene / porous web of polymethacrylate ultra-fine fibers / 30g/m^2 of polypropylene. FIG. 14 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the embodiment 6.

[96] For the filter matter of the comparative example 1, a dust collecting efficiency was measured using TSI 8130 model by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min. A test piece prepared for the measurement of dust collecting efficiency was made in a three-layered structure of 100g/m^2 of polyvinylidenefluoride / porous web of polystyrene ultra-fine fibers / 30g/m^2 of polypropylene. FIG. 15 is a graph showing a dust collecting efficiency and a pressure drop of the filter matter according to the comparative example 1.

[97] FIG. 16 is a graph in which the dust collecting efficiencies and the pressure drops according to the embodiments 1 to 6 and the comparative example 1 are compared in log-converted numerals. It would be understood that the porous web of polyvinylidenefluoride ultra-fine fibers used in the comparative example 1 shows a relatively lower dust collecting efficiency with respect to the pressure drop than the porous web of ultra-fine fibers prepared according to the embodiments.

[98] It should be understood that the terms used in the specification and the appended claims should not be construed as limited to general and dictionary meanings, but in-

terpreted based on the meanings and concepts corresponding to technical aspects of the present invention on the basis of the principle that the inventor is allowed to define terms appropriately for the best explanation.

[99] Therefore, the description proposed herein is just a preferable example for the purpose of illustrations only, not intended to limit the scope of the invention, so it should be understood that other equivalents and modifications could be made thereto without departing from the spirit and scope of the invention.

Industrial Applicability

[100] According to the present invention, an ultra-fine fiber web with a low adhesion characteristic is coated on a ventilating support by means of electro-spinning, so a filter matter shows a low pressure drop and a high dust collecting efficiency. Accordingly, the filter matter of the present invention may give an excellent dust collecting efficiency with small energy consumption, so it may be effectively used for an air-cleaning filter.

Claims

[1] A filter matter for air cleaning, which includes a ventilating support and a porous web laminated on one side of the ventilating support and made of ultra-fine fibers formed by electro-spinning,
wherein the ultra-fine fibers are made of any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethyl-methacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI), polyimide (PI) and polyamideimide (PAI).

[2] The filter matter for air cleaning according to claim 1,
wherein the porous web made of ultra-fine fibers laminated per a unit area of the ventilating support has a mass of 0.1 to 10 g/m^2.

[3] The filter matter for air cleaning according to claim 2,
wherein the porous web made of ultra-fine fibers laminated per a unit area of the ventilating support has a mass of 0.2 to 4.0 g/m^2.

[4] The filter matter for air cleaning according to claim 1,
wherein the ultra-fine fibers have an average diameter of 200 nm to 5 ㎛.

[5] The filter matter for air cleaning according to claim 2,
wherein the ultra-fine fibers have an average diameter of 300 nm to 5 ㎛.

[6] The filter matter for air cleaning according to claim 1,
wherein the ventilating support is a non-woven fabric made of at least one material or a mixture of at least two materials selected from the group consisting of polyethyleneterephthalate, polyolefin and cellulose.

[7] The filter matter for air cleaning according to claim 1,
wherein the filter matter for air cleaning shows a pressure drop and a dust collecting efficiency of 0.2 to 1.2 mmH_2O and 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3㎛ against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

[8] An air-cleaning filter, made using the filter matter for air cleaning, which is defined in any one of the claims 1 to 7.

[9] A method for making a filter matter for air cleaning, comprising:
preparing a ventilating support;
preparing a polymer solution containing any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS), polymethyl-methacrylate (PMMA), polyethyleneterephthalate (PET), polyetherimide(PEI),

polyimide (PI) and polyamideimide (PAI); and
electro-spinning the polymer solution to one surface of the ventilating support to form a porous web of ultra-fine fibers.

[10] The method for making a filter matter for air cleaning according to claim 9, wherein the porous web of ultra-fine fibers is laminated on one surface of the ventilating support with a mass of 0.1 to 10 g/m^2.

[11] The method for making a filter matter for air cleaning according to claim 10, wherein the porous web of ultra-fine fibers is laminated on one surface of the ventilating support with a mass of 0.2 to 4.0 g/m^2.

[12] The method for making a filter matter for air cleaning according to claim 9, wherein the ultra-fine fibers have an average diameter of 200 nm to 5 □.

[13] The method for making a filter matter for air cleaning according to claim 12, wherein the ultra-fine fibers have an average diameter of 300 nm to 5 □.

[14] The method for making a filter matter for air cleaning according to claim 12, wherein the ventilating support is a non-woven fabric made of at least one material or a mixture of at least two materials selected from the group consisting of polyethyleneterephthalate, polyolefin and cellulose.

[15] The method for making a filter matter for air cleaning according to claim 12, wherein the filter matter for air cleaning shows a pressure drop and a dust collecting efficiency of 0.2 to 1.2 mmH_2O and 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3□ against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

AMENDED CLAIMS

received by the International Bureau on 14 March 2008(14.03.2008)

【Claim 1】 (amended)

A filter matter for air cleaning, which includes a ventilating support and a porous web laminated on one side of the ventilating support and made of ultra-fine fibers formed by electro-spinning,

wherein the ultra-fine fibers are made of any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS) and polymethylmethacrylate (PMMA),

wherein the filter matter for air cleaning shows a pressure drop and a dust collecting efficiency of 0.2 to 1.2 mmH_2O and 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3㎛ against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

【Claim 2】 (original)

The filter matter for air cleaning according to claim 1,

wherein the porous web made of ultra-fine fibers laminated per a unit area of the ventilating support has a mass of 0.1 to 10 g/m^2.

【Claim 3】 (original)

The filter matter for air cleaning according to claim 2,

wherein the porous web made of ultra-fine fibers laminated per a unit area of the ventilating support has a mass of 0.2 to 4.0 g/m^2.

【Claim 4】 (original)

The filter matter for air cleaning according to claim 1,

wherein the ultra-fine fibers have an average diameter of 200 nm to 5 ㎛.

【Claim 5】 (original)

The filter matter for air cleaning according to claim 2,

wherein the ultra-fine fibers have an average diameter of 300 nm to 5 ㎛.

【Claim 6】 (original)

The filter matter for air cleaning according to claim 1,

wherein the ventilating support is a non-woven fabric made of at least one material or a mixture of at least two materials selected from the group consisting of polyethyleneterephthalate, polyolefin and cellulose.

【Claim 7】 (cancelled)

【Claim 8】 (amended)

An air-cleaning filter, made using the filter matter for air cleaning, which is defined in any one of the claims 1 to 6.

【Claim 9】 (amended)

A method for making a filter matter for air cleaning, comprising:

preparing a ventilating support;

preparing a polymer solution containing any one material or a mixture of at least two materials selected from the group consisting of polysulfone (PSU), polyethersulfone (PES), polycarbonate (PC), polystyrene (PS) and polymethylmethacrylate (PMMA); and

electro-spinning the polymer solution to one surface of the ventilating support to form a porous web of ultra-fine fibers,

wherein the filter matter for air cleaning shows a pressure drop and a dust collecting efficiency of 0.2 to 1.2 mmH_2O and 65 to 99%, respectively, when being measured by passing NaCl aerosol particles with an average particle diameter of 0.3㎛ against an air flow of 32 l/min in a filter measuring device of TSI 8130 model.

【Claim 10】 (original)

The method for making a filter matter for air cleaning according to claim 9,

wherein the porous web of ultra-fine fibers is laminated on one surface of the ventilating support with a mass of 0.1 to 10 g/m^2.

【Claim 11】 (original)

The method for making a filter matter for air cleaning according to claim 10,

wherein the porous web of ultra-fine fibers is laminated on one surface of the ventilating support with a mass of 0.2 to 4.0 g/m^2.

【Claim 12】 (original)

The method for making a filter matter for air cleaning according to claim 9,

wherein the ultra-fine fibers have an average diameter of 200 nm to 5 ㎛.

【Claim 13】 (original)

The method for making a filter matter for air cleaning according to claim 12,

wherein the ultra-fine fibers have an average diameter of 300 nm to 5 ㎛.

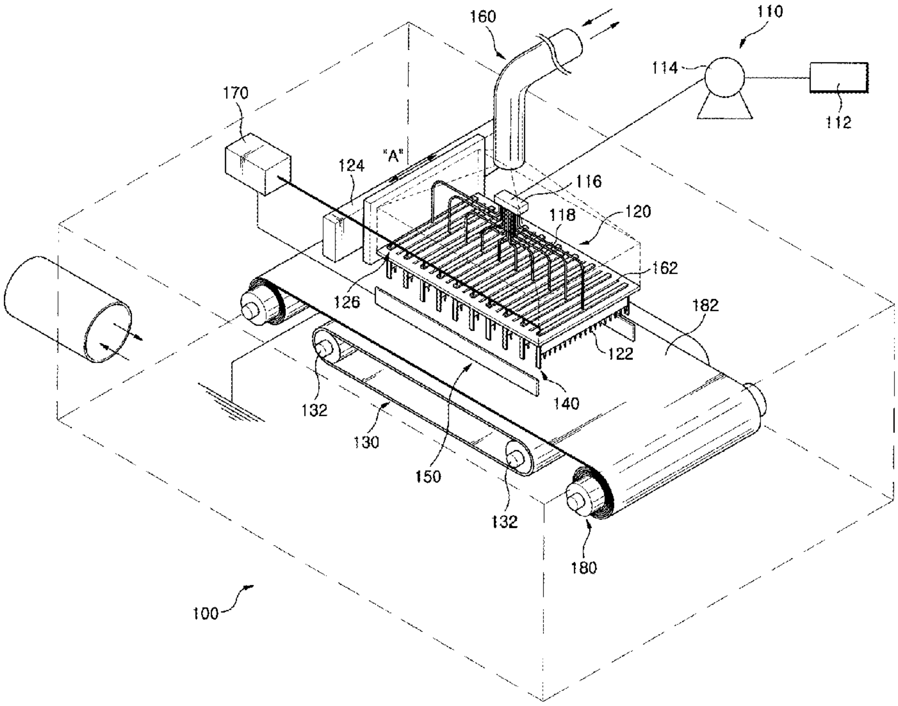
【Claim 14】 (original)

The method for making a filter matter for air cleaning according to claim 12,

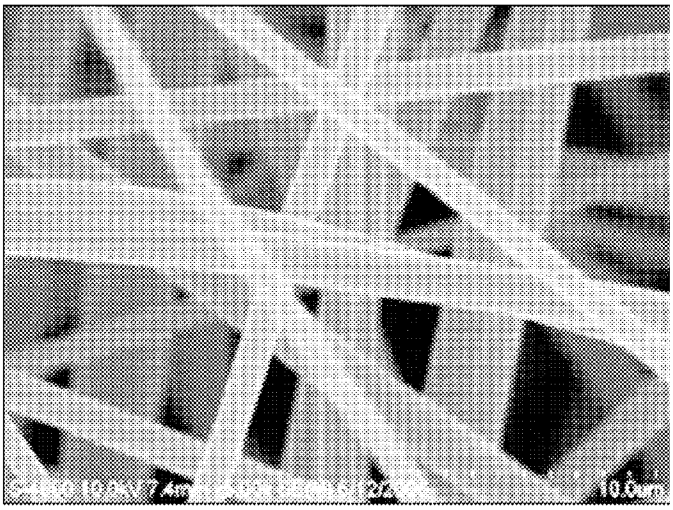
wherein the ventilating support is a non-woven fabric made of at least one material or a mixture of at least two materials selected from the group consisting of polyethyleneterephthalate, polyolefin and cellulose.

【Claim 15】 (cancelled)

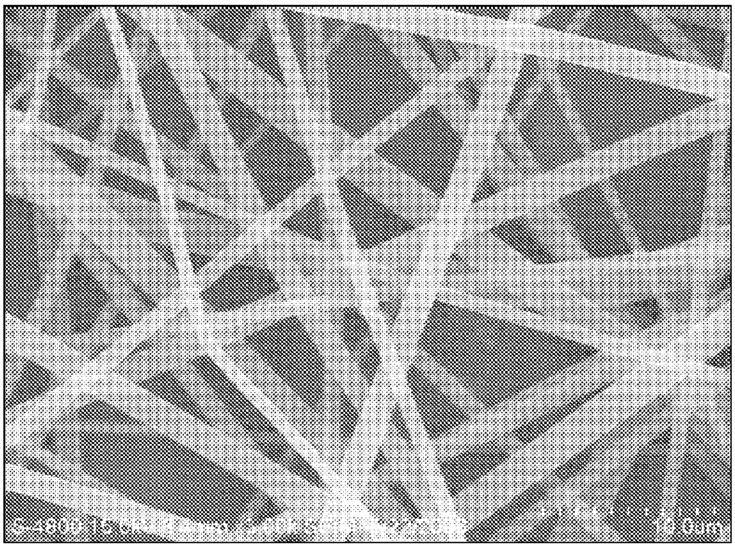
[Fig. 1]



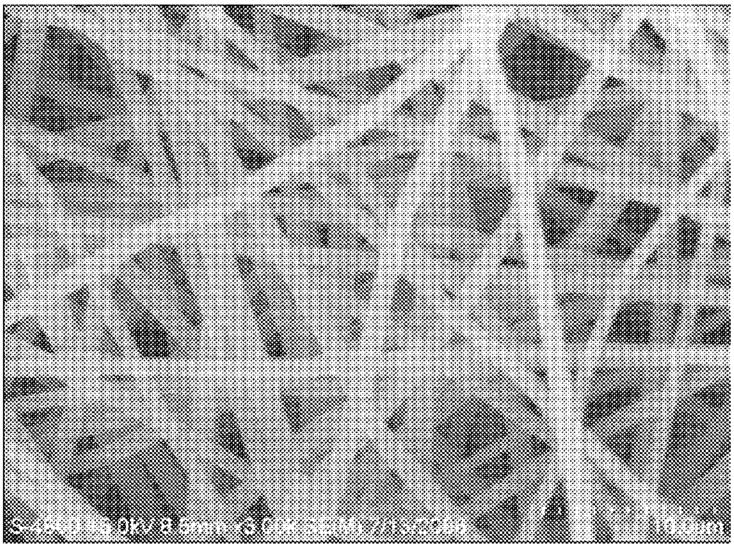
[Fig. 2]



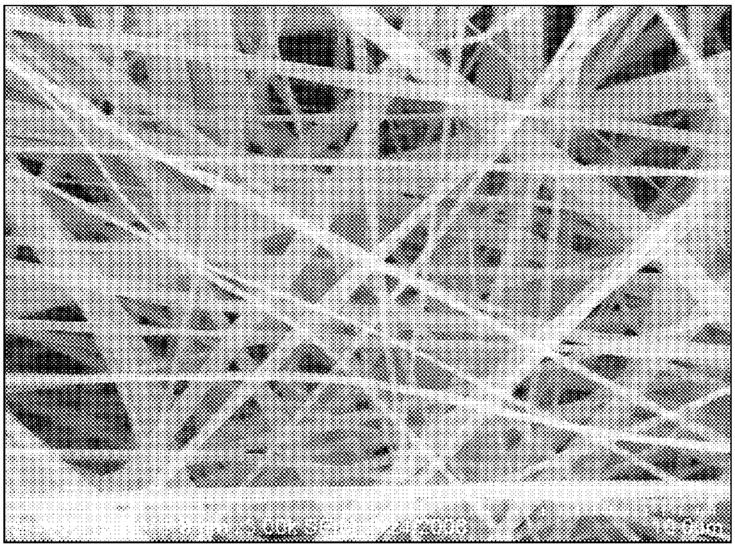
[Fig. 3]



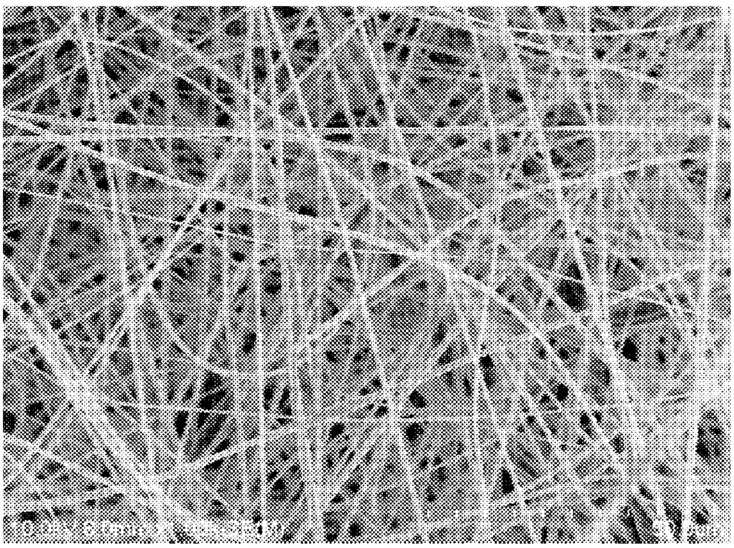
[Fig. 4]



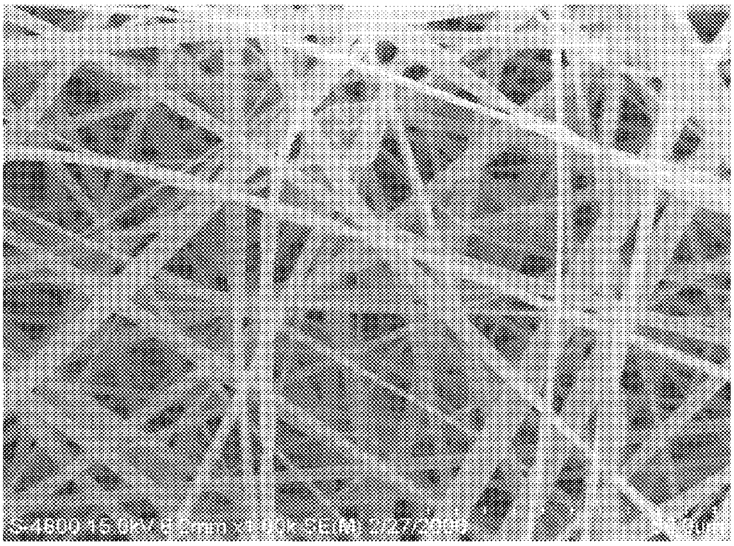
[Fig. 5]



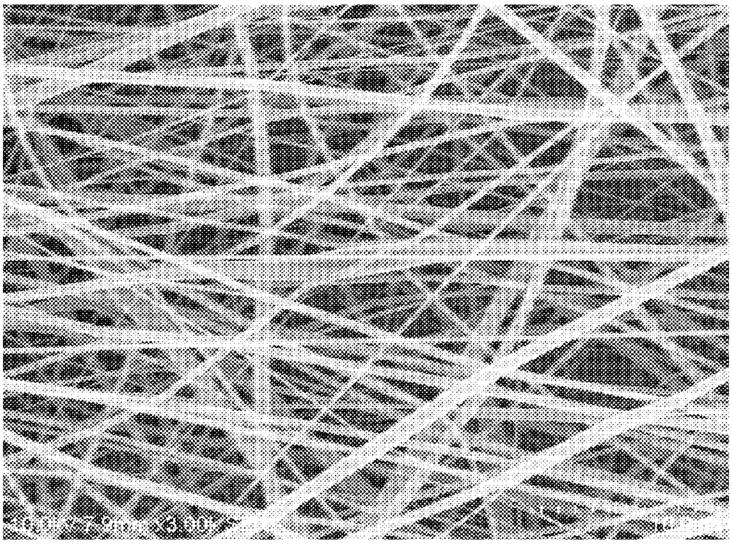
[Fig. 6]



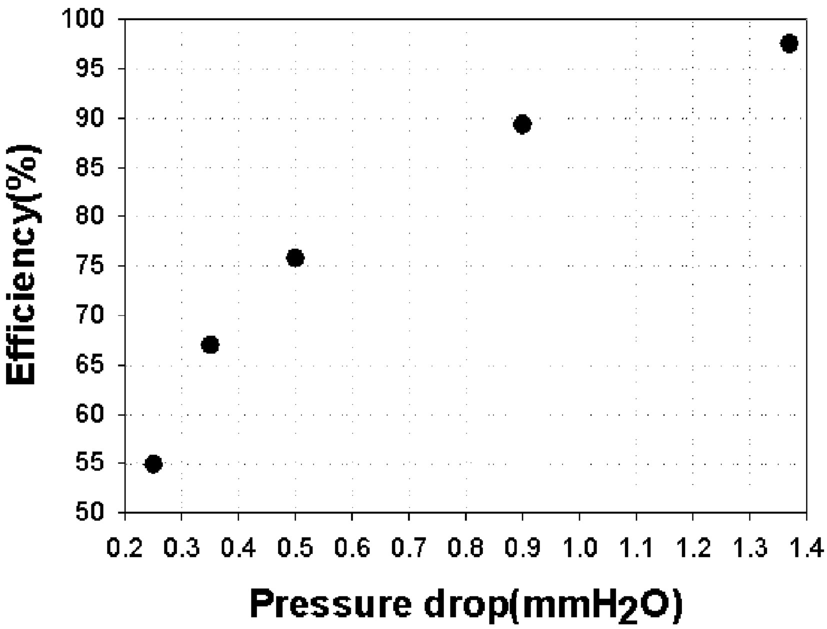
[Fig. 7]



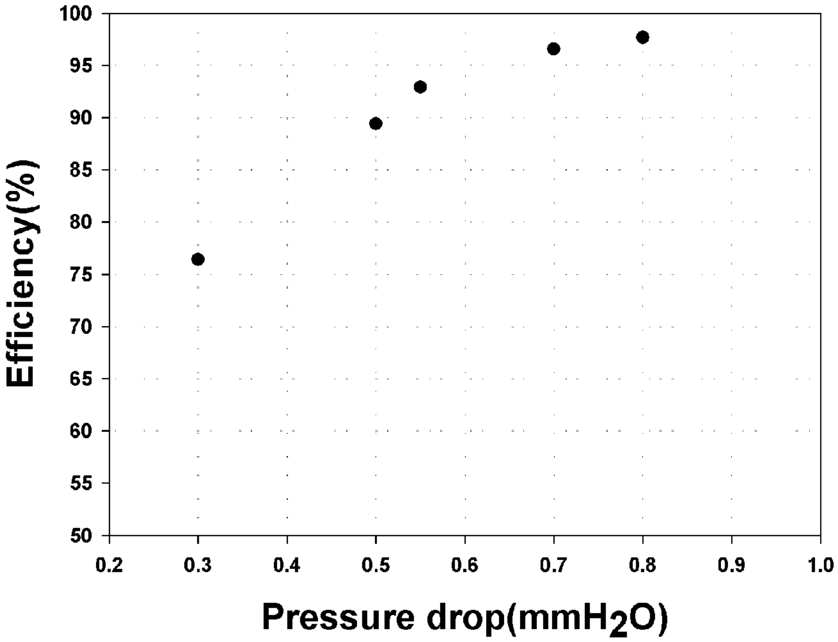
[Fig. 8]



[Fig. 9]



[Fig. 10]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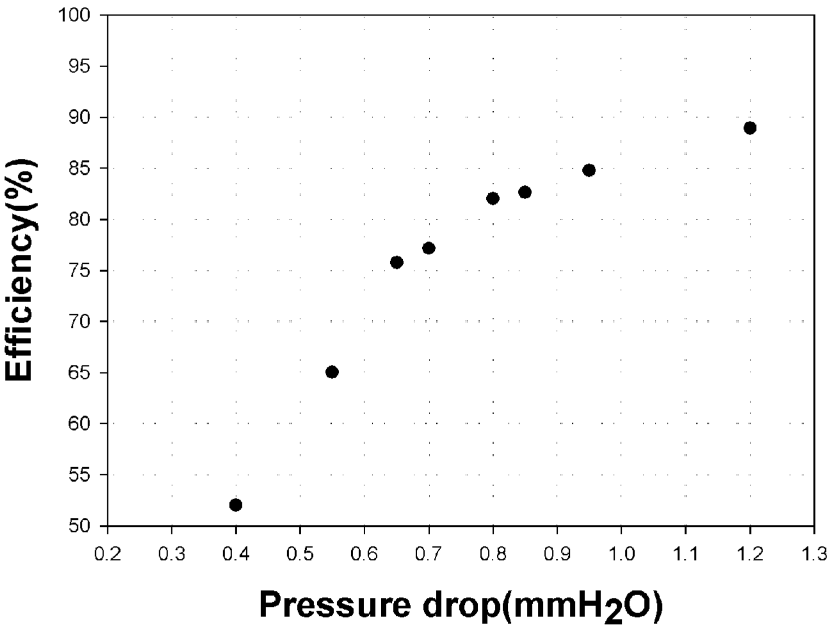
90
85
80
75
70
65
60
55
50
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Pressure drop(mmH2O)

[Fig. 11]


Efficiency(%)
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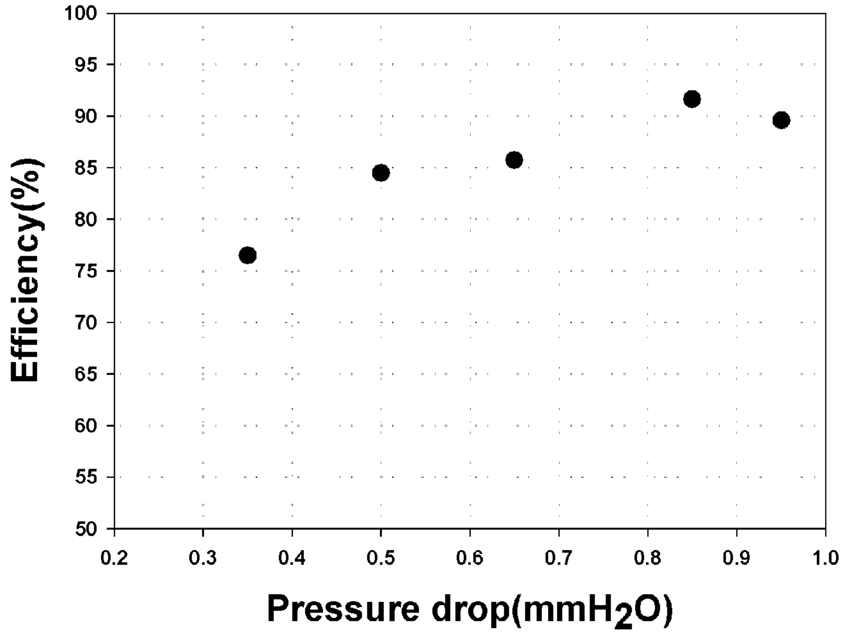
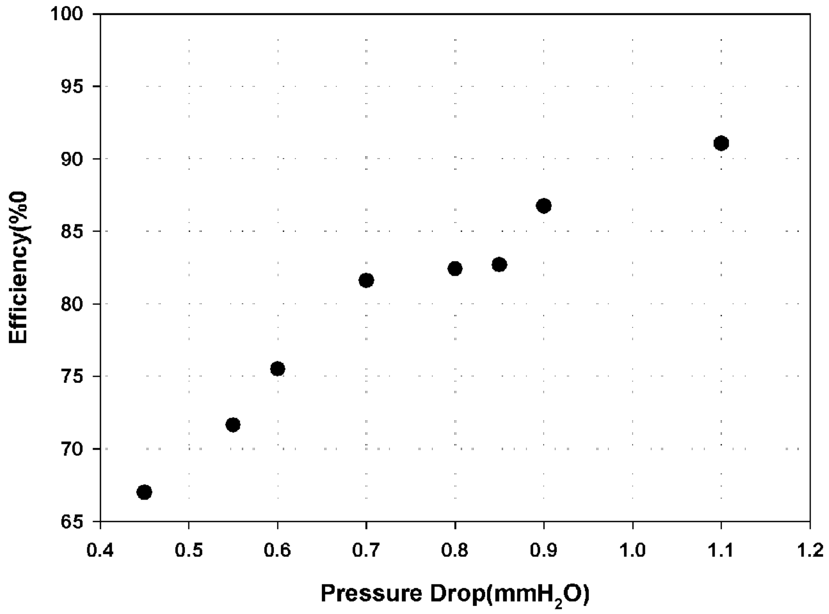
95
90
85
80
75
70
65
60
55
50
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
Pressure drop(mmH2O)

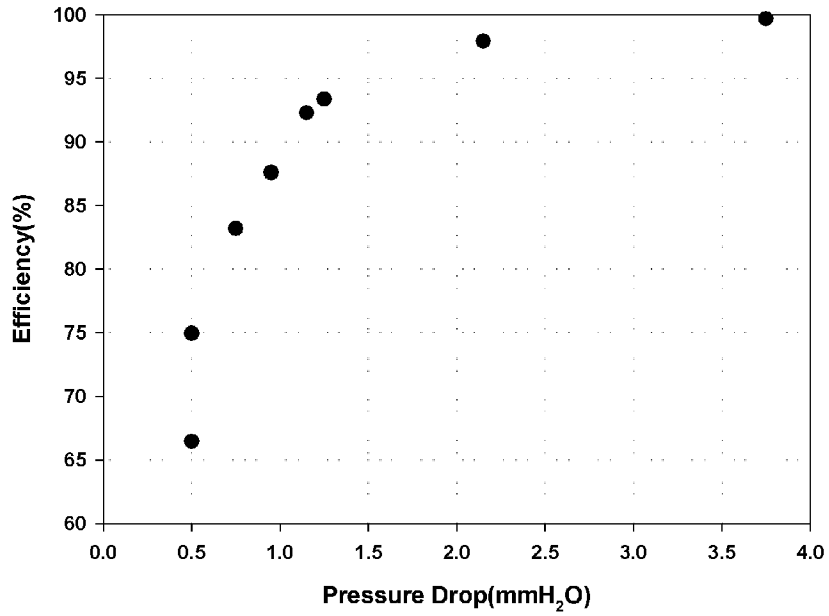
[Fig. 12]



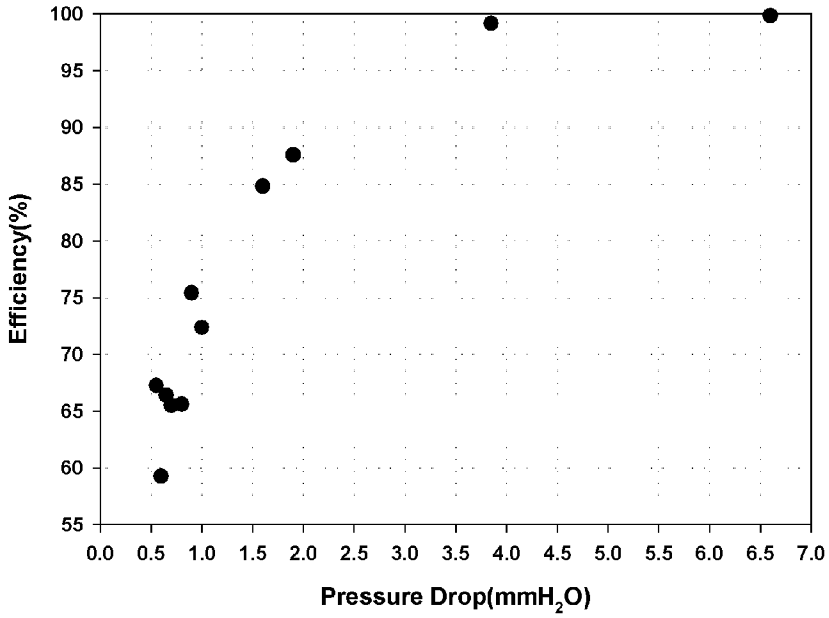
[Fig. 13]



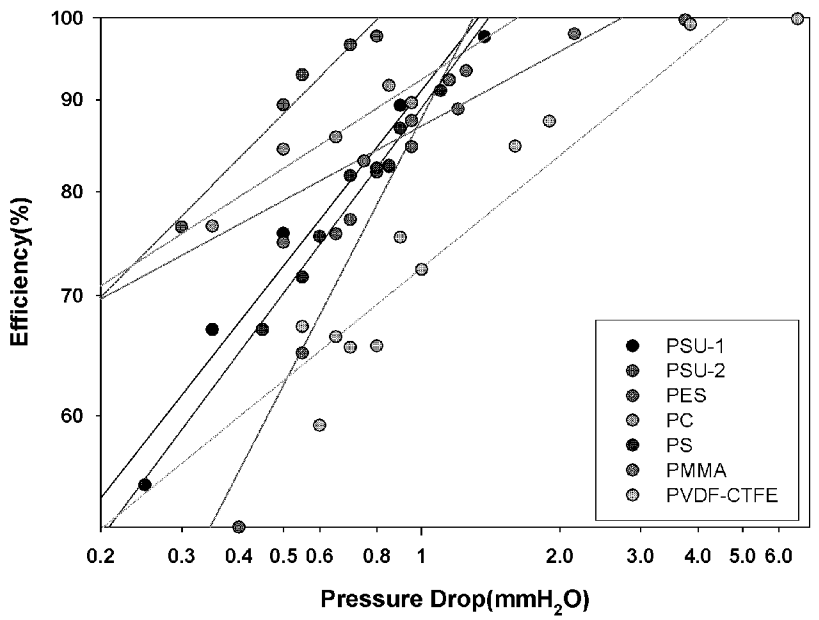
[Fig. 14]



[Fig. 15]


Efficiency(%)
100
95
90
85
80
75
70
65
60
55
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
Pressure Drop(mmH2O)

[Fig. 16]


Efficiency(%)
100
90
80
70
60
0.2 0.3 0.4 0.5 0.6 0.8 1 2.0 3.0 4.0 5.0 6.0
Pressure Drop(mmH2O)
PSU-1
PSU-2
PES
PC
PS
PMMA
PVDF-CTFE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/005369

A. CLASSIFICATION OF SUBJECT MATTER

B01D 39/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 8 : B01D 29, 39, 46, 69

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal) "filter", "air", "cleaning", "support", "porous", "web", "electrospinning", "pressure drop", "efficiency", "polysulfone", "polyethersulfone", "polycarbonate", "polystyrene", "polymethymethacrylate", "polyethyleneterephthalate"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2005-0037906 A (SAMSHIN CREATION CO., LTD.) 25 April 2005 See abstract, page 3-5, claims 1, 3-5, 10, 14-16, figure 1	1-15
A	KR 10-2001-0097747 A (KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY) 08 November 2001 See abstract, claims 1-3	1-15
A	US 6302934 B1 (NORIKANE NABATA et al.) 16 October 2001 See abstract, claim 1, figures 1-4	1-15
A	US 6149702 A (EIZO KAWANO et al.) 21 November 2000 See abstract, claims 1, 3, figures 2-5	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 JANUARY 2008 (30.01.2008)	**30 JANUARY 2008 (30.01.2008)**

Name and mailing address of the ISA/KR
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Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
LEE, Kyung Yul
Telephone No. 82-42-481-5582

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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