(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 628 108 B1**

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **13.12.95**

(51) Int. Cl.[6]: **D21H 23/50**, D21H 19/24

(21) Application number: **93905232.0**

(22) Date of filing: **01.02.93**

(86) International application number:
PCT/EP93/00229

(87) International publication number:
WO 93/18228 (16.09.93 93/22)

(54) **PROCESS FOR TREATING AND SIZING PAPER SUBSTRATES**

(30) Priority: **02.03.92 US 844346**

(43) Date of publication of application:
14.12.94 Bulletin 94/50

(45) Publication of the grant of the patent:
13.12.95 Bulletin 95/50

(84) Designated Contracting States:
BE DE DK ES FR GB IT NL SE

(56) References cited:
EP-A- 0 186 983
FR-A- 1 156 723

PATENT ABSTRACTS OF JAPAN vol. 009, no. 160 (C-289)4 July 1985 & JP,A,60 035 066 (JIYOUETSU GIKEN KOGYO KK) 22 February 1985

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Description

Field of Invention

The present invention is concerned with a process for treating and sizing paper substrates with an isocyanate. In particular, the present invention is concerned with a process for strengthening and sizing paper with an isocyanate characterized in that the isocyanate does not contain water and is applied to paper by means of an electrostatic spraying device.

Background of Invention

The treatment of paper with isocyanates has been disclosed. For example, a process for treating paper with isocyanates is disclosed in EP-A-140537. In US-A-4,505,778, a process for applying a size of an aqueous emulsion of an aromatic isocyanate to a wet paper web is disclosed. However, neither patent discloses a process in which isocyanates are electrostatically sprayed onto paper.

Isocyanates emulsified with water have been applied to paper using a size press and unemulsified isocyanates have been applied using a rotogravure coating machine. When conventional means of spraying isocyanates are used, they are characterized by low transfer efficiencies. As a result, significant amounts of isocyanate are released into the atmosphere, thereby creating potential health problems. In addition, when the isocyanate that is applied to paper is not sprayed, solvent diluted, or emulsified, it is very difficult to apply the isocyanate at levels below 5 to 10 percent by weight based upon the weight of the paper. Lower isocyanate levels can be achieved by using emulsified isocyanates. However, pot life problems with the isocyanate can arise when the isocyanates are emulsified because the water begins to react with the isocyanate groups. Furthermore, depending upon when in the process the emulsion is added, it can result in additional drying requirements. There is therefore a need for a process for efficiently applying isocyanates to paper substrates at levels below 5 percent by weight based upon the weight of the paper substrates and a process that does not utilize emulsified isocyanates, although emulsifiable isocyanates may be used.

Surprisingly it has been found that these needs can be met by using an electrostatic spraying device to apply isocyanates to paper. By using this electrostatic spraying device, transfer efficiencies above 90 percent can be achieved and the isocyanate can easily be applied to paper substrates at levels well below 5 percent by weight. The amount of isocyanate needed according to the invention can be as low as 0.5 g/m^2. However, in commercial production settings, the amount of isocyanate needed is generally about 1.0 to 1.5 g/m^2.

Electrostatic spraying devices as such are known. See, for example, US-A-4854506 and 4846407 and EP-A-193348. The electrostatic spraying of various polymeric materials onto paper has also been disclosed in US-A-3930614, 4609686 and 4837057.

However, none of these patents disclose the electrostatic spraying of isocyanates onto paper.

It is an object of this invention to provide a means for efficiently applying an isocyanate to a paper substrate.

It is a further object to provide a means for improving the crush strength, water resistance and wet strength of paper products.

It is yet another object to provide a means of applying a uniform coating of isocyanate onto a paper substrate.

It is also an object to apply an isocyanate to paper in an environmentally safe manner.

These and other objects are obtained by the process of this invention.

Summary of Invention

The process of this invention is a process for treating a paper substrate with an isocyanate comprising the step of applying an isocyanate which does not contain water to the paper substrate by means of an electrostatic spraying device.

In a preferred embodiment, the process for treating a paper substrate with an isocyanate comprises the step of applying an isocyanate which does not contain water to the paper substrate by means of an electrostatic spraying device which is comprised of an electrostatic sprayhead having a linear orifice, means for applying a first electrical potential to liquid isocyanate which emerges from the sprayhead, an electrode comprised of two mutually spaced, parallel arranged linear electrode elements, with one electrode element being mounted adjacent to one side of the sprayhead's orifice and the other element being mounted

adjacent to the other side of the sprayhead's orifice, and means for applying a second electrical potential to the electrode such that an intense electrical field is developed between the emerging liquid and the electrode, the intensity ofthe field being sufficient to cause atomization of the emerging liquid, the electrode comprising a core of conducting or semiconducting material contained in a tubular sheath, characterized in that the sheath has a wall and the volume resistivity of a section of the wall of said sheath which is 1 cm in length is within the range of 5×10^{11} to 5×10^{13} ohm cms.

The process of this invention provides light weight, uniform coatings of isocyanates on paper substrates and improves some of the physical properties of coated paper substrates, such as water resistance, wet strength and crush strength.

Detailed Description of Invention

The process involves the electrostatic spraying of isocyanates onto paper substrates. The electrostatic spraying device employed to spray isocyanates onto paper substrates preferably comprises an electrostatic sprayhead having a linear orifice, means for applying a first electrical potential to liquid isocyanate which emerges from the sprayhead, an electrode comprised of two mutually spaced, parallel arranged linear electrode elements, with one electrode element being mounted adjacent to one side of the sprayhead's orifice and the other element being mounted adjacent to the other side of the sprayhead's orifice, and means for applying a second electrical potential to the electrode such that an intense electrical field is developed between the emerging liquid and the electrode, the intensity of the field being sufficient to cause atomization of the emerging liquid, the electrode comprising a core of conducting or semiconducting material contained in a tubular sheath, characterized in that the sheath has a wall and the volume resistivity of a section of the wall of said sheath which is 1 cm in length is within the range of 5×10^{11} to 5×10^{13} ohm cms. Such a device and its operating parameters have been fully described in United States Patent No. 4854506, which is incorporated herein by reference in its entirety.

Generally, as the liquid isocyanate passes through the linear orifice of the device of US-A-4854506, the isocyanate is charged at 30 to 40 kV by the means for applying an electrical potential to the isocyanate. Preferably, the isocyanate is positively charged. Once the liquid isocyanate is charged, it breaks into droplets having diameters typically ranging from 40 to 150 microns in an electric field created between the charged liquid and the electrode comprised of the two linear electrode elements, which are usually charged between 10 kV and 25 kV and at the same polarity as the liquid. Generally, the voltage difference between the liquid isocyanate and the electrode comprised of the two linear electrode elements is between 15 and 30 kV. This voltage difference is called "stress."

The isocyanates that are employed should have a viscosity in the range of 1 to 750 mPa.s, preferably in the range of 1 to 300, and a volume resistivity in the range of 1×10^{6} to 1×10^{11} ohm cms, preferably in the range of 5×10^{6} to 5×10^{9}, and most preferably in the range of 5×10^{7} to 5×10^{8} ohm cms. Generally, the higher the viscosity of the isocyanate, the more difficult it is to apply the isocyanate.

Any isocyanate having one or more isocyanate groups and a viscosity and a resistivity between the above indicated limits can be employed. The isocyanates which may be used include aliphatic, cycloaliphatic, araliphatic and aromatic isocyanates, especially those that are liquid at room temperature. Aromatic isocyanates, especially aromatic polyisocyanates, are preferred. Mixtures of isocyanates can be used and also isocyanates which have been modified by the introduction of urethane, allophanate, urea, biuret, carbodiimide, uretonimine or isocyanurate residues.

Examples of suitable aromatic isocyanates include m- and p-phenylenediisocyanate, toluene-2,4-and 2,6-diisocyanates, diphenylmethane-4,4'diisocyanate, diphenylmethane-2,4'-diisocyanate, chlorophenylene-2,4-diisocyanate, diphenylene-4,4'-diisocyanate, 4,4'-diisocyanate-3,3'-dimethyldiphenyl, 3-methyldiphenyl-methane-4,4'-diisocyanate and diphenyletherdiisocyanate and 2,4,6-triiso-cyanatotoluene and 2,4,4'-triisocyanatodiphenylether. There may be present mixtures of isocyanates far example a mixture of toluene diisocyanate isomers such as the commercially available mixtures of 2,4- and 2,6-isomers and also the mixture of di and higher isocyanates produced by phosgenation of aniline/formaldehyde condensates. Such mixtures are well known in the art and include the crude phosgenation products containing mixtures of methylene bridged polyphenylpolyisocyanates including diisocyanate, triisocyanate and higher polyisocyanates together with any phosgenation by-products.

Preferred compositions of the present invention are those wherein the isocyanate is an aromatic diisocyanate or polyisocyanate of higher functionality in particular crude mixtures of methylene bridged polyphenylpolyisocyanates containing diisocyanate, triisocyanate and higher functionality polyisocyanates. The methylene bridged polyphenylpolyisocyanates are sometimes referred to as polymeric methylene polyphenyldiisocyanate (MDI). Polyphenylpolyisocyanates are well known in the art and usually have an

isocyanate functionality ranging from 2.0 to 3.0. They are prepared by phosgenation of corresponding mixtures of polyamines obtained by condensation of aniline and formaldehyde.

Isocyanate-terminated prepolymers may also be employed and are prepared by reacting an excess of polyisocyanate with polyols, including aminated polyols or imines/enamines thereof, or polyamines.

Emulsifiable isocyanates may also be employed. An emulsifiable isocyanate is an isocyanate/isocyanate prepolymer blend which is made by incorporating into an isocyanate a prepolymer formed by reacting monoalkyl ethers of polyalkylene glycols or polyester polyether glycols with a polyisocyanate to form an isocyanate terminated urethane adduct. Such blends are well known to be emulsifiable in water. Suitable emulsifiable isocyanates and their preparation are described in US-A-3,996,154 and 4,505,778, which are incorporated herein by reference. Of the emulsifiable isocyanates, emulsifiable MDI is the most preferred.

The most preferred aromatic isocyanates are polymeric MDI, emulsifiable MDI, MDI variants, and mixtures thereof. Suitable MDI variants include compounds in which the MDI has been modified by the introduction of urethane, allophanate, urea, biuret, amide, carbodiimide, uretonimine and/or isocyanurate residues.

Examples of suitable aliphatic polyisocyanates include ethylene diisocyanate, 1,6-hexamethylene diisocyanate, isophorone diisocyanate, cyclohexane 1,4-diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, saturated analogues of the above mentioned aromatic isocyanates, mixtures thereof and the like.

If the isocyanate to be used is a solid at the temperature of spraying, which temperature generally is 10 to 30 °C and preferably 20 to 25 °C, the isocyanate may be heated in order to liquefy it and the heated isocyanate can be sprayed. However, the isocyanate should generally not be heated to temperatures above 38 °C before being sprayed. Preferably the isocyanate is liquid at the spraying temperature.

The liquid isocyanate is placed into a vessel from which the isocyanate can be pumped into the sprayhead of the electrostatic sprayer. Generally a hose connects the vessel and the electrostatic sprayer. The vessel is usually equipped with or connected to a means for pumping the isocyanate to the sprayhead at variable flowrates. The flowrate can vary from 0.5 to 150 g/minute/cm of nozzle width, and preferably is in the range of 1.5 to 75 g/minute/cm of nozzle width. The selected flowrate will depend upon factors such as how much isocyanate is to be applied to the paper substrate and the speed at which the paper substrate is passing below the nozzle of the sprayer.

A wide variety of paper substrates can be treated according to the process of this invention. The process can be used to strengthen and size paper, corrugated paper containers, paper labels and paperboard. The process is especially useful in strengthening and sizing corrugated paper containers, such as containers that are likely to come into contact with moisture.

The paper substrate, when being sprayed, needs to be in contact with a conducting surface in order to prevent the paper substrate from building up a charge due to the deposition of charged isocyanate particles on the surface of the paper substrate. If a charge builds up on the surface of the paper substrate, the charge will repel charged isocyanate particles thereby leading to reduced transfer efficiencies and a non-uniform coating of isocyanate on the paper substrate. In practice the paper substrate is usually in contact with a metal roller over which the paper substrate passes. However, when individual paper articles are being treated, they can be passed under the nozzle while in contact with a flat metal plate or sheet, such as a sheet of aluminum foil.

Preferably, the nozzle is wider than the width of the paper substrate being sprayed so as to insure that the entire surface of the substrate is coated with isocyanate. The distance of the nozzle from the surface of the paper substrate should be in the range of 7 to 23 cm. If the nozzle is too close, there can be sparking between the nozzle and the conducting surface in contact with the paper substrate. Also, a striped spray pattern may be produced on the substrate. On the other hand, if the distance is greater than 23 cm, the charged isocyanate particles tend to spread out and wander thereby lowering the transfer efficiency and making it difficult to have a uniform coating on the paper substrate.

It is important to insure that objects surrounding the nozzle of the spraying device not be too close to the nozzle. The reason is that surrounding objects that are too close to the nozzle will compete with the paper substrate for the charged isocyanate particles and thereby reduce transfer efficiencies. As a result, surrounding objects should generally be kept away from the nozzle at a distance at least four times the distance between the nozzle and the paper substrate.

The paper substrate can be treated on one side or both sides. If treated on both sides, it is preferred for the isocyanate coating of the first treated side to be cured before treating the second side.

Since the isocyanates can be applied to paper substrates without being emulsified, it is not necessary to expose the substrate to a heat treatment step in order to drive off water that is used to emulsify isocyanates. Nevertheless, it is preferred to include a heat treatment step in the process of this invention

because heating the paper substrate after the isocyanate is applied promotes curing and can have a beneficial effect upon some of the physical properties of the coated paper substrate, such as crush strength. When a heat step is included, the paper substrate is usually exposed to a temperature in the range of 65 to 205 °C for about 1 to 30 seconds. The heat treatment of the paper substrate usually takes place in an oven through which the substrate is passed.

Although it is preferred to apply neat isocyanate to the paper substrates, additives which are compatible with the isocyanate and do not contain water can be mixed with the isocyanate prior to applying the isocyanate to the paper substrate. For example, propylene carbonate can be added to the isocyanate to modify the viscosity of the isocyanate. However, too much propylene carbonate should not be added because the propylene carbonate tends to lower the resistivity of the isocyanate.

By using the process of this invention to treat paper substrates with isocyanates, the physical properties of the substrates can be improved. For example, the water resistance, the wet strength, and the crush strength of the substrates can be increased by using the process of this invention. The process also results in a uniform distribution of isocyanate on the paper substrates. Since charged particles are employed in the process and the particles seek to ground themselves instead of floating around in the atmosphere, the process results in greatly reduced levels of isocyanate in the atmosphere compared to conventional methods of applying isocyanates to paper substrates. Conventional spray techniques release so much isocyanate into the atmosphere that the process must be enclosed with high air extraction.

The invention is illustrated, but not limited, by the following examples.

Examples

1. The electrostatic spraying device used was a device according to United States Patent No. 4854506 having a linear orifice and the following characteristics:

- the device was equipped with a linear nozzle spraying blade having a width of about 50 cm (20 inches)
- the device was equipped with two field adjusting electrodes, which were two semi-conducting rods and which were placed parallel to the linear nozzle orifice at both sides.

Rubinate XI-241, which is polymeric MDI, is available from ICI Americas Inc or Rubicon Inc, has a viscosity of 200 mPa.s, has a volume resistivity of 1×10^8 ohm cms and is liquid at room temperature, was placed into a pressure vessel which was connected to the electrostatic spraying device. The liquid isocyanate was delivered to the device from the pressure vessel using air at about 80 pounds/inch^2 (5.62 kg/cm^2). The air pressure was regulated by means of a pressure regulator so as to give a flow rate of 40 g/min or 0.8 g/minute/cm of nozzle width. The pressure was about 12 pounds/inch^2 (0.84 kg/cm^2). Once the linear nozzle spraying blade was completely wetted with isocyanate and the isocyanate was dripping off the blade, the power to the nozzle and the field adjusting electrodes was turned on so as to give a charge of -38 kV on the nozzle and a charge of -13 kV on the field adjusting electrodes.

A 60 x 60 cm (2 x 2 ft) piece of 40 lb/1000ft^2 (0.195 kg/m^2) linerboard was then manually passed under the nozzle of the electrostatic spraying device. The nozzle was about 12.5 cm (5 inch) above and perpendicular to the paper. The paper was in contact with a steel plate while the paper passed beneath the nozzle to simulate paper going over a roller. After being coated on one side, the paper was allowed to cure for 24 hours at room temperature. It was then passed under the nozzle to coat the other side of the paper. The amount of isocyanate applied to the paper was 3.6% by weight calculated on the paper weight.

The physical properties of the treated paper were tested and are set forth in Table I below. The treated paper had excellent water resistance and wet strength compared to an untreated piece of paper and had improved crush strength as well.

2. Example 1 was repeated except that 10% by weight of propylene carbonate was added to the polyisocyanate. The amount of this composition applied to the paper calculated on the weight of paper was 3.5% by weight. The physical properties of the paper were tested and the results are set forth in Table I below.

3. The electrostatic spraying device of claim 1 was used to treat paper on a conventional paper coating machine. A Carrier Ross roll coater machine was equipped with the electrostatic spraying device of claim 1 so that the paper would be sprayed prior to entering an oven. The nozzle was situated six inches (15.24 cm) directly above a metal roller so that the paper would be in contact with the metal roller at the point where the isocyanate was sprayed onto the paper. A roll of 65lb/3000ft^2 (0.106 kg/m^2) bag paper comprised of 20 percent recycled newspaper was placed on the Carrier Ross machine and fed underneath the nozzle of the spraying device at a rate of 230 feet per minute. (70.1 m per minute)

The isocyanate sprayed onto the paper was Rubinate XI-242, which is a water emulsifiable MDI, is available from ICI Americas Inc. and Rubicon Inc., has a viscosity of 250 mPa.s, and has a volume resistivity of 5 x 10^7 ohm cms. The charge on the isocyanate was -37.1 kV and the charge on the field adjusting electrodes was -18.1 kV. The flowrate of the isocyanate was 40 g/min or 0.8 g/minute/cm of nozzle width. After being sprayed with the isocyanate, the paper was run through a 121 °C oven to dry the isocyanate. The amount of isocyanate applied to the paper was about 1 percent by weight based upon the weight of the paper.

After being treated with the isocyanate, the physical properties of the paper were tested. The paper had improved crush strength and exhibited a dramatic increase in water resistance and wet strength compared to an untreated piece of paper.

TABLE I

Isocyanate	None	MF-184	MF-184 with 10% propylene carbonate
[1]MD Tear (g)	444	416	424
[2]CD Tear (g)	496	452	412
Burst (psig)(kPa)	71.2 (491)	96 (662)	86.3 (595)
Wet Burst (psig)(kPa)	30.7 (212)	36.5 (252)	36 (248)
CD Ring Crush(lb)(kg)	72.6 (32.9)	91 (41.3)	93 (42.2)
CD Ring Crush (90% RH)(lb)(kg)	36.9 (16.7)	52.4 (23.8)	51 (23.1)
MD Tensile Wet (lb/in) (kg/cm)	3.82 (0.68)	21.3 (3.80)	27.5 (4.91)
CD Tensile Wet lb/in) (kg/cm)	2.32 (0.41)	9.79 (1.75)	12.3 (2.20)
Cobb Size (g/m^2)	62.9	4.88	4.25

[1]MD = Machine Direction
[2]CD = Cross Direction

The examples demonstrate that treating paper substrates with isocyanates leads to dramatic improvements in the water resistance and wet strength as well as improvements in the crush strength of the paper substrates.

Claims

1. A process for treating a paper substrate with an isocyanate by spraying, characterized by the step of applying an isocyanate which does not contain water to the paper substrate by means of an electrostatic spraying device having a linear orifice.

2. The process according to claim 1 in which the device for applying said isocyanate comprises means for applying a first electrical potential to liquid isocyanate which emerges from the sprayhead, an electrode comprised of two mutually spaced, parallel arranged linear electrode elements, with one electrode element being mounted adjacent to one side of the sprayhead's orifice and the other element being mounted adjacent to the other side of the sprayhead's orifice, and means for applying a second electrical potential to the electrode such that an intense electrical field is developed between the emerging liquid and the electrode, the intensity of the field being sufficient to cause atomization of the emerging liquid, the electrode comprising a core of conducting or semiconducting material contained in a tubular sheath, the sheath has a wall and the volume resistivity of a section of the wall of said sheath which is 1 cm in length is within the range of 5 x 10^{11} to 5 x 10^{13} ohm cms.

3. The process according to claim 1 or 2 wherein the isocyanate has a viscosity in the range of 1 to 750 mPa.s and a volume resistivity in the range of 1 x 10^6 - 1 x 10^{11} ohm cms.

4. The process according to claim 3 wherein the isocyanate has a viscosity in the range of 1 to 300 and a volume resistivity in the range of 5 x 10^6 to 5 x 10^9.

5. The process according to claim 4 wherein the isocyanate has a volume resistivity in the range of 5 x 10^7 to 5 x 10^8.

6. The process according to claim 1 or 2 wherein the isocyanate is applied to the paper substrate at a flow-rate of 0.5 to 150 g/minute/cm of nozzle width.

7. The process according to claim 6 wherein the flowrate is in the range of 1.5 to 75 g/minute/cm of nozzle width.

8. The process of claim 1 or 2 wherein the isocyanate is an aromatic isocyanate.

9. The process according to claim 8 wherein the isocyanate is a polymeric MDI, an emulsifiable MDI, an MDI variant or mixtures thereof.

10. The process according to claim 9 wherein the isocyanate is an emulsifiable MDI.

11. The process of claim 1 or 2 wherein after the isocyanate is applied to the paper substrate, the paper substrate is heated at a temperature in the range of 65 to 205 °C.

Patentansprüche

1. Verfahren zur Behandlung eines Papiersubstrats mit einem Isocyanat mittels Besprühens, das durch den Schritt der Aufbringung eines Isocyanats, das kein Wasser enthält, auf das Papiersubstrat mittels einer elektrostatischen Sprühvorrichtung mit einer linearen Austrittsöffnung gekennzeichnet ist.

2. Verfahren nach Anspruch 1, in dem die Vorrichtung für das Aufbringen des Isocyanats die nachstehenden Bestandteile umfaßt: eine Einrichtung zum Anlegen eines ersten elektrischen Potentials an das flüssige Isocyanat, das aus der Sprühdüse austritt, eine Elektrode, die aus zwei voneinander beabstandeten, parallel angeordneten, linearen Elektrodenelementen besteht, wobei ein Elektrodenelement so montiert ist, daß es einer Seite der Austrittsöffnung der Sprühdüse benachbart ist, und das andere Element so montiert ist, daß es der anderen Seite der Austrittsöffnung der Sprühdüse benachbart ist, und eine Einrichtung zum Anlegen eines zweiten elektrischen Potentials an die Elektrode, so daß sich ein starkes elektrisches Feld zwischen der austretenden Flüssigkeit und der Elektrode ausbildet, wobei die Stärke des Feldes ausreicht, um eine Versprühung der austretenden Flüssigkeit zu veranlassen, wobei die Elektrode einen Kern aus einem leitenden oder halbleitenden Material umfaßt, der in einer röhrenförmigen Hülle enthalten ist, wobei die Hülle eine Wand aufweist und der spezifische Volumenwiderstand eines Bereichs der Wand der Hülle, der eine Länge von 1 cm aufweist, innerhalb eines Bereichs von 5×10^{11} bis 5×10^{13} ohm•cm liegt.

3. Verfahren nach Anspruch 1 oder Anspruch 2, wobei das Isocyanat eine Viskosität im Bereich von 1 bis 750 mPa•s und einen spezifischen Volumenwiderstand im Bereich von 1×10^{6} - 1×10^{11} ohm•cm aufweist.

4. Verfahren nach Anspruch 3, wobei das Isocyanat eine Viskosität im Bereich von 1 bis 300 und einen spezifischen Volumenwiderstand im Bereich von 5×10^{6} bis 5×10^{9} aufweist.

5. Verfahren nach Anspruch 4, wobei das Isocyanat einen spezifischen Volumenwiderstand im Bereich von 5×10^{7} bis 5×10^{8} aufweist.

6. Verfahren nach Anspruch 1 oder Anspruch 2, wobei das Isocyanat auf das Papiersubstrat mit einer Durchflußmenge von 0,5 bis 150 g/Minute/cm Düsenbreite aufgebracht wird.

7. Verfahren nach Anspruch 6, wobei die Durchflußmenge im Bereich von 1,5 bis 75 g/Minute/cm Düsenbreite liegt.

8. Verfahren nach Anspruch 1 oder Anspruch 2, wobei das Isocyanat ein aromatisches Isocyanat ist.

9. Verfahren nach Anspruch 8, wobei das Isocyanat ein polymeres MDI, ein emulgierbares MDI, eine MDI-Variante oder eine Mischung davon ist.

10. Verfahren nach Anspruch 9, wobei das Isocyanat ein emulgierbares MDI ist.

11. Verfahren nach Anspruch 1 oder 2, wobei das Papiersubstrat auf eine Temperatur im Bereich von 65 bis 205 °C erhitzt wird, nachdem das Isocyanat auf dem Papiersubstrat aufgebracht ist.

Revendications

1. Procédé de traitement d'un substrat en papier avec un isocyanate par pulvérisation, caractérisé par l'étape d'application d'un isocyanate qui ne contient pas d'eau au substrat en papier au moyen d'un dispositif de pulvérisation électrostatique ayant un orifice linéaire.

2. Procédé suivant la revendication 1, dans lequel le dispositif d'application de l'isocyanate comprend un moyen pour appliquer un premier potentiel électrique à l'isocyanate liquide qui sort de la tête de pulvérisation, une électrode constituée de deux éléments d'électrode linéaires disposés en parallèle, mutuellement espacés, un élément d'électrode étant monté en position adjacente à une face de l'orifice de la tête de pulvérisation et l'autre élément étant monté en position adjacente à l'autre face de l'orifice de la tête de pulvérisation, et un moyen pour appliquer un second potentiel électrique à l'électrode de telle sorte qu'un champ électrique intense soit engendré entre le liquide émergeant et l'électrode, l'intensité du champ étant suffisante pour provoquer une atomisation du liquide émergeant, l'électrode comprenant un noyau de matière conductrice ou semiconductrice logé dans une gaine tubulaire, la gaine comprenant une paroi et la résistivité volumique d'une section de la paroi de ladite gaine, ayant une longueur de 1 cm, étant comprise dans l'intervalle de 5×10^{11} à 5×10^{13} ohms.cm.

3. Procédé suivant la revendication 1 ou 2, dans lequel l'isocyanate a une viscosité comprise dans l'intervalle de 1 à 750 mPas et une résistivité volumique comprise dans l'intervalle de 1×10^{6} à 1×10^{11} ohms.cm.

4. Procédé suivant la revendication 3, dans lequel l'isocyanate a une viscosité comprise dans l'intervalle de 1 à 300 et une résistivité volumique comprise dans l'intervalle de 5×10^{6} à 5×10^{9}.

5. Procédé suivant la revendication 4, dans lequel l'isocyanate a une résistivité volumique comprise dans l'intervalle de 5×10^{7} à 5×10^{8}.

6. Procédé suivant la revendication 1 ou 2, dans lequel l'isocyanate est appliqué au substrat en papier à un débit de 0,5 à 150 g/minute/cm de largeur de buse.

7. Procédé suivant la revendication 6, dans lequel le débit est compris dans l'intervalle de 1,5 à 75 g/minute/cm de largeur de buse.

8. Procédé suivant la revendication 1 ou 2, dans lequel l'isocyanate est un isocyanate aromatique.

9. Procédé suivant la revendication 8, dans lequel l'isocyanate est un MDI polymérique, un MDI émulsionnable, une variante de MDI ou un de leurs mélanges.

10. Procédé suivant la revendication 9, dans lequel l'isocyanate est un MDI émulsionnable.

11. Procédé suivant la revendication 1 ou 2, dans lequel, après application de l'isocyanate au substrat en papier, le substrat en papier est chauffé à une température comprise dans l'intervalle de 65 à 205 °C.