

NANOFIBER ELECTROSTATIC SPINNING DEVICE

FIELD OF INVENTION

[0001] The present invention relates to the technical field of electrostatic spinning, and more specifically, the present invention relates to a nanofiber electrostatic spinning device for producing nanofibers.

BACKGROUND

[0002] Electrostatic spinning, also known as electrospinning, as the name suggests, is the use of polymer liquid to form a polymer micro jet via electrostatic atomizing, and eventually forming solidified fibers. In recent years, nanofibers materials prepared through electrospinning have become the world's most important topics in the areas of material science and technology.

[0003] Today's electrospinning technology, due to its simple manufacturing equipment, inexpensive spinning, and process controllability, etc., it has become one of the main effective preparations of nanofibers. In the preparation process, the polymer solution is fed to a high-voltage nozzle. Due to the influence of high voltage, the electrostatic force will be generated between the nozzle tip and the electrode plate and pulls the polymer solution into the Taylor cone. If the polymer solution has a sufficient viscosity, under the guidance of the electrostatic force, the polymer solution will form a jet, and then the outer electric field and the inner repulsive force of the fiber leads to the bending and rotation of the fiber, and the nanofiber formed and deposited on the collection device. So far, the researchers have successfully prepared an extensive variety of nanofibers, including organic nano fiber, inorganic nanofibers and organic / inorganic composite nanofibers. Electrospinning nanofibers have a wide range of potential applications in reinforced composite materials. micro nano electronics, nano-sensors, filtration and separation, biomedical, protective clothing, and many other fields.

[0004] However, in conventional needle electrospinning system, because a direct current

voltage is applied to the nozzle head, and the diameter of nozzle needle is small, discharge phenomena are easy to happen once the voltage is high, hence there is high risk to safety. On the other hand, a single nozzle needle can only produce a single polymer spinning, and the yields are low. If one wants to increase production, it requires a lot of spinning needles, which in turn will cause the device to become large complex systems, making production management difficult. Therefore, from an industrial point of view, the difficulty to produce a large number of high quality nanofibers is still a technical problem that needs to be addressed.

SUMMARY OF THE INVENTION

[0005] In order to address the above-mentioned prior art problems, the present invention provides a nanofiber electrospinning device.

[0006] In order to increase production and to improve the uniformity of the voltage applied to the nozzle head, the present invention discloses a set of spinning electrodes which is circumferentially fixed to the central axis and can rotate around the central axis in a uniform speed. A part of the set of the spinning electrodes is immersed in the polymer solution, and then the spinning electrodes, via the uniform rotation of the spinning electrodes about the central axis, brings the polymer solution into the electric field, so as to generate nanofibers which are brought to collecting electrodes via the Coulomb force. Meanwhile, the polymer solution which is not consumed returns to the solution tank with the rotation, avoiding the waste of the polymer solution. Said central axis of the spinning electrode is made of an insulating material, preventing the influence of double electric field. The present invention has the advantage that the equipment made of the spinning systems is smaller, more compact, with higher safety performance. The adhesion of the fiber layer on the base material is more uniform.

[0007] The present invention is described hereinafter as follows.

[0008] The present invention discloses a nanofiber electrostatic spinning device comprising a high-voltage electrostatic generator, an electrostatic spinning generating device, and a collecting device. Said electrostatic spinning generating device comprises an open-top solution tank and a

rotary spinning mechanism disposed at the open-top of the solution tank, said rotary spinning mechanism comprising a central rotating shaft made of an insulating material, a pair of insulating end faces disposed vertically to the central rotating shaft, and a plurality of spinning electrodes being parallel to the central rotating shaft and extending between the pair of insulating end faces. Said high-voltage electrostatic generator provides an electric field between the plurality of spinning electrodes and the collecting device. Said central rotating shaft is driven to rotate by a drive mechanism for rotating the plurality of spinning electrodes and bringing a polymer solution in the solution tank to the electric field between the plurality of spinning electrodes and the collecting device, generating nanofibers which are received and collected by the collecting device. Said collecting device comprises an insulating base, wherein linear sliding rails are disposed on the opposite sides of a bottom of the insulating base. The collecting device is disposable on the linear sliding rails, and the collecting device is one of a low-speed collecting device and a high-speed collecting device.

[0009] Preferably, said plurality of spinning electrodes of the nanofiber electrostatic spinning device are sheets-like spinning electrodes.

[0010] Preferably, the electrostatic spinning generating device further comprises a supporting base for supporting the solution tank, wherein an elevating mechanism is installed at a bottom of the supporting base for adjusting a distance between the plurality of spinning electrodes and the collecting device.

[0011] The number of said solution tank is preferable to be at least one.

[0012] The collecting device is preferably a low-speed collecting device comprising a first collection module component and a first positioning connector component. The first collection module component is installed on the linear sliding rails of the insulating base via the first positioning connector component. The first collection module component comprises a high-temperature resistance metal mesh belt having two ends of the high-temperature resistance metal mesh belt connected to the first collection module component; a driving roller and a driven roller for driving the high-temperature resistance metal mesh belt back and forth; a tensioning

roller for adjusting tension of the high-temperature resistance metal mesh belt; a stepper motor which provides driving force to the driving roller; and a hot air stove pipe and an electrode receiving plate disposed on an inside of the high-temperature resistance metal mesh belt.

[0013] Alternative to being a low-speed collecting device, the collecting device is a high-speed collecting device comprising a second collection module component and a second positioning connector component. The second collection module component is installed on the linear sliding rails of the insulating base via the second positioning connector component. Said second collection module component comprises: a cylinder; a metal mesh tube disposed on a circumferential surface of the cylinder; a hot air inlet disposed on a first plane of the cylinder; and a servo motor disposed on a second plane of the cylinder, the servo motor for rotating the cylinder.

[0014] Preferably, the nanofiber electrostatic spinning device further comprises a cabinet, wherein the high-voltage electrostatic generator is disposed in a bottom layer of the cabinet. Said electrostatic spinning generating device is disposed in an intermediate layer of the cabinet, and said collecting device is disposed in a top layer of the cabinet.

[0015] Said intermediate layer preferably has transparent protective glass around four sides of the intermediate layer. A transparent night roller blind is disposed on left and right sides of the intermediate layer, and said top layer is provided with a sight glass window.

[0016] A polymer collector is preferably disposed in the top layer of the cabinet.

[0017] An operation platform is preferably disposed on an outer wall of the bottom layer of the cabinet. Said operation platform comprises: a touch-screen interface; a high voltage power supply voltmeter; a high voltage power supply ammeter; a voltage adjustment knob; a high voltage power supply switch; a high voltage power supply indicator; a device power supply switch; and an emergency stop button.

[0018] Compared with the prior art, the present invention has the following beneficial effects.

[0019] (1) In the nanofiber electrospinning device of the present invention, the electrostatic spinning generating device and collecting device are disposed in enclosed cabinets, which not only ensures the safety of operation, but also mitigates risk of pollution and harm caused by the polymer solution to the surrounding environment and the human body. Further, the device of the present invention is manufactured with reasonable structure, is safe, easy to operate, and suitable for laboratory operations.

[0020] (2) The electrostatic spinning generating device of the present invention can be applied to the nanofiber electrostatic spinning device using the polymer solution or water. The electrostatic spinning generating device can maintain uniform circular motion, adopting special sheets-like spinning electrode instead of wire electrodes as in the traditional design, which not only increases the spinning area, but also overcome the influence of the uneven discharge of the wire electrodes. This significantly improves the efficiency of the spinning and the fiber quality. Further, the electrostatic spinning apparatus of the present invention uses rotary spinning electrodes and a variety of collecting devices which match the spinning electrodes.

[0021] (3) The blended spinning of nanofibers and formation of composite nanofiber structure can be realized by the nanofiber electrospinning device of the present invention. Said elevating mechanism is for adjusting the distance between the spinning electrodes and the receiving electrodes, thereby obtaining nanofibers with different diameters and greatly enriching the types of nanofibers.

BRIEF DESCRIPTION OF DRAWINGS

[0022] Figure 1 is a schematic illustration of the nanofiber electrostatic spinning apparatus in the preferred embodiment.

[0023] Figure 2 is a schematic illustration of the electrostatic spinning generating device in the preferred embodiment.

[0024] Figure 3 is a schematic illustration of the high-speed collecting device in the preferred embodiment.

[0025] Figure 4 is a schematic illustration of the low-speed collecting device in the preferred embodiment.

DETAILED DESCRIPTION

[0026] With reference to the drawings, a preferred embodiment of the present invention will be further described. However, the present invention is not limited to the described preferred embodiment.

[0027] Preferred Embodiment

[0028] As shown in Figure 1 to 4, nanofibers electrostatic spinning equipment made in laboratory in this embodiment comprises a cabinet 10, wherein the bottom layer 12 of the cabinet 10 is to accommodate a high-voltage electrostatic generator. The intermediate layer 14 of the cabinet 10 is accommodated with an electrostatic spinning generating device 20. The top layer 16 of the cabinet 10 houses a collecting device and the polymer collector 18. Around the intermediate layer 14 there is transparent protective glass 17 and a transparent night roller blind. The top layer 16 is provided with a sight glass window 19. There is an operation platform 13 on an outer wall of the bottom layer 12. Said operation platform 13 is provided with a touch-screen interface, a high voltage power supply voltmeter, a high voltage power supply ammeter, a voltage adjustment knob, a high voltage power supply switch, a high voltage power supply switch, a device power supply switch, and an emergency stop button.

[0029] Said electrostatic spinning generating device 20 comprises an open-top solution tank 21 and a rotary spinning mechanism 22 disposed at the open-top of the solution tank. Said solution tank 21 according to the actual needs can be one or more than one. Said rotary spinning mechanism 22 comprises a central rotating shaft 23 made of an insulating material, a pair of insulating end faces 24 disposed vertically to the central rotating shaft 23, and a plurality of

sheets-like spinning electrodes 25 being parallel to the central rotating shaft 23 and extending between the pair of insulating end faces 24. The solution tank 21 is supported by the supporting base, wherein an elevating mechanism is installed at a bottom of the supporting base for adjusting a distance between the plurality of spinning electrodes and the collecting device. Said high-voltage electrostatic generator provides an electric field between the plurality of spinning electrodes and the collecting device. Said central rotating shaft is driven to rotate by a drive mechanism for rotating the plurality of spinning electrodes and bringing a polymer solution in the solution tank to the electric field between the plurality of spinning electrodes and the collecting device, thereby generating nanofibers which are received and collected by the collecting device. Said collecting device comprises an insulating base 30, wherein linear sliding rails 32 are disposed on opposite sides of a bottom of the insulating base 30. The collecting device is disposable on the linear sliding rails 32, and the collecting device is one of a low-speed collecting device and a high-speed collecting device.

[0030] The low-speed collecting device would comprise a first collection module component 40 and a first positioning connector component 41. The first collection module component 40 is installed on the linear sliding rails 32 of the insulating base 30 via the first positioning connector component 41. The first collection module component 40 comprises: a high-temperature resistance metal mesh belt 42 having two ends of the high-temperature resistance metal mesh belt connected to the first collection module component 40; a driving roller 43 and a driven roller 44 for driving the high-temperature resistance metal mesh belt back and forth; a tensioning roller 45 for adjusting tension of the high-temperature resistance metal mesh belt; a stepper motor 46 which provides driving force to the driving roller; a hot air stove pipe 47; and an electrode receiving plate 48 disposed on an inside of the high-temperature resistance metal mesh belt.

[0031] The high-speed collecting device would comprise a second collection module component 50 and a second positioning connector component 51. The second collection module component 50 is installed on the linear sliding rails 32 of the insulating base 30 via the second positioning connector component 51. Said second collection module component 50 comprises a cylinder 52; a metal mesh tube 53 disposed on a circumferential surface of the cylinder 52; a hot air inlet 54 disposed on a first plane of the cylinder; and a servo motor 55 disposed on a second

plane of the cylinder, the servo motor for rotating the cylinder.

[0032] In the electrostatic spinning apparatus of the present invention, the electrostatic spinning generating device and the collecting device are disposed in a closed cabinet to not only ensure the safety of operation, but also mitigates the risk of the pollution and hazards of the polymer solution to the surrounding environment and human. The device of the present invention is manufactured with reasonable structure, is safe, easy to operate, and suitable for laboratory operations. Further, the electrostatic spinning apparatus of the present invention uses rotary spinning electrodes and a variety of collecting devices which match the spinning electrodes, significantly improving the efficiency of nanofiber spinning. The electrostatic spinning generating device of the present invention can be applied to the nanofiber electrostatic spinning device using the polymer solution or water. The electrostatic spinning generating device can maintain uniform circular motion, adopting special sheets-like spinning electrode instead of wire electrodes as in the traditional design. This feature not only increases the spinning area, but also overcome the influence of the uneven discharge of the wire electrodes, significantly improving the efficiency of the spinning and the quality and variety of the fiber.

[0033] The disclosure of the present invention has been elaborated in detail via the preferred embodiment in this disclosure. However, persons with ordinary skills in the art can understand that it can be implemented in other equivalent replacement or equivalent modification, without going beyond the scope of the present invention. Hence, the scope of the present invention is not limited to the preferred embodiment in this disclosure. Any embodiments without going beyond the substance of the invention fall within the scope of the present disclosure and the following claims.

CLAIMS

1. A nanofiber electrostatic spinning device comprising:

- a high-voltage electrostatic generator;
- an electrostatic spinning generating device; and
- a collecting device,

wherein said electrostatic spinning generating device comprises an open-top solution tank and a rotary spinning mechanism disposed at the open-top of the solution tank, said rotary spinning mechanism comprising a central rotating shaft made of an insulating material, a pair of insulating end faces disposed vertically to the central rotating shaft, and a plurality of spinning electrodes being parallel to the central rotating shaft and extending between the pair of insulating end faces;

wherein said high-voltage electrostatic generator provides an electric field between the plurality of spinning electrodes and the collecting device;

wherein said central rotating shaft is driven to rotate by a drive mechanism for rotating the plurality of spinning electrodes and bringing a polymer solution in the solution tank to the electric field between the plurality of spinning electrodes and the collecting device, generating nanofibers which are received and collected by the collecting device;

wherein said collecting device comprises an insulating base;

wherein linear sliding rails are disposed on the opposite sides of a bottom of the insulating base;

wherein the collecting device is disposable on the linear sliding rails; and

wherein the collecting device is one of a low-speed collecting device and a high-speed collecting device.

2. The nanofiber electrostatic spinning device as in claim 1, wherein said plurality of spinning electrodes are sheets-like spinning electrodes.

3. The nanofiber electrostatic spinning device as in claim 2, wherein the electrostatic spinning generating device further comprises a supporting base for supporting the solution tank, wherein an elevating mechanism is installed at a bottom of the supporting base for adjusting a distance

between the plurality of spinning electrodes and the collecting device.

4. The nanofiber electrostatic spinning device as in claim 3, wherein the number of said solution tank is at least one.

5. The nanofiber electrostatic spinning device as in claim 4, wherein the collecting device is a low-speed collecting device comprising a first collection module component and a first positioning connector component,

wherein the first collection module component is installed on the linear sliding rails of the insulating base via the first positioning connector component, the first collection module component comprising:

a high-temperature resistance metal mesh belt having two ends of the high-temperature resistance metal mesh belt connected to the first collection module component;

a driving roller and a driven roller for driving the high-temperature resistance metal mesh belt back and forth;

a tensioning roller for adjusting tension of the high-temperature resistance metal mesh belt;

a stepper motor which provides driving force to the driving roller; and

a hot air stove pipe and an electrode receiving plate disposed on an inside of the high-temperature resistance metal mesh belt.

6. The nanofiber electrostatic spinning device as in claim 4, wherein the collecting device is a high-speed collecting device comprising a second collection module component and a second positioning connector component,

wherein the second collection module component is installed on the linear sliding rails of the insulating base via the second positioning connector component, said second collection module component comprising:

a cylinder;

a metal mesh tube disposed on a circumferential surface of the cylinder;

a hot air inlet disposed on a first plane of the cylinder; and

a servo motor disposed on a second plane of the cylinder, the servo motor for rotating the cylinder.

7. The nanofiber electrostatic spinning device as in any one of claims 1 to 6, further comprising a cabinet,

wherein the high-voltage electrostatic generator is disposed in a bottom layer of the cabinet;

wherein said electrostatic spinning generating device is disposed in an intermediate layer of the cabinet; and

wherein said collecting device is disposed in a top layer of the cabinet.

8. The nanofiber electrostatic spinning device as in claim 7,

wherein said intermediate layer has transparent protective glass around four sides of the intermediate layer;

wherein a transparent night roller blind is disposed on left and right sides of the intermediate layer; and

wherein said top layer is provided with a sight glass window.

9. The nanofiber electrostatic spinning device as in claim 8, wherein a polymer collector is disposed in the top layer of the cabinet.

10. The nanofiber electrostatic spinning device as in claim 9,

wherein an operation platform is disposed on an outer wall of the bottom layer of the cabinet,

wherein said operation platform comprises:

a touch-screen interface;

a high voltage power supply voltmeter;

a high voltage power supply ammeter;

a voltage adjustment knob;

a high voltage power supply switch;

a high voltage power supply indicator;

a device power supply switch; and
an emergency stop button.