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THE EFFECT OF SIZING AND WET*-STRENGTH AGENTS
ON THE EASE OF INK REMOVAL IN RECLAIMING OF
INK PRINTED WASTE PAPER.

By

EBERE ONWUNEME

A Thesis Submitted to the Faculty
of the Department of Paper Science
and Engineering
in
partial fulfillment of the
Degree of Bachelor of Science

Western Michigan University

Kalamazoo Michigan

April 1979.

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INTRODUCTION

The new call for conservation of resources inherent in the ecological movement has put a spotlight on the recycling of materials. Not the least of these materials are paper and paperboard of which some 58 million tons were used in the United States in the year 1969. About 40 million tons of this was discarded which resulted in a severe trash removal problem. Paper accounts for 35% of the total solid waste collected and disposed of in most municipalities. 1

Burning, or interment in a sanitary land fill are not the only means of paper disposal. It can be recycled and reused. However, industries using wood fiber face a common problem for the future: how will the raw material demand of the next two to three decades be met and the problems of the chemicals used in the manufacture of waste paper. Recycling is a complex problem whose health and growth will depend on a multitude of factors which includes the development of advanced processing techniques. 1

In recent years, efforts have been made to repulp all available and to reintroduce recovered fibers, (termed secondary fibers), to the paper machine. The major obstacle that this process faces is the fact that the properties of many of the materials applied to paper during converting operations disable conventional pulp cleaning equipment from removing them from secondary fiber pulps. though if not taken out, their thermoplastic properties or inherent tackiness will create major problems on the paper machine. Among these contaminants are sizing and wet strength agents applied to the virgin fiber to increase or improve their bonding strength properties but these pulping render the waste paper hard to repulp. This is not surprising since the increase in the strength of the fibers are due to their presence. 1, 2, 4

In the pulping of waste paper, another problem is the removal of printing inks. The ink mostly affects the brightness of the secondary fiber by reducing it. Efforts have been and are currently being made to develop the techniques of ink removal and to explore the knowledge of the effect of additives on ink removal. Since sizing and wet strength agents play a role to the fibers in their bonding properties, one can assume that they also play a role in the bonding of the ink to the paper.

Hypothetically, when a nail is nailed into there are three forces acting on the nail: the force used to drive the nail in, and the horizontal and vertical forces exerted on the nail by the wood. This is the case in the bonding of ink to paper. The force in the ink is supplied by the ink binder while the horizontal and vertical forces are supplied by the paper. There are no technological limitations on the reuse of newsprint and paperboard. However, there are technical, processing, and economical problems in the reuse of magazine and most miscellaneous grades due to filler materials such as clay, resins, starches, hot melt adhesives, certain inks, and noncellulose inserts and staples.

The investigation of the effect of sizing and wet strength agents on ink removal and the resulting problems form the basis of this research. In order that the reader have a thorough understanding of this investigation, I will first review the chemistry of sizing and wet strength agents.

SIZING AGENTS

The permeability of paper to fluids is an important property in the recycling process. Sizing implies to the resistance of paper to the penetration of liquids; primarily aqueous writing inks and non-aqueous printing inks. Paper which is resistant to inks is called sized paper and non-resistant paper is called unsized paper. This paper will concentrate on the effect of sizing on the process of printing ink removal. (2)

The two principal sizing processes are Internal sizing and Surface sizing. Internal sizing consists of mixing a sizing agent with a fibrous furnish and forming the entire mass into a sheet containing a uniform distribution of fibers and sizing agent. Surface sizing is the application of sizing agents to the completed paper. Materials used in paper sizing agents include animal glue, rosin size, synthetic resins, casein, polyvinyl alcohol, starch, and wax emulsions. Rosin size will be used in this paper. (2)

Rosin size increases the angle of contact between the fiber surface and water as it also facilitates the penetration of oil-based inks. The distribution of Rosin sizing is directly related to the consistency of the stock: the higher the consistency, the poorer the distribution. The amount of sizing to be used ranges between 0.75% and 2% of the fiber weight and the PH of the system should range between four and five. (2)

SURFACE SIZING

In surface sizing, the sizing agent is applied directly to the paper's surface where it cements the fibers to the body of the paper, and deposits a more or less continuous film on the paper surface. The advantage of surface sizing is that a smooth hard film is produced on the surface of the paper which will not catch the pen when the paper is written upon and will not pick if paper is printed with tacky inks. The oil resistance of paper is increased since the surface pores of the paper are sealed. 2

AQUAPEL EMULSION

Aquapel alkyketene dimers are highly effective sizing agents that reacts directly with cellulose under neutral or alkaline conditions. These reaction conditions produce brighter, stronger, more permanent and highly sized paper. They are applicable in emulsion form. Aquapel Emulsion 360XC is a 6% solids emulsion with a cationic starch derivative that serves as a protective colloid. 10

Product Specifications.....

Total solids, %..... 7.7 \pm 0.2
Aquapel dimer content, %.... 6.0 min.

Typical properties

Ionic character..... cationic
Density at 25°C, lbs/gal (kg/liter)..... 8.50(1.02)
Specific gravity at 25/15.6°C..... 1.02
Viscosity, centipoises at 25°C..... 25-100
Average particle size, microns..... 1.0
pH..... 3.5-4.0

Compatibility: Alum seriously impedes the reaction between Aquapel and cellulose, and every effort should be made to keep alum out of the system when Aquapel is used. Some fillers, such as diatomaceous earth and small-

particle -size clays,also interfere with this reaction. (10)

Typical uses

Internal addition; Optimum results are obtained by adding the diluted Aquapel emulsion to dilute stock close to the paper machine. Violent agitation after addition is harmful. Optimum results are obtained by adding the Aquapel emulsion to dilute stock close to the paper machine.

Even though Aquapel contains a cationic starch derivative the quantity is not enough for sufficient retention, To attain maximum sizing, it is usually augmented with a cationic retention aid such as Kymene 557H. For surface sizing, Aquapel may be supplied as a dilute solution, a normal size-press component, or a calendar solution. During this process the temperature should be kept below 150°F (66°C) to limit (10) hydrolysis of the alkylketone dimer. Under neutral or alkaline conditions, Aquapel reacts directly with the hydroxyl groups on the cellulose to form an ester that is water repellent and chemically inert. The efficiency rate directly increases with pH, therefore, the reaction can be completed within one to three days after removal from the paper machine. Following is an analytic chart of Aquapel:

TYPICAL PROPERTIES

IONIC CHARACTER ——— CATIONIC
DENSITY AT 25°C ——— 8.50 lbs/gal (1.02 kg/liter)
SPECIFIC GRAVITY AT 25/15.6°C ——— 1.02
VISCOSITY, CENTIPOISES AT 25°C ——— 25 thru 199
AVERAGE PARTICLE SIZE (MICRONS) ——— 1.0
pH ——— 3.5 thru 4.0

DIMER CONTENT — 6.0 min.
TOTAL SOLIDS — 7.7%
DIMER CONTENT 6.0 min. (10)

wet strength

Wet strength is defined as a paper which has extraordinary resistance to rupture or disintegration when saturated with water. Untreated paper made from cellulose fibers retain only 5-10% of its dry strength after being wet with water. After applying wet strength, the amount of dry strength ranges between 10% and 40%. When wet strength has been cured and then exposed to high humidity, it gradually loses its wet strength. The rate of loss is accelerated by any increase in temperature or acidity. To remedy this, methods using low pH, elevated temperature and agitation are employed. It is frustrating to define wet strength broke in neutral cold water by mechanical action. 4,12

KYMENE 557H

Kymene 557H is a high efficiency cationic wet strength resin that functions under acid or alkaline papermaking conditions. It is primarily used to impart wet strength. The following chart depicts its components of this compound: (9)

TYPICAL PROPERTIES

APPEARANCE	PALE AMBER LIQUID
TOTAL SOLIDS	12.5% ± 2.2
WEIGHT	8.62 lbs/gal (1.03 kg/liter)
VISCOSITY AT 25°C, cps	40 thru 60
pH	4.6 thru 4.9
FREEZING POINT	30°F (-1°C)
NITROGEN, DRY BASIS (KJELDTHA:)	12.8%
SHELF LIFE STORED BELOW 90°F (30°C)	3 months

WET STRENGTH APPLICATION

Kymene 557H is effective over a stock pH range of 4-10; however, best performance is obtained at pH 5.5 to 9.0. Optimum results are obtained by adding diluted Kymene 557H to high consistency stock, either before or after refining. The wet strength obtained with Kymene 557H is highly permanent i.e., 95 thru 100% of its original wet strength is retained after prolonged exposure to heat, high humidity, hot

and cold water, or acidic and mildly alkaline penetrants.

(7)

PAPER AND BOARD SIZED WITH AQUAPEL

Writing papers and milk carton are some of the grades now sized at neutral pH with Aquapel. Better fiber and filler retention and improved sizing efficiency are the primary advantages of using Kymene 557H in writing papers sized with Aquapel. (9)

MECHANISM OF RETENTION

The absorption and retention of polymers by cellulose fibers has a major importance in modern papermaking. Addition of small amounts of suitable polymers to the fiber-water system improve fiber dispersion, enhance fiber to fiber bonding, and produce improvements in wet and dry-strength properties of paper and paperboard. Total free energy of the system may have several components such as the interfacial and surface energies, solvation energy, and configurated free energy (entropy). To attain retention, the change in surface and configurated energies upon absorption of a highly solvated substance must be greater than the change of its solvation energy.

The Thermodynamic Theory of heterogeneous systems decrees that a spontaneous process such as absorbtions on a solid surface, must involve a reduction of the overall free energy of the system. The equation

$$\Delta F = \Delta H - T\Delta S \quad \text{where}$$

- ΔF = the change in free energy of the system
- ΔH = the heat of absorption of the process
- T = the absolute temperature
- ΔS = the change in the entropy of the system (4)

Under certain conditions, the interfaces of colloidal particles may acquire a preferential electrical charge that helps determine their stability and rate of configuration. This influences the rate and extent of absorption of electrically charged wet strength resins by electrically charged cellulose fiber surfaces. The three methods by which a surface may become electrically charged are 1) direct ionization of the surface, 2) preferential absorption of a particular type of ion, and 3) electricification by contacts similar to the triboelectric and piezoelectric effects. The electrical charge on the particles becomes significant to the system's behaviour if the solid is dispensed in fine particle form within a liquid or if any two phases possess a large surface area-to-volume ratio. 4, 12

The acquisition of the electrical charge gives rise to an electrical double layer on the surface of the solid, that is believed responsible for the primary electrokinetic effects, electrophoresis, electroosmosis, streaming potential and current, sedimentation potential, and the secondary electrokinetic phenomena of surface conductance and electroviscosity. (4)

The fundamental quantity is the electrokinetic effects is the so-called zeta potential, which is the potential drop across the movable part of the electrical double layer system at the interface of the solid particle. The zeta potential has commonly been related to the stability of colloidal particles in terms of the electrical repulsion or attraction developed when two electrical double layers begin to interpenetrate. If two or more particles have zeta potentials which are alike in sign and sufficient in size, the colloidal system is generally stable. Coagulation can occur when the potentials are low or unlike in sign because of ubiquitous Van Der Waals forces of attraction between the particles. Zeta potential has been quantitatively useful in explaining peptization and flocculation of finely divided solids and liquids. (4)

Present wet strength resins obtain their cationic charge through direct ionization of nitrogen atoms within the polymer structure. If the charge density (the number of electrical charges per repeating unit) is too high, the interaction of such polymer with the negative electrical charge on the cellulose fiber produces an isoelectric condition and little polymer is absorbed by the cellulose fibers. Under those conditions, very little wet strength resin may be absorbed to produce the desired degree of wet strength in the final paper. (4)

To successfully remove inks from paper stocks, it is desired to know both their ingredients and their reaction towards deinking agents. It is also important for the papermaker to understand the general trends in inkmaking practice for future developments. The ink industry realizes how well the dependant paper mills would welcome an ink, which, despite such properties as instantaneous drying, scratch resistance, alkali proofness, e.t.c., could also be easily removed from the stock. However, since that is a property contradiction there has been little exploration of this possibility. Unless buyers can be persuaded to moderate their resistance demands, the modern papermaker can expect more, rather than less, difficulties in the future. 3, 5

The four major printing processes in use today are typographic, lithographic, rotogrowing, and flexographic and the inks for each have individual characteristics. The ink used for this research is litho offset. 3, 5

Inks primarily consist of a) pigments, b) a binder or non-volatile vehicle, c) solvent, d) drier and e) additives.

PIGMENTS

Pigment is the coloring of the ink. The most important purpose of deinking is to eliminate the color which the pigments add to the stock. Pigments are really supernumeraries in the deinking process; the binder that is used with them plays the most important role. Many pigments are immune to alkalis, e.t.c., but they may be released by the binder when it is attacked by deinking reagents and they are flushed away while suspended in the solution. Titanium Dioxide, Lithopone, Carbon and Lamp blacks, Ultramarine and phthalocyanine blues, and many others react in this manner. Alkali decomposes most inks to a soluble colorless ferrocyanide with a residue of iron oxide or hydroxide which have a

(11)

tendency to precipitate on the fibers unless silicate or phosphate agents are present to hold them in suspension. Some organic colors remain unaffected by alkali while others may be decolorized or change to a different hue. 3

BINDERS OR VEHICLES

The required drying rate and the use specifications determine vehicle composition more than the mode of application. Typographic and Lithographic inks are very similar as it is difficult to discern the two. High speed printing allows no time for oxidization or polymerization: the vehicle must instantly convert to a dry solid from a liquid. The only way to achieve this is to use a rosin agent in a solvent that evaporates from the thin film in a fraction of a second. The remaining binder must be hard and free from stickiness in the disappearance of the solvent. 3

Another class of lithographic inks with fast air drying characteristics are known by various trade names but are generically called "Wink_dri". Used on speedy jobs, and where the run is not large enough to warrant the make-ready and costs of putting it on a heat-set press, they depend upon the dispersion or latex, finely divided, undissolved synthetic or derivative rubber particles. Upon application, the volatile portions of the vehicle are rapidly absorbed or evaporated and the solid rubbery particles remain with the pigment as a dry film on the paper surface. Although these inks are strongly alkali-resistant they will be employed in this experiment. 3

SOLVENTS AND DRIERS

Solvents regulate the consistency of the ink for application but disappear before the paper is complete. Only those inks which contain oxidizable oils or alkyd resins have driers. Being metallic compounds (Cobalt, Lead, Manganese), they act as catalysts and speed up the absorption of oxygen, but have no effect on the resin used in heatset, steamset, rotogravure, or flexographic inks. 3

The composition of "compounds" added to various kinds of inks are another problem in the deinking process. They are usually blends of waxy materials with solvents, oils, and driers. Judiciously mixed by the manufacturer or the printer supposedly to assure better performance on the press but in reality making the ink shorter or less inclined to pick the paper. Compounds containing polyethylene are being added to a considerable variety of inks so that one must keep a sharp lookout for trouble. 3

The surface-active agents and other miscellaneous additives in ink are employed in such a minute quantities that they exert no appreciable influence in deinking. Surface active agents help to emulsify the pigments and binders in the alkaline solution. In general, inks contain many oils, resins, and waxy materials which meet buyer's demands and are difficult to remove by deinking agents. 3

REPULPING OF POLYAMIDE-TYPE WET-STRENGTH BROKE

Kymene 557, an alkaline curing wet strength resin, has recently been made available to the paper industry. The resin is a cationic water soluble condensate of a basic polyamide and epichlorohydrin, and can be introduced at any point in the wet end of the papermaking process. It may be used efficiently over a pH range of 4-10, although 6-8 is preferred. Broke containing polyamide type wet strength resin can be repulped in the presence of NaOH at a pH=10 and a temperature of 38°C. The rate of repulping is not increased significantly at higher temperatures. The use of hypochlorite ion, or other oxidizing salts, increases the rate of repulping substantially, the rate in this case being dependant upon the concentration of the oxidizing salt, the pH of the slurry, and the temperature. This method is particularly useful with bleached brokes. 7

Paper containing a wet strength resin requires the use of special techniques or procedures not commonly used in the reworking of non-wet-strength broke. For example, paper wetted with ureaformaldehyde or melamine-formaldehyde resins may be reclaimed best in hot water in the presence of alum or dilute acid. In general, at any given temperature condition and pH level it takes twice as long to defiber ⁷ melamine-formaldehyde resin broke as it takes to defiber ureaformaldehyde resin broke. Kymene 557 imparts a satisfactory degree of wet strength to a sheet when used at any pH from 4-10. The use of this resin makes it possible to produce paper having a high degree of wet strength under alkaline conditions. Among the advantages are increased softness, absorbency and strength of the sheet, and reduction in the amount of downtime due to corrosive action on drier surfaces and wires. Among these is the repulping of alkaline-curing resin wet strength broke. The difficulty encountered in repulping polyamide-type broke is not especially dependent on the age of the broke. Artificial curing (heating at 105°C for one hour) develops wet strength as measured by tensile strength 20 to 40% beyond the amount usually obtained by natural curing. This additional curing, increases the difficulty with which the broke can be repulped. ⁷

The two ways in which internal addition wet strength may be removed or rendered ineffective are by extensive mechanical work in refiners or by breaking the resin molecules either or without breaking the fiber bonded resin. The first additional refining is usually undesirable not only because of the production costs but because its success depends on the smaller, shorter fibers and increased fines concentration which leads to increased losses in white water and production of a weaker sheet. The second way involves chemical reaction with a part of the resin molecule in contact with or bonded to the fiber. Urea⁶-formaldehyde and melamine formaldehyde is reworkable at pH 3.5 to 4.5 because of

acid hydrolysis of the amide-type groups present in such resin which leads to fragmentation of the resin molecules attached to the fiber, which reduces the cured resin's molecular size sufficiently to destroy its wet strengthening ability. 7

It has been noted that no increase in repulping rate is achieved by carrying out the procedure above 75°C.

In conclusion, Polyamide-type wet strength broke can be repulped at a practical rate with Sodium Hydroxide at a pH of about 10. It has been shown that repulping time is not appreciably shortened by increasing the temperature from 38 to 74°C, or higher. Hypochlorite ion increases the rate at which defibering can be completed. The extent of the increase is dependent upon the concentration of the hypochlorite ion, the pH of the slurry and the temperature. 7

REMOVAL OF INKS

There are many chemicals and processes of ink removal but the chemical of much interest is Sodium Hydroxide, Sodium Hypochlorite, and soap. The process involves treatment with a colloid foaming solution in which the pigment will become and remain completely dispersed for a long time and which will pass through the filter paper. Once the carbon is dispersed, the removal of the liquid by filtering or pressing leaves the pulp ink free and without agglomerated particles of the ink embedded in the fibers. (5)

It has been found that by using Sodium Hydroxide and Sodium Hypochlorite and Sodium Palmitate (soap) to pulp the waste printed paper, the ink was completely dispersed in a colloidal solution and remained in such a state for weeks without breaking. Such colloidal solution can be filtered or pressed from the pulp, leaving it free from ink. The use of caustic soda will result in a pH of 11.6. But, effective carbon particle remover can be attained at pH between 8.5 and 10.5 to disperse the carbon and prevent irreversible darkening of the fibers. The soap may be in solution, chips, or other forms. Also Sodium soap of unsaturated fatty acids, such as oleic and linoleic acid, have been found satisfactory.

The ink particles may be free from the paper fibers by adding an inactivatable dispersing agent which is then inactivated before agitating the mixture in the presence of the collecting solids. The dispersing agent may be a soluble soap or Sodium Silicate and the inactivation may involve precipitation with Calcium ions. (8)

REMOVAL OF SIZING AGENTS

Sizing agents are easily dissolved during the treatment process of soaking waste paper in hot aqueous alkali.

SUMMARY OF LITERATURE SURVEY

Since the effect of sizing, and wet strength agents on the paper and the printing inks, has been emphasized so that one would anticipate how they will effect the removal of printing inks, and thus paper with a high brightness will be obtained. Paper sized with Aquapel will repel oily based inks thus one expects that the ink particles will be easily removed from the paoersurface.

The fact that wet strength agents improve the bonding properties of fibres indicate t hat the surface charge or the zeta potential of the fibers or wet strength agents plays a part in holding the ink to the paper. In o rder to make correct estimation..of the effect of wet strength, measurement will be made of the zeta potential of the fiber slurry, wet strength agent in the ink. Also, working with papers with different levels of wet strength but the same ink level will allow for the estima tion of the effect of wet strength when the corosponding values of wet strength used is plotted against the brightness.

Plotting the zeta pofential of the wet strength agent against brightness also indicates the degree of ink removal. One expects a reduction of brightness at increasing zeta potential. Plotting the zeta potential of the wet strength against the zeta potential of the ink, and comparing this with a plot of zeta potential of the fiber slurry and ink, it is possible to determine which plays an imprtant role in t he unitation of the ink with the paper.

EXPERIMENTAL OUTLINEPURPOSE:

The primary purpose of the experimental work connected with this study was an attempt to determine the effect of sizing and wet strength agents on ink absorption to the paper in the absence of any paper additive. In the art of secondary fiber reclamation, ink has posed a great problem to the quality of the recovered pulp and little is known about the bonding chemistry of the ink to the paper. While other paper additives as coating pigments and adhesives, including fines may effect the amount of ink transferred to the paper, this experimental observation is limited to the effect of sizing and wet strength agents. Thus coating pigments and adhesives were not employed in this experimental observation.

INK: The predominant black color of ink is due to the presence of carbon and when printed papers are repulped, the carbon plays a vital role by diminishing the brightness of the paper made from the reclaimed pulp. To successfully remove the ink from the stocks, it is desirable to know both their ingredients and their reactions towards deinking agents. The ink used in this experiment consisted of pigment that is carbon black, non-drying vehicle or binder and is rubber based. The based rubber is suppose to hold the ink to the paper, thereby allowing efficient ink transfer. However the ink transfer to the samples were fairly uniform.

WET STRENGTH AGENT:

The bonding strength of Kymene 557 substantially increase the strength of the paper and renders it hard to repulp. The resin is cationic in nature and water soluble but at a pH of 10, the resin can easily be removed from the paper. Although the resin can be removed at a

temperature of 38°C, a temperature of 70°C was employed in the observation. Latter in analysis of the result, we shall explore how the concentration of oxidizing salt, the pH of the slurry and temperature affected the rate of removal of Kymene and thus removing the ink.

SIZING AGENT:

The effect of Aquapel on paper is to make the paper water repellent. Aquapel is highly effective and reacts directly with the cellulose. It improves the surface of the paper by smoothing it, thus preventing picking. Aquapel can be easily removed by soaking in a hot aqueous alkali thus releasing the ester formed when aquapel reacted with the OH group of the cellulose. In this experiment attempt was made to eliminate the Aquapel thus freeing the ink particles.

The wet-strenght agent through its strenghtening ability could be thought to aid in binding the ink to the paper while the sizing agent can absorb the ink. Through a simple method of fiber reclamation the effect of the two chemicals can be verified thus helping to characterise each with ink absorption and dissorption when the paper is repulped.

MATERAILS USED:

The materials used during the course of this included the following: a 50% bleached Western softwood kraft pulp and a 50% hardwood, Whearing blender, NaOH, Sodium Silicate, Sodium hypochlorite as OCl, Triton X-100, thermometer, bunsen burner, Kymeme 557, Aquapel, Ink Stirrer, brightness meter, pH meter, and balance

EXPERIMENTAL INVESTIGATION

Preparation Of Constituent Pulps:

The initial experimental work was the preparation of the pulp of the pulps used in the paper making. A 50/50 blend of softwood and refined for 35 minutes to a freeness of 350 cfs

The refined pulp was run through the foudrinier paper machine at a feed of 120lbs/hr and a consistency of 0.1%. The Kymene and Aquapel were diluted to 62.5gals and 30gals respectively and metered to the headbox at different addition levels.

<u>CHEMICAL</u>	<u>LEVELS OF ADDITION</u>					
Kymene	.2%	.4%	.6%	.8%	1.0%	
Aquapel	.4%	.8%	1.2%	1.6%	2.0%	
Kymene/Aquapel	.1/.2%	.2/.4%	.3/.6%	.4/.8%	.5/1.0%	.75/1.5%
Basis Wt.	= 60lbs					
lbs/hr	=120lbs					
Freeness	=350cfs					
Consistency	=0.1%					
pH	=8.5					

PRINTING PROCEDURE

The paper samples from the above were stored in a constant humidity room, cut in size 8.5 by 11 inches and printed with the litho offset printing. The ink used contained carbon black pigment and is rubber based. The ink application was fairly uniform.

REPULPING PROCEDURE:

Thirty grams of the printed samples was added to 1500mls of hot water, 3.5% by weight of NaOH, 5% Sodium silicate, 5% bleach as NaOCl , and 1% triton X-100. The stock was repulped at 2% consistency at a pH

of 10.5. Each sample was repulped for ten minutes with a whearing blender and stirred to a temperature of 70°C for another ten minutes.

The slurry was diluted to 6% consistency and washed in a seive and rinsed with 4000mls of hot water. The final reclaimed fibers were made into papers using noble and wood handsheet machine. The brightness of the handsheets were again obtained.

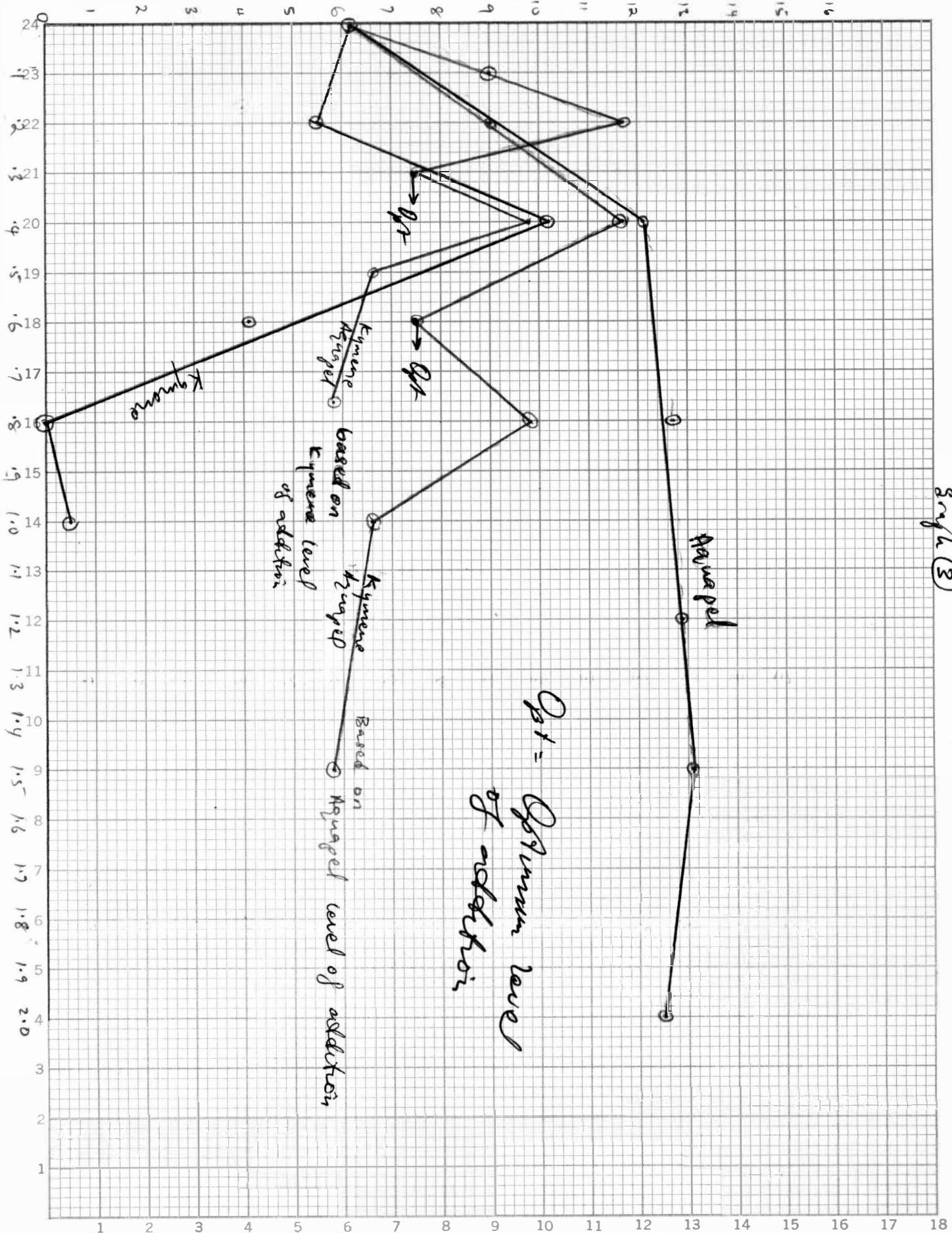
The final brightness was substracted from the original brightness. The difference was then expressed as percent loss in brightness. This was plotted against the percent additions.

DISCUSSION OF RESULT

Both the Kymene and Aquapel were discovered to affect the removal properties of the ink. During the original paper making, samples of the drainage water were collected in order to obtain their Zeta potential. This action and analysis helped to find out which of the chemicals retained its charge on the paper. However Kymene appeared to lose its charge at a higher concentration, that is, at a higher concentration, Kymene does not retain its charge on the paper. On the other hand, Aquapel retains its charge at a higher concentration. This can be explained that Aquapel reacts with the hydroxyl group of the cellulose. Later the effect of zeta potential on ink absorption and dissorption will be explained. Graph 2 shows the relationship of zeta potential to the different levels of chemical addition.

The brightness loss of aquapel was greater than that of Kymene. As the concentration increases, the brightness diminishes. This observation is explained in both graph 3 and 4. The effect of kymene can be explained that at a higher concentration kymene does not act as a bonding agent. Since the charge is not retained at a higher concentration, the brightness of the paper would be less affected.

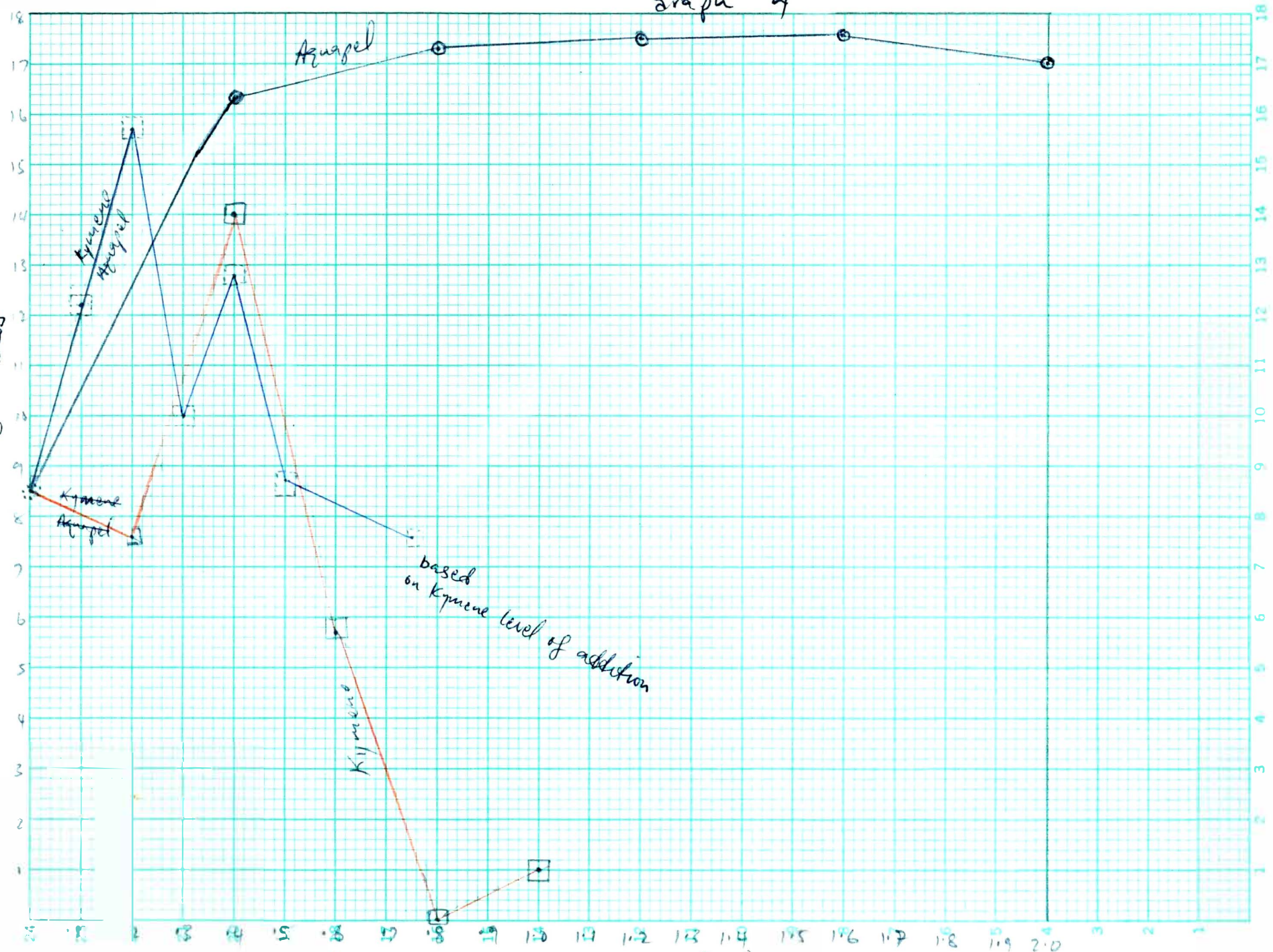
Loss in brightness



Graph 3

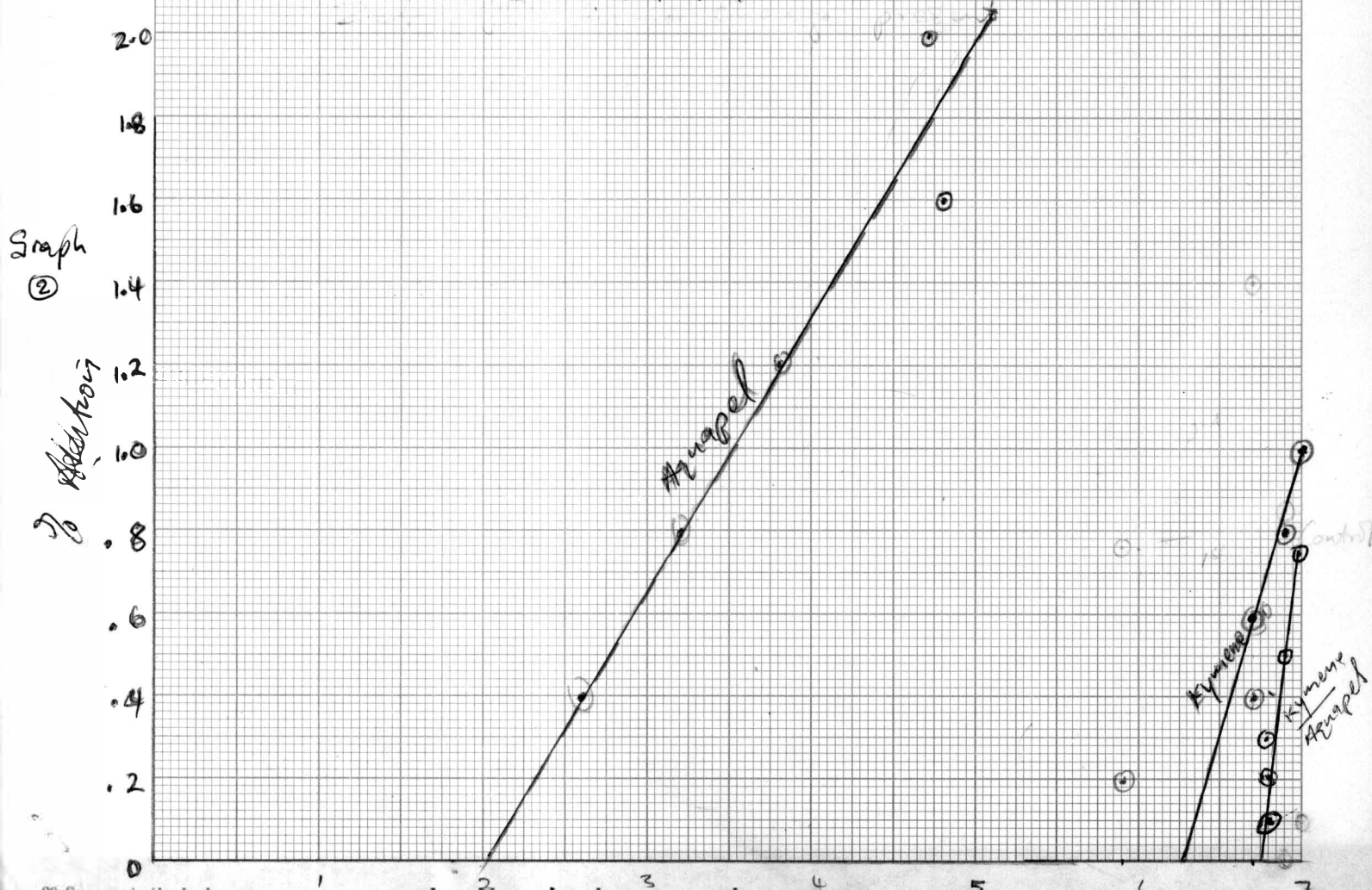
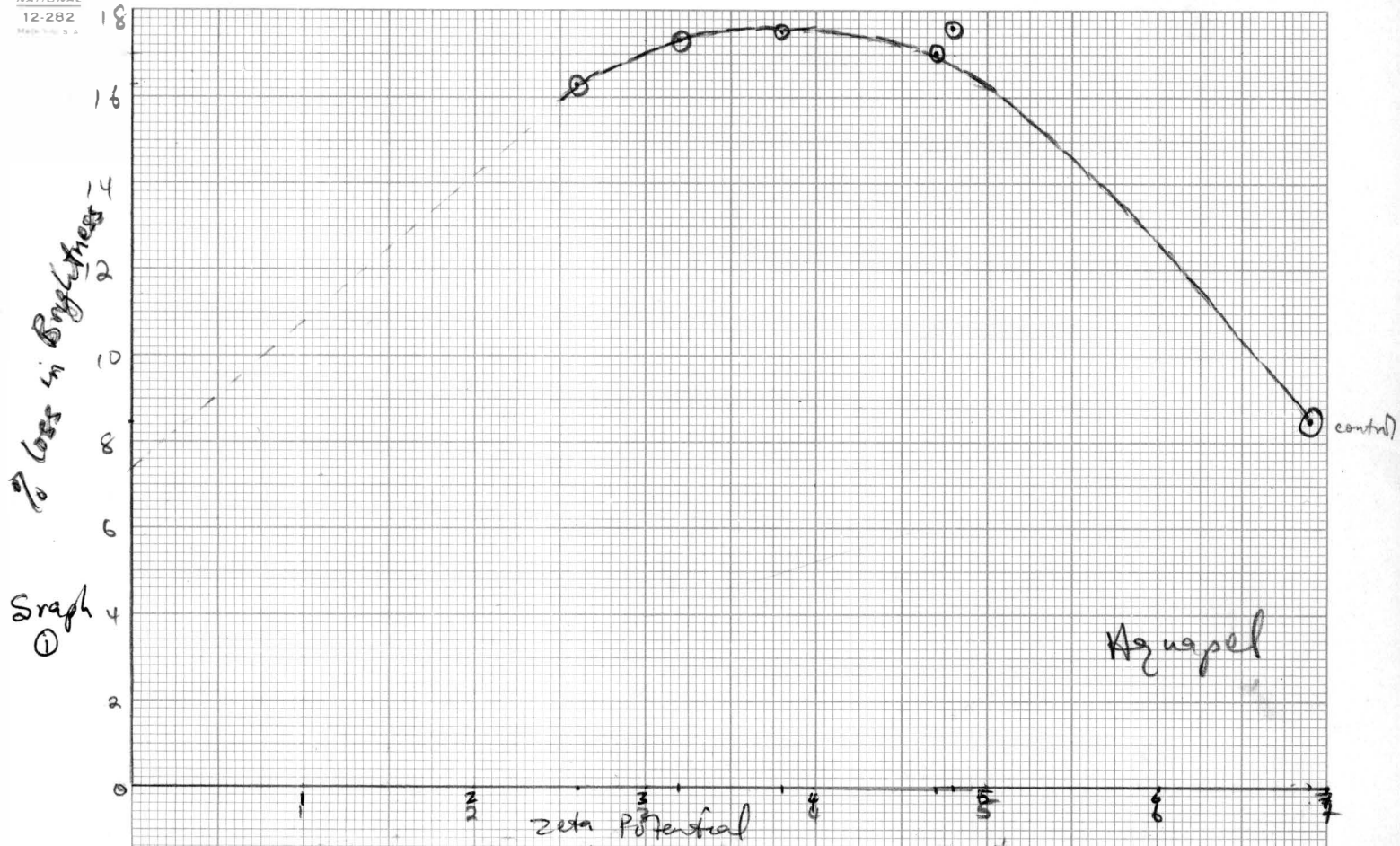
Graph 4

↳ loss in brightness



based on Kymene level of addition

↳ 1111 chemical



The ink was rubber based which helps it to stick to the paper. This leaves the ink negatively charged. Thus the negative charge of the ink reacted with the positive charge released during the reaction of aquapel with the cellulose. Thus on repulping the ink on the precipitated aquapel on the paper surface was not easily released. Graph 1 helps to explain that the the loss in brightness is directly related to the zeta potential. As more charge of aquapel is retained on the paper, the more ink is absorbed. On the other hand the limited amount kymene retained caused the ink to be dissorbed.

CONCLUSION

This observation was conducted with the intent of finding out the effect of kymene and aquapel on ink absorption and dissorption. Within the limits of experimental error, the following conclusions can be made;

- 1) Kymene at a higher concentration does not retain its charge on the paper thus does not absorb the ink to the paper. The ink is the easily removed at a pH of 10.5 using both the oxidizing agents, sodium hypochlorite and sodium silicate both of which effected the hydrolysis of kymene. at 70°C.
- 2) Kymene is only useful at lower concentrations and employment of it in paper making at higher concentration is a waste,
- 3) Aquapel at any concentration retains almost all its charges due to reaction with the ⁻OH group of the cellulose.
- 4) This charge retention helps the surface of the paper to absorb the ink. Thus the close adherence reduces the brightness of the paper when repulped.
- 5) Addition of kymene with aquapel helps to reduce the effect of aquapel on the ink. As you go higher in aquapel and kymene, the loss in brightness is reduced.

6) The optimum effect of aquapel and kymene together can be obtained at about .3% kymene and .6% aquapel. At the combination of the above mentioned concentration about 7.5% loss in brightness can be obtained.

From the result of this investigation, it is apparent that the charge of aquapel or kymene retained in the paper affect the amount of ink transferred to the paper. Aquapel at any concentration absorbs the ink while at a higher concentration kymene does not absorb the ink due to the fact that all its charges were not retained in the paper. Therefore, within the limits of experimental error, aquapel has been proven to be more effective in the surficial absorption of ink on paper than kymene.

TABLE ONE: PRINT DENSITIESCONTROL

1.30	1.37	1.44	1.33
1.34	1.32	1.35	1.44
1.29	1.39	1.34	1.35

MEAN: = 1.35.4% AQUAPEL

1.32	1.29	1.30	1.20
1.14	1.34	1.24	1.15
1.27	1.32	1.36	1.24

MEAN: = 1.28.8% AQUAPEL

1.26	1.25	1.31	1.39
1.20	1.12	1.21	1.32
1.27	1.19	1.28	1.32

MEAN: = 1.271.2% AQUAPEL

1.50	1.32	1.28	1.32
1.36	1.22	1.24	1.26
1.33	1.26	1.23	1.22

MEAN: = 1.301.6% AQUAPEL

1.36	1.35	1.39	1.31
1.18	1.18	1.13	1.28
1.34	1.34	1.27	1.30

MEAN: = 1.282.0% AQUAPEL

1.35	1.49	1.40	1.52
1.33	1.37	1.46	1.43
1.35	1.43	1.40	1.34

MEAN: = 1.41.2% KYMENE

1.24	1.22	1.19	1.14
1.01	1.08	.99	1.03
1.19	1.30	1.15	1.21

MEAN: = 1.15

.4% KYMENE

1.12	1.20	1.27	1.26
.99	1.80	1.32	1.20
1.16	.98	1.24	1.28

MEAN: = 1.23

.6% KYMENE

1.20	1.15	1.16	1.19
1.14	.91	.94	1.14
1.21	1.19	1.16	1.21

MEAN: = 1.14

.8% KYMENE

1.33	1.30	1.25	1.31
1.24	1.18	1.17	1.22
1.27	1.26	1.27	1.29

MEAN: = 1.25

1.0% KYMENE

1.45	1.49	1.37	1.30
1.38	1.41	1.29	1.07
1.39	1.45	1.30	1.18

MEAN: = 1.33

.1/.2 K/A

1.33	1.18	1.18	1.28
1.13	1.04	1.06	1.10
1.28	1.33	1.22	1.20

MEAN: = 1.21

.2/.4 K/A

1.17	1.28	1.37	1.44
1.25	1.23	1.36	1.36
1.34	1.33	1.37	1.34

MEAN: = 1.34

.3/.6 K/A

1.30	1.35	1.42	1.44
1.28	1.34	1.48	1.35
1.40	1.40	1.37	1.50

MEAN: = 1.39

	<u>.4/.8 K/A</u>			
1.12	1.04		.94	
1.13	1.20		.90	
1.13	1.04		1.16	<u>MEAN:</u> = 1.23 1.10
	<u>.5/1.0 K/A</u>			
1.30	1.42	1.28	1.33	
1.14	1.14	1.16	1.25	
1.31	1.30	1.10	1.33	<u>MEAN:</u> = 1.14 1.29
	<u>.75/1.5 K/A</u>			
1.41	1.35	1.40	1.33	
1.27	1.17	1.15	1.18	
1.30	1.38	1.29	1.32	<u>MEAN:</u> = 1.25 1.30

TABLE TWO

ZETA POTENTIAL

AQUAPEL

KYMENE

KYMENE/AQUAPEL

Control = 6.9

.4% = 2.6	.2% = 5.9	.1/.2% = 6.8
.8% = 3.2	.4% = 6.7	.2/.4% = 6.8
1.2% = 3.8	.6% = 6.7	.3/.6% = 6.8
1.6% = 4.8	.8% = 6.9	.4/.8% = 6.8
2.0% = 4.7	1.0% = 7.0	.5/1.0% = 6.9
		.75/1.5% = 7.0

TABLE THREE
ORIGINAL BRIGHTNESS

.4% AQUAPEL

72.9 73.7
73.6 74.6
73.9 74.0

MEAN := 73.8

.8% AQUAPEL

73.4 75.5
72.9 75.1
72.0 72.4

MEAN := 73.6

1.2% AQUAPEL

74.4 75.1
75.7 74.8
75.8 74.1

MEAN := 75.0

1.6% AQUAPEL

74.2 73.7
74.2 74.4
74.7 76.8

MEAN := 74.4

2.0% AQUAPEL

75.8 75.8
76.1 75.2
75.3 75.3

MEAN := 73.6

.2% KYMENE

72.6 71.7
71.4 73.1
72.4 72.6

MEAN := 72.3

.4% KYMENE

73.1 71.9
72.3 73.3
72.9 69.2

MEAN := 72.7

.6% KYMENE

71.5 70.8
71.1 72.6
70.9 71.3

MEAN := 71.5

.8% KYMENE

70.0 70.9
70.3 70.5
73.4 71.1

MEAN := 71.0

1.0% KYMENE

73.4 72.5
73.6 72.2
72.2 72.7

MEAN := 72.4

CONTROL

72.4 74.0
72.6 73.2
73.1 73.2

MEAN := 73.1

.1/.2% K/A

73.4 70.4
72.3 73.3
72.8 73.9

MEAN := 73.7

.2/.4% K/A

74.4 74.6
74.5 74.8
74.6 75.4

MEAN := 74.6

.3/.6% K/A

74.6 74.0
74.0 75.3
75.8 73.7

MEAN := 74.8

.4/.8% K/A

76.1 76.4
75.7 76.1
76.4 76.6

MEAN := 76.3

.5/1.0% K/A

75.5 74.9
75.5 75.5
76.1 75.6

MEAN := 75.5

.75/1.5% K/A

76.6 77.0
75.9 76.8
76.3 76.3

MEAN := 76.5

TABLE FOURSECONDARY BRIGHTNESS.4% AQUAPEL

61.9	63.3	65.4	61.0	57.5	60.6
61.5	67.2	64.4	60.5	57.4	60.1
62.6	64.8	62.9	63.1	57.0	58.1
MEAN:=	63.8		MEAN:=	59.5	

OVERALL MEAN:= 61.7.8% AQUAPEL

62.1	58.0	62.5	61.6	64.2	59.8
59.7	57.5	59.9	61.1	63.6	61.0
60.0	57.6	62.2	61.5	64.1	60.5
MEAN: =	59.9		MEAN:=	61.9	

OVERALL MEAN = 60.91.2% AQUAPEL

63.8	62.8	62.2	62.6	64.8	59.9
61.7	67.0	62.6	62.4	63.4	61.4
62.5	64.6	59.9	62.4	63.8	62.0
MEAN;=	63.0		MEAN:=	61.2	

OVERALL MEAN:= 62.11.6% AQUAPEL

60.9	60.8	61.2	61.7	57.8	60.9
63.9	64.7	61.1	63.6	57.3	59.1
63.7	61.8	62.9	62.1	57.3	63.0
MEAN:=	62.3		MEAN:=	60.3	

OVERALL MEAN:= 61.32% AQUAPEL

65.4	58.7	59.7	62.6	62.0	
63.2	58.4	61.7	62.1	62.5	<u>OVERALL MEAN</u> := 61.1
60.2	58.2	61.4	62.4	61.0	
MEAN:=	60.5		MEAN:=	61.7	

TABLE FOUR CONT.

.2% KYMENE

63.5	65.6	66.6	70.0	68.4	67.0
61.8	65.4	69.1	54.0	68.5	67.5
62.7	68.3	67.8	55.3	68.0	68.1
MEAN:= 65.6			MEAN:= 67.9		

OVERALL MEAN:= 66.8

.4% KYMENE

61.8	66.8	65.3	60.1	65.2	
63.6	66.1	63.4	62.0	58.2	
58.9	66.8	63.0	58.6	61.8	
MEAN:= 64.0			MEAN:= 61.0		

OVERALL MEAN:= 62.5

.6% KYMENE

67.5	62.3	65.8	66.3	68.1	65.4
67.2	65.1	69.0	66.9	67.6	70.1
69.6	62.6	67.5	68.5	68.8	67.7
MEAN:= 66.3			MEAN:= 68.4		

OVERALL MEAN:= 67.4

.8% KYMENE

70.1	70.0	68.6	73.5		
70.3	70.8	67.4	73.2		
70.5	70.9	67.0	72.2		
MEAN:= 69.5			MEAN:= 73.0		

OVERALL MEAN:= 71.2

1.0% KYMENE

72.2	73.8	72.0	70.8	73.3	72.4
72.7	71.6	71.5	73.1	73.0	70.8
71.3	73.5	71.2	71.3	71.8	70.6
MEAN:= 71.5			MEAN:= 71.9		

OVERALL MEAN:= 71.7

TABLE FOUR CONT..1/.2% K/A

62.4	63.5	61.6	69.2	68.5	68.0	
62.8	63.6	61.6	68.0	69.2	68.3	<u>OVERALL</u>
62.2	62.7	63.3	67.7	69.8	67.5	MEAN:= 64.7
	MEAN:= 62.6			MEAN:= 66.8		

.2/.4% K/A

62.1	60.8	61.2	65.8	64.0	65.6	
60.8	60.8	61.2	64.4	64.4	65.4	<u>OVERALL</u>
62.3	61.2	61.3	64.7	64.9	64.8	MEAN:= 62.9
	MEAN:= 61.3			MEAN:= 64.5		

.3/.6% K/A

66.0	64.3	69.4	70.2	66.7	70.3	
65.7	63.6	69.9	70.9	66.8	71.0	<u>OVERALL</u>
65.8	64.1	66.8	69.9	66.8	69.5	MEAN:= 67.3
	MEAN:= 65.5			MEAN:= 69.1		

.4/.8% K/A

65.8	62.7	64.2	67.1	69.9	69.2	
65.0	63.9	64.1	67.7	70.2	68.0	<u>OVERALL</u>
65.4	63.3	66.2	67.8	69.4	69.4	MEAN:= 66.5
	MEAN:= 64.5			MEAN:= 68.4		

.5/1.0% K/A

68.6	68.3	71.9	69.8	66.9	67.2	
67.8	69.3	71.6	68.6	66.5	67.0	<u>OVERALL</u>
68.7	68.5	71.5	69.1	66.4	66.5	MEAN:= 68.9
	MEAN:= 70.1			MEAN:= 67.6		

TABLE FOUR CONT.

.75/1.0% K/A

5.3	68.8	70.8	71.3	71.0	71.5
5.4	76.1	71.9	70.8	70.5	71.8
5.9	69.2	71.7	71.9	71.1	71.8
MEAN := 69.5		MEAN := 71.8			

OVERALL

MEAN := 70.7

CONTROL

9.8	67.8	69.8	63.4	64.8	64.1
0.0	66.7	68.4	64.5	63.4	65.2
9.4	69.8	69.5	63.8	65.8	67.4
MEAN := 69.0		MEAN := 64.7			

OVERALL

MEAN := 66.9

TABLE FIVE

PERCENT LOSS IN BRIGHTNESS

AQUAPEL

4% = 16.3
8% = 17.3
1.2% = 17.5
1.6% = 17.6
1.0% = 17.0

KYMENE

.2% = 7.6
.4% = 14.0
.6% = 5.7
.8% = 0
1.0% = 1.0

KY/AQ

1/.2% = 12.2
2/.4% = 15.7
3/.6% = 10.0
4/.8% = 12.8
5/1.0% = 8.7
7.5/1.50% = 7.6

CONTROL

8.5

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