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PAPERMAKING PROCESS AND PRODUCT

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This invention relates to a new method for making paper containing substantial amounts of regenerated cellulose fiber and to a papermaking slurry containing regenerated cellulose fiber which has certain advantageous characteristics.

Many suggestions have been made for incorporating regenerated cellulose fiber into paper. Because regenerated cellulose fiber can be carefully controlled as to diameter, length and other physical properties, it offers certain advantages in the manufacture of paper. To date, however, it has not been used extensively in papermaking for a variety of reasons, one of which is the difficulty in getting good dispersions of fiber stock when regenerated cellulose fiber is introduced into the mixture, particularly when fiber lengths of over ¼ inch are used. Up until the present time, when regenerated cellulose fiber was introduced into paper-making dispersions the fiber was found to clump or form in masses in the dispersion and it was impossible to obtain a smooth and even sheet.

It is an object of the present invention to provide a method for making paper which will enable large portions of regenerated cellulose fiber to be introduced into the paper.

It is another object of the invention to provide a method for papermaking employing substantial quantities of regenerated cellulose fiber which will avoid formation of clumps in the papermaking slurry.

It is another object of the invention to provide a papermaking slurry containing large proportions of regenerated cellulose fiber which is free from clumps.

Other objects will appear from a consideration of the following specification and claims.

In accordance with the invention these and other objects are obtained by introducing a relatively minor proportion of polyacrylic acid into the papermaking slurry.

The invention, therefore, comprises a method for making paper containing regenerated cellulose staple fiber which comprises adding polyacrylic acid to an aqueous slurry containing regenerated cellulose staple fiber. The invention also comprises an aqueous papermaking slurry comprising regenerated cellulose fiber and between about 0.01% and 1.0% polyacrylic acid.

Polyacrylic acid is readily available on the open market. It may be made by the polymerization of acrylic acid ($H_2C=CHCOOH$) with hydrogen peroxide in the presence of acetic acid, according to the technique described by Schildknecht in Vinyl and Related Polymers, John Wiley & Sons. For purposes of the present invention polyacrylic acid having a molecular weight between about 200,000 and about 860,000 is preferred.

The present invention will be used with papers containing regenerated cellulose fibers in various proportions. Normally, however, the regenerated cellulose fiber will comprise at least 10% by weight of the total fiber. There is no upper limit to the proportion of regenerated cellulose fiber which may be used. However, if more than about 75% on the weight of total fiber is used, special steps have to be taken to insure that the paper product has sufficient strength for practical purposes. It may be pointed out that conventional papers made from wood pulp and the like acquire their strength through the interlocking of fibrils which are created when the paper stock is beaten. Normal regenerated cellulose fibers do not fibrillate sufficiently on beating to permit

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paper to be made from them. Therefore, when the regenerated cellulose content of the paper stock is above about 75%, some step must be taken to insure that there is sufficient bonding between the fibers so that the paper sheets has enough strength. Various means may be taken to achieve this result. Thus, for example, in one conventional procedure an adhesive such as rosin size is added to the papermaking slurry and the pH adjusted to 4.5 with alum. In another process, the newly made paper may be treated with caustic to cause coalescence and bonding of adjacent fibers.

In addition to regenerated cellulose fiber, paper made according to the present invention may include natural cellulosic fiber, e.g. wood pulp or rag stock, and other fibrous material such as nylon fibers, acrylic fibers, polyester fibers and fibers of cellulose acetate and other organic esters of cellulose.

In practicing the process, a suitable fibrous slurry is first prepared. If natural cellulosic fibers are to be used these may first be beaten to the desired freeness (say 500 Canadian) in a beater. The regenerated cellulose fiber and the polyacrylic acid are then added to the slurry and the solution is brought to a pH corresponding to the viscosity desired.

It may be pointed out that the viscosity of polyacrylic acid solutions varies with pH, the maximum viscosity for any given concentration being at a point between say 6.5 and 8, usually about 7.2. It is ordinarily desirable to use as little polyacrylic acid as possible (for reasons of economy), and so the pH of the solution is usually brought to that corresponding to maximum viscosity. Since the solutions are naturally acidic this involves adding an innocuous base, such as the alkali and alkaline earth metal hydroxides, the alkali metal carbonates or similar substances to the solution.

The slurry may then be circulated through the beater for a short time (say 5 to 120 minutes). The slurry, containing say 1.0 to 6% by weight fiber, may then be diluted by about one-half and sent to a Jordan engine for further mixing and further refining of the natural fibers. After processing in the Jordan, the slurry may be formed into paper by any conventional method. In the laboratory, test sheets are made from a slurry having a fiber concentration of say 0.05 to 0.2% on a Standard British Sheet Mold. Usually, following TAPPI Standard T205 M-53, a concentration of 0.15% is used. For large scale production, any conventional machine of the Fourdrinier type may be used. In such machines an aqueous slurry containing say 0.1 to 1.0% fiber is formed in the head box of the machine and is then poured onto a moving screen where the water is sucked off to form the paper. The paper may be pressed and dried as desired in accordance with conventional practice.

If desired, conventional sizes may be added to the fiber at any stage in the process, from the beater to the head box of the papermaking machine. Alternatively, sizes may be applied to the paper after it has been formed. The character and quantity of the size depends on the use to which the paper is to be put, as will be understood by those skilled in the art.

The invention will be further described with reference to the following specific examples which, it will be understood, are given for purposes of illustration only and are not to be taken as in any way restricting the invention beyond the scope of the appended claims.

EXAMPLE

In carrying out the specific examples, sulfate pulp was charged to a beater and processed at 3.7% (wt.) consistency to 500 Canadian Standard Freeness. An appropriate amount of textile grade regenerated cellulose staple fiber was then added together with 0.1% poly-

acrylic acid (mol. wt.=860,000) with sufficient NaOH to bring the pH to 7.2 and thereby obtain maximum viscosity.¹ After further mixing in the beater, the slurry was diluted to 1.4% and then refined in a Jordan for 2 minutes. It was pumped to the head box of a conventional papermaking machine, diluted to 0.33% fiber by weight and as such deposited on the Fourdrinier wire.

The results are shown in the following table:

Table

	Sample					
	A	B	F	E	C	D
Harmac Pulp (percent)---	90	90	90	80	90	90
Rayon Fiber (percent)---	10	10	10	20	10	10
Type-----	Brt.	Brt.	Dull	Dull	Dull	Dull
Length (inch)-----	0.5	0.5	0.25	0.25	0.5	0.5
Denier-----	1.5	1.5	1.5	1.5	1.5	1.5
Polyacrylic acid (wt. percent)-----	0	0.1	0	0.1	0	0.1
Basis Weight (lb.) ¹ (24 x 36--500)-----	35.8	39.0	48.1	45.2	47.4	43.5
Caliper (0.001/inch) ² -----	5.4	6.1	7.3	6.3	7.3	6.5
Apparent Density (lb./pt. cal.)-----	6.6	6.5	6.6	7.2	6.5	6.7
Mullen (points) ³ -----	23.6	28.7	33.1	34.8	31.0	33.9
Mullen (percent) ⁴ -----	65.9	73.6	68.8	77.0	65.4	77.9
Porosity (sec./100 cc.) ⁵ -----	18.6	3.0	3.2	4.0	3.6	4.0
Tensile (lb./1" width) ⁶ MD-----	21.7	24.0	26.0	28.9	23.3	27.8
Breaking length (meters) ⁷ MD-----	6,554	6,747	5,945	7,014	5,395	7,014
Stretch (percent) ⁸ CD-----	6.4	5.5	5.2	6.4	4.4	5.4
Fold (M.I.T.) ⁹ CD-----	162	376	131	231	146	198
Brightness ¹⁰ : Top side-----	80.1	83.3	82.4	83.2	82.1	83.3
Bottom side-----	79.5	82.5	82.2	83.0	81.9	83.1

¹ TAPPI Standard T 410 M45.

² TAPPI Standard T 411 M44.

³ TAPPI Standard T 403 M53.

⁴ Mullen (points)/Basis weight.

⁵ TAPPI Standard T 460 M49.

⁶ TAPPI Standard T 404 M50 (MD=main direction).

⁷ TAPPI Standard T 404 M50 (calculated).

⁸ TAPPI Standard T 457 M46 (CD=cross direction).

⁹ TAPPI Standard T 423 M50.

¹⁰ TAPPI Standard T 452 M48.

Samples were conditioned and tested at 73° F. and 50% relative humidity.

In general, the present invention permits improved dis-
persions of rayon fibers to be obtained, using fibers which

¹ The viscosity (Brookfield) of an aqueous solution contain-
ing 0.1% polyacrylic acid of molecular weight about 860,000
at pH 7.2 is about 25.5 centipoises.

are of greater length than have hitherto been usable. Greater proportions of conventional textile grade rayon can be employed to give better sheet formation and a final product having improved properties as to Mullen test, porosity, breaking length, stretch, fold strength (MIT) and brightness.

What is claimed is:

1. A method for making paper which comprises forming an aqueous paper-making slurry having a fibrous component comprising between about 10% and about 75% by weight regenerated cellulose fiber and between about 90% and about 25% by weight natural cellulose fiber, said slurry also containing between about 0.01 and about 1% by weight of a polyacrylic acid having a molecular weight between about 200,000 and about 860,000, and forming said slurry into paper.

2. A method for making paper which comprises forming an aqueous paper-making slurry having a fibrous component comprising between about 10% and about 75% by weight regenerated cellulose fiber and between about 90% and about 25% by weight natural cellulose fiber, said slurry also containing between about 0.01 and about 1% by weight of a polyacrylic acid having a molecular weight between about 200,000 and about 860,000, adjusting the pH of said slurry to between about 6.5 and about 8, and forming a paper sheet from said slurry.

3. The method claimed in claim 2 wherein the pH of the slurry is brought to the value corresponding to maximum viscosity.

4. An aqueous papermaking slurry consisting essentially of water, a fibrous component containing between about 10 and about 75% by weight regenerated cellulose fiber and between about 90% and about 25% by weight natural cellulose fiber, and between about 0.01% and about 1% by weight of a polyacrylic acid having a molecular weight between about 200,000 and about 860,000, said slurry having a pH between about 6.5 and about 8.

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