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(54) **Hydrophilic dispersion polymers for paper applications**

(57) A papermaking process comprising forming an aqueous cellulosic papermaking slurry and adding a hydrophilic dispersion polymer to the slurry to increase retention and/or drainage is disclosed. The hydrophilic dispersion polymer comprises (a) a cationic monomer and (b) a second monomer represented by (meth)acrylamide (in an aqueous solution of a polyvalent anionic salt), wherein the polymerization is carried out in the presence of either an organic high-molecular weight multivalent cation comprising a water-soluble polymer containing at least one (a) monomer and/or poly diallyl dimethyl ammonium chloride (DADMAC). After addition of the polymers, the slurry is drained to form a sheet, and the sheet is dried.

EP 0 831 177 A2

Description**Background of the Invention****1. Field of the Invention**

The invention relates to the field of papermaking, and, in particular, to an improved papermaking process utilizing hydrophilic dispersion polymers as retention and drainage aids.

2. Description of the Prior Art

In the manufacture of paper an aqueous cellulosic suspension or slurry is formed into a paper sheet. The cellulosic slurry is generally diluted to a consistency (percent dry weight of solids in the slurry) of less than 1 percent, and often below 0.5 percent, ahead of the paper machine, while the finished sheet must have less than 6 weight percent water. Hence, the dewatering aspects of papermaking are extremely important to the efficiency and cost of the manufacture.

The least costly dewatering method is drainage, and thereafter more expensive methods are used, including vacuum pressing, felt blanket blotting and pressing, evaporation and the like, and any combination of such methods. Since drainage is both the first dewatering method employed and the least expensive, improvement in the efficiency of drainage will decrease the amount of water required to be removed by other methods and improve the overall efficiency of dewatering and reduce the cost thereof.

Another aspect of papermaking that is extremely important to the efficiency and cost of manufacture is retention of furnish components on and within the fiber mat being formed during papermaking. A papermaking furnish contains particles that range in size from about the 2 to 3 millimeter size of cellulosic fibers to fillers measuring only a few microns. Within this range are cellulosic fines, mineral fillers (employed to increase opacity, brightness and other paper characteristics) and other small particles that generally, without the inclusion of one or more retention aids, would pass through the spaces (pores) between the cellulosic fibers in the fiber mat being formed.

One method of improving the retention of cellulosic fines, mineral fillers and other furnish components on the fiber mat is the use of a coagulant/flocculant system, added ahead of the paper machine. In such a system there is first added to the furnish a coagulant, for instance a low molecular weight cationic synthetic polymer or a cationic starch which coagulant generally reduces the negative surface charges present on the particles in the furnish, particularly cellulosic fines and mineral fillers, and thereby agglomerates such particles. The coagulant is followed by the addition of a flocculant. The flocculant is generally a high molecular weight cationic or anionic synthetic polymer which bridges the particles and/or agglomerates, from one surface to another, binding the particles into large agglomerates. The presence of such large agglomerates in the furnish increases retention. The agglomerates are filtered out of the water onto the fiber web, where unagglomerated particles otherwise would to a great extent pass.

While a flocculated agglomerate generally does not interfere with the drainage of the fiber mat to the extent that would occur if the furnish were gelled or contained an amount of gelatinous material, when such flocs are filtered by the fiber web the pores thereof are reduced, thus reducing drainage efficiency. Hence, the retention is increased at the expense of decreasing drainage.

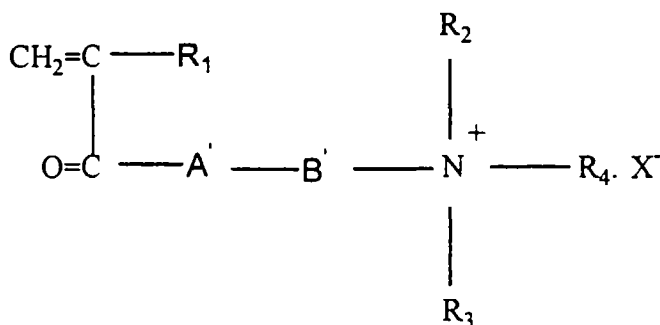
Another system employed to provide an improved combination of retention and dewatering is described in U.S. Patent Nos. 4,753,710 and 4,913,775, inventors Langley et al., issued respectively June 28, 1988 and April 3, 1990, the disclosures of which are incorporated herein by reference. In brief, such method adds to the aqueous cellulosic papermaking suspension first a high molecular weight linear cationic polymer before shearing the suspension, followed by the addition of bentonite after shearing. The shearing generally is provided by one or more of the cleaning, mixing and pumping stages of the papermaking process, and the shearing breaks down the large flocs formed by the high molecular weight polymer into microflocs, and further agglomeration then ensues with the addition of the bentonite clay particles.

Another system uses the combination of cationic starch followed by colloidal silica to increase the amount of material retained on the web by charge neutralization and adsorption of smaller agglomerates. This system is described in U.S. Patent No. 4,388,150, inventors Sunden et al, issued June 14, 1983.

U. S. Patent Nos. 5,098,520 and 5,185,062, issued to Begala, the disclosures of which are incorporated herein, describe methods of improving dewatering in a papermaking process.

Summary of the Invention

A papermaking process comprising forming an aqueous cellulosic papermaking slurry and adding a hydrophilic dispersion polymer to the slurry to increase retention and/or drainage is disclosed. The hydrophilic dispersion polymer comprises (a) a cationic monomer represented by the following general formula (I):



wherein R_1 is H or CH_3 ; each of R_2 and R_3 is an alkyl group having 1 to 2 carbon atoms; R_4 is H or an alkyl group of 1 to 2 carbon atoms; A is an oxygen atom or NH; B is an alkylene group of 2 to 4 carbon atoms or a hydroxypropylene group; and X^- is an anionic counterion: and (b) a second monomer represented by (meth)acrylamide (in an aqueous solution of a polyvalent anionic salt), wherein the polymerization is carried out in the presence of either an organic high-molecular weight multivalent cation comprising a water-soluble polymer containing at least one monomer of formula (I) and/or poly diallyl dimethyl ammonium chloride (DADMAC). After addition of the polymers, the slurry is drained to form a sheet, and the sheet is dried.

Brief Description of the Drawings

FIG. 1 is a graph comparing turbidity reduction between three dispersion polymers and the standard latex retention aid.

FIG. 2 is a graph comparing drainage activity between three dispersion polymers and the standard latex retention aid.

FIG. 3 is a graph showing retention activity of higher intrinsic viscosity dispersion copolymers containing 10 and 20 mole % DMAEA • MCQ.

FIG. 4 is a graph showing drainage activity of higher intrinsic viscosity dispersion copolymers containing 10 and 20 mole % DMAEA • MCQ.

FIG. 5 is a graph comparing the retention performance of dispersion latex and dry polymers.

FIG. 6 is a graph comparing turbidity reduction of various dispersion polymers with standard flocculants.

FIG. 7 is a graph comparing the drainage activity of various dispersion polymers with standard flocculants.

FIG. 8 is a graph comparing retention performance of dispersion polymers to standard latex polymer.

FIG. 9 is a graph comparing drainage performance of dispersion polymers to standard latex polymer.

FIG. 10 is a graph comparing retention performance of dispersion polymers combined with standard coagulants to dispersion polymers alone.

FIG. 11 is a graph comparing draining performance of dispersion polymers combined with standard coagulants to dispersion polymers alone.

Description of the Preferred Embodiments

The invention comprises a papermaking process for improving retention and drainage comprising forming an aqueous cellulosic papermaking slurry and adding a hydrophilic dispersion polymer to the slurry. The slurry is then formed into a sheet and dried.

Preferably, the hydrophilic dispersion polymer of the invention is a copolymer of dimethylaminoethyl (meth)acrylate methyl chloride quat (DMAEA • MCQ) cationic monomer and (meth)acrylamide (AcAm). It has been found that the pol-

mer described above confers advantages for use in a papermaking process. Specifically, the hydrophilic dispersion polymers of the invention show improved retention activity compared to dimethylaminoethyl acrylate benzyl chloride quat (DMAEA • BCQ)/acrylamide(AcAm) dispersion copolymer and DMAEA methyl chloride quaternary latex of the same charge. Latex is defined within this application as an inverse water-in-oil emulsion polymer.

In an alternative embodiment, the DMAEA • MCQ/AcAm hydrophilic dispersion polymers show nearly equal activity with respect to retention and drainage as compared to the commercial standard latex cationic polymers.

Examples 1-4 below outline processes for preparing the copolymer at various ratios of the monomer components. Preferably, the amount of dimethylaminoethyl acrylate methyl chloride quaternary present in the copolymer is from about 3 mole percent to about 20 mole percent. Further, the range of intrinsic viscosities for the hydrophilic dispersion polymers of the invention is preferably from about 11.9 to about 21.2 dl/g. According to the preferred method of the invention, the dispersion polymer is added in an amount from about 0.5 to about 5.0 pounds of active per ton of slurry solids.

The present process is believed applicable to all grades and types of paper products and further applicable for use on all types of pulps including chemical pulps, including sulfate and sulfite pulps from both hard and soft woods and acid pulps, thermomechanical pulps, mechanical pulps, recycle pulps and ground wood pulps. Typically, such furnishes will have a pH of from about 3.0 to about 9.0.

The following examples are presented to describe preferred embodiments and utilities of the invention and are not meant to limit the invention unless otherwise stated in the claims appended hereto.

Example 1 - Process for Synthesizing Dispersion Copolymers of Acrylamide and 3 mole % DMAEA • MCQ.

To a two-liter resin reactor equipped with stirrer, temperature controller and water cooled condenser, was added 287.59 grams of a 48.1 % solution of acrylamide (1.9461 moles), 7.24 grams of an 80.6% solution of DMAEA • MCQ (0.0301 moles), 250 grams of ammonium sulfate, 225.59 grams of deionized water, 27 grams of glycerol, 56.25 grams of a 16% solution of polyDADMAC (poly diallyl dimethyl ammonium chloride)(IV= 1.5 dl/gm), 18 grams of a 20% solution of polyDMAEA • MCQ (IV=2.0dl/gm), and 0.3 grams of EDTA. The mixture was heated to 48°C and 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride was added. The resulting solution was sparged with 1000 cc/min. of nitrogen. After 15 minutes, polymerization began and the solution became viscous. Over the next 4 hours the temperature was maintained at 48°C and a solution containing 95.86 grams (0.6487 moles) of 48.1 % acrylamide, 12.07 grams (0.0502 moles) of an 80.6% solution of DMAEA • MCQ, 9 grams of glycerol and 0.1 gram of EDTA was pumped into the reactor using a syringe pump. To the resulting polymer dispersion was added 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride. The dispersion was then further reacted for 2.5 hours at a temperature of 48°C to 55°C. The resulting polymer dispersion had a Brookfield viscosity of 5600cps. To the above dispersion was added 10 grams of 99% acetic acid and 20 grams of sodium sulfate. The resulting dispersion had a Brookfield viscosity of 1525 cps and contained 20% of a 97/3 copolymer of acrylamide and DMAEA • MCQ with an intrinsic viscosity of 12.1 dl/gm in 0.125 molar NaNO₃.

Example 2 - Process for Synthesizing Dispersion Copolymers of Acrylamide and 5 mole % DMAEA • MCQ.

To a two-liter resin reactor equipped with stirrer, temperature controller, and water cooled condenser, was added 281.68 grams of a 48.1 % solution of acrylamide (1.9061 moles), 12.07 grams of an 80.6% solution of DMAEA • MCQ (0.05023 moles), 250 grams of ammonium sulfate, 225.10 grams of deionized water, 27 grams of glycerol, 33.75 grams of a 16% solution of polyDADMAC (IV=1.5 dl/gm), 36 grams of a 20% solution of polyDMAEA • MCQ (IV=2.0 dl/gm), and 0.3 grams of EDTA. The mixture was heated to 48°C and 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride was added. The resulting solution was sparged with 1000 cc/min. of nitrogen. After 15 minutes, polymerization began and the solution became viscous. Over the next 4 hours the temperature was maintained at 48°C and a solution containing 93.89 grams (0.6354 moles) of 48.1 % acrylamide, 20.11 grams (0.08368 moles) of an 80.6% solution of DMAEA • MCQ, 9 grams of glycerol and 0.1 grams of EDTA was pumped into the reactor using a syringe pump. To the resulting polymer dispersion was added 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride. The dispersion was then further reacted for 2.5 hours at a temperature of 48°C to 55°C. The resulting polymer dispersion had a Brookfield viscosity of 10000cps. To the above dispersion was added 10 grams of 99% acetic acid and 20 grams of sodium sulfate. The resulting dispersion had a Brookfield viscosity of 2825 cps and contained 20% of a 95/5 copolymer of acrylamide and DMAEA • MCQ with an intrinsic viscosity of 14.1 dl/gm in 0.125 molar NaNO₃.

Example 3 - Process for Synthesizing Dispersion Copolymers of Acrylamide and 10 mole % DMAEA • MCQ.

To a two-liter resin reactor equipped with stirrer, temperature controller, and water cooled condenser, was added 239.38 grams of a 48.1% solution of acrylamide (1.6199 moles), 21.63 grams of an 80.6% solution of DMAEA • MCQ

(0.09001 moles), 260 grams of ammonium sulfate, 258.01 grams of deionized water, 18 grams of glycerol, 33.75 grams of a 16% solution of polyDADMAC (IV= 1.5 dl/gm), 36 grams of a 20% solution of polyDMAEA • MCQ (IV=2.0dl/gm), and 0.3 grams of EDTA. The mixture was heated to 48°C and 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride was added. The resulting solution was sparged with 1000 cc/min. of nitrogen. After 15 minutes, polymerization began and the solution became viscous. Over the next 4 hours the temperature was maintained at 48°C and a solution containing 79.79 grams (0.5399 moles) of 48.1% acrylamide, 36.04 grams (0.1500 moles) of an 80.6% solution of DMAEA • MCQ, 6 grams of glycerol and 0.1 gram of EDTA was pumped into the reactor using a syringe pump. To the resulting polymer dispersion was added 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride. The dispersion was then further reacted for 2.5 hours at a temperature of 48°C to 55°C. The resulting polymer dispersion had a Brookfield viscosity of 7600cps. To the above dispersion was added 10 grams of 99% acetic acid and 20 grams of sodium sulfate. The resulting dispersion had a Brookfield viscosity of 2100 cps and contained 20% of a 90/10 copolymer of acrylamide and DMAEA • MCQ with an intrinsic viscosity of 15.5 dl/gm in 0.125 molar NaNO₃.

Example 4 - Process for Synthesizing Dispersion Copolymers of Acrylamide and 20 mole % DMAEA • MCQ.

To a two-liter resin reactor equipped with stirrer, temperature controller, and water cooled condenser was added 136.03 grams of a 48.1 % solution of acrylamide (0.9205 moles), 37.12 grams of an 80.6% solution of DMAEA • MCQ (0.1545 moles), 190 grams of ammonium sulfate, 50 grams of sodium sulfate, 267.99 grams of deionized water, 13.2 grams of glycerol, 33.75 grams of a 16% solution of polyDADMAC (IV= 1.5 dl/gm), 45 grams of a 20% solution of poly-DMAEA • MCQ (IV=2.0dl/gm), and 0.2 grams of EDTA. The mixture was heated to 48°C and 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride was added. The resulting solution was sparged with 1000 cc/min. of nitrogen. After 15 minutes, polymerization began and the solution became viscous. Over the next 4 hours the temperature was maintained at 48°C and a solution containing 111.29 grams of 48.1% acrylamide, 63.47 grams (0.2641 moles) of an 80.6% solution of DMAEA • MCQ, 10.8 grams of glycerol and 0.2 grams of EDTA was pumped into the reactor using a syringe pump. To the resulting polymer dispersion was added 0.50 grams of a 4% solution of 2,2' Azobis(2 amidinopropane) dihydrochloride. The dispersion was then further reacted for 2.5 hours at a temperature of 48°C to 55°C. The resulting polymer dispersion had a Brookfield viscosity of 2160 cps. To the above dispersion was added 10 grams of 99% adipic acid and 30 grams of ammonium sulfate. The resulting dispersion had a Brookfield viscosity of 1325 cps and contained 20% of an 80/20 copolymer of acrylamide and DMAEA • MCO with an intrinsic viscosity 13.7 dl/gm in 0.125 molar NaNO₃.

The following examples utilized the test polymers and furnishes described below.

Polymer Samples

POLYMER DESCRIPTION		
Dispersions		
Dispersion A	3 mole% DMAEA • MCQ	IV 12.1 dl/g
Dispersion B	5 mole% DMAEA • MCQ	IV 14.1 dl/g
Dispersion C	10 mole % DMAEA • MCQ	IV 14.8 dl/g
Dispersion D	10 mole% DMAEA • MCQ	IV 17.0 dl/g
Dispersion E	10 mole% DMAEA • MCQ	IV 18.2 dl/g
Dispersion F	20 mole% DMAEA • MCQ	IV 21.2 dl/g
Dispersion G	20 mole% DMAEA • MCQ	IV 19.4 dl/g
Dispersion H	10 mole% DMAEA • MCQ	IV 19.2 dl/g
Other Polymers		
Polymer A	10 mole% DMAEA • MCQ Latex	IV 17.7 dl/g
Polymer B	10 mole% DMAEA • MCQ Latex	IV 19.1 dl/g
Polymer C	10 mole% DMAEA • BCQ Dispersion	IV 12.9 dl/g
Polymer D	70/30 mole% AcAm/NaAc Latex	
Polymer E	10 mole% DMAEA • MCQ Dry polymer (Floerger)	
Polymer F	Epi-DMA solution polymer	
Polymer G	Poly(DADMAC) solution polymer	IV 0.55 dl/g
Polymer H	Poly(DADMAC) solution polymer	IV 1.9 dl/g

IV Measurement

IV measurements of polymer samples were carried out in 0.125 M NaNO₃ solution. The procedure comprises:

1. Prepare a 1% dispersion product (0.2% polymer actives) solution by injecting 2 g of the dispersion polymer with a syringe into the vortex of 198 g of DI water. Continue stirring at 800 rpm for 30 minutes.
2. Prepare a 0.045% polymer actives working solution from:

0.2% Polymer actives solution	22.5 g
Sodium acetate solution	1.0 g
0.25 Molar Sodium nitrate	50.0 g
DI water	26.5 g

3. Fill 2 ml of 0.125 Molar sodium nitrate solution into a capillary viscometer. Measure the time t_0 .

4. Remove the sodium nitrate solution and clean the viscometer. Fill 2 ml of the 0.045% polymer actives solution into the viscometer. Measure the time t_1 .

Furnish Preparation

Three of the furnishes used for polymer activity testing were prepared from thick stock obtained from paper mills and diluted to a consistency of approximately 0.5% with formulation water. The fourth furnish was a synthetic alkaline furnish which comprised 70 weight % fiber and 30 weight % filler, diluted to a consistency of approximately 0.5% with

formulation water. The formulation water contained 200 ppm calcium hardness (added as CaCl_2), 152 ppm magnesium hardness (added as MgSO_4) and 110 ppm bicarbonate alkalinity (added as NaHCO_3).

Drainage and Retention Tests

The Britt CF Dynamic Drainage jar was used for uniform mixing of polymer and furnish; the mixing speed of the Britt jar was 500 rpm. The drainage tester simulates gravity drainage on a paper machine. The test procedures for drainage and retention are given below:

1. Measure a 500 ml sample of the thin stock using a graduated cylinder.
2. Add thin stock to the Britt jar.
3. Begin stirring (500 rpm) and add starch or coagulant using a syringe (when required).
4. After 10 seconds, add polymer solution to the furnish using a syringe.
5. Stop stirring after a total time of 30 seconds. i.e. 20 seconds after adding polymer.
6. Immediately transfer the treated furnish into the reservoir of the drainage tester.
7. Remove the stopper and collect the filtrate for 5 seconds.
8. Record the weight of filtrate.
9. Measure the filtrate turbidity at 450 nm on a DR-2000 Spectrometer. The filtrate was diluted (x2) with DI water.

Drainage and turbidity data were obtained for dispersion and latex polymers using the test procedures described above. In these examples, a measure of retention is given by the percent reduction in the turbidity obtained with no polymer treatment (blank). Dosage curves of Drainage Improvement (%) and Turbidity Reduction (%) were determined for polymers tested. It is well known that the retention and drainage activities of polymers depend on several factors including the type of furnish to be treated. For this reason furnishes were selected which were significantly different from each other. The first was a 100% recycled linerboard furnish. The second was a furnish used for the production of corrugated folding grade products. This furnish was a mixture of old corrugated cardboard (OCC), newsprint and boxboard. Thick stocks and other additives used for the manufacture of publication grade paper were collected to prepare the third furnish. The fourth furnish was prepared in the laboratory and closely resembles the alkaline furnish used by the paper industry for the production of fine paper.

Using the test furnishes described above, the Drainage and Retention tests also described above were employed to determine drainage and retention activities of Dispersions A-H and Polymers A-H in Examples 5-9.

Example 5

The initial activity testings of the DMAEA • MCQ dispersion polymers were done with 100% recycled linerboard. This furnish contained no added filler and retention was primarily for fines from the fiber. Figure 1 shows a plot of % turbidity reduction vs polymer dosage for three of the hydrophilic dispersion polymers and Polymer A, a standard latex flocculant. The compositions of the dispersions were (1) AcAm/DMAEA • MCQ:97/3, (2) AcAm/DMAEA • MCQ:95/5, and (3) AcAm/DMAEA • MCQ:90/10. Dispersions A, B and C showed increased efficiency of retention performance as compared to Polymer A. In addition, Figure 1 shows that turbidity reductions between 60 and 70% were achieved with the dispersion polymers for dosage of approximately 0.8 lbs active/t.

Figure 2 shows the drainage improvements realized by the dispersion polymers described above. The copolymer containing 5 mole % DMAEA • MCQ showed the best drainage behavior amongst the dispersions. However, the latex polymer, Polymer A outperformed the dispersions for the entire dosage range tested. It should be noted that the intrinsic viscosities of the first batches of hydrophilic dispersions were significantly lower than Polymer A.

Example 6

The corrugated coated furnish was a mixture of OCC, newsprint and boxboard. Unlike the recycled linerboard this furnish contained CaCO_3 as filler. The % ash was found by gravimetric measurement to be 7.3%. Preliminary activity

testings were carried out with the lower IV (11.9 - 15.7 dl/g) polymer samples and the data indicated some important trends in polymer performances. Both retention and drainage performances of the dispersion polymers improved with increasing mole% of DMAEA • MCQ. Overall, the 10 mole% DMAEA • MCQ copolymer showed the best drainage and retention performances among the dispersions tested.

The retention performances of the higher IV (17.0 - 21.2 dl/g) dispersion copolymers containing 10 and 20 mole% DMAEA • MCQ are shown in Figure 3. Dispersions D, E, F and G, containing 10 and 20 mole% DMAEA • MCQ showed comparable retention activities to Polymer A with corrugated coated furnish.

Figure 4 shows the drainage activities of the higher IV dispersion copolymers containing 10 and 20 mole% DMAEA • MCQ. The results clearly demonstrate that for the dosage range 0 to 1.5 lbs active/t the hydrophilic dispersion polymers were comparable to the standard flocculant, Polymer A. As the polymer dosage was increased to 4.0 lbs active/t, the 20 mole% DMAEA • MCQ copolymers continued to show drainage behavior similar to Polymer A.

Example 7

The publication grade furnish was a blend of 90% (softwood, hardwood, high ash broke, low ash broke) and 10% (CaCO₃, TiO₂, starch, alum). The flocculant used at the time of the test was Polymer D (AcAm/NaAc:70/30). Figure 5 shows the results of Britt jar screening of dispersion and dry polymers. On an equal actives basis at 1.5 lbs/t, the 10 mole% DMAEA • MCQ dispersion (Dispersion E) outperformed all polymers including Polymer C, Polymer D and Polymer E, a dry polymer available from Floerger.

Results of retention and drainage testings performed with this furnish are given in Figures 6 and 7. Two hydrophilic dispersions containing 10 mole% DMAEA • MCQ were compared with Polymer A and Polymer D. The plot of % turbidity reduction vs dosage. Figure 6, shows that for low dosages of flocculants significant reductions in turbidity (~90%) were achieved for each polymer. In addition, there were no differences in retention activities among the dispersion and latex polymers.

Figure 7 shows that the drainage activities of the latex and dispersion polymers were quite different. The latex polymer Polymer A, gave the best drainage performance. This was followed by the higher IV dispersion polymer. At dosages above 1.0 lb/t, the drainage improvements for the two dispersion polymers were greater than Polymer D.

Example 8

A synthetic alkaline furnish was prepared, containing approximately 30% CaCO₃ as filler and, therefore had the highest filler loading among the furnishes prepared. In Example 8, cationic starch was charged to the furnish in the amount of about 10 lb/ton of dry weight of slurry solids.

Figure 8 shows the dosage retention curves for two hydrophilic dispersions containing 10 mole% and 20 mole% DMAEA • MCQ (Dispersion E, G) compared to Polymer B and Polymer C. Polymer B (IV 19.1 dl/g) is a higher molecular weight material than Polymer A (IV 17.7 dl/g). The results indicate that the hydrophilic dispersion polymers containing 10 and 20 mole% DMAEA • MCQ are also very effective retention aids for fine paper application.

Drainage data for the polymers tested with the standard alkaline furnish are given in Figure 9. The hydrophilic dispersion containing 20 mole% DMAEA • MCQ showed better drainage than Polymer C and the 10 mole% DMAEA • MCQ dispersion polymer. Its drainage performance was comparable to Polymer B.

The preceding results demonstrated that the hydrophilic dispersion polymers are effective retention and drainage aids for a range of furnishes. The activities of the new dispersion polymers in the single polymer program were comparable to or sometimes better than the inverse emulsion polymer, Polymer A

Example 9

The effects of coagulants on the retention and drainage activities of two DMAEA • MCQ dispersion polymers (10 and 20 mole% DMAEA • MCQ) were evaluated in a dual polymer program and are shown in Figures 10 and 11. The corrugated coated furnish was selected for this study. Coagulants, including Polymer F, (Epi/DMA), Polymer G (polyDADMAC IV = 0.55) and Polymer H (polyDADMAC, IV = 1.9) were used. Figure 10 shows an increase of approximately 30% in retention performance for Dispersion F, the 20 mole% DMAEA • MCQ polymer with the addition of 2.0 lbs/ton of the high IV polyDADMAC. There were also measurable increases in retention with Polymer F and Polymer C. There were no significant changes in retention activities for the 10 mole% DMAEA • MCQ (Dispersion D) polymer with the addition of coagulants. The coagulants showed a less beneficial effect on the drainage activities of the two DMAEA • MCQ dispersion polymers (Figure 11).

Changes can be made in the composition, operation and arrangement of the method of the present invention described herein without departing from the concept and scope of the invention as defined in the following claims:

Claims

1. A papermaking process comprising:

5 forming an aqueous cellulosic papermaking slurry;
 adding a hydrophilic dispersion polymer to the slurry;
 draining the slurry to form a sheet; and
 10 drying the sheet.

2. The method of Claim 1 wherein the hydrophilic dispersion polymer is selected from the group consisting of a copolymer of dimethylaminoethyl acrylate methyl chloride quaternary and acrylamide, a copolymer of dimethylaminoethyl methacrylate methyl chloride quaternary and acrylamide, dimethylaminoethyl acrylate methyl chloride quaternary and methacrylamide and dimethylaminoethyl methacrylate methyl chloride quaternary and methacrylamide.

3. The method of Claim 2 wherein the hydrophilic dispersion polymer is a copolymer of dimethylaminoethyl acrylate methyl chloride quaternary and acrylamide and wherein the amount of dimethylaminoethyl acrylate methyl chloride quaternary present in the copolymer is from about 3 mole percent to about 20 mole percent.

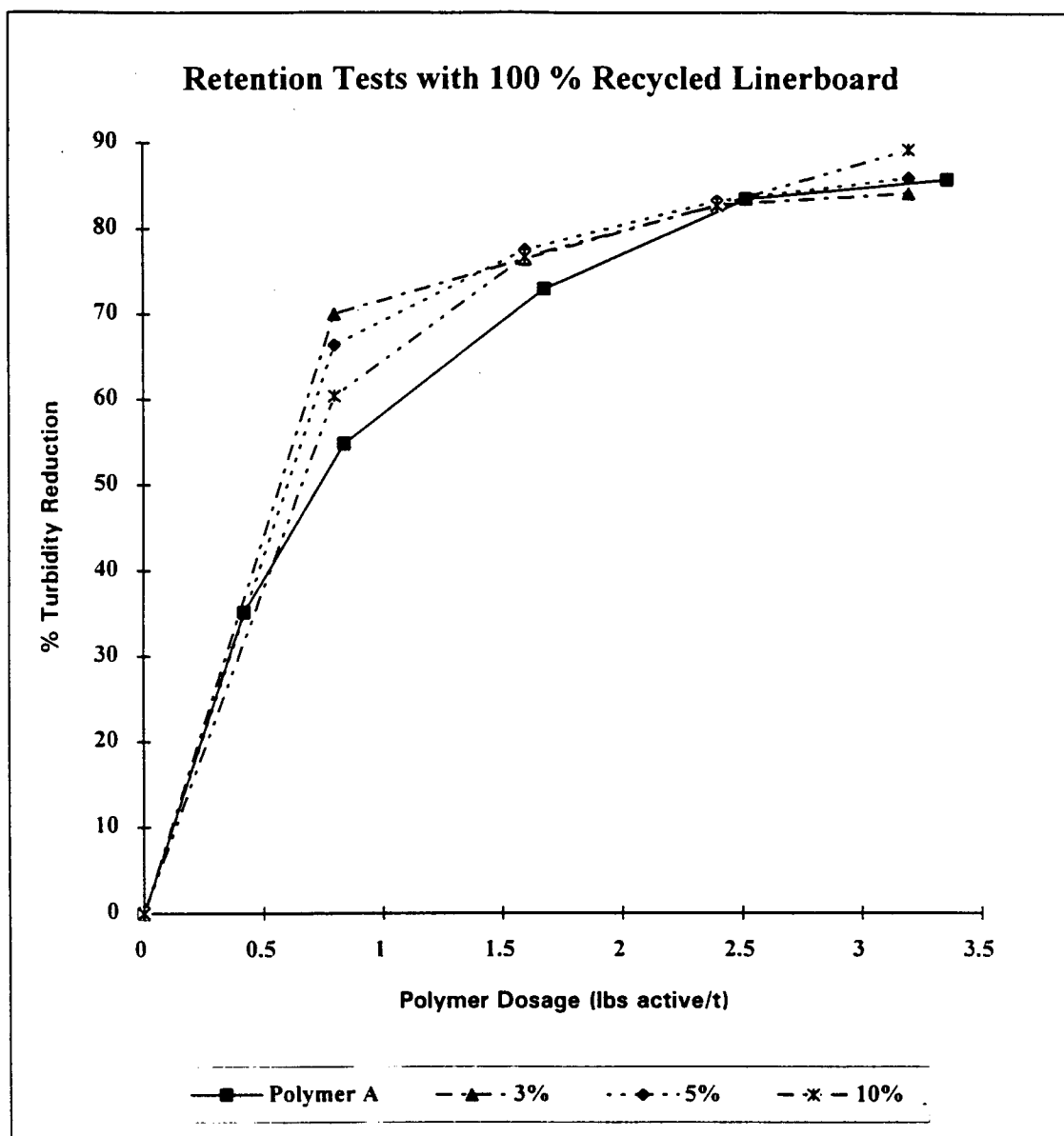
4. The method of Claim 1 wherein the dispersion polymer is added in an amount from about 0.8 to about 2.0 pounds of active per ton of slurry solids.

5. The method of Claim 1 wherein the hydrophilic dispersion polymer has an intrinsic viscosity of from about 11.9 to about 21.2 dl/g.

6. The method of Claim 1 further comprising the step of adding a coagulant before the addition of the hydrophilic dispersion polymer, the coagulant being selected from the group consisting of Epi/DMA and polymeric diallyl dimethyl ammonium chloride.

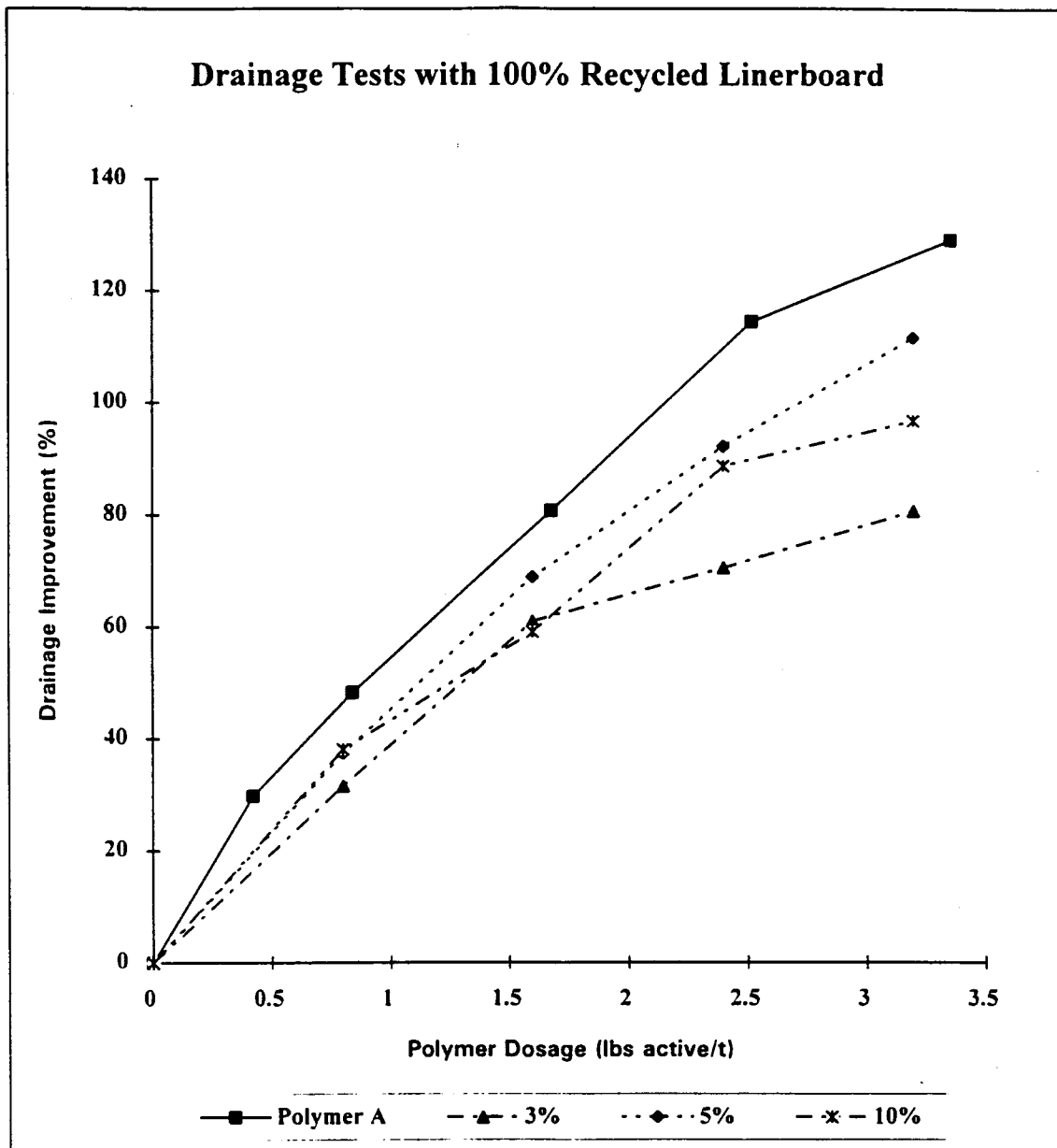
7. The method of Claim 6 further comprising the step of adding a cationic starch to the furnish in an amount of about 10 lb/ton of dry weight of slurry solids.

FIGURE 1



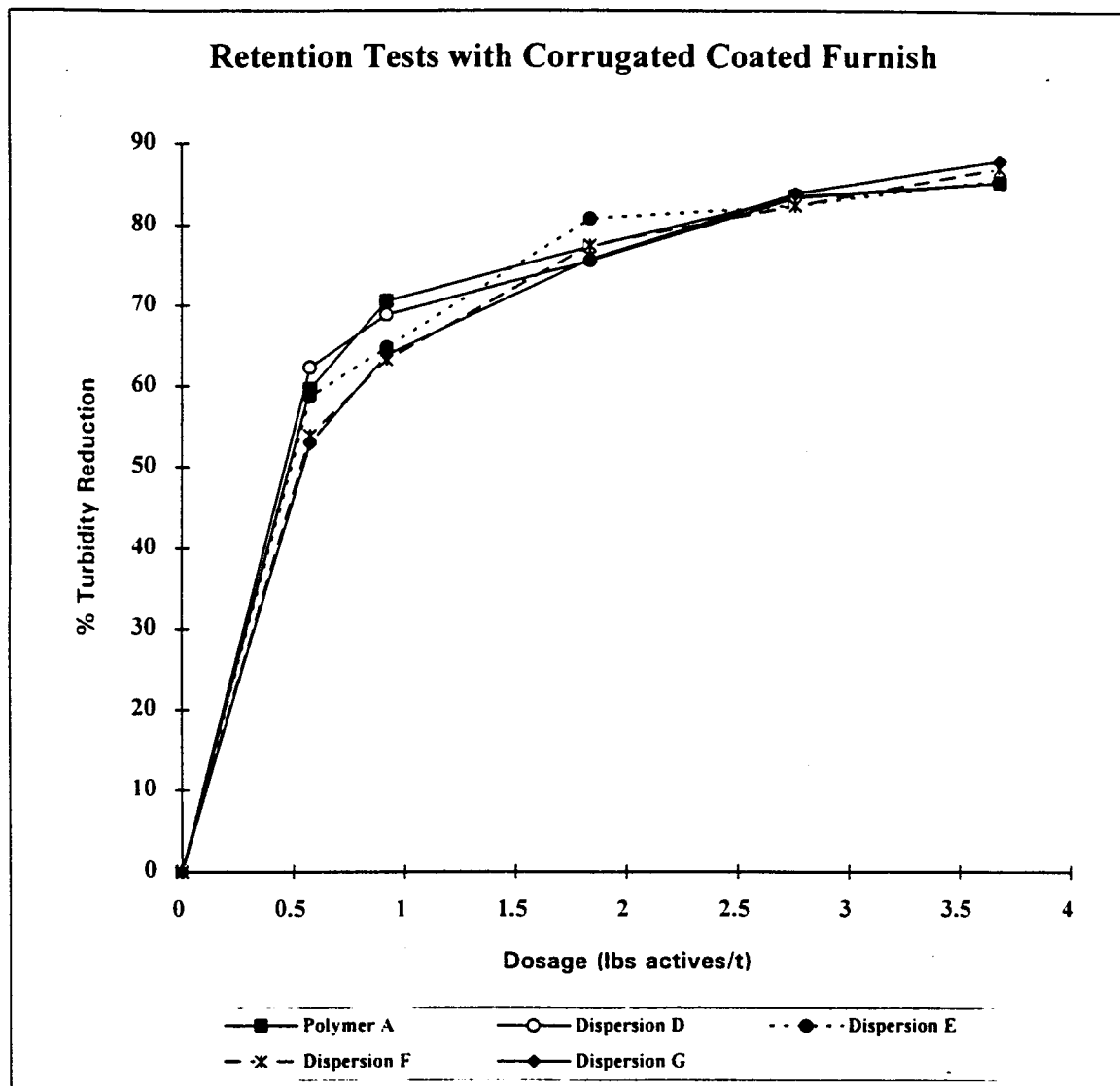
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA. BCQ Mole %	IV 0.125N NO3 (dl/g)
Polymer A	10	10	0	17.7
Dispersion A	3	3	0	12.1
Dispersion B	5	5	0	14.1
Dispersion C	10	10	0	14.8

FIGURE 2



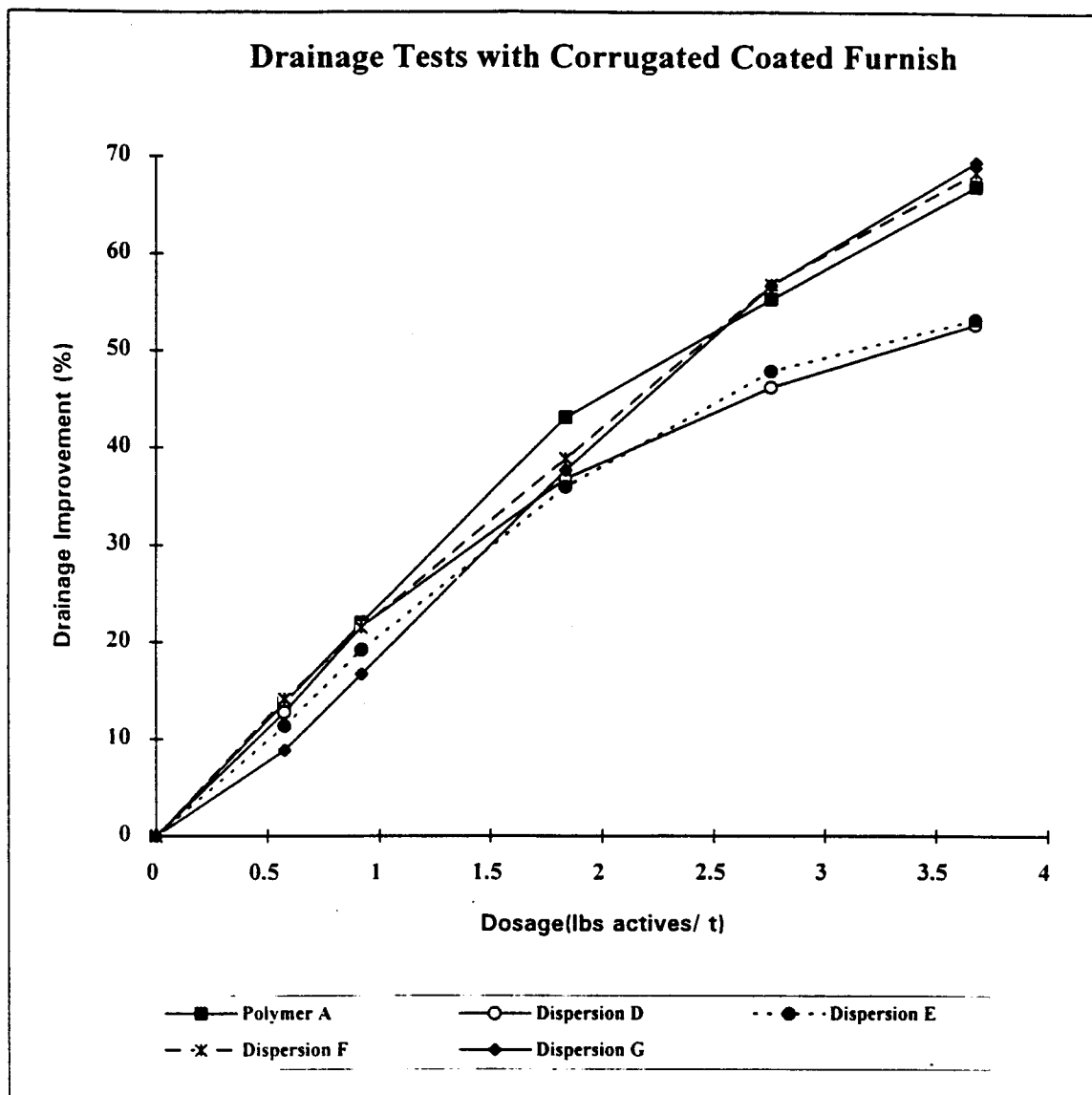
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA. BCQ Mole %	IV 0.125N NO ₃ (dl/g)
Polymer A	10	10	0	17.7
Dispersion A	3	3	0	12.1
Dispersion B	5	5	0	14.1
Dispersion C	10	10	0	14.8

FIGURE 3



Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO3 (dl/g)
Polymer A	10	10	0	17.70
Dispersion D	10	10	0	17.00
Dispersion E	10	10	0	18.20
Dispersion F	20	20	0	21.20
Dispersion G	20	20	0	19.40

FIGURE 4



Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO3 (dl/g)
Polymer A	10	10	0	17.70
Dispersion D	10	10	0	17.00
Dispersion E	10	10	0	18.20
Dispersion F	20	20	0	21.20
Dispersion G	20	20	0	19.40

FIGURE 5
Retention Tests with Publication Grade Furnish

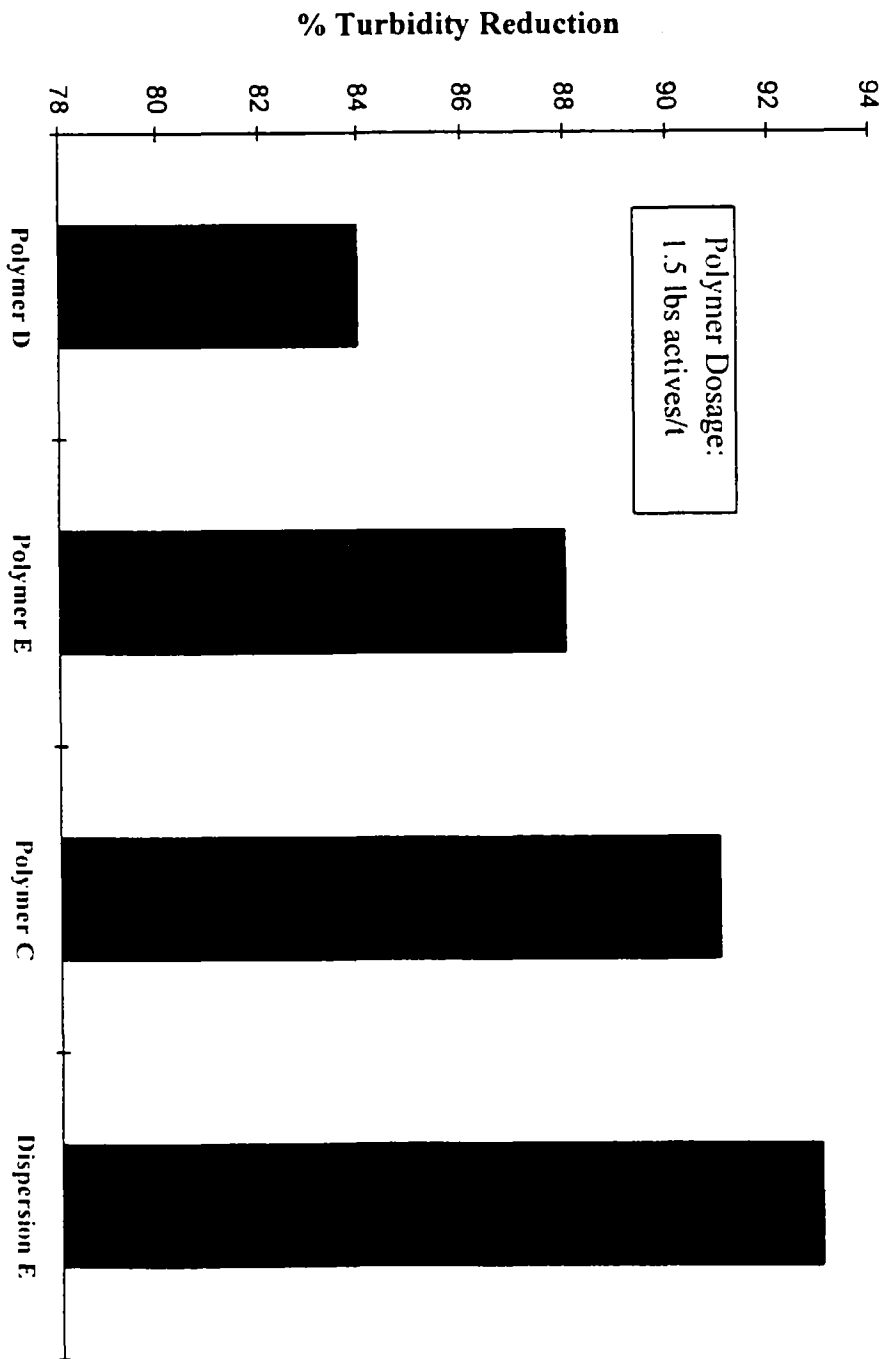
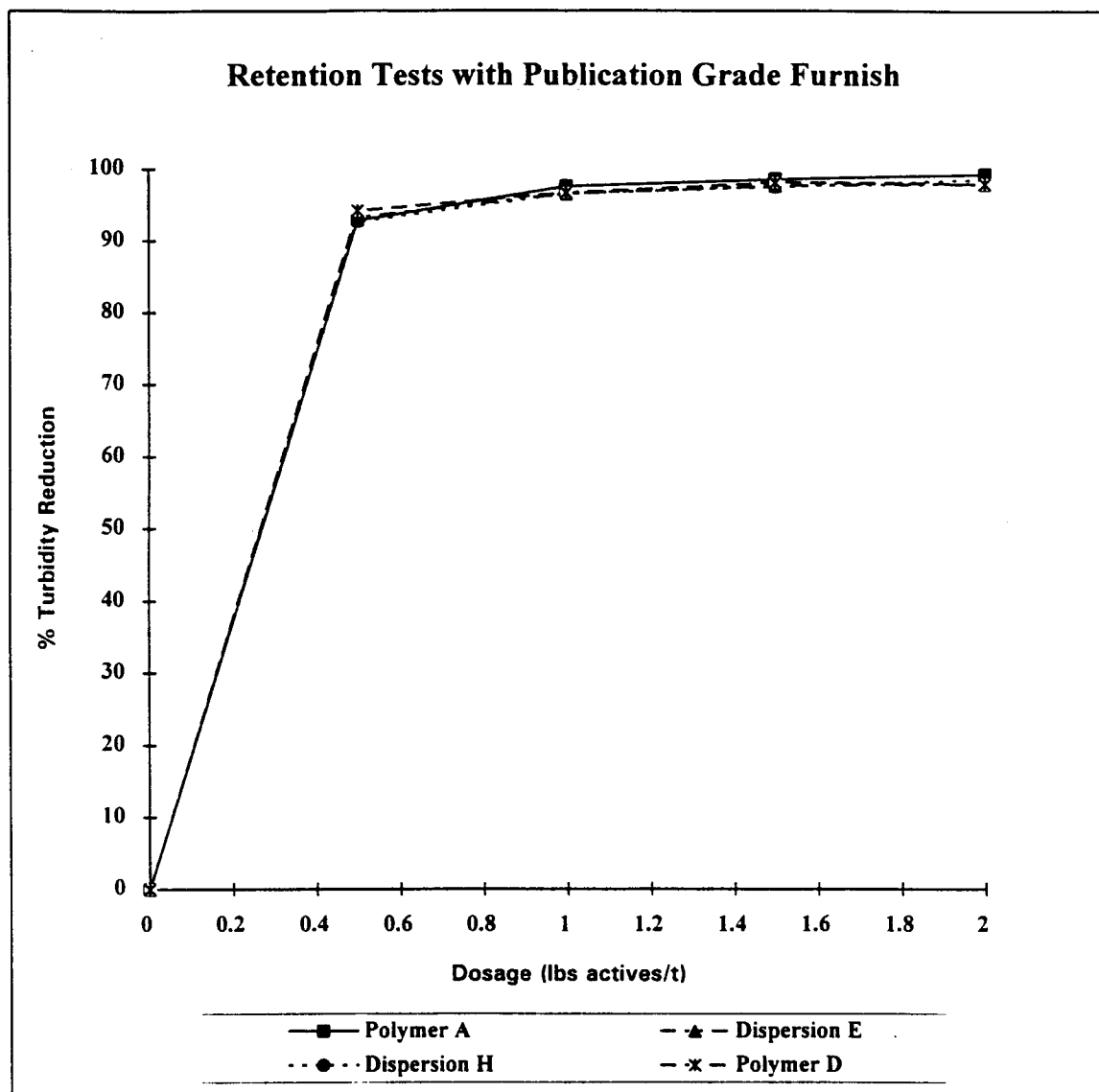
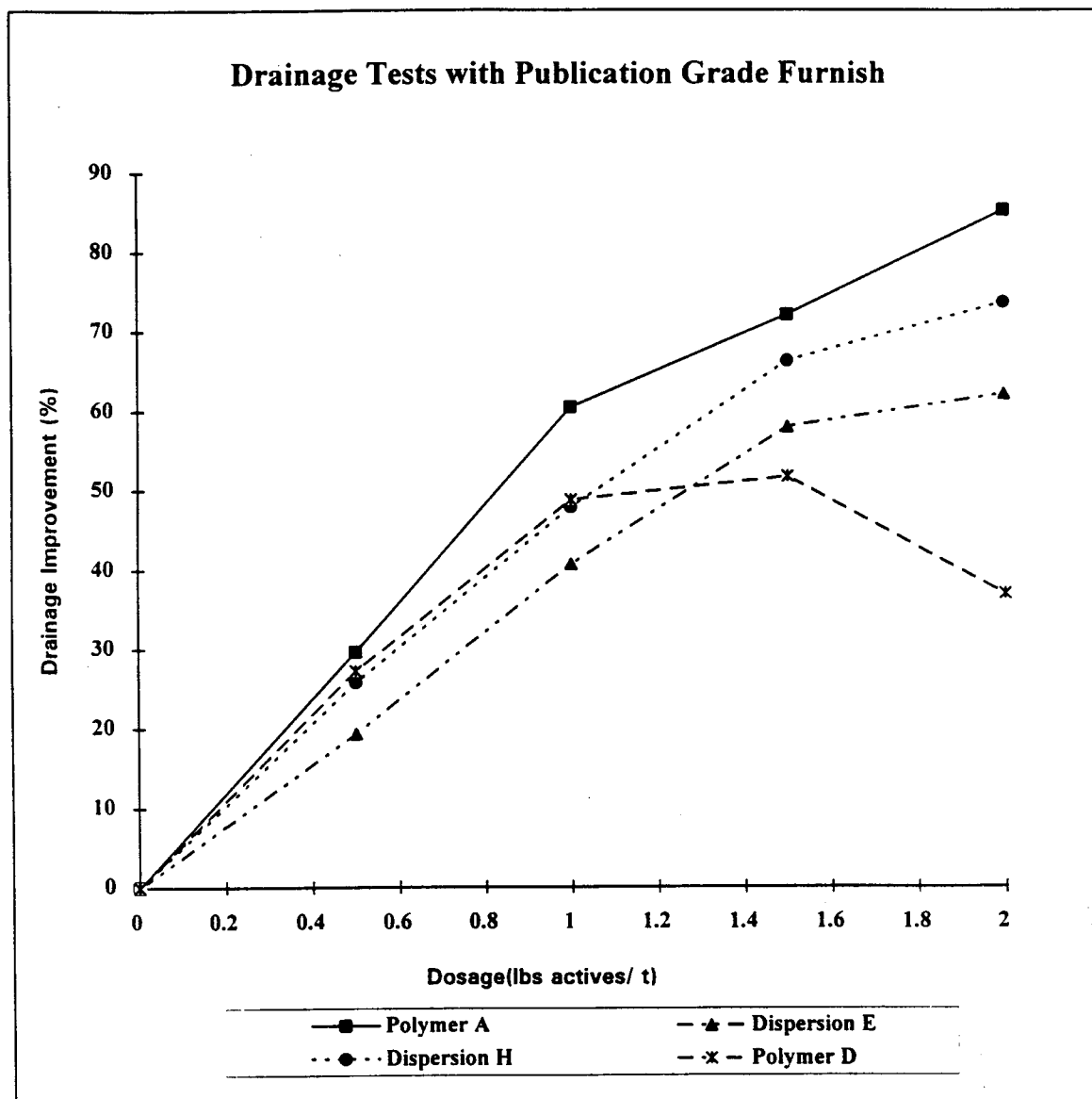


FIGURE 6



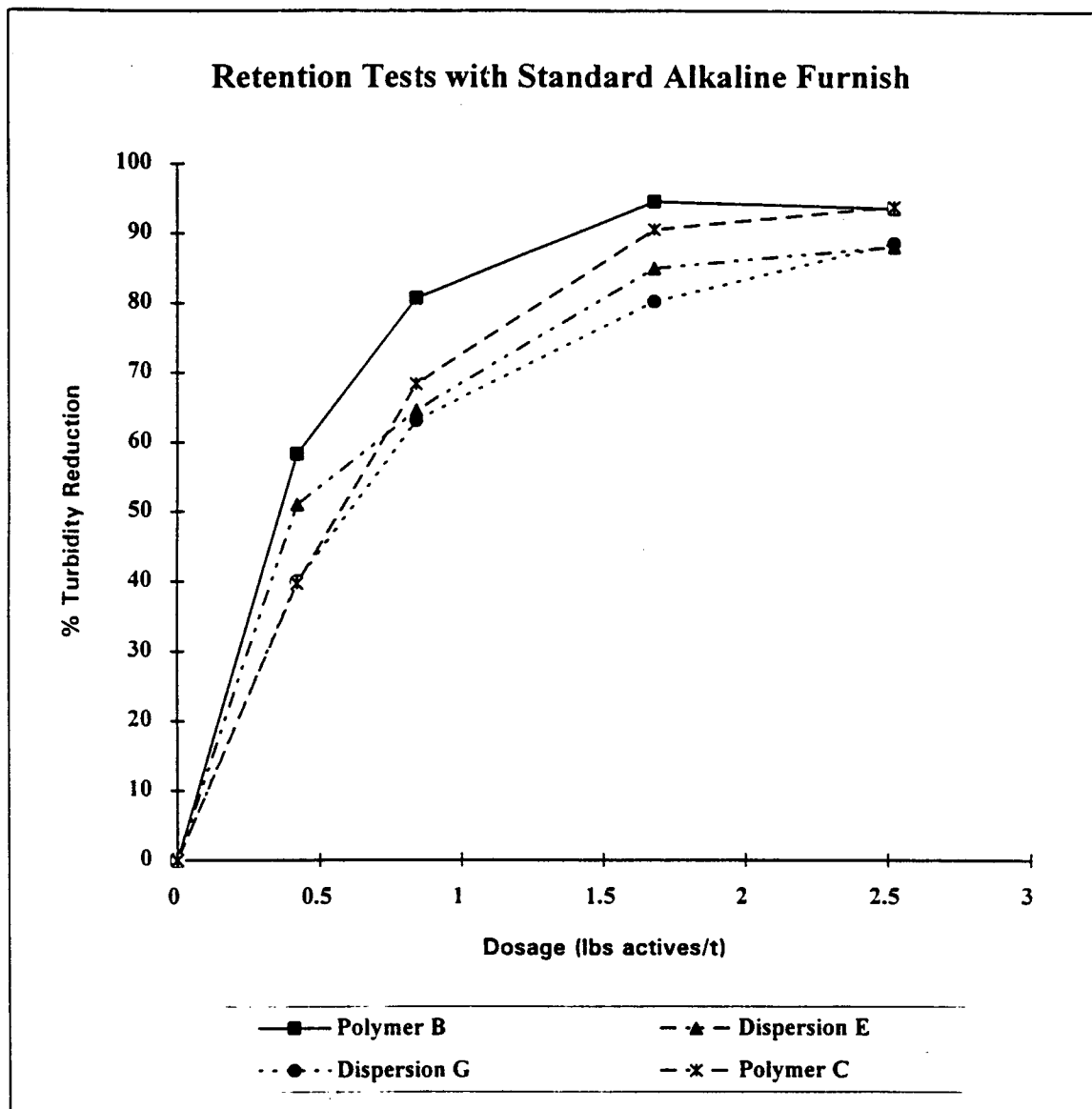
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO3 (dl/g)
Polymer A	10	10	0	17.7
Dispersion E	10	10	0	18.2
Dispersion H	10	10	0	19.2
Polymer D	70/30 mole% AcAm/NaAc		—	—

FIGURE 7



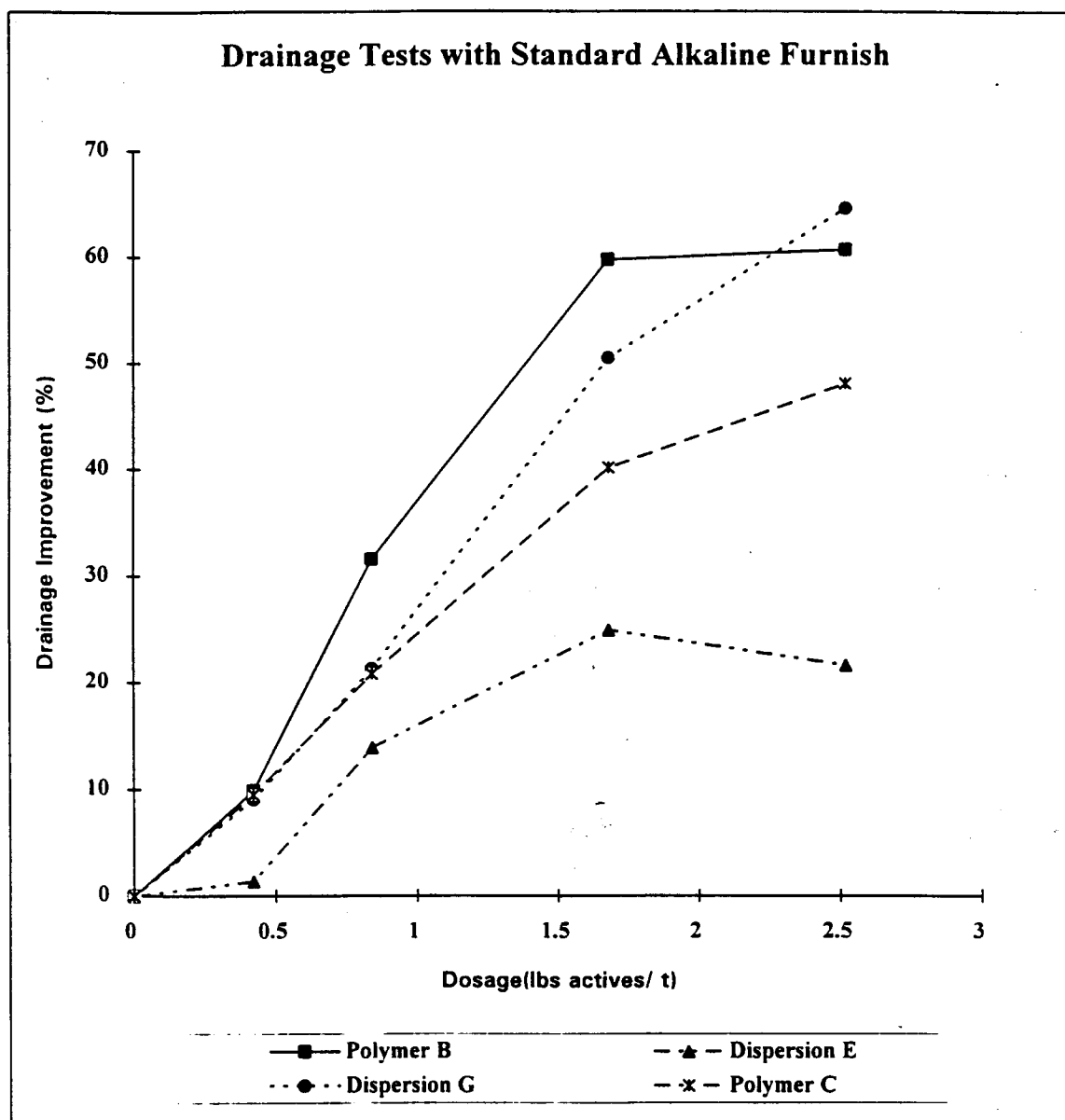
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO3 (dl/g)
Polymer A	10	10	0	17.7
Dispersion E	10	10	0	18.2
Dispersion H	10	10	0	19.2
Polymer D	70/30 mole% AcAm/NaAc		—	—

FIGURE 8



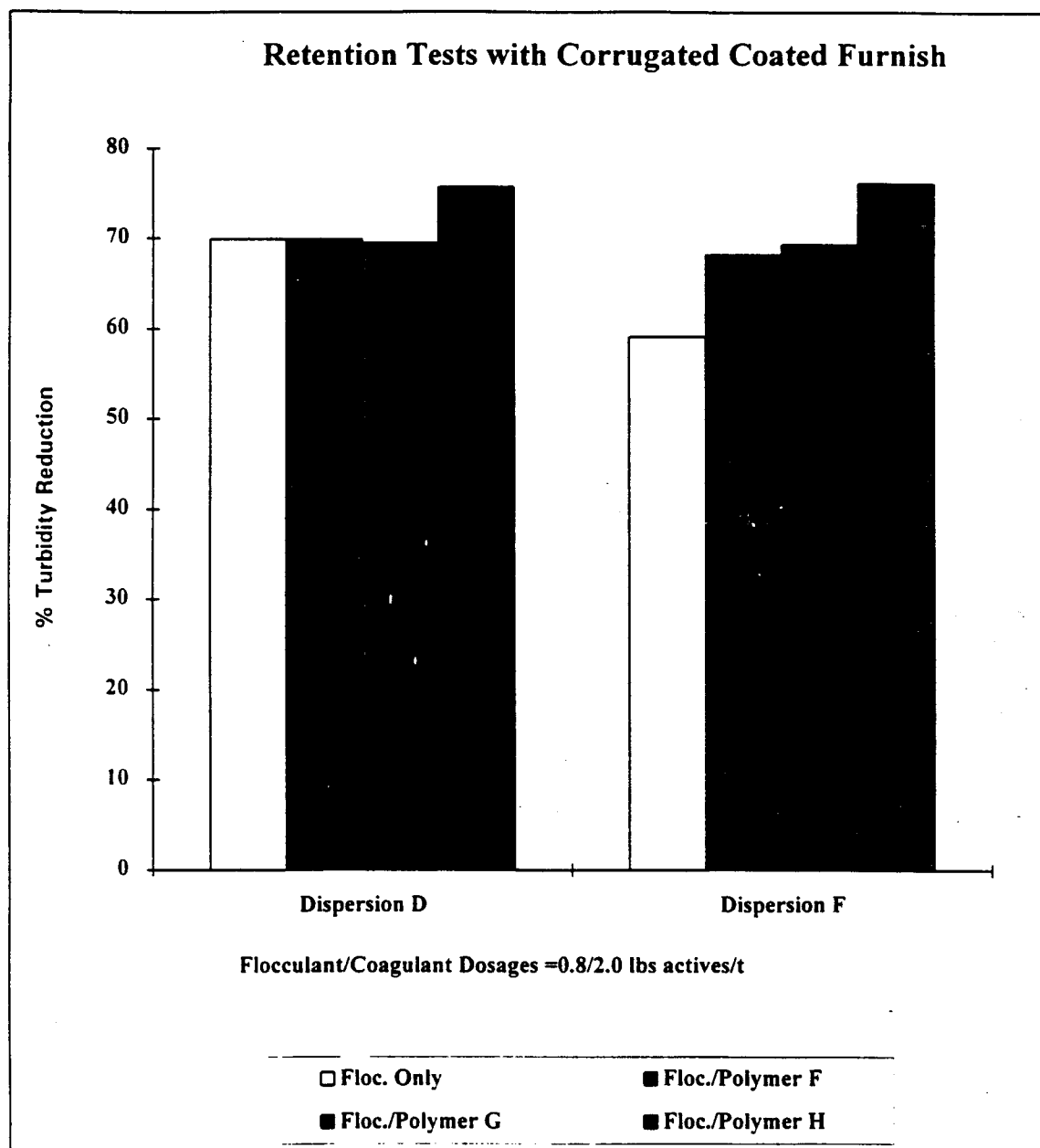
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO ₃ (dl/g)
Polymer B	10	10	0	19.1
Dispersion E	10	10	0	18.2
Dispersion G	20	20	0	19.4
Polymer C	10	0	10	12.9

FIGURE 9



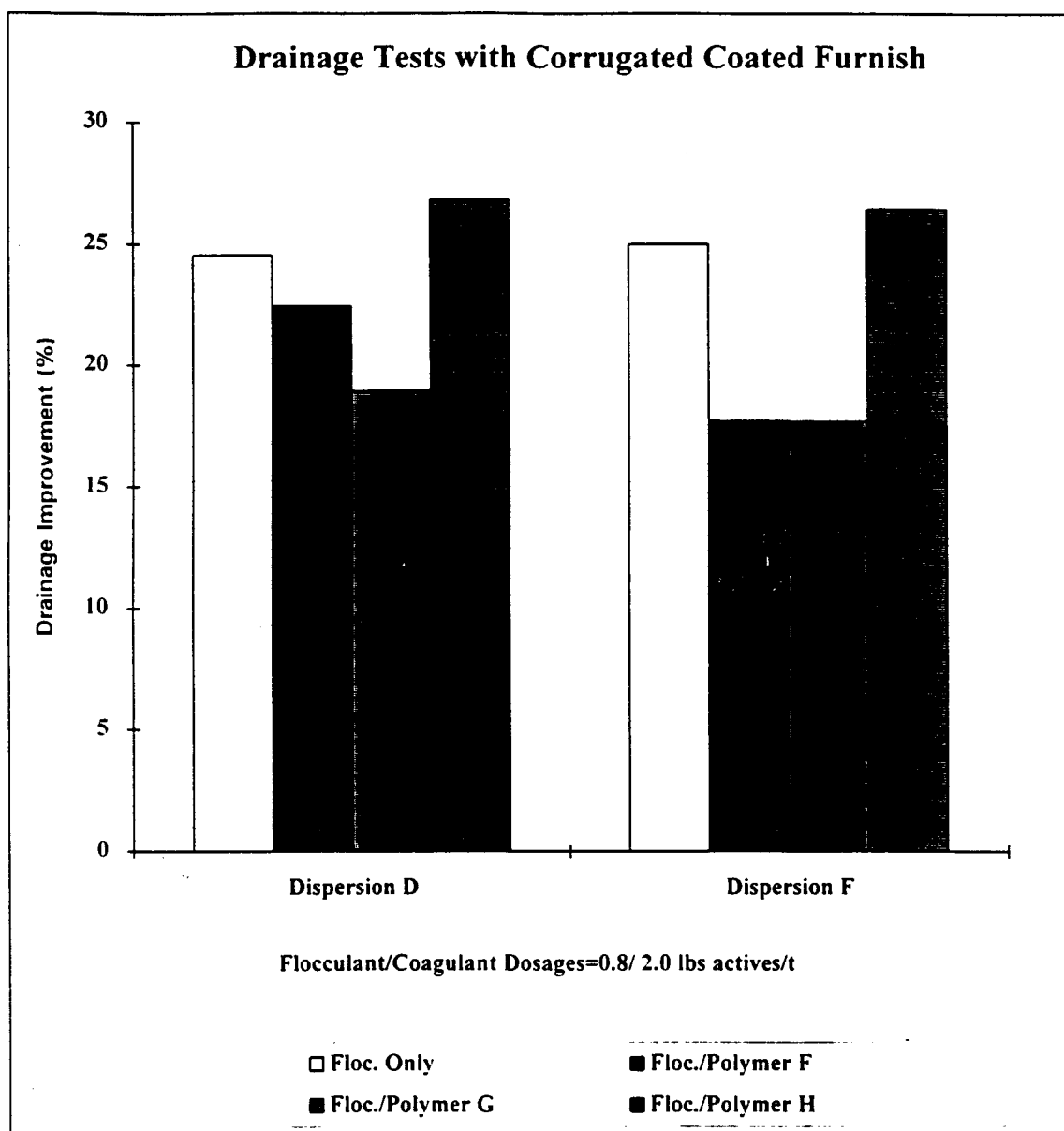
Polymer Description	Cationic Mole %	DMAEA. MCQ Mole %	DMAEA BCQ Mole %	IV 0.125N NO ₃ (dl/g)
Polymer B	10	10	0	19.1
Dispersion E	10	10	0	18.2
Dispersion G	20	20	0	19.4
Polymer C	10	0	10	12.9

FIGURE 10



Polymer Description	Type	Polymer Composition	DMAEA. MCQ Mole %	IV 0.125N NO ₃ (dl/g)
Dispersion D	Flocculant	AcAm/MCQ	10	17.0
Dispersion F	Flocculant	AcAm/MCQ	20	21.2
Polymer F	Coagulant	Epi/DMA	-	-
Polymer G	Coagulant	Poly(DADMAC)	-	Low
Polymer H	Coagulant	Poly(DADMAC)	-	High

FIGURE 11



Polymer Description	Type	Polymer Composition	DMAEA. MCQ Mole %	IV 0.125N NO ₃ (dl/g)
Dispersion D	Flocculant	AcAm/MCQ	10	17.0
Dispersion F	Flocculant	AcAm/MCQ	20	21.2
Polymer F	Coagulant	Epi/DMA	—	—
Polymer G	Coagulant	Poly(DADMAC)	—	Low
Polymer H	Coagulant	Poly(DADMAC)	—	High