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Anionic trash control in high-yield pulp (HYP) containing furnish by using a poly-DADMAC based commercial formulation

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ABSTRACT

High-yield pulp (HYP) is gaining increasing interest in papermaking, the presence of anionic trash has been limiting its application in high-end paper products such as fine papers. In order to control the anionic trash of HYP, the performances of three anionic trash catchers in terms of charge control and fiber fines and filler retention enhancement were compared in a laboratory study. It was found that a poly-DADMAC based commercial product had the highest efficiency. The use of CPAM/Bentonite system resulted in highest fiber fines and filler retention. The best anionic trash control was achieved when HYP was treated separately.

1. Introduction

Due to the limited forest resources, high-yield pulp (HYP), is particularly popular in China. HYP, also known as bleached chemi-thermo-mechanical pulp (BCTMP), alkaline peroxide mechanical pulp (APMP), and preconditioning refiner chemical-treatment alkaline peroxide mechanical pulp (P-RC APMP), has received increasing interests in the production of uncoated fine papers, coated fine papers and paperboards, because of its functionality and comparatively low cost [1–6]. HYP has imparted many attractive features to the final paper products: high bulk, high stiffness, high opacity, and good printability [1–4]. In contrast to bleached kraft pulps, HYP is more environmentally friendly in terms of pulp yield, water and energy consumption [2]. However, HYP contains much more anionic groups (e.g., sulfonic and carboxylic groups) due to its unique pulping and bleaching processes, thus leading to a higher fiber charge density in comparison with bleached kraft pulp [4,7–11]. Also due to the same reason, HYP contains more dissolved and colloidal substances (DCS) or anionic trash, which can have negative consequences in the papermaking wet-end, including unbalanced wet-end charge system, increased wet-end chemicals consumption, increased drainage time and reduced product quality [7–9].

The anionic trash in HYP encompasses a wide range of substances, both organics and inorganics. The organics are usually hemicellulose, lipophilic extractives and lignin-related compounds [4,10,12]. The anionic trash can lead to increased drainage time, lower retention, higher charge demand, and higher COD load of the white water [9,12,13]. This would be of particular concern if the paper mills try to increase the HYP content in the whole stock composition. Usually, the use of anionic trash catcher (ATC) is a good control strategy for minimizing the negative effect of the anionic trash. Typical ATCs are positively charged linear polymer, and their functions are usually based on charge neutralization, patch coagulation, or bridging flocculation [12,13]. Common inorganic ATCs include aluminum sulfate, poly-(aluminum chloride) (PAC), while organic ATCs include polyamine (PA), poly-ethyleneimine (PEI), poly-diallyldimethylammonium chloride (poly-DADMAC), poly-vinylamine [12–14]. Other ATCs include highly substituted starch ($DS > 0.1$) or highly cationic guar gum [13].

High efficiency, low cost, and good compatibility anionic trash catchers are always desirable for a paper mill, and this is no exception in the highly competitive Chinese pulp and paper industry. In this study, the use of three types of commercial anionic trash catchers in HYP-containing furnish was evaluated, and the wet-end programs and ATC addition points were investigated. The objectives of this study are: (1) to compare the efficiency of different types of ATCs in decreasing the cationic demand; (2) to investigate the effect of ATCs on fiber fines and filler retention; (3) to investigate the effects of the retention aid systems and ATC addition points on ATC's performance.

2. Experimental

2.1. Materials

2.1.1. Pulps

The softwood bleached kraft pulp (SWBKP) and hardwood bleached kraft pulp (HWBKP) were obtained from a mill in

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Shandong Province, China. The two pulps were refined to the target freeness of 400 mL CSF (freeness is a measure of how quickly water is allowed to drain from a fiber furnish sample) by using a PFI mill. HYP was obtained from a Canadian HYP producer, and it was hot-disintegrated in a standard disintegrator to remove the latency. The percentage of SWKP was fixed at 15%, HYP content varied from 0 to 50%, the rest percentage of the pulp furnish was balanced by bleached hardwood kraft pulp.

2.1.2. Chemicals

Ground calcium carbonate (GCC) was provided by an uncoated paper mill in China. A is a highly cationic polyvinylamine-based polymer, with Mw ≈ 400,000, and charge density of 10.7 meq/g; B is polyamine (amine)-based polymer, with Mw ≈ 500,000, and charge density of 7.3 meq/g; C is a ploy-diallyldimethylammonium based polymer, with Mw = 500,000, and charge density of 7.0 meq/g. CPAM (Percol 292), starch, anionic bentonite, APAM (Percol 155), silicate, PAC were obtained from a paper mill. All of the chemicals were used as received.

2.2. Methods

The anionic trash catcher performance study was conducted on 500.0 g (0.5% pulp consistency) of the mixed furnish slurry in a Dynamic Drainage Jar (DDJ), with 750 rpm agitation rate. The sequences of chemicals addition were ATC, 30% GCC filler, then retention aid system. One set was used for the Zeta potential measurement (SZP-06 Zeta potential tester). Another set was used to drain the filtrate for cationic demand and retention analysis.

2.2.1. Measurement of cationic demand

The cationic demand (CD) was titrated by using 0.0001 N poly-DADMAC on a Mütec PCD-04, after collecting the pulp filtrate from the DDJ.

2.2.2. First-pass retention and ash retention

The first pass retention (FPR) is defined as the proportion of total solids in the stock suspension retained in the sheets, which indicates the efficiency of fine materials retained in a web paper. The first pass ash retention (FPAR) is defined as the proportion of the mineral fillers in the stock suspension retained in the sheets. Ash indicates the amount of inorganic residues after ignition at 525 °C, ash content is determined from the dry weight of the sample and the weight of the ash. The first pass retention (FPR) and first pass ash retention (FPAR) were determined by using a DDJ. The DDJ filtrate was drained using pre-dried and weighed ashless filter papers. The residues were dried at 105 °C and reweighed to determine the solids content. The GCC filler content in the filtrate was measured based on the ash content after the residues staying in an oven at 525 °C for 5 h.

2.2.3. Focused beam reflectance measurement

Focused beam reflectance measurement (FBRM) was used to observe the flocculation. The filtrates of 100% HYP suspension were prepared by using the DDJ. The filtrates were allowed to settle down for 24 h to separate the DCS from fibers. The ATC polymer at different dosages was added to the filtrate. The flocculation behavior was then observed by FBRM.

3. Results and discussion

3.1. Effect of HYP substitution on Zeta potential, cationic demand, FPR and FPAR

Typically, HYP contains more anionic trash and fines than a hardwood bleached kraft pulp. The effect of HYP content in the pulp furnish on the Zeta potential, cationic demand, FPR and FPAR is shown in Table 1. It can be seen that Zeta potential of the HYP-containing furnish decreased with the HYP substitution, which is due to the anionic trash originating from HYP. The anionic trash in HYP can be present in different forms: (1) polygalacturonic acids, (2) fatty and resin acids, (3) dissolved lignin [10]. The negative charge of the anionic trash is derived from the carboxylic groups. If the system pH is higher than the pKa of the component (e.g., the pKa of uronic acid is 3.28), the acids can be ionized. The present system contains large amount of calcium carbonate particles, with pH of 7–7.5, the ionization of the carboxylic acid groups led to a negative Zeta potential [15]. It can be seen from Table 1 that the cationic demand increased with the increase in HYP substitution. For example, the cationic demand of HYP-free furnish was 39.6 μeq/mL, and increased to 43.7 μeq/mL at a 20% HYP substitution, and further reached 56.8 μeq/mL at the HYP substitution of 50%. It should be pointed out that the pH of the system was about 7, and the increased cationic demand was derived from fatty and resin acids, and oxidized lignin [4,10]. At a pH of above 5, the increased negative effect of anionic trash on cationic demand from a higher HYP substitution was also reported by Zhang et. al [7]. As shown in Table 1, HYP had marginal effect on the first pass retention at the HYP substitution of less than 10%. This may be due to the high amount of sulfonic and carboxyl groups on the HYP fibers and fines [16], these functional groups can help improve the retention of fiber fines. However, if the HYP substitution further increased beyond 10%, the presence of anionic trash and fiber fines resulted in enhanced negative effects on the retention, the first pass retention decreased with the increasing of the HYP content. The effect of HYP on first pass ash retention was more pronounced than first pass retention. This is contributed by the higher anionic trash and fines content in the system, which interfered with the retention agents and resulted in the lower filler retention. To minimize the negative effects of anionic trash, ATCs were employed to improve the wet-end performance of HYP-containing furnish, which is to be discussed in the next section.

3.2. Addition of ATCs to HYP-containing furnish

3.2.1. Zeta potential and cationic demand

Fig. 1 shows the effect of ATC type on Zeta potential in a microparticle retention aid system (microparticle retention aid

Table 1
Effect of HYP substitution on Zeta potential, cationic demand, first pass retention (FPR) and first pass ash retention (FPAR).

HYP content (%)	Zeta potential (mv)	Cationic demand (μeq/mL)	FPR (%)	FPAR (%)
0	−17.5	39.6	82.0	66.5
10	−17.8	41.2	81.8	63.7
20	−18.2	43.7	80.3	60.1
30	−18.8	46.4	79.4	57.2
40	−19.8	49.0	77.9	54.5
50	−21.2	56.8	75.6	50.3