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(71) Applicant: **National Security Ventures FZE**
Sharjah (AE)

(72) Inventors:
- **KOHUT, Pavlo Petrovych**
Zhytomir district, 11601 (UA)
- **SIDORENKO, Yuri Grygorovych**
Kyiv, 01033 (UA)

(74) Representative: **von Füner, Nicolai et al**
Von Füner Ebbinghaus Finck Hano
Patentanwälte
Mariahilfplatz 3
81541 München (DE)

(54) DIRT- AND OIL-REPELLENT COATING FOR BANKNOTE PAPER AND METHOD FOR PRODUCING SAME

(57) The present inventions relate to a dirt and grease resistant coating for paper intended primarily for the production of banknotes and to a method for its manufacturing. The dirt and grease resistant coating for banknote paper containing fibrous base according to the invention comprises the following ingredients: binder polymer, reticular agent, filler, grease resistant substance and water with the following ingredients' ratio (in wt.%): binder polymer — 18 to 25 of absolutely dry substance; reticular agent — 1 to 2 of absolutely dry substance; filler — 0.5 to 4 of absolutely dry substance; grease resistant substance — 0.2 to 1.0 of absolutely dry substance; water — necessary quantity to reach 100 in total.

The method for manufacturing a dirt and grease resistant coating for banknote paper includes the preparation of a liquid composition with a polyurethane-containing binder polymer and subsequent forming of banknote paper coating from the liquid composition obtained in such a manner, ***wherein*** according to the invention, the liquid composition is made of the following ingredients (in wt.%): binder polymer — 18 to 25 of absolutely dry substance; reticular agent — 1 to 2 of absolutely dry substance; filler — 0.5 to 4 of absolutely dry substance; grease resistant substance — 0.2 to 1.0 of absolutely dry substance; water — necessary quantity to reach 100 in total; the above mentioned ingredients are mixed at a temperature of 15°C to 40°C with continuous stirring in the reactor until a homogeneous water dispersion is obtained, said dispersion having a total solids content within a range of about 12% to 32% of the dispersion weight (preferably about 20% to 25%) and a neutral acidity value (pH).

The present inventions are aimed to create such a dirt and grease resistant coating for banknote paper and such a method for its manufacturing that would make it possible to obtain a coating with enhanced dirt and grease resistance properties. The problem is solved by creating conditions for the formation, in the proposed coating, of a composition aimed at forming, in the binder polymer — the polyurethane film, a microporous structure possessing sufficient adhesion to printing inks and at the same time demonstrating a grease resistant effect against contaminants — the sweat and grease secretions of human hands and the everyday oil/grease soiling, including those caused by food.

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Description

[0001] The present inventions relate to a dirt and grease resistant coating for paper intended primarily for the production of banknotes and to a method for manufacturing of such coating.

[0002] The circulation time of banknotes of various denominations is an important indicator that is taken into account by countries' central banks when planning the emissions. One of the ways to reduce the costs associated with providing countries with the necessary banknote supply is to increase the banknote circulation time. At the same time, a banknote should not only be in circulation, but also retain its appearance, so that its quality meets a certain standard, i.e. conforms to a set of characteristics such as wear resistance, soiling resistance, color retention, ease of recognition, resistance to counterfeiting, etc. Banknotes pass through many hands and therefore they have to possess sufficient strength, withstand dust, grease and soiling, humid and dry environments and should be resistant to heat, frost and mist. The introduction of security threads and complex high-security printing features, as well as the strict conditions of the modes of the printing itself (the use of various types of paper-deforming embossed patterns) require an assessment of their negative impact on the overall paper strength and impose additional requirements to the surface strength properties of the paper, the fulfillment of which cannot be imagined without the research and usage of new fibrous or synthetic materials as well as without modern paper-sizing technologies.

[0003] It is the soiling, which is the most important factor affecting the wear and tear of banknotes and their withdrawal from circulation. Studies show that such defects as damage to security features are least common. Extraneous inscriptions on banknotes cause withdrawal of up to 10% of banknotes from circulation, but as the area occupied by security elements on a banknote increases, their effect on durability tends to increase. The next category of reasons for banknotes' withdrawal from circulation is represented by mechanical damages (10% to 25%). However, the main reason why banks withdraw banknotes from circulation is their soiling. In the process of cash circulation, banknotes are exposed to contaminants. Meanwhile, the degree of soiling is determined by the adhesive properties of the paper base bearing a printed image applied thereon. Imparting certain antiadhesive properties to the paper base reduces the tendency of a banknote material to become soiled and extends its circulation time.

[0004] Contaminants include dry dust and pigment dirt, soot, clay, mineral pigments, water suspensions of various mineral and/or organic substances, sweat-and-grease and oil contaminants. These are the liquid types of contaminants, which deeply permeate the structure of paper and become firmly fixed within the fibers mass, while changing their natural color. Therefore, liquid types of contaminants have the maximum negative effect on the condition and lifespan of banknotes. Particularly dangerous are fat-containing substances, possessing high penetrating and adhesion power and containing bound moisture. Combined with the nutrients of the paper structure (pulp), this moisture becomes a favorable environment for the growth of pathogenic bacteria, which may potentially get from a banknote into a human body. That is, banknotes can be biologically unsafe for humans.

[0005] In terms of the achieved result, the closest analogue of the coating according to the present invention is a dirt and grease resistant coating for banknote paper that contains a fibrous base and a filler [EP1783273 (A1), IPC (2006.01) D21H21/40; D21H19/82; Publication date: 09.05.2007, Patentblatt: 2007/19]. The above disclosure pertains to a coating for banknote paper, such coating comprising a fluorinated resin.

[0006] The described dirt and grease resistant coating for banknote paper does not sufficiently resist the negative factors affecting banknotes, since the use of compositions with compounds selected from the group of fluorine-containing cationic substances facilitates adhesion of anionic contaminants, thus significantly reducing the effectiveness of the dirt and grease resistant coating.

[0007] At the same time, unbalanced share of fluorinated resins in the coating, such resins possessing certain hydrophobic and oleophobic properties, negatively affects the ink trapping by the special coating and the fixation of printing inks in this structure at the stage of applying a banknote image by printing.

[0008] In terms of the achieved result, the closest prior art of the method according to the present invention is a method for manufacture of dirt and grease resistant coating for banknote paper with a fibrous base, said method including the preparation of a liquid composition with a polyurethane-containing binder polymer and subsequent forming of banknote paper coating from the liquid composition obtained in such a manner [EP1783273 (A1), IPC (2006.01) D21H21/40; D21H19/82; Publication date: 09.05.2007, Patentblatt: 2007/19]. The above mentioned document claims a method for manufacture of a coating containing fluorinated resin for banknote paper with a fibrous base.

[0009] The coating produced in accordance with the above method does not sufficiently resist contaminants and negative factors affecting banknotes, since the use of a composition with compounds selected from the group of fluorine-containing cationic substances facilitates adhesion of anionic contaminants, thus significantly reducing the effectiveness of the dirt and grease resistant coating. In addition, unbalanced share of fluorinated resins in the coating material, such resins possessing certain hydrophobic and oleophobic properties, negatively affects the ink trapping by the special coating and the fixation of printing inks in this structure at the stage of applying a banknote image by printing.

[0010] The proposed inventions are aimed to create such a dirt and grease resistant coating for banknote paper with a fibrous base and such a method for its manufacturing that would make it possible to obtain a coating with enhanced

dirt and grease resistance properties. The problem is solved by creating conditions for the formation, in the proposed coating, of a composition capable of forming, in the binder polymer — the polyurethane film, a microporous structure possessing sufficient adhesion to printing inks and at the same time demonstrating a grease resistant effect against contaminants — the sweat and grease secretions of human hands and the everyday oil/grease soiling, including those caused by food.

[0011] Similarly to the coating of the prior art, the dirt and grease resistant coating for banknote paper containing fibrous base according to the invention comprises the following ingredients: binder polymer, reticular agent, filler, grease resistant substance and water with the following ingredients' ratio (in wt.%):

binder polymer — 18 to 25 of absolutely dry substance;
reticular agent — 1 to 2 of absolutely dry substance;
filler — 0.5 to 4 of absolutely dry substance;
grease resistant substance — 0.2 to 1.0 of absolutely dry substance;
water — necessary quantity to reach 100 in total.

[0012] A feature of the coating of the present invention is that the coating uses aliphatic or aliphatic-aromatic polyurethane as the binder polymer.

[0013] Another feature of the coating of the present invention is that the coating uses polyaziridine as the reticular agent.

[0014] Yet another feature of the coating of the present invention is that the coating uses an organic filler as the filler — formaldehyde and urea condensate with reactive methylol groups.

[0015] Yet another feature of the coating of the present invention is that a non-ionic fluoropolymer may be used as the grease resistant substance in the coating.

[0016] Similarly to the method of the prior art, the method for manufacturing a dirt and grease resistant coating for banknote paper with a fibrous base according to the invention includes the preparation of a liquid composition with a polyurethane-containing binder polymer and subsequent forming of banknote paper coating from the liquid composition obtained in such a manner, ***wherein*** according to the invention, the liquid composition is made of the following ingredients (in wt.%):

binder polymer — 18 to 25 of absolutely dry substance;
reticular agent — 1 to 2 of absolutely dry substance;
filler — 0.5 to 4 of absolutely dry substance;
grease resistant substance — 0.2 to 1.0 of absolutely dry substance;
water — necessary quantity to reach 100 in total,

the above mentioned ingredients are mixed at a temperature of 15°C to 40°C with continuous stirring in the reactor until a homogeneous water dispersion is obtained, said dispersion having a total solids content within a range of about 12% to 32% of the dispersion weight (preferably about 20% to 25%) and a neutral acidity value (pH).

[0017] The inventors have experimentally determined the optimal ratio of the ingredients that form a dirt and grease resistant coating for banknote paper.

[0018] Specifically, binder polymer accounts for 18 to 25 wt.% of absolutely dry substance. If the amount of the binder polymer decreases below 18 wt.%, the overall decrease in paper soiling resistance properties is observed. The binder polymer amounts over 25 wt.% significantly increase the prime cost of a banknote. Therefore, the optimal quantity of the binder polymer is 18 to 25 wt.% of absolutely dry substance.

[0019] The reticular agent quantity should not exceed 2 wt.% of absolutely dry substance, and the amount of the filler should not exceed 4 wt.% of absolutely dry substance, since experiments suggest that such higher amounts reduce the dirt and grease resistant effect of the coating against the contaminants, eg. the sweat and grease secretions of human hands and the everyday oil/grease soiling.

[0020] As a binder polymer, aliphatic or aliphatic-aromatic polyurethane can be used in the coating, which makes it possible to obtain a protective film that is both dry and waterproof, demonstrates a barrier effect against soiling, is sufficiently resistant to harmful mechanical and chemical effects, retains a certain elasticity and, therefore, maintains resistance to paper folding and creasing.

[0021] The inventors have experimentally identified the optimal filler composition for the coating. It turned out to be an organic filler, namely formaldehyde and urea condensate with reactive methylol groups. The strict control of this filler content allows to create a microporous structure in the polyurethane coating, such structure being especially favorable for the ink trapping by the surface and the fixation of the ink on this surface.

[0022] The use of polyaziridine as a reticular agent in the coating comprehensively increases the resistance to external influencing factors.

[0023] A non-ionic fluoropolymer may be used as a grease resistant substance in the coating, said polymer imparting

increased anti-soiling and strength properties to the coating, in addition to sufficient grease resistance properties. Meanwhile, the quantity of fluoropolymer in the coating is safe for human health.

[0024] At the time of patent information research performed in the process of the present application the inventors have not revealed any dirt and grease resistant coatings for banknote paper with a fibrous base and methods for making such coatings possessing the above mentioned combination of essential features, which proves that the claimed technical solutions comply with the "novelty" patentability criterion.

[0025] The technical result obtained from the implementation of the present invention is the creation of conditions for the formation, in the proposed coating, of a composition aimed at forming, in the binder polymer — the polyurethane film, a microporous structure possessing sufficient adhesion to printing inks and at the same time demonstrating a grease resistant effect against contaminants — the sweat and grease secretions of human hands and the everyday oil/grease soiling, including those caused by food.

[0026] The inventors have not revealed the indicated technical result in the known technical solutions of the prior art, therefore the proposed dirt and grease resistant coating for banknote paper with a fibrous base and the method of manufacture thereof may be deemed to comply with the "inventive step" patentability criterion.

[0027] The proposed dirt and grease resistant coating for banknote paper with a fibrous base contains substances, which may be manufactured using presently known technological methods, means and materials. It can be used for the manufacture of banknotes and security blanks, which may be used in various sectors of economy, therefore it is possible to conclude that the proposed solutions comply with the "industrial applicability" patentability criterion.

[0028] Example. The proposed dirt and grease resistant coating for banknote paper was obtained as follows.

[0029] At a preliminary step, sheets of base paper were made on a cylinder machine by wet processing, from water suspension containing only cotton fibers and a filler (titanium dioxide) in an amount of 3 wt.% of dry matter calculated based on total weight of fibers, and a substance increasing moisture resistance — polyamide amine epichlorohydrin resin — in an amount of 2.5 wt.% of dry matter calculated based on the total weight of fibers, and sodium carboxymethylcellulose in an amount of 0.7 wt.% of dry matter calculated based on the total weight of fibers.

[0030] A layer of polyvinyl alcohol was applied to each base sheet in an amount of 4.7 wt.% of dry matter calculated based on the total weight of fibers. Each obtained base sheet had a weight of 95.4 g/m^2 and a thickness of 116 μm.

[0031] To determine the optimum ratio of the ingredients, a layer of dirt and grease resistant coating was applied to each base sheet obtained, the former containing a binder polymer, a reticular agent, a filler, a grease resistant substance, and water with a ratio of ingredients specified for each sheet. For this purpose, a water dispersion containing the above ingredients was prepared and used to impregnate base sheets having the same ingredients as in the case of the coating manufacture of the closest prior art. Aliphatic or aliphatic-aromatic polyurethane was used as the binder polymer in the coating. Polyaziridine was used as a reticular agent. An organic filler — formaldehyde and urea condensate with reactive methylol groups — was used as a filler. A non-ionic fluoropolymer may be used as the grease resistant substance in the coating. Each base sheet was immersed, on a two-shaft size press, into liquid dispersion of the coating, with which the base was impregnated; then, the excess of the dispersion was pressed out between the press shafts, and the coated paper sheet thus obtained was dried. After that, the yield of the absolutely dry substance of the coating amounted to 8.4% to 9.7% of the total weight of fibers. The resulting coated paper sheet had a weight of 96.2 g/m^2 and a thickness of 110 to 114 μm. The overall thickness of the proposed coating per side amounted to 2.5 to 3.8 μm. Each manufactured sheet of coated paper (sample) was tested for circulation endurance, in particular for resistance to dust soiling in a dry environment, for rubbing in a humid environment, and for the grease resistance in the presence of oil and grease soiling agents, and a cumulative assessment of the coating was obtained. When making a cumulative assessment of the proposed coating, the inventors used the known resistance and durability tests for banknotes, as well as the test for resistance to washing off. The research data are presented in the table:

Table

Sample No.	Binder polymer amount, in wt.% of absolutely dry substance	Reticular agent amount, in wt.% of absolutely dry substance	Filler amount, in wt.% of absolutely dry substance	Grease resistant substance amount, in wt.% of absolutely dry substance	Circulation endurance test results: "1" - excellent; "2" - satisfactory; "3" - unsat- isfactory
1	16	1.5	2.0	0.5	3
2	18	1.5	2.0	0.5	2
3	25	1.5	2.0	0.5	1
4	27	1.5	2.0	0.5	1
5	25	0.3	2.0	0.5	2

(continued)

Sample No.	Binder polymer amount, in wt.% of absolutely dry substance	Reticular agent amount, in wt.% of absolutely dry substance	Filler amount, in wt.% of absolutely dry substance	Grease resistant substance amount, in wt.% of absolutely dry substance	Circulation endurance test results: "1" - excellent; "2" - satisfactory; "3" - unsat- isfactory
6	25	1.0	2.0	0.5	1
7	25	1.5	2.0	0.5	1
8	25	2.0	2.0	0.5	1
9	25	3.0	2.0	0.5	1
10	25	1.5	0.5	0.5	1
11	25	1.5	1.0	0.5	1
12	25	1.5	3.0	0.5	1
13	25	1.5	4.0	0.5	2
14	25	1.5	5.0	0.5	2
15	25	1.5	2.0	0.1	2
16	25	1.5	2.0	0.2	2
17	25	1.5	2.0	0.8	1
18	25	1.5	2.0	1.0	1
19	25	1.5	2.0	1.5	1

[0032] In addition to the samples listed in the table, a paper base was made, where a part of the cotton fibers was replaced with flax fibers so that the share of cotton fibers amounted to 85 wt.% of dry matter, and the share of flax fibers respectively amounted to 15 wt.% of dry matter calculated based on the total weight of fibers. After forming, a surface coating layer was applied to the obtained paper sheet as described above.

[0033] The yield of the absolutely dry substance of the coating amounted to 9.1% to 9.4% of the total weight of fibers. The resulting sheet of paper had a weight of 94.8 to 95.2 g/m^2, and a thickness of 112 to 113 μm, and its qualitative characteristics were close to the respective properties of the paper with a cotton-fiber base, but paper with flax fibers had a greater rupture strength, tear resistance, and breaking resistance under double folds.

[0034] As a result of the research, the following optimum ratio of coating ingredients (wt.%) was determined:

binder polymer — 18 to 25 of absolutely dry substance;
reticular agent — 1 to 2 of absolutely dry substance;
filler — 0.5 to 4 of absolutely dry substance;
grease resistant substance — 0.2 to 1.0 of absolutely dry substance;
water — necessary quantity to reach 100 in total.

[0035] The present inventions allow to obtain a coating that increases the lifespan of a banknote with a coating compared to that of a banknote with a coating obtained by the closest prior art method by about 25-30% under conditions close to those of the real world.

Claims

1. A dirt and grease resistant coating for banknote paper containing fibrous base, ***characterized in that*** the coating comprises the following ingredients: binder polymer, reticular agent, filler, grease resistant substance and water with the following rate of the ingredients (in wt.%):

   binder polymer — 18 to 25 of absolutely dry substance;
   reticular agent — 1 to 2 of absolutely dry substance;

filler — 0.5 to 4 of absolutely dry substance;
grease resistant substance — 0.2 to 1.0 of absolutely dry substance;
water — necessary quantity to reach 100 in total.

2. The dirt and grease resistant coating for banknote paper according to claim 1, ***characterized in that*** the binder polymer used in the coating is aliphatic or aliphatic-aromatic polyurethane.

3. The dirt and grease resistant coating for banknote paper according to claim 1, ***characterized in that*** *the* reticular agent used in the coating is polyaziridine.

4. The dirt and grease resistant coating for banknote paper according to claim 1, ***characterized in that*** the filler used in the coating is an organic filler, namely formaldehyde and urea condensate with reactive methylol groups.

5. The dirt and grease resistant coating for banknote paper according to claim 1, ***characterized in that*** the grease resistant substance used in the coating is non-ionic fluoropolymer.

6. A method for manufacturing a dirt and grease resistant coating for banknote paper with a fibrous base, which includes the preparation of a liquid composition with a polyurethane-containing binder polymer and subsequent forming of a banknote paper coating from the liquid composition obtained in such a manner, ***characterized in that*** the liquid composition is made of the following ingredients (in wt.%):

binder polymer — 18 to 25 of absolutely dry substance;
reticular agent — 1 to 2 of absolutely dry substance;
filler — 0.5 to 4 of absolutely dry substance;
grease resistant substance — 0.2 to 1.0 of absolutely dry substance;
water — necessary quantity to reach 100 in total,

the above mentioned ingredients are mixed at a temperature of 15°C to 40°C with continuous stirring in the reactor until a homogeneous water dispersion is obtained, said dispersion having a total solids content within a range of about 12% to 32% of the dispersion weight (preferably about 20% to 25%) and a neutral acidity value (pH).

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER
D21H 19/10 (2006.01); D21H 19/12 (2006.01); D21H 21/14 (2006.01); B41M 3/14 (2006.01)

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)
D21H 19/00, 19/10-19/16, 19/20, 19/24-19/30, 19/44, 19/56-19/62, 21/00, 21/02, 21/14, 21/16-21/20. 21/40-21/48. B41M 3/00. 14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Espacenet, PatSearch, RUPTO, USPTO, DWPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	RU 2138593 C1 (PORTALS LIMITED), 27.09.1999, p. 4 col. 1 line 38 -col. 2 line 3, p. 5 col. 1 lines 33-40, examples	1-3, 5, 6
A		4
Y	EP 1783273 A1 (GIESECKE & DEVRIENT GMBH), 09.05.2007, [0015]-[0017], [0019], [0039]-[0042]	1-3, 5, 6
A	CN 103061205 A (MCC MEILI PAPER INDUSTRY CO), 24.04.2013	1-6
A	WO 2009/150117 A1 (CARTIERE FEDRIGONI & C. S.P.A.), 17.12.2009	1-6

☐ 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
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"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
18 June 2019 (18.06.2019)	20 June 2019 (20.06.2019)
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1783273 A1 **[0005] [0008]**