Title: DEVICE FOR PRODUCTION OF NANOFIBRES AND/OR NANOPARTICLES FROM SOLUTIONS OR MELTS OF POLYMERS IN ELECTROSTATIC FIELD

Abstract: Device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field between at least one spinning electrode and at least one collecting electrode, through which there is guided sufficiently electrical conductive substrate material, whereas the collecting electrode is in contact with substrate material.
Device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field

Technical field

Technical solution relates to the device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field between at least one spinning electrode and at least one collecting electrode, through which there is guided sufficiently electrically conductive substrate material.

Background art

The most significant production method of polymer nanofibres and/or polymer nanoparticles is the method, at which a suitable solution or melt of polymer is brought, e.g. on surface of rotating spinning electrode, into electrostatic field, which is generated by difference of electric potentials of at least one spinning electrode and at least one collecting electrode. This electrostatic field is acting on solution or melt of polymer by means of so called Coulomb forces, thanks to whose size and orientation the layer of solution or melt of polymer is deformed, while the balanced state of all participating forces results in formation of so called Taylor cones. From Taylor cones are, upon continuous action of Coulomb forces, the primary nucleuses of fibres elongated, from which are through consequent splitting and solidification of individual branches the final polymer nanofibres produced. If, during this process e.g. due to extremely high values of Coulomb forces with regard to the viscosity of solution or melt of polymer, or due to mechanical intervention, the Taylor cone or the primary nucleus of fibre is violated, then the polymer nanoparticles, eventually mixtures of polymer nanofibres and polymer nanoparticles, are produced. Nanofibres and/or nanoparticles being produced in electrostatic field by action of Coulomb forces move towards the collecting electrode, while it is advantageous if, still before their contact with the collecting electrode, they are caught and transported from the active space, in which the process of
production of nanofibres and/or nanoparticles takes place. To catch nanofibres and/or nanoparticles there is usually inserted a suitable substrate into the space between the spinning electrode and collecting electrode on whose surface the nanofibres and/or nanoparticles deposit, and by means of continuous or discontinuous motion of this substrate are transported out of the active space. A suitable substrate is electrically conductive material, e.g. metal foil, textile formation with sufficient electrical conductivity or textile formation whose electrical conductivity is increased e.g. in a method according to CZ PV 2005-702.

Due to the fact that the nanofibres and/or nanoparticles being produced bring with them on the substrate material electrical charge acquired through contact of solution or melt of polymer with electrically charged spinning electrode or through bringing electrical voltage itself into the solution, the substrate material is after impact of nanofibers and/or nanoparticles charged, while the rate of this charging and its time and surface stability is related to overall electrical properties of the substrate material. Charging of substrate with the same polarity as that of the spinning electrode causes weakening of electric field, which moreover becomes non-homogenous and non-static. The process is either totally stopped or it runs in a lower and unstable intensity, while the newly lifted material and substrate are repulsed and this lifted material therefore moves in a not coordinated manner in the space and deposits where it is for it, from a physical point of view, optimal. With respect to that for generation of electrostatic field of intensity sufficient to create nanofibres and/or nanoparticles an electric voltage, whose value varies reaches tens of kV, is used, electric charge brought to substrate disables or markedly complicates guiding of substrate material, its connection with the means for initiating motion of substrate material and placing of substrate with deposited nanofibres and/or nanoparticles to the cloth bobbin. Possible contact between the charged substrate and other parts in active space would result in damage of these parts due to high voltage. Bringing of electrical charge to any part in the active space and its charging would further cause substantial disturbance and deformations of electrostatic field, eventually also change in direction of motion of nanofibres.
and/or nanoparticles and their undesirable depositing elsewhere than on the substrate.

Another problem, with the same or very similar consequences, which occurs by till this time known devices for production of nanofibres and/or nanoparticles in electrostatic field, relates to overall geometry and structure of the collecting electrode, which is generally formed by a metal plane board. In vicinity of sharp edges or peaks (generally parts with a high degree of curvature) of such collecting electrodes, and also in vicinity of contact of conductive body of electrode with non-conducting means for its mounting in active space, after the high voltage is brought to electrode the corona, what is a bunched electrical discharge, is created, which quite frequently undesirably affects total electrostatic field between the collecting electrode and spinning electrode. Coronas and with them connected stream of electrically charged particles destabilise electrostatic field, what in final result causes time and space instability of the process itself with negative impact on quality of layers of nanofibres and nanoparticles.

To overcome these disadvantages, the collecting electrode according to CZ PV 2006-477 was created, which comprises conductive thin-walled body of electrode, in which there is performed at least one opening, along whose perimeter there is arranged a border, while in an inner space of electrode body there is mounted at least one electrode carrier interconnected with at least one brace mounted in the spinning chamber, while the electrode carrier is arranged behind border of an opening. The advantage of such structure of the collecting electrode is that it does not contain any sharp forms, and that the places, where three differently dielectric solid environments come into contact (triple points), are hidden inside the electrode body, where an electric field shows practically zero intensity. In a final result it causes, that electrode does not produce corona. Next to this, this type of electrode with its overall geometry better meets requirements on configuration of electric field for setting the process.

Further patent documents disclose devices for production of nanofibres, which mutually differ by embodiment of the spinning as well as collecting electrodes, nevertheless at any of these devices there is not by any concrete
mean solved how to remove or compensate the charge being deposited on substrate by means of nanofibres and/or nanoparticles. This is understandable, because laboratory scale of the process never produces such quantity of charge and in such a short time, so that these effects could express themselves markedly. Sensitivity of the process on these effects is increasing only with a more massive production of nanofibrous layers.

The goal of technical solution is to propose device for production of polymer nanofibres and/or nanoparticles, that eliminates disadvantages of background art, and thus reliably contribute to generation of defined and stable electrostatic field of necessary intensity. Technical solution is focused first of all on elimination of electric charge brought by nanofibres and/or nanoparticles from the substrate material, upon simultaneous usage of knowledge arising out of structure of the collecting electrode according to PV 2006-477.

**Principle of the invention**

The goal of technical solution is achieved by the device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field between at least one spinning electrode and at least one collecting electrode, whose principle consists in that the collecting electrode is in contact with substrate material.

At the same time it is advantageous, if the collecting electrode extends with at least one of its dimensions along entire width of substrate material.

In advantageous embodiment the collecting electrode comprises a conducting thin-walled body provided on its faces with openings, along whose circumference there is arranged a border, while in the inner space of the body behind the border there is mounted at least one carrier connected with at least one brace mounted in the spinning chamber.

Electrical charge brought to substrate material by nanofibres and/or nanoparticles is due to contact of substrate material with conducting body of an elongated collecting electrode of a cylindric shape led away from substrate material, what remedies the disadvantages of present background art, because
the electrostatic field is not weakened and its homogeneity violated. Between nanofibres and/or nanoparticles and the substrate material occurs no mutual repulsion.

Thanks to the fact that the collecting electrode is performed as non-corona collecting electrode according to the patent file PV 2006-477, it is simultaneously ensured, that electrostatic field will not be disturbed by generation of coronas on surface of the collecting electrode.

The device according to the technical solution achieves a reliable leading away of electrical charge, which is on the substrate material brought by nanofibres and/or nanoparticles after their impact on substrate material.

**Examples of embodiment**

The device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field according to the technical solution will be explained on an example of embodiment of the device for production of nanofibres through electrostatic spinning of polymer solution, nevertheless the principle of technical solution is not limited to this device only, and it is usable also at other constructional embodiments of the devices for production of nanofibres and/or nanoparticles from solutions or melts of polymers. Next to this, the principle of the technical solution may be used also at already existing devices regardless of the construction and number of spinning or collecting electrodes, at which the produced electrically charged nanofibres and/or nanoparticles are deposited on electrically conductive substrate material. The conductive substrate material shall be understood such a material, whose electrical properties enable transfer of at least a part of electrical charge applied to one point of substrate on entire or a part of its surface, immediately or in a short time interval after the applying.

The device for production of nanofibres through electrostatic spinning of polymer solutions comprises the spinning chamber, in which there is mounted a cylindrical spinning electrode, elongated collecting electrode of a cylindric shape and reservoir of polymer solution. The spinning electrode is in a known manner
rotatably mounted in the reservoir of polymer solution, while by a section of its surface it extends into the polymer solution.

Above the spinning electrode and reservoir of polymer solution there is arranged the elongated collecting electrode of cylindric shape, performed e.g. according to PV 2006-477, while its longitudinal axis is parallel with longitudinal axis of spinning electrode, and both axes are laying in shared vertical plane being perpendicular to the plane of substrate fabric. At the same time the longitudinal axis of elongated collecting electrode of cylindric shape is perpendicular to the direction of motion of substrate fabric.

The collecting electrode and the spinning electrode are in a known not represented manner connected with opposite poles of high voltage source, or one of them is grounded while the second is connected with one pole of high voltage. Through this the electrostatic field, defining the active space, is generated between them, which through the action of force on layer of polymer solution on surface of the spinning electrode ensures formation of Taylor cones and consequently also production of polymer nanofibres. Voltage may be brought to the spinning electrode also by bringing voltage into the polymer solution being subject to spinning by means of any of known manners.

In the spinning chamber is between the spinning electrode and the collecting electrode performed a guiding of electrically conductive substrate flat fabric, at the same time the substrate flat fabric is guided tangentially to the surface of the collecting electrode and is in contact with it. Contact between the collecting electrode and substrate flat fabric is realised on a contact abscisse which is parallel with longitudinal axis of collecting electrode.

Upon rotation of the spinning electrode around its longitudinal axis the spinning electrode brings on its surface a layer of polymer solution into the electrostatic field between the spinning electrode and collecting electrode, in which thanks to action of force on the polymer solution on surface of the spinning electrode the Taylor cones are formed, and from them are subsequently produced the polymer nanofibres, which deposit on substrate surface fabric. The collecting electrode, next to co-generating of the electrostatic field, fulfils also a function of leading away the charge brought to
substrate fabric by means of polymer nanofibres, which results in entire remedy of disadvantages of present background art, while the substrate fabric is not being charged in uncontrolled manner and electrostatic field is not weakened, its homogeneity not violated and electrically charged nanofibres running towards substrate fabric are not repulsed.

In further examples of embodiment may be the functions of co-generating of electrostatic field and leading away the charge from substrate textile divided between two or more collecting electrodes, while in contact with substrate fabric is only the collecting electrode, eventually the collecting electrodes, designated at least for leading away the charge.

In principle, all present devices for production of nanofibres and/or nanoparticles or other nanostructures in electrostatic field, at which the produced nanostructures are bringing electrical charge to electrically conductive substrate material, may be added by at least one elongated collecting electrode of cylindrical shape. The collecting electrode may be grounded or connected with high voltage source, whose polarity is opposite than the polarity of the spinning electrode.

At the described example of embodiment the collecting electrode, which is in contact with substrate material, is positioned on opposite side of substrate material than the spinning electrode, nevertheless in cases when the electrostatic field is not effected negatively, it is possible that the grounded collecting electrode designated for leading away of the electrical charge from substrate material is positioned on the same side of substrate material as the spinning electrode outside the active space.

To ensure a reliable leading away of the electrical charge from substrate material, it is further possible that the contact between the collecting electrode and substrate material is realised not only on a contact abscisse, but on contact surface made of a section of surface of the collecting electrode, which is partially looped by a substrate material.
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CLAIMS

1. Device for production of nanofibres and/or nanoparticles from solutions or melts of polymers in electrostatic field between at least one spinning electrode and at least one collecting electrode, through which there is guided sufficiently electrical conductive substrate material, **characterised in that the** collecting electrode is in contact with substrate material.

2. Device according to the claim 1, **characterised in that the** collecting electrode at least with one of its dimensions extends along entire width of substrate material.

3. Device according to the claim 2, **characterised in that the** collecting electrode comprises a conducting thin-walled body provided on faces with openings, along whose circumference there is arranged a border, while in the inner space of the body behind the border there is mounted at least one carrier connected with at least one brace mounted in the spinning chamber.