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(54) Colloidal alumina as a paper retention aid.

(57) A binder which is added to a paper-making furnish comprising:
a colloidal alumina sol having a positive surface charge and a colloidal alumina concentration in the range between 0.1-1%, the colloidal alumina having a particle size in the range between 1-50 nanometers and is added to the furnish in an amount between about 0.025-0.5% by weight; and
an anionic polymer flocculant which is added to the furnish in an amount between about 0.01-0.1% by weight.

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COLLOIDAL ALUMINA AS A PAPER RETENTION AID

BACKGROUND OF THE INVENTION

The invention dramatically improves the drainage and retention characteristics of a paper-making furnish by the addition of colloidal alumina. In paper-making processes a furnish containing pulp, filler and water is added to the head box of a paper-making machine. The pulp and filler are typically admixed with a binder. The present invention provides a novel binder of a colloidal alumina sol and an anionic polymer flocculant.

Various ionically charged binders have been developed for use in paper-making to increase the drainage of liquids from pulp fibers while increasing the retention characteristics between the fibers. The use of a binder allows the paper-maker to operate at higher speeds because the paper sheet formed is more easily dewatered. Furthermore, retention of added mineral materials used in paper-making processes, such materials being various clays, TiO_2 and other pigments, is also enhanced by the addition of appropriate binders to the furnish.

One particular binder which has been used in paper-making is set forth is U.S. Patent No. 4,643,801 (K. Johnson), issued February 17, 1987. The Johnson patent provides a binder comprising a cationic starch having a degree of substitution ranging between about 0.01 to about 0.20, a high molecular weight anionic polymer having a molecular weight of at least 500,000 and degree of anionic substitution of at least 0.01, and dispersed silica having a particle size ranging from between about 1-50 nanometers. The dispersed silica has a negative surface charge.

In most cases an untreated furnish will have an overall negative charge due to the anionic nature of pulp fibers, fines, and calcium carbonate filler particles in water. Anionic polymers are not very effective as flocculants unless the anionic charge of the furnish is first neutralized by a cationic source. In accordance with the Johnson patent (U.S. Patent No. 4,643,801) the cationic source used in neutralizing the anionic furnish is a cationic starch. The binder constituents used in accordance with the Johnson patent are added to the furnish in the following sequence: cationic starch, followed by anionic polymer, and finally dispersed silica. Additionally, a small amount of an alumina source, e.g., paper-maker's alum, sodium aluminate or polyhydroxyaluminum chloride, may be added to the furnish subsequent to the addition of the aforementioned binder. The alumina source is added in an amount from 0.01-10 pounds of active Al_2O_3 per ton of paper (dried) manufactured.

The present inventor has discovered through laboratory experimentation that the drainage and retention characteristics of a paper-making furnish may be dramatically improved if instead of using the binder set forth in the Johnson patent, i.e., a cationic starch, anionic flocculant, and colloidal silica, a binder comprising a colloidal alumina sol and an anionic flocculant is used. The colloidal alumina used in accordance with the present invention has a positive surface charge, as compared to the negative surface charge of the colloidal silica, which enhances the electroneutrality of the furnish, enhances adhesion by the positively charged alumina to negatively charged pulp fibers, and increases flocculation due to the interaction between the cationic alumina attached to pulp fibers and the anionic polymer flocculant. It has also been discovered by the present inventor that the use of very small particles with a positive surface charge, such as a colloidal alumina sol, can be very advantageous in the paper-making process as will be described below.

The present invention provides for the use of an alumina sol as the cationic source which can be used alone or in conjunction with the cationic starch of the Johnson patent. The colloidal alumina sol of the present invention offers an increase in flocculation and drainage efficiency that cannot be obtained by cationic starches alone, presumably because of the geometry with which the charge is carried, i.e., the charge is contained on the alumina particle rather than in the polymeric form as provided by cationic starches. Furthermore, the use of a colloidal alumina sol does not require the use of dispersed silica in the binder, thus decreasing the overall cost of the binder used in the paper-making process.

The use of a colloidal alumina sol in paper-making furnishes has been disclosed in the following patents and articles: Japanese Patent No. 87/125096, issued June 6, 1987; Alince, B. and Robertson, A. A, "Colloidal Aspects of the Retention of Positively Charged Additives", Pulp Paper Research Institute of Canada, TAPPI, 61 (11), pp. 111-114 (1978); Russian Patent No. 538084, issued December 5, 1976; Japanese Patent No. 76/35712, issued March 26, 1976; and Russian Patent No. 471412, issued May 25, 1975.

Japanese Patent No. 87/125096 discloses a binder which includes:

(a) adding 0.4% of a high molecular weight anionic flocculant, e.g., a terpolymer of (meth)-acrylamide (75-94 mole percent), dialkylaminoalkyl-(meth)acrylamide (5-20 mole percent), and (meth)-

acrylic acid (1-5 mole percent), preferably in a mole ratio of 90:7:3; and

(b) 0.2% of an alumina solution with an alumina concentration of 0.05-1 weight percent, a particle diameter of 5-20 micrometers, and a specific surface area of more than 200 sq. m/g, or polyaluminum hydroxide (0.05-1 weight percent), e.g., colloidal alumina, $AlCl_3$, and/or $Al(OH_3)$.

The use of a colloidal alumina solution as provided in Japanese Patent No. 87/125096 has a number of disadvantages. Initially, the sequence of binder addition in Japanese Patent No. 87/125096 provides for the addition of anionic flocculant followed by a colloidal alumina solution. Since the pulp fibers have an anionic charge, the addition of anionic flocculant is very ineffective in flocculating the pulp due to the lack of electroneutrality in the furnish. The addition of a colloidal alumina solution after anionic flocculant results in poor adhesion between the colloidal alumina particles and the pulp fibers.

Furthermore, Japanese Patent No. 87/125096 makes use of colloidal alumina having very large particle size, i.e., 5-200 micrometers. Use of large colloidal alumina particles is disadvantageous due to their poor adhesion with pulp fibers, reduced surface area and lower particle charge. The use of such large alumina particles requires a much greater total mass to obtain the needed charge for electroneutrality of the furnish which is economically undesirable.

The Alince et al. article discloses the deposition of positively charged quaternized polystyrene and colloidal Al_2O_3 on negatively charged kraft pulp fibers.

Russian Patent No. 538084 describes a method of processing cellulose pulp by adding: 0.5-35% filler; 0.5-1.5% rosin adhesive; 2.5-3% Al_2O_3 and 0.1-0.5% copolymer of (diethylamino) ethyl methacrylate-methacrylamide as flocculant.

Japanese Patent No. 76/35712 discloses a pulp slurry mix with: 10% calcium carbonate filler; 0.5% colloidal alumina; 0.5% epichlorohydrin-modified polyamide; and then 0.3% Na perfluorheptanoate.

Russian Patent No. 471412 discloses a pulp used for the production of drawing and drafting paper which contains: 91.8-96% cellulose; 1-1.2% rosin; 0.5-4% modified starch; and 2.5-3% precipitating agent, such as alumina.

The present inventor has discovered that the sequential use of a colloidal alumina sol followed by an anionic polymer flocculant provides a much improved paper-making furnish, wherein the drainage and retention characteristics are enhanced. The binder of the present invention provides better electroneutrality in the furnish, enhanced adhesion between positively charged colloidal alumina and negatively charged pulp fiber, and increased flocculation due to the interaction between the anionic flocculant and the alumina particles attached to the pulp fibers. Furthermore, the use of much smaller alumina particles provides greater surface area for interaction with the anionic fibers and flocculants, rendering a furnish having improved drainage and retention characteristics. Since charge is proportional to surface area, smaller particles of equal total mass result in a higher particle charge than larger particles. Additional advantages of the present invention shall become apparent as described below.

SUMMARY OF THE INVENTION

It is the primary object of the present invention to improve the drainage and retention characteristics of a paper-making furnish using a colloidal alumina sol. A furnish containing pulp and fillers is added to the head box of a paper-making machine, wherein a binder is admixed with the furnish in the following order:

a colloidal alumina sol having a colloidal alumina concentration in the range between 0.1-1%, the colloidal alumina having a particle size in the range between 1-50 nanometers and is added to the furnish in an amount between about 0.025-0.5% by weight; and

an anionic polymer flocculant which is added to the furnish in an amount between about 0.01-0.1% by weight.

The anionic polymer flocculant is a polymer inverted in water at from about 0.2 0.6% polymer solids and thereafter diluted to about 0.02-0.04% polymer solids. A preferred anionic polymer flocculant is a copolymer of sodium acrylate and acrylamide with a mole ratio of about 31:69. The colloidal alumina sol has a pH in the range between about 4.8-5.2, and a preferred particle size in the range between about 2-4 nanometers.

It is also an object of the present invention wherein the anionic polymer flocculant and colloidal alumina are added to the furnish in a ratio between about 1:10 to 3:1. That is, the colloidal alumina is added in an amount of about 0.5-10 pounds per ton of dry paper manufactured and the anionic polymer flocculant is added in an amount of about 0.15-1.5 pounds per ton of dry paper manufactured.

It is often preferable to add an additional cationic source to the furnish prior to the step of adding the colloidal alumina sol. Additional cationic sources may be those selected from the group consisting of cationic starches, low molecular weight organic coagulants, alum, and combinations thereof. The cationic starches are those having a degree of substitution ranging from between about

0.01-0.20, such as, potato starch, corn starch, or waxy maize. The low molecular weight organic coagulant is typically a 50% active solution of ammonia crosslinked with dimethylamine-epichlorohydrin diluted to between about 0.1-1%. Alum compositions suitable for use as additional cationic sources are paper-maker's alum, sodium aluminate, and polyhydroxyaluminum chloride. The cationic starch is added to the furnish in an amount between about 0-1.25% by weight, and the low molecular weight organic coagulant is added in an amount between about 0-0.25% by weight.

Additionally, it is an object of the present invention wherein the colloidal alumina sol is replaced with either an alum (aluminum sulfate), or a 30% aluminum acetate coated silica sol having a particle size in the range between about 1-50 nanometers and a positive surface charge. The colloidal alumina sol is typically dissolved in water to a concentration in the range between about 0.1% to 1.0% prior to admixing with the furnish. Aluminum acetate coated silica is added to the furnish in an amount between about 0.025 to 0.5% by weight.

The present invention may also include many additional features which shall be further described below.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph which plots the percent drainage improvement versus anionic polymer flocculant dose for silica sol, aluminum acetate coated silica sol, and alumina sol;

Fig. 2 is a graph which plots Alchem drainage versus anionic polymer flocculant dose for silica sol, alum, alumina sol, alum with no starch, and alumina sol with no starch;

Fig. 3 is a graph which plots Alchem turbidity versus anionic polymer flocculant dose for silica sol, alum, alumina sol, alum with no starch, and alumina sol with no starch;

Fig. 4 is a graph which plots Alchem drainage versus anionic polymer flocculant dose for silica sol, alum, and alumina sol; and

Fig . 5 is a graph which plots Alchem turbidity versus anionic polymer flocculant dose for silica sol, alum and alumina sol.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a novel method for improving the drainage and retention characteristics of a paper-making furnish using a colloidal alumina sol. Paper-making furnish typically includes pulp, filler, binder, and water. The furnish is added to the head box of a paper-making machine wherein the pulp fibers are flocculated, dewatered and formed into paper. The binder assists in the flocculation of the pulp fibers and also aids in the drainage of water from the furnish resulting in a dry paper product.

The novel binder set forth herein is admixed with the pulp, filler and water to form a furnish having improved drainage and retention characteristics. The components of the binder are added to the furnish in the following order:

a colloidal alumina sol having a colloidal alumina concentration in the range between 0.1-1%, the colloidal alumina having a particle size in the range between 1-50 nanometers and is added to the furnish in an amount between about 0.025-0.5% by weight; and

an anionic polymer flocculant is subsequently added to the furnish in an amount between about 0.01-0.1% by weight.

It is preferable that the anionic polymer flocculant and colloidal alumina be added to the furnish in a ratio of between about 1:10 to 3:1.

The colloidal alumina sol is approximately 10% colloidal alumina by weight diluted to 0.1-1% with water. The colloidal alumina sol has a pH in the range between about 4.8-5.2. The colloidal alumina used in this solution has a particle size in the range between about 1-50 nanometers, preferably 2-4 nanometers. The colloidal alumina sol is added to the furnish such that the colloidal alumina represents between about 0.025-0.5% by weight of total solids in the furnish. That is, colloidal alumina is present in an amount of about 0.5-10 pounds per ton of dry paper manufactured.

The anionic polymer flocculant is typically a polymer inverted in water at from about 0.2-0.6% polymer solids and thereafter diluted to about 0.02-0.04% polymer solids. One preferred anionic polymer flocculant is a copolymer of sodium acrylate and acrylamide. The anionic polymer represents between 0.01-0.1% by weight of the total solids in the furnish, and also between about 0.15-1.5 pounds per ton of dry paper produced.

The anionic polymer flocculants used in accordance with the present invention are preferably water-soluble vinylic polymers containing monomers from the group acrylamide, acrylic acid, AMPS and/or admixtures thereof, and may also be either hydrolyzed acrylamide polymers or copolymers of acrylamide or its homologues, such as methacrylamide, with acrylic acid or its homologues, such as methacrylic acid, or perhaps even with monomers, such as maleic acid, itaconic acid, or even monomers such as vinyl sulfonic acid, AMPS, and other sulfonate containing monomers. The anionic polymer flocculant may be homopolymers, copolymers, terpolymers or multiple monomeric repeating units. The anionic polymers may also be sulfonate or phosphonate containing polymers which have been synthesized by modifying acrylamide polymers by such a way as to obtain sulfonate or phosphonate substitution, or admixtures thereof. The anionic polymers may be used in solid, powder form, after dilution in water, or may be used as water-in-oil emulsions, wherein the polymer is dissolved in the dispersed water phase of these emulsions.

The anionic polymers have a molecular weight of at least 500,000. The preferred molecular weight is at least 1,000,000, and most preferably having a molecular weight ranging from between 5-25 million. The anionic polymers have a degree of substitution of at least 0.01, preferably a degree of substitution of at least 0.05, and most preferably a degree of substitution in the range between about 0.01-0.95. By degree of substitution, it is meant that the polymers contain randomly repeating monomer units containing chemical functionality which when dissolved in water become anionically charged, such as carboxylate groups, sulfonate groups, phosphonate groups, and the like. As an example, a copolymer of acrylamide and acrylic acid wherein the monomer mole ratio is 90:10, would have a degree of substitution of 0.10. Similarly, a copolymer with a monomer mole ratio of 50:50 would have a degree of anionic substitution of 0.5.

The anionic polymer flocculant to colloidal alumina ratio of between about 1:10-3:1 is based on an anionic polymer flocculant dose of 0.5-1.5 pounds of polymer solids per ton of dry paper manufactured and a colloidal alumina dose of 0.5-5 pounds per ton of dry paper manufactured.

In accordance with another embodiment aluminum sulfate (alum) may be substituted for the colloidal alumina sol as the cationic source used in the furnish.

Also in place of the colloidal alumina sol, a 30% aluminum acetate coated silica sol having a particle size in the range between about 1-50 nanometers may be used as the cationic source in the furnish. The aluminum acetate coated silica is added to the furnish in an amount between about 0.025 to 0.5% by weight. A suitable aluminum acetate coated silica is a 30%, 20 nanometer aluminum acetate coated silica sol with a positive surface charge. This aluminum acetate coated silica sol is typically made from a silica sol having a particle size of approximately 20 nanometers.

It may be preferable in some instances to add an additional cationic source to the furnish prior to the step of adding the colloidal alumina. The cationic source may be one selected from the group consisting of cationic starches, low molecular weight organic coagulants, alum and combinations thereof.

Cationic starches such as those set forth in U.S. Patent No. 4,643,801, which is incorporated herein by reference, are satisfactory for use as additional cationic sources. In particular, a cationic starch having a degree of substitution ranging from about 0.01-0.20 is particularly desirable. Such cationic starches are potato starches, corn starches, and waxy maize. For example, the cationic starch may be a potato starch derivatized to a quaternary amine structure with a degree of substitution of about 0.01.

Instead of using a cationic starch, a cationic coaqulant may be used. Preferably, a low molecular weight organic coagulant having a 50% active solution of ammonia crosslinked with dimethylamine-epichlorohydrin.

Cationic starch is added to the furnish is an amount between about 0-1.25% by weight of total solids in the furnish. The low molecular weight organic coagulant is added to the furnish in an amount between about 0-0.25% by weight of total solids in the furnish. That is, cationic starch is present in an amount between about 0-25 pounds per ton of dry paper manufactured, and organic coagulant is present in an amount between about 0-5 pounds per ton of dry paper manufactured.

It is also possible that an additional cationic source such as alum may be added to the furnish prior to the step of colloidal alumina addition. The alum may be one selected from the group consisting of paper-maker's alum, sodium aluminate, and polyhydroxyaluminum chloride.

The addition sequence when using additional cationic sources is preferentially treating the furnish first with the additional cationic source, followed by the colloidal alumina sol, and lastly adding the anionic polymer flocculant.

EXAMPLE 1

The test was performed on a 50/50 Hardwood Kraft/Softwood Kraft furnish, i.e., pulp fiber, filler, binder and water, with 20-30% calcium carbonate filler. The pH of the furnish was adjusted to between 8.0-8.1. The standard alkaline furnish containing 20-30% calcium carbonate filler was treated by addition of the following:

(a) a cationic starch in an amount of 15 pounds per ton of dry paper manufactured;

(b) either colloidal alumina sol, a silica sol, or aluminum acetate coated silica sol; and

(c) an anionic polymer flocculant.

In accordance with this experiment, the amount of cationic starch was constant at 15 pounds per ton of dry paper produced, whereas the amount of anionic polymer flocculant was increased from about 0-3 pounds per ton of dry paper produced. As shown in Figure 1 six (6) samples were run adding various cationic or anionic binder additives to the standard alkaline furnish set forth above to determine the percent drainage improvement as the dose of anionic polymer flocculant was increased from 0 to 3 pounds per ton of dry paper.

The six (6) samples tested in accordance with this experiment were made up of the following:

(1) no sol addition,

(2) a silica sol having a particle size of approximately 20 nanometers (#20 silica sol),

(3) a silica sol having a particle size of about 4-7 nanometers (#4 silica sol),

(4) a 30% aluminum acetate coated silica sol with a positive surface charge having a particle size of 20 nanometers,

(5) a 30% aluminum acetate coated silica sol having a positive surface charge and a particle size of about 4-7 nanometers, and

(6) a colloidal alumina sol having colloidal alumina particles with a positive surface charge and a particle size of approximately 2-4 nanometers.

Referring to Figure 1, it is clear that the positively charged aluminum acetate coated silica sol outperformed the negatively charged silica sol in improving the drainage as the anionic polymer flocculant dosage was increased. The biggest drainage improvement, however, came from the use of positively charged colloidal alumina sol.

EXAMPLE 2

Testing was performed on a 50/50 Hardwood Kraft/Softwood Kraft furnish with 20-30% calcium carbonate filler. The pH of the filler was adjusted to between 8.0-8.1. Similar to experiment 1 above a cationic starch having a concentration of 15 pounds per ton of dry paper produced was first added to the furnish. The cationic starch was followed by the addition of samples comprising: no sol, silica sol, aluminum sulfate (alum), or colloidal alumina sol.

The purpose of this experiment was to determine if addition of alum would have the same effect on Alchem retention and drainage as the colloidal alumina. The results of experiment 2 are graphically shown in the Figures 2 and 3. With 15 pounds/ton of cationic starch and gradually increasing dosages of anionic polymer flocculant, the samples containing alum yielded the best improvement in both retention and turbidity followed closely by the colloidal alumina. Both of these cationic sources yielded better results in improving the retention and drainage characteristics of the furnish than did the negatively charged silica solution.

While results similar to those yielded by the colloidal alumina were obtained with alum, the colloidal alumina can be used where pH or deposit problems preclude the use of alum.

Experiments were also conducted wherein either alum or colloidal alumina with 3 pounds/ton of anionic polymer flocculant were added to the furnish without any cationic starch. The addition of colloidal alumina with no cationic starch proved to have very good results in both drainage and turbidity testing, as demonstrated in Figures 2 and 3.

EXAMPLE 3

Testing was performed on a 50/50 Hardwood Kraft/Softwood Kraft furnish with 20-30% calcium carbonate filler. The pH of the furnish was adjusted to between 8.0-8.1.

In place of the cationic starch used in examples 1 and 2 above, a low molecular weight organic coagulant having a positive charge was added to the furnish. Thereafter, four (4) samples containing either no sol, silica sol, alum, or colloidal alumina, were added to the furnish. The anionic polymer flocculant was increased from 0-3 pounds per ton of dry paper produced. Using the low molecular weight organic coaqulant, alum, silica sol and colloidal alumina all showed similar improvement in Alchem drainage as depicted in Figure 4, but the colloidal alumina showed a slight adverse effect on retention (turbidity) when an organic coagulant was added as demonstrated in Figure 5.

While we have shown and described several embodiments in accordance with our invention, it is to be clearly understood that the same are susceptible to numerous changes and modifications apparent to one skilled in the art. Therefore, we do not wish to be limited to the details shown and described but intend to show all changes and modifications which come within the scope of the appended claims.

Claims

1. In a paper-making process in which a furnish comprising pulp, filler and water is added to the head box of a paper-making machine, wherein a binder is admixed with said furnish in the following order, said binder comprising:
a colloidal alumina sol having a colloidal alumina concentration in the range between 0.1-1%, said colloidal alumina has a particle size in the range between 1-50 nanometers and is added to said

furnish in an amount between about 0.025-0.5% by weight; and
an anionic polymer flocculant which is added to said furnish in an amount between about 0.01-0.1% by weight.

2. The process according to claim 1, wherein said anionic polymer flocculant and said colloidal alumina are added to said furnish in a ratio of between about 1:10 to 3:1.

3. The process according to claim 1, wherein said anionic polymer flocculant is a polymer inverted in water at from about 0.2-0.6% polymer solids and thereafter diluted to about 0.02-0.04% polymer solids.

4. The process according to claim 3, wherein said anionic polymer flocculant is a copolymer of sodium acrylate and acrylamide.

5. The process according to claim 1, wherein said colloidal alumina sol has a pH in the range between about 4.8-5.2.

6. The process according to claim 1, wherein said colloidal alumina has a particle size in the range between about 2-4 nanometers.

7. The process according to claim 1, wherein said colloidal alumina is added in an amount of about 0.5-10 pounds per ton of dry paper manufactured and said anionic polymer flocculant is added in an amount of about 0.15-1.5 pounds per ton of dry paper manufactured.

8. The process according to claim 1, wherein an additional cationic source is added to said furnish prior to the step of adding said colloidal alumina sol.

9. The process according to claim 8, wherein said additional cationic source is one selected from the group consisting of cationic starches, low molecular weight organic coagulants, alum, and combinations thereof.

10. The process according to claim 9, wherein said cationic starch is one having a degree of substitution ranging between about 0.01-0.20.

11. The process according to claim 10, wherein said cationic starch is one selected from the group consisting of potato starch, corn starch, and waxy maize.

12. The process according to claim 9, wherein said low molecular weight organic coagulant is a 50% active solution of polymer diluted to between about 0.1-1%.

13. The process according to claim 12, wherein said low molecular weight organic coagulant is a solution of ammonia crosslinked with dimethylamine-epichlorohydrin.

14. The process according to claim 9, wherein said cationic starch is added to said furnish in an amount between about 0-1.25% by weight.

15. The process according to claim 9, wherein said low molecular weight organic coagulant is added to said furnish in an amount between about 0-0.25% by weight.

16. The process according to claim 9, wherein said alum is one selected from the group consisting of paper-maker's alum, sodium aluminate, and polyhydroxyaluminum chloride.

17. In a paper-making process in which a furnish comprising pulp, filler and water is added to the head box of a paper-making machine, wherein a binder is admixed with said furnish in the following order, said binder comprising:
an aluminum sulfate; and
an anionic polymer flocculant which is added to said furnish in an amount between about 0.01-0.1% by weight.

18. The process according to claim 17, wherein an additional cationic source is added to said furnish prior to the step of adding said aluminum sulfate.

19. In a paper-making process in which a furnish comprising pulp, filler and water is added to the head box of a paper-making machine, wherein a binder is admixed with said furnish in the following order, said binder comprising:
an aluminum acetate coated silica sol having a positive surface charge and a particle size in the range between about 1-50 nanometers; and
an anionic polymer flocculant which is added to said furnish in an amount between about 0.01-0.1% by weight.

20. The process according to claim 19, wherein said aluminum acetate coated silica is added to said furnish in an amount between about 0.025 to 0.5% by weight.

21. The process according to claim 19, wherein an additional cationic source is added to said furnish prior to the step of adding said acetate aluminum coated silica sol.

22. The process according to claim 19, wherein said aluminum acetate coated silica sol has a concentration of about 30%.

23. A binder for use in a paper-making process in which a furnish comprising pulp, filler and water is added to the head box of a paper-making machine, said binder comprising:
a colloidal alumina sol having preferably a pH in the range between 4,8 - 5,2 and having a colloidal alumina concentration in the range between 0,1 - 1 %, said colloidal alumina having a particle size in the range between 1 - 50 nanometers, preferably in the range between 2 - 4 nanometers, and an anionic polymer flocculant.

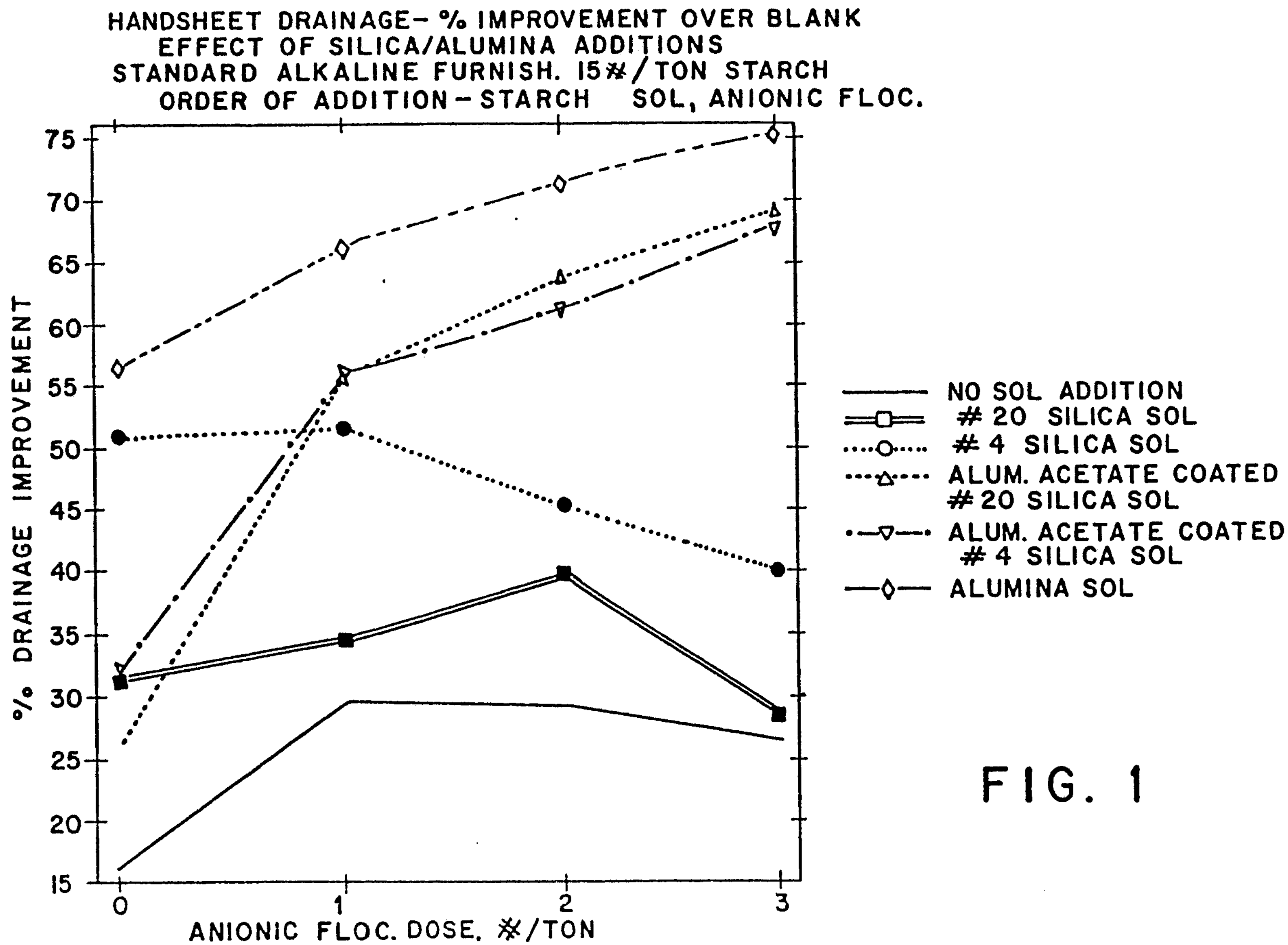
24. The binder according to claim 23, which comprises said anionic polymer flocculant and said colloidal alumina in a ratio of between about 1:10 to 3:1.

25. The binder according to claim 23 or 24, wherein said anionic polymer flocculant is a poly-

mer, preferably a copolymer of sodium acrylate and acrylamide, inverted in water at from about 0,2 - 0,6%copolymer solids and thereafter diluted to about 0,02 - 0,04 % polymer solids.

26. The binder according to any of claims 23 - 25, wherein the colloidal alumina sol is replaced partially or completely with an aluminum sulfate or an aluminum acetate coated silica sol having a positive surface charge and a particle size in the range between 1 - 50 nanometers.

27. The binder according to claim 26, wherein said aluminum acetate coated silica sol is a 30 % aluminum acetate coated silica sol.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EFFECT OF SILICA/ALUMINA ADDITIONS
STANDARD ALKALINE FURNISH. 15#/TON STARCH
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% DRAINAGE IMPROVEMENT
75
70
65
60
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20
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2
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ANIONIC FLOC. DOSE. #/TON
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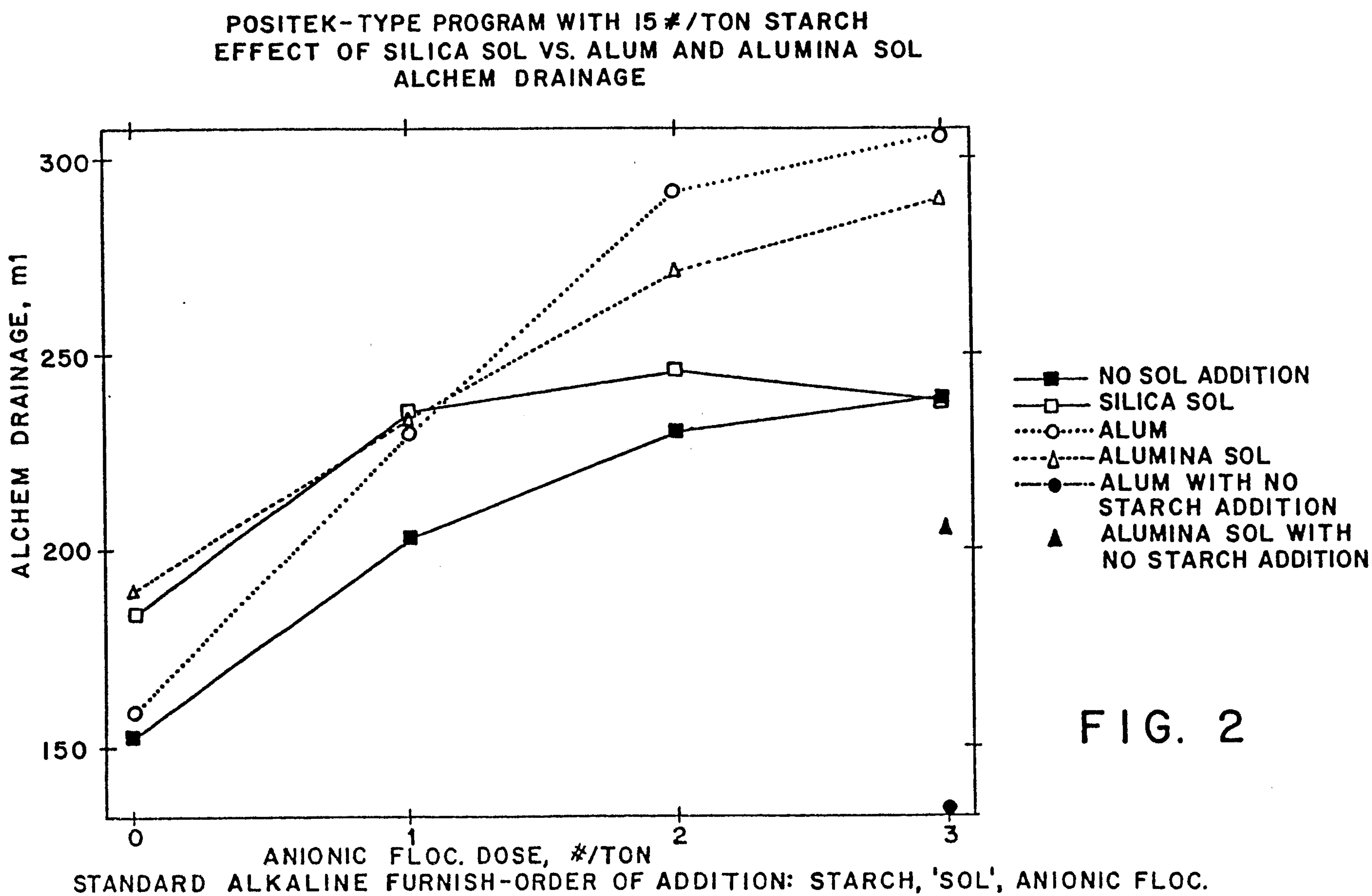
ALUMINA SOL

FIG. 1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ALCHEM DRAINAGE, ml
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250
200
150
0
1
2
3
ANIONIC FLOC. DOSE, #/TON
STANDARD ALKALINE FURNISH-ORDER OF ADDITION: STARCH, 'SOL', ANIONIC FLOC.
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ALUMINA SOL WITH NO STARCH ADDITION

FIG. 2

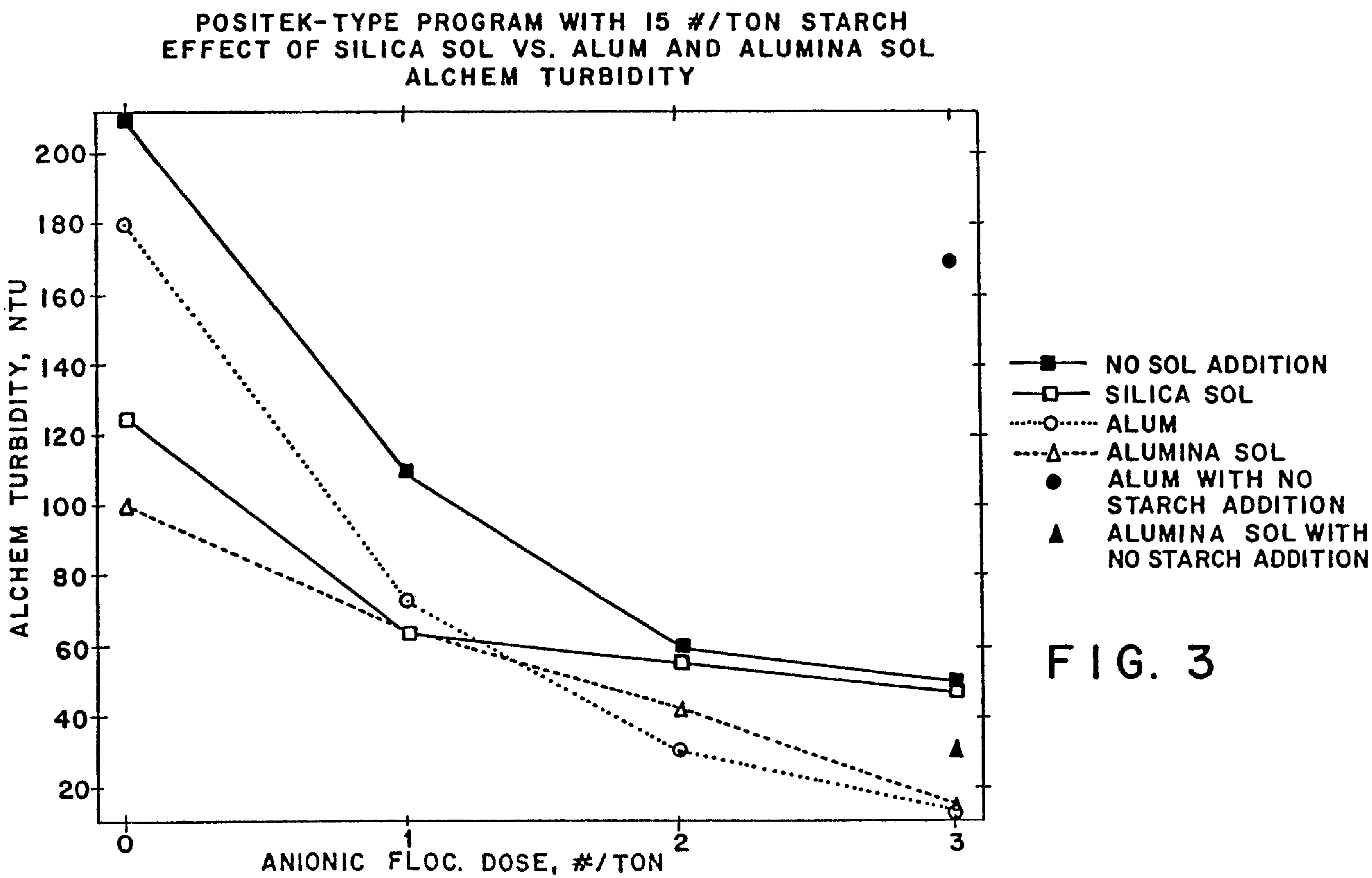

FIG. 3

STANDARD ALKALINE FURNISH-ORDER OF ADDITION: STARCH, 'SOL', ANIONIC FLOC.

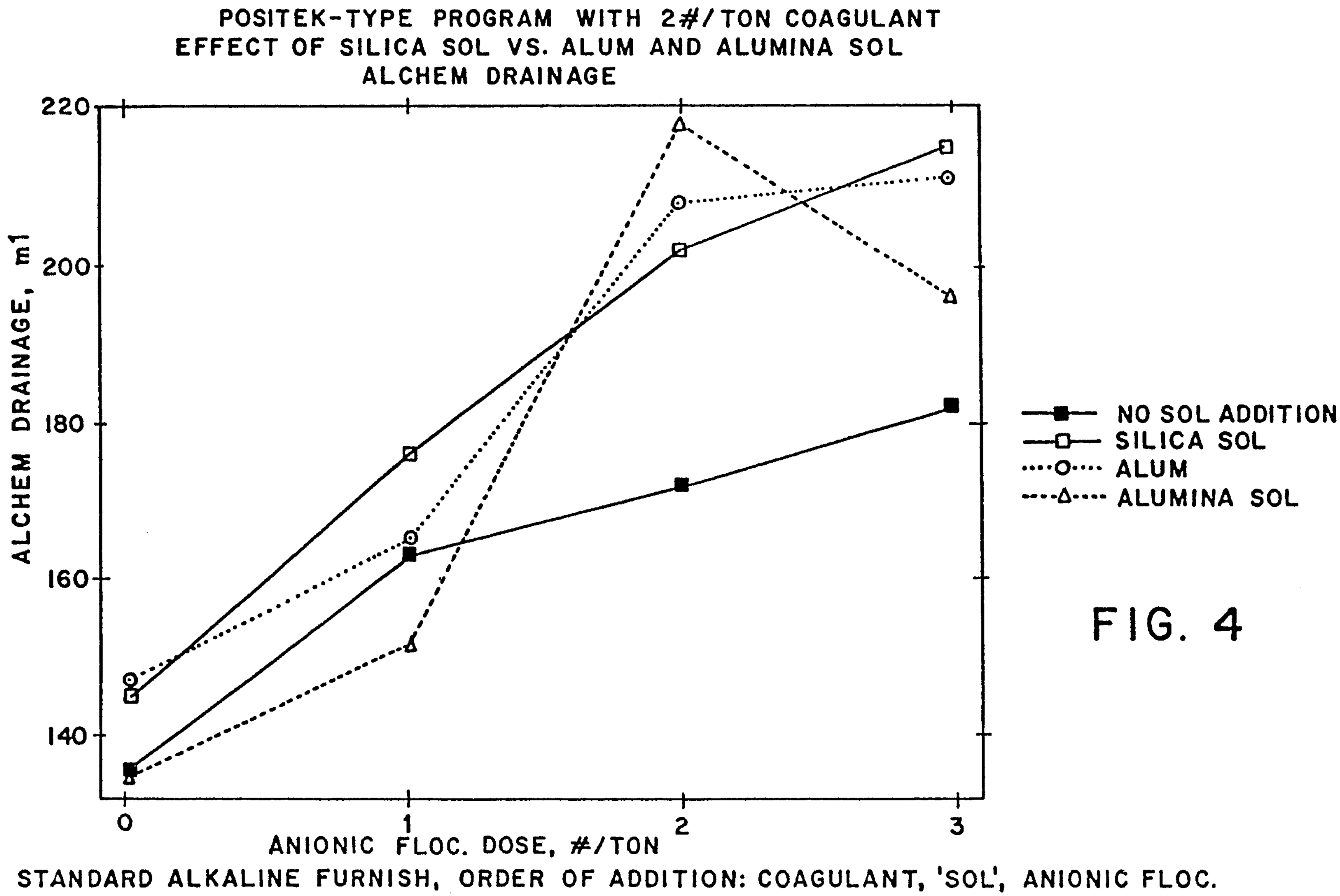
POSITEK-TYPE PROGRAM WITH 2#/TON COAGULANT
EFFECT OF SILICA SOL VS. ALUM AND ALUMINA SOL
ALCHEM DRAINAGE
ALCHEM DRAINAGE, ml
220
200
180
160
140
0
1
2
3
ANIONIC FLOC. DOSE, #/TON
STANDARD ALKALINE FURNISH, ORDER OF ADDITION: COAGULANT, 'SOL', ANIONIC FLOC.
NO SOL ADDITION
SILICA SOL
ALUM
ALUMINA SOL

FIG. 4

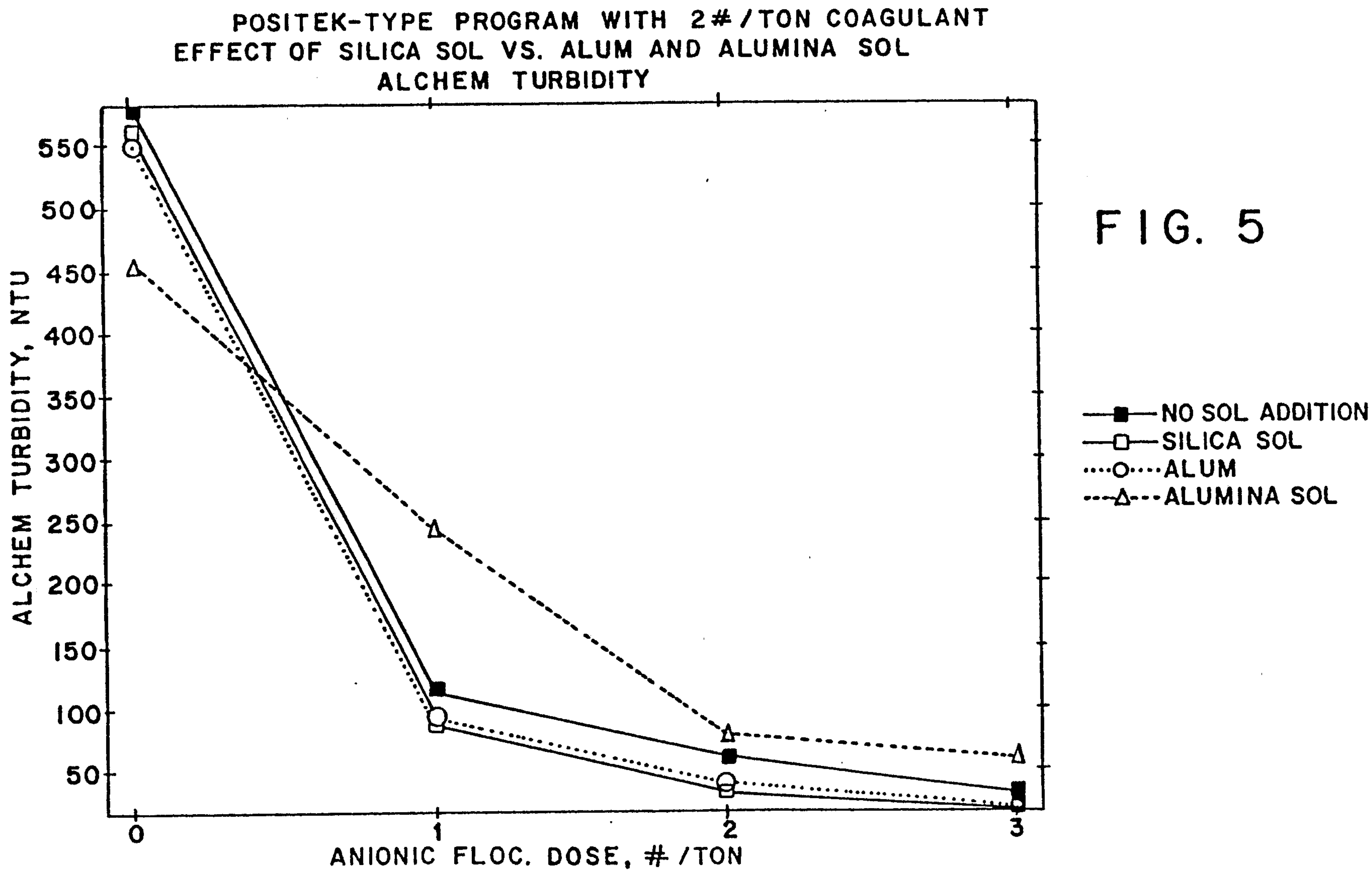

FIG. 5

STANDARD ALKALINE FURNISH-ORDER OF ADDITION: COAGULANT, 'SOL', ANIONIC FLOC.