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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **RECLABLE PAPER OF HIGH WET STRENGTH**

(57) There is provided a paper comprising polyamino amide epichlorohydrin (PAE) resin and glyoxylated polyacrylamide (G-PAM), wherein the amount of PAE resin is 0.15-1.75 kg/tonne dry paper.

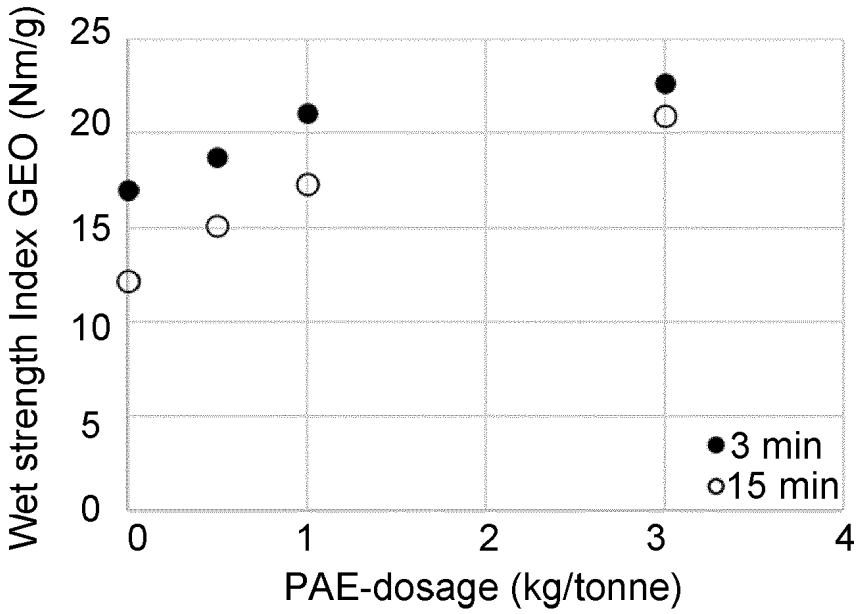

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the field of paper and in particular recyclable paper having relatively high wet strength.

BACKGROUND

[0002] Paper for some applications must retain some strength also if wetted. Hence, various "wet-strength agents" have been developed for papermaking. A common drawback of the use of such wet-strength agents is that it is difficult to repulp and hence recycle the paper.

SUMMARY

[0003] An objective of the present disclosure is to provide a paper of relatively high wet strength that is recyclable.

[0004] Accordingly, the present disclosure provides a paper (preferably a kraft paper) comprising polyamino amide epichlorohydrin (PAE) resin and glyoxylated polyacrylamide (G-PAM), wherein the amount of PAE resin is 0.15-1.75 kg/tonne dry paper.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005]

Figure 1 shows the geometrical wet tensile strength index (Nm/g) measured after 3 or 15 minutes of wetting time for paper sheets comprising different amounts (kg/tonne) of PAE resin.

Figure 2 shows the recyclability (%) according to PTS Method PTS-RH 021/97 for paper sheets comprising different amounts (kg/tonne) of PAE resin.

[0006] Further details of the paper sheets are given in the Examples section below.

DETAILED DESCRIPTION

[0007] As a first aspect of the present disclosure, there is provided a paper comprising polyamino amide epichlorohydrin (PAE) resin and glyoxylated polyacrylamide (G-PAM). The amount of PAE resin is 0.15-1.75 kg/tonne dry paper.

[0008] The amount of G-PAM is preferably 0.5-6.0 kg/tonne dry paper and more preferably 1.0-5.0 kg/tonne dry paper, such as 1.5-4.0 kg/tonne dry paper.

[0009] The amount of PAE resin is preferably 0.25-1.50 kg/tonne dry paper, more preferably 0.30-1.25 kg/tonne dry paper, such as 0.30-1.10 kg/tonne dry paper or 0.40-1.25 kg/tonne dry paper.

[0010] The paper of any one of the preceding claims, wherein said G-PAM is cationic G-PAM.

[0011] In the papermaking, the PAE resin and the G-PAM is typically added in the wet end. The PAE resin and the G-PAM are thus wet end chemicals.

[0012] The paper is preferably a kraft paper, such as a machine glazed (MG) kraft paper.

[0013] The paper may be bleached or unbleached. Bleached paper is typically easier to repulp and may therefore be preferred.

[0014] The grammage of the paper is typically 35-200 g/m^2 and preferably 50-140 g/m^2. In one embodiment, the grammage is 50-110 g/m^2. In another embodiment, the grammage is 60-120 g/m^2. In yet another embodiment, the grammage is 35-55 g/m^2. In the present disclosure, grammage is measured according to ISO 536:2019.

[0015] The teachings of the present disclosure are not intended for tissue paper, such as bath, towel, facial or napkin paper. Accordingly, the paper of the present disclosure typically has a density of at least 600 kg/m^3, such as 600-1000 kg/m^3. In the present disclosure, density is measured according to ISO 534:2011.

[0016] To improve the performance in wet conditions, the water absorbency of the paper is preferably relatively low. Hence the Cobb 60 s value of at least one side of the paper is preferably below 40 g/m^2, more preferably below 30 g/m^2, such as below 25 g/m^2. In one embodiment, both sides of the paper have a Cobb 60 s value below 40 g/m^2, such as below 30 g/m^2, such as below 25 g/m^2. In the present disclosure, Cobb 60 s is measured according to ISO 535:2014.

[0017] To obtain a relatively low Cobb 60 s value, hydrophobic size may be added, typically in the wet end of the paper machine. Examples of hydrophobic size are AKD, ASA and rosin size.

[0018] Typically, not only the wet tensile strength, but also the dry tensile strength is of interest in the application in which the paper is used. In one embodiment, the (dry) geometrical tensile index measured according to ISO 1924-3:2005 is at least 50 Nm/g, such as 50-150 Nm/g.

[0019] The geometrical wet tensile index measured according to ISO 1924-3:2005 (using a wetting time of 10 min) of the paper is typically at least 10 Nm/g, such as at least 15 Nm/g, such as at least 16 Nm/g.

[0020] The paper is preferably formed from a softwood pulp or a mixture of a softwood pulp and a hardwood pulp. Softwood pulp typically provides better strength and hardwood typically provides better surface properties.

[0021] In one embodiment, at least 75% by dry weight of the fibres of the paper are virgin fibres and preferably at least 90% by dry weight of the fibres of the paper are virgin fibres. Virgin fibres provide better strength than recycled fibres.

[0022] Starch is often added as a strength agent in papermaking. However, the above-mentioned addition of G-PAM allows for a relatively low amount of starch. In one embodiment, the paper of the present disclosure comprises less than 3.5 kg/tonne dry paper of starch, such as 1-3 kg/tonne dry paper of starch.

[0023] The starch is preferably cationic starch.

[0024] Strength may be impaired by the addition of inorganic filler to the paper pulp. A high amount of filler corresponds to a high ash content. The paper of the present disclosure preferably has an ash content of less than 7.0% by dry weight, such as less than 5.5% by dry weight.

[0025] As a second aspect of the present disclosure there is provided a package comprising a paper according to the first aspect of the present disclosure. In one embodiment, the package is a Quick Service Restaurant food package. In this embodiment, the package is typically a bag or a wrap. In another embodiment, the package is a medical device package, in particular a medical device package that will undergo or has undergone gas or steam sterilization. Further, the package may be a sack, such as a potato sack or a sack for a hydraulic binder (e.g. a cement sack), a garbage bag, a pouch for foods (e.g. fruits or vegetables) or an e-commerce bag.

[0026] In the Quick Service Restaurant food package, the grammage of the paper is typically in the range of 35-55 g/m^2.

[0027] As a third aspect of the present disclosure, there is provided a coated barrier paper comprising a paper substrate, which is a paper according to the first aspect, and a barrier coating provided on the paper substrate.

EXAMPLES

[0028] Lab sheets were produced in a dynamic sheet former. The target grammage was 80 g/m^2. The lab procedure started with the preparation of a fiber suspension, which was a mixture bleached softwood kraft pulp and bleached hardwood kraft pulp in a dry weight ratio of 70:30. Both pulps were taken from the production of MG paper in Billerud-Korsnäs' mill in Skärblacka. The pulps were diluted with tap water to obtain a fibre consistency of 12.5 g/l and the pH was adjusted 8.0. Furnishes for sheet forming were then prepared according to Table 1.

Table 1. "PAE" was Kymene GHP20 from Solenis, which is a polyamino amide epichlorohydrin resin. "AKD" was FennoSize 364M from Kemira. "G-PAM" was Fennobond 3150E from Kemira, which is a cationic glyoxylated polyacrylamide. "Silica" was FennoSil 442 from Kemira. "Starch" was Solbond PC$_{35}$ from Solenis which is a cationic starch with degree of substitution 35%.

Step	Additive	Fibre consist. (g/l)	Dosage (g/kg dry fibre)	Stirring time (s)
1	Fibre	12.5		
2	PAE	12.5	Acc. to Table 2	30
3	AKD	12.5		30
4	G-PAM	12.5	Acc. to Table 2	15
5	Tap water	5		15
5	Alum	5	4	Added with the tap water
5	Sulphuric acid	5	To obtain pH 6	Added with the tap water
6	Starch	5	Acc. to Table 2	20
7	Silica	5	0.25	10

Table 2.

	PAE (kg/tonne)	G-PAM (kg/tonne)	Starch (kg/ton)
Series 1	3	0	4
Series 2	1	2.8	2
Series 3	0.5	2.8	2
Series 4	0	2.8	2

[0029] Ten sheets per series were made. Pressing was carried out by two passes through a nip press (5 bar). Drying was carried out in a "STFI dryer" at 130 °C for 10 minutes.

[0030] To simulate the curing that paper typically undergoes in the paper machine and after the paper machine, but before the paper is used by the customer, the sheets were cured at 105 °C for 2 * 30 minutes.

[0031] After curing, sheets were tested for the following properties: dry tensile strength (ten stripes per series in MD and seven stripes per series in CD except for series 2 for which only two stripes could be tested due to restricted amount of paper); COBB 60 s; air resistance (Gurley); and wet tensile strength measured after wetting times of 1, 3, 5, and 15 minutes (ten stripes per series in MD and seven stripes per series in CD except for series 2 for which only two stripes could be tested due to restricted amount of paper).

[0032] Tensile index values were calculated by dividing the tensile strength values by the grammage. Geometrical tensile index values were calculated as the geometrical mean of the tensile index in MD and the tensile index in CD.

[0033] Further, sheets were sent to Karlstad University for recyclability testing in accordance with PTS Method PTS-RH 021/97.

[0034] Results of the tests are presented in the tables 3 and 4 below.

Table 3. "WS_3" means average geometrical wet tensile strength index measured after 3 minutes of wetting time. "WS_5" means average geometrical wet tensile strength index measured after 5 minutes of wetting time. "WS_{15}" means average geometrical wet tensile strength index measured after 15 minutes of wetting time.

Series	PAE (kg/ tonne)	G-PAM (kg/ tonne)	Recyclability* (%)	WS_3 (Nm/g)	WS5 (Nm/g)	WS_{15} (Nm/g)
1	3.0	0	46,5	22.7	21.6	21.0
2	0	2.8	99.7	17.0	14.9	12.2
3	0.5	2.8	98.0	18.8	17.1	15.1
4	1.0	2.8	93.7	21.1	18.3	17.3
* Recyclability (%) means the percentage suitable for recycling or usable in papermaking. It corresponds to the total mass of the sample (50g oven-dry $\hat{=}$ 100%) less the total reject.						

[0035] The results of Table 3 are also presented in figures 1 and 2. Notably, figure 1 shows a sharp increase in the wet strength when 0.5 kg/tonne and 1.0 kg/tonne PAE is added, but a more modest increase when the amount is higher. Conversely, figure 2 shows a relatively modest decrease of the recyclability when 0.5 kg/tonne and 1.0 kg/tonne PAE is added, and a sharper decrease beyond those amounts. Consequently, figures 1 and 2 together show that the optimal amount of PAE is from about 0.25 kg/tonne to about 1.5 kg/tonne when high wet strength is to be combined with high recyclability, provided that G-PAM has been added.

[0036] Further properties of the sheets are presented in table 4 below.

[0037] Table 4. Average values for Cobb, Gurley and dry strength. The tests behind the results in this table were carried out between the first and the second curing, i.e. after curing at 105 °C for 1 * 30 minutes.

Series	PAE (kg/ tonne)	G-PAM (kg/ tonne)	Cobb 60s (g/m^2)	Gurley (s)	Geometrical dry tensile strength index (Nm/g)
1	3.0	0	21.4	18.5	99.3
2	0	2.8	19.3	24.2	107.2
3	0.5	2.8	18.9	22.6	105.9
4	1.0	2.8	18.9	15.4	110.0

Claims

1. A paper comprising polyamino amide epichlorohydrin (PAE) resin and glyoxylated polyacrylamide (G-PAM), wherein the amount of PAE resin is 0.15-1.75 kg/tonne dry paper.

2. The paper of claim 1, wherein the amount of G-PAM is 0.5-6.0 kg/tonne dry paper, preferably 1.0-5.0 kg/tonne dry paper, such as 1.5-4.0 kg/tonne dry paper.

3. The paper of claim 1 or 2, wherein the amount of PAE resin is 0.25-1.50 kg/tonne dry paper, preferably 0.30-1.25 kg/tonne dry paper, such as 0.30-1.10 kg/tonne dry paper or 0.40-1.25 kg/tonne dry paper.

4. The paper of any one of the preceding claims, wherein said G-PAM is cationic G-PAM.

5. The paper of any one of the preceding claims, which is a kraft paper, such as a machine glazed (MG) kraft paper.

6. The paper of any one of the preceding claims, which is bleached.

7. The paper of any one of the preceding claims, wherein the grammage measured according to ISO 536:2019 is 35-200 g/m^2, such as 50-200 g/m^2, preferably 50-140 g/m^2, such as 50-110 g/m^2 or 60-120 g/m^2.

8. The paper of any one of the preceding claims, wherein the density measured according to ISO 534:2011 is at least 600 kg/m^3, such as 600-1000 kg/m^3.

9. The paper of any one of the preceding claims, wherein the Cobb 60 s value measured according to ISO 535:2014 of at least one side of the paper is below 40 g/m^2, preferably below 30 g/m^2, such as below 25 g/m^2.

10. The paper of any one of the preceding claims, wherein the geometrical tensile index measured according to ISO 1924-3:2005 is at least 50 Nm/g, such as 50-150 Nm/g.

11. The paper of any one of the preceding claims, wherein the geometrical wet tensile index measured according to ISO 1924-3:2005 is at least 10 Nm/g, such as at least 15 Nm/g, such as at least 16 Nm/g.

12. The paper of any one of the preceding claims, which is formed from a softwood pulp or a mixture of a softwood pulp and a hardwood pulp.

13. The paper of any one of the preceding claims, wherein at least 75% by dry weight of the fibres of the paper are virgin fibres and optionally wherein at least 90% by dry weight of the fibres of the paper are virgin fibres.

14. The paper of any one of the preceding claims, wherein the paper comprises less than 3.5 kg/tonne dry paper of starch, such as 1-3 kg/tonne dry paper of starch.

15. A package comprising a paper according to any one of the preceding claims.

Amended claims in accordance with Rule 137(2) EPC.

1. A paper comprising polyamino amide epichlorohydrin (PAE) resin, glyoxylated polyacrylamide (G-PAM) and starch, wherein:

    - the amount of PAE resin is 0.15-1.75 kg/tonne dry paper;
    - the amount of starch is less than 3.5 kg/tonne dry paper, such as 1-3 kg/tonne dry paper; and
    - the dry geometrical tensile index measured according to ISO 1924-3:2005 is at least 50 Nm/g, such as 50-150 Nm/g.

2. The paper of claim 1, wherein the amount of G-PAM is 0.5-6.0 kg/tonne dry paper, preferably 1.0-5.0 kg/tonne dry paper, such as 1.5-4.0 kg/tonne dry paper.

3. The paper of claim 1 or 2, wherein the amount of PAE resin is 0.25-1.50 kg/tonne dry paper, preferably 0.30-1.25

kg/tonne dry paper, such as 0.30-1.10 kg/tonne dry paper or 0.40-1.25 kg/tonne dry paper.

4. The paper of any one of the preceding claims, wherein said G-PAM is cationic G-PAM.

5. The paper of any one of the preceding claims, which is a kraft paper, such as a machine glazed (MG) kraft paper.

6. The paper of any one of the preceding claims, which is bleached.

7. The paper of any one of the preceding claims, wherein the grammage measured according to ISO 536:2019 is 35-200 g/m^2, such as 50-200 g/m^2, preferably 50-140 g/m^2, such as 50-110 g/m^2 or 60-120 g/m^2.

8. The paper of any one of the preceding claims, wherein the density measured according to ISO 534:2011 is at least 600 kg/m3, such as 600-1000 kg/m3.

9. The paper of any one of the preceding claims, wherein the Cobb 60 s value measured according to ISO 535:2014 of at least one side of the paper is below 40 g/m^2, preferably below 30 g/m^2, such as below 25 g/m^2.

10. The paper of any one of the preceding claims, wherein the geometrical wet tensile index measured according to ISO 1924-3:2005 is at least 10 Nm/g, such as at least 15 Nm/g, such as at least 16 Nm/g.

11. The paper of any one of the preceding claims, which is formed from a softwood pulp or a mixture of a softwood pulp and a hardwood pulp.

12. The paper of any one of the preceding claims, wherein at least 75% by dry weight of the fibres of the paper are virgin fibres and optionally wherein at least 90% by dry weight of the fibres of the paper are virgin fibres.

13. A package comprising a paper according to any one of the preceding claims.

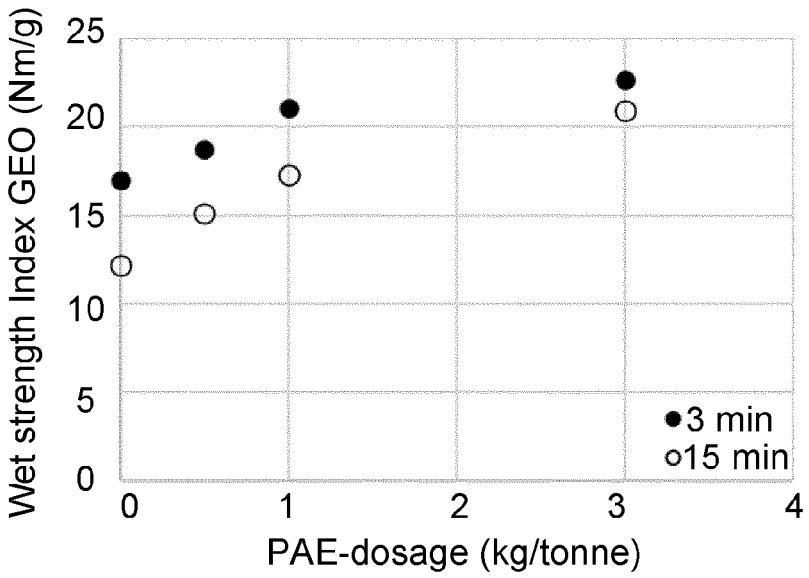
Wet strength Index GEO (Nm/g)
25
20
15
10
5
0
0
1
2
3
4
PAE-dosage (kg/tonne)
3 min
15 min

Fig. 1

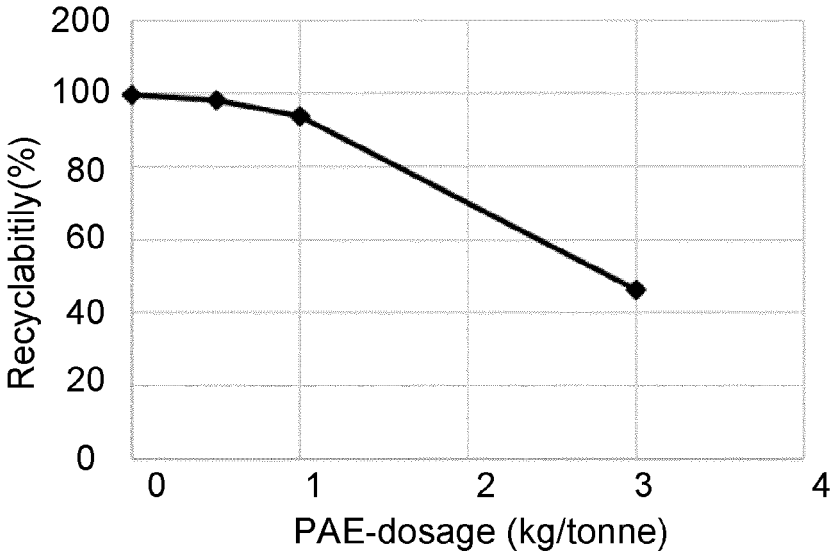
Recyclabitily(%)
200
100
80
60
40
20
0
0
1
2
3
4
PAE-dosage (kg/tonne)

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 June 2022	Karlsson, Lennart

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