



Western Michigan University  
ScholarWorks at WMU

---

Paper Engineering Senior Theses

Chemical and Paper Engineering

---

6-1978

## The Effect of Auxiliary Dispersants on the Dispersion and Properties of Coating Made with Domestic Clays

Carroll A. Brandt  
*Western Michigan University*

Follow this and additional works at: <https://scholarworks.wmich.edu/engineer-senior-theses>



Part of the Wood Science and Pulp, Paper Technology Commons

---

### Recommended Citation

Brandt, Carroll A., "The Effect of Auxiliary Dispersants on the Dispersion and Properties of Coating Made with Domestic Clays" (1978). *Paper Engineering Senior Theses*. 51.  
<https://scholarworks.wmich.edu/engineer-senior-theses/51>

This Dissertation/Thesis is brought to you for free and open access by the Chemical and Paper Engineering at ScholarWorks at WMU. It has been accepted for inclusion in Paper Engineering Senior Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact [wmu-scholarworks@wmich.edu](mailto:wmu-scholarworks@wmich.edu).



THE EFFECT OF AUXILIARY DISPERSANTS  
ON THE DISPERSION AND PROPERTIES OF  
COATINGS MADE WITH DOMESTIC CLAYS

by  
Carroll A. Brandt

A thesis submitted  
in partial fulfillment of  
the course requirements for  
the Bachelor of Science Degree

Western Michigan University  
Kalamazoo, Michigan  
June 1978

## ABSTRACT

Polymeric organic dispersants are now being used to replace all or part of the inorganic dispersants currently in use for pigmented coatings. They are generally recommended for hard-to-disperse or for special applications where unusual coating requirements must be obtained.

This study showed the effect of some of these auxiliary dispersants when used with tetrasodium pyrophosphate (TSPP) to disperse domestic clay.

The results of this study showed that the most effective type of dispersants for this application are the acrylic-based polymers. The lignosulfate derivative and styrene maleic anhydride did not look as good as the acrylic-based polymers. When used in coatings with straight TSPP as a control, the acrylic-based dispersants gave lower initial coating viscosity, better viscosity stability with respect to time, temperature and pH and lower rate of reagglomeration of clay particles.

## TABLE OF CONTENTS

	Page No.
Introduction	1
Theoretical Discussion	3
Types of Dispersants	3
Chemical Properties of Organic Dispersants	5
Mechanisms of Dispersion	7
Double Layer Theory	7
Hydroxyl Ion Theory	8
Relationship of Polymeric Organic Dispersants in the Dispersion Mechanism	9
Benefits of Organic Dispersants	12
Summary	13
Experimental Procedure	15
Discussion of Data	18
Summary and Conclusions	23
Literature Cited	24
Appendix	26

## INTRODUCTION

Paper coating has reached the point in its evolution where it is no longer an art but rather a science. Paper coatings are suspensions consisting of two phases, a liquid phase and a solid phase dispersed in the liquid phase. The solid phase is made up of the pigment which is the main ingredient, the adhesive, and other solid materials for special purposes. The usefulness of the coating depends on the order and degree to which these materials can be dispersed.

Specialty coatings and high solids coatings for high speed applications are making increasingly complex demands on techniques of dispersion. Dispersants in common use today cannot meet the requirements of these coatings. These dispersants are used presently because of low cost and they are effective for ordinary applications. Auxiliary dispersants are required to meet the needs of wider applications in specialty coatings. These auxiliary dispersants may also be used to aid in ordinary applications to insure and aid the effects of more common dispersants.

This study was carried out to investigate the effectiveness of certain organic polymeric compounds which have shown qualities as auxiliary dispersants. When used with

polyphosphate dispersants for paper coating pigments additional properties can be obtained which would not be possible with polyphosphates alone. Some of these benefits are lower viscosity and better coating stability with respect to time, temperature and pH and an increase in optical properties of the coated paper.

## THEORETICAL DISCUSSION

### Types of Dispersants

The most common group of materials used for dispersants are the complex phosphates or polyphosphates. TSPP (tetrasodium pyrophosphate) is the most widely used member of this group. It is very effective on domestic kaolin clay and is also used for calcium carbonate. Its low cost and efficient dispersing ability make it the leading dispersant. Calgon (sodium hexametaphosphate) is another common dispersant used primarily on calcium carbonate and also domestic clay. Sodium metaphosphate and sodium tetraphosphate are other members of this family, but they are not as well known or well used.

Another group of dispersants used are the sodium silicates. These are commonly used for  $\text{TiO}_2$  and clay. Sodium hydroxide and sodium carbonate have also been shown to be useful as dispersants, but sometimes they cause harmful side effects to coating properties.

A third group of materials aiding in dispersion of pigments are the protective colloids such as casein and protein. These materials are used primarily as binders (adhesives) in the coatings but aid in dispersing pigments such as calcium carbonate and satin white and to a lesser degree, domestic clay. These materials also aid

water retention of the coating and keep the heavier pigment particles from settling out, which can occur with the other dispersants unless they are kept at high solids.

The fourth group of dispersants are polymeric organic compounds. There are quite a few of these materials coming on the market, especially in the paint industry for specialty purposes. A number of these appear in Table 1 with a description of their chemical make-up. These compounds are being used in conjunction with materials like TSPP and protein to give special properties to the coating rheology and stability.

Table 1

Tamol 850	sodium salt of polymethacrylic acid
Dispex N40	sodium polyacrylate terpolymer
Dispex A40	ammonium polyacrylate terpolymer
Goodrite K-702	polyacrylic acid
Tamol SN	napthalene sulfonate
Nopcosant L	polymethacrylic copolymer
Nopcosant K	polymethacrylic copolymer
Lytron 810	styrene-maleic anhydride copolymer
Lytron 820	styrene-maleic anhydride copolymer
Lytron 822	styrene-maleic anhydride copolymer

Some other organic materials that have found uses as dispersants in either paper or paint industries are various copolymers based on maleic anhydride, polyvinylpyrrolidone and lignosulfate derivatives.



## Chemical Properties of Organic Dispersants

The materials listed in Table 1 are materials recommended by their respective manufacturers for use as either auxiliary or sole dispersants for paper coating pigments. The chemical structures vary and therefore their respective uses vary.

Goodrite chemical's K-702 is a polyacrylic acid with a molecular weight of about 90,000. It is infinitely soluble in water and very stable over a wide range of applications. It can be neutralized with either NaOH or  $\text{NH}_4\text{OH}$ , depending on the end use. This salt then acts as both dispersing agent and binder if used in a large enough quantity. Since it has no known application in the paper industry at present, there is no method of use recommended. Figure 1 shows the chemical unit structure.

Figure 2 shows the basic chemical unit for methacrylic acid of which family Tamol 850 belongs. This material is a sodium salt of methacrylic acid. Its molecular weight or acid number is not given in the technical information (1). It is recommended as an auxiliary dispersant at as little as .04% on clay solids, and it can be used as a sole dispersant.

Nopcosant K and L (2) are polymethacrylic copolymers recommended as auxiliary dispersants for clay at the rate

of 0.2 to 0.5% in the weight of dry clay. The technical information states that it improves aging stability of coatings and an increase of 1 to 2 points opacity in the finished coating.

Dispex A40 and N40 (3) are salts of polyacrylic terpolymers, ammonia and sodium respectively. They are recommended as dispersing agents at the rate of 0.1 to 0.3% on the weight of dry pigment. It can also be used for an auxiliary dispersant.

Tamol SN is a naphthalene-sulfonate type dispersant. It is formed by the reaction:



This particular product is a sodium salt supplied as a powder and readily soluble in water (1). It is very stable and effective in both acidic and basic applications. A level of 0.5 to 1.5% on the weight of clay is effective in dispersing clay.

Monsanto's series of Lytron resins are styrene-maleic anhydride copolymers (4). Table II shows the various properties of these resins.

Table II

	<u>Acid No.</u>	<u>M.W.</u>
Lytron 810	320	50,000
Lytron 820	180	20,000
Lytron 822	190	10,000

These materials are supplied as powders dispersable in water under alkaline conditions. Lytron resins are more in the family of protective colloids than true dispersants however. They are recommended at 3 - 10% on the dry weight of pigment. They also act as binders improving the water resistance of the coating.

#### Mechanisms of Dispersion

The first step in making a coating is to deflocculate and wet the pigment. Kaolin particles are made up of layers of aluminum and silicon oxides which tend to separate into hexagonally shaped flakes. The faces of these plates have a negative charge and the edges have a positive charge. There are several theories on how a dispersant works in keeping these particles separated.

#### Double Layer Theory

The clay particles are mechanically separated by grinding in the presence of water and a dispersing agent. The double layer theory states that the anion of the

polyphosphate dispersant is absorbed on the edges of the clay particle to form a layer of negative charges on the surface of the particle. The cation of the dispersant then forms a counter ion cloud around the particle (see Figure 3) preventing it from being attracted to other particles in the suspension. A very good detailed description of this theory is discussed by Robinson and Thompson (5) in Tappi Monograph No. 25 on Paper Coating Additives.

### Hydroxyl Ion Theory

An older, less widely accepted theory states that the important ion present in reducing viscosity of a clay slip is the hydroxyl ion (6). According to this theory the  $\text{-OH}$  ion is preferentially adsorbed and the polyphosphate is used in precipitating the heavy metal ions present. Work by Swanson and Hemstock (7) supports this theory in part by showing that with an increase in pH (free hydroxyl ion) there is a corresponding increase in polyphosphate available which in turn decreases viscosity of the clay slip. There is also an increase in ionic strength.

In reality these two theories cannot be separated. Rohman (8) has shown that there is a relationship between negative zeta potential (ionic strength) and the efficiency of a dispersant. There is more adsorption of the disper-

sant in the presence of a higher negative zeta potential. Further work showing the inter-relationship of polyphosphates and the -OH ion by Michaels (9) shows that better deflocculation of clay is obtained with the higher molecular weight phosphates up to the tetramer (TSPP). More efficient occupation of the cationic sites on the plate edges takes place, the effect of which tapers off after the tetramer.

### Relationship of Polymeric Organic Dispersants in the Dispersion Mechanism

This explanation shows the mechanism of dispersion by conventional means is limited in its usefulness. There are a number of conditions which may cause a detrimental effect on the stability of the dispersion. Extended periods of time, elevated temperatures, pH, and the presence of multivalent cations have detrimental effects on the stability of coating and pigment dispersions.

Time, temperature, and pH have an interrelated effect on the dispersion. Harn and Fritz (10) theorize in their article on auxiliary dispersants that the polyphosphates decompose and hydrolyze to orthophosphates. TSPP is formed from disodium orthophosphate:



It seems likely then, that TSPP in the presence of water in the dispersion under these conditions would tend to break down by reversing the reaction of formation. Since the orthophosphates are a much less efficient dispersant the viscosity is greatly increased. Dennison and Toms (11) support this theory by their work which showed that the polyphosphate does degrade under these conditions to form orthophosphates. They also stated that polymeric organic dispersants, because of their chemical nature, are not affected by these conditions.

Polyphosphate dispersants are also very sensitive to multivalent cations such as  $\text{Ca}^{++}$  and  $\text{Al}^{+++}$ . These ions reduce the thickness of the positively charged counter-ion cloud (see Figure 3) and react with the polyphosphates. Reduction of the counter-ion cloud causes agglomeration of the pigment by allowing the particles to get too close to one another. When this happens, a force of attraction between molecules, called Van der Waals-London force, takes effect. The resulting effect is agglomeration of particles in the suspension. Polyphosphate dispersants also act as a sequestering agent in the presence of free  $\text{Ca}^{++}$  and  $\text{Al}^{+++}$ . This reduces the amount of polyphosphate available to the clay. These effects can be reduced by the use of polymeric organic dispersants. In work quoted in a review article by Athey (12) the multivalent cations, Ca, Al, and Fe, can precipi-

tate polycarboxylic acids. However, these compounds also act as protective colloids and the effects are not as drastic on the properties of the dispersion.

The binders used in paper coatings also affect the dispersion and viscosity characteristics of the finished coatings. Natural binders such as protein and casein are protective colloids and are used as dispersants for certain pigments. The hydroxyls on these materials are attracted by the positive sites on the clay particles. Another natural binder is starch which does not have a great degree of influence on the dispersion mechanism. Salzburg and Marino (13) point out that casein in acting as a protective colloid is adsorbed on the clay particle and a corresponding increase in zeta potential occurs. The casein also protects the clay particles from changes in the system such as pH drift and the presence of polyvalent cations. Protective colloids such as these hinder the effects of polymeric organic dispersants by blocking the cationic sites. However, in Rohman's (8) work with English clay, satin white and casein, adding polyacrylates reduced the amount of casein necessary as binder by increasing the amount of casein in the water phase.

Synthetic binders affect coating dispersion by introducing soap and other flow modifiers present in the manufacture of these latices. Hamann (14) has shown that the

amount of soap adsorbed by the clay particles from the latex is reduced with addition of small amounts of polymeric organic dispersants. This work is supported by Rohman (8) and Dennison and Toms (11).

The polycarboxylated organic dispersants when added to the pigment slurry attach themselves to the clay particles in much the same fashion as the soap and block these sites from the soap and surfactants (see Figure 4). Also, being stable, they will not give up these sites as in the case of polyphosphates. Care must be taken that the polymeric dispersant is not too long in chain length or mobility of the particle will be reduced. Also, if there are not enough anionic sites on the polymer, it will not effectively protect the clay particle.

The requirements of a good organic dispersant are, therefore:

1. low molecular weight
2. high number of active sites
3. short chain length
4. good stability in the presence of polyvalent cations.

#### Benefits of Polymeric Organic Dispersants

It can be seen by this study that a number of beneficial attributes are found when polymeric organic dis-



persants are used in conjunction with polyphosphates as auxiliary dispersants.

1. Reduced high shear viscosity.
2. Increased coating stability in regard to time, temperature, pH and presence of polyvalent cations.
3. Increased amounts of natural binders available for use as binder rather than as protective colloid.
4. It has also been theorized by Hern and Fritz (10) that use of auxiliary dispersants allows better optical property development.

Further work on these auxiliary dispersants may yield further advantages and information on the relationships of pigment particles to this family of dispersants. There are presently quite a few of these compounds used in the paint industry and, to a lesser degree, in the paper industry for special applications and special pigments.

### Summary

It is felt that since most of these materials are used for special applications with a relatively good degree of success that they could be used everyday with beneficial results. Polymeric organic dispersants have shown the ability to reduce high shear viscosity and

maintain coating stability for special pigments so they should also show these properties when used with domestic clay.

It is seen that use of these dispersants increases the amount of casein in the water phase of a coating. If this same relationship occurs with domestic clay, and it seems very likely, there should be a corresponding increase in the water retention ability of the coating.

It is also seen that much work has been done showing the relationship between zeta potential and the degree of dispersion and viscosity. But this effect can only be seen at low solids. How does high solids effect the rate of flocculation with and without presence of polymeric organic dispersants?

If it is felt that these questions deserve further investigation through experimenting by replacing part of the polyphosphate dispersant by various organic dispersants. The effect of these dispersants could then be measured and compared for their relative efficiency.

## EXPERIMENTAL PROCEDURE

The first step of this study was to determine the effect of various auxiliary dispersants on a 70% clay slurry. A No. 2 non-predispersed coating clay from J. M. Huber Co. was used to minimize experimental variables. Table III contains the list of auxiliary dispersants evaluated in this study.

Viscosity curves were made using 0.2% (dry basis) TSPP as the base slurry and adding additional small increments of auxiliary dispersant. Viscosity was checked and plotted as a function of dispersant level (see Table IV, Figures 5 and 6). As a result of this step Tamol 850, Dispex N-40 and Nopcosant K were chosen to be evaluated further.

Step two of this experiment was to make up coatings using the three auxiliary dispersants chosen against TSPP as the control. Three series of latex-starch coatings were made using these dispersants. The level of starch (Penford Gum 280, a low-viscosity ethylated starch) was varied from 0 to 4 to 8 parts per 100 parts clay. The total binder was held constant at 16 parts. Two latexes were used; Dow 620 (SBR type); and Dow 673, an alkali swellable type to keep the viscosity range up in the coating with 0 parts starch. The formulas and procedures

were as follows:

#### 100-8-8 Series

Dry Wts.		Total Wts.
-	water	54.5 g
.35 g	TSPP	.35 g
100.00 g	clay	100.00 g
8.00 g	Penford Gum 280	8.00 g

Cook in lab Kady mill for 20 minutes @ 200°F and cool to 125°F. Add remaining ingredients in lab mixer.

8.00 g	Dow 620	16.00 g
.04 g	Dowisil 75	.04 g
<u>116.39 g</u>		<u>178.89 g</u>

Adjust to pH 8

Final solids 65.2%

#### 100-4-12 Series

Dry Wts.		Total Wts.
-	water	62.65 g
.35 g	TSPP	.35 g
100.00 g	clay	100.00 g
4.00 g	Penford Gum 280	4.00 g

Cook in Kady mill for 20 minutes @ 200°F and cool to 125°F. Add remaining ingredients in lab mixer.

12.00 g	Dow 620	24.00 g
.02 g	Dowisil 75	.02 g
<hr/>		
116.37 g		179.02 g

Adjust to pH 8

Final solids 65.3%

These were the basic formulas. Some adjustments were necessary to keep the solids level constant to those coatings containing auxiliary dispersants.

The third step of this study was to test these coatings for viscosity changes and rate of pigment agglomeration over a period of time when stored at 100-105°F and high pH to accelerate the breakdown of the dispersion. Brookfield viscosity (at 20 rpm), Hercules high shear viscosity, and Hegman fineness of grind were the tests made on the coatings. The high shear viscosity was done only on the first day to determine the flow characteristics. The other two tests were run at 1, 4 and 7 days to find the rate of change in the dispersion. The results were tabulated and are included in the data section as Tables V and VI.

## DISCUSSION OF DATA

The first step in this study was to determine which of the auxiliary dispersants listed in Table I would be useful in dispersing domestic clay. TSPP alone proved to be the best dispersant in that the slurry prepared with TSPP had the lowest minimum viscosity. The next best dispersants were Tamol 850 and Dispex N-40. The slurries prepared with these materials reached their respective minimum viscosities at lower total dispersant levels than the slurry prepared with TSPP. The other auxiliary dispersants in order of effectiveness are Noposant K, Goodrite K-702 (NaOH neutralized), Arco SMA 1140H, and Tamol SN. The Goodrite K-702 dispersant caused a minor pigment shock when added to the clay slurry. If a large amount had been added, it is possible that severe shocking could have occurred rendering the clay slurry useless. None of the others caused any pigment shock, but Tamol SN and the Arco SMA resin were slower in acting, causing a delayed decrease in viscosity. The acrylic based resins, Tamol 850, Dispex N-40 and Nopcosant K, gave an instant decrease in viscosity upon addition to the slurry.

As a result of this work, the three acrylic-based products were chosen as auxiliary dispersants for the second phase of this study.

Due to the viscosity masking effect of starch as a binder, it was expected that the 100-8-8 series should show the least viscosity difference between dispersant systems. However this was not true. The coating prepared with Tamol 850 as part of the dispersant showed a much lower initial viscosity (see Table V) than the other three coatings using this binder level. The order of effectiveness of dispersant systems for this series was TSPP + Tamol 850, TSPP + Dispex N-40, TSPP + Nopcosant K and TSPP alone. However, using the Hercules high shear rheograms (see Figure 7), the TSPP control was the second best dispersant system due to the extreme dilatancy occurring in the coatings using the Dispex and Nopcosant dispersants. Even after a four day period the TSPP coating showed a 90% increase in viscosity compared to a less than 50% increase for the other three coatings containing auxiliary dispersants.

The 100-4-12 coating series gave initial viscosity data that showed less difference between dispersant systems (see Table V). The order of effectiveness was Nopcosant K, Dispex N-40, Tamol 850 and TSPP was last again. All the coatings in this series were dilatant, but the high shear viscosity (see Figure 8) was lower than the 100-8-8 series. The least dilatancy occurred in the TSPP dispersion, and the most dilatancy occurred in the coating prepared with Dispex N-40 dispersant system. Over a period of time the

Tamol 850 and Dispex N-40 dispersant systems had the lowest viscosity increase. Again TSPP showed the greatest increase in viscosity.

The 100-0-16 series should show the most effect of the auxiliary dispersants due to the lack of starch which has a large effect on the viscosity of the coatings. The order of dispersant system effectiveness for both Brookfield and Hercules viscosity turned out to be the same for this series of coatings. Tamol 850 was best followed by TSPP, Dispex N-40 and Nopcosant K (see Figure 9). Nopcosant K showed the greatest increase in viscosity with respect to time and it also had the greatest degree of dilatancy of the coatings in this series.

The fact that these coatings showed a high degree of dilatancy was not surprising. The solids are quite high and since clay slurries are naturally dilatant at high shear, dilatant coatings were expected.

The rate of reagglomeration of clay particles was also tested. This was done by using a simple test called hegman fineness of grind. The test is done by making a drawdown of coating on a plate that has a groove ground into its surface of varying depth from 4 to 0 mils. To read the results, marks in increments of .25 mils are made along the edge of the groove. Large particles cause



scratches and where these appear is the agglomerate size. In reading this, two bits of information are found. The first is what are the largest particles sizes determined by the first scratch and the second is the average particle size which is determined by where a whole row of scratches appear. Therefore, the data in Table VI gives the largest particle size and the average particle size.

In studying Table V and Table VI, it can be seen that the ability of the auxiliary dispersants to reduce formation of agglomerates was closely related to its effectiveness as a dispersant. The 100-0-16 series shows the greatest rate of agglomerate formation. Since the viscosity is so low, the particles are not suspended well enough, and it is easier for agglomerates to form. The 100-4-12 series shows the least build-up of agglomerates. In the two series of coatings with starch the clay particles are held in suspension and the restricted movement slows the rate of agglomeration. One other possible reason for the greater rate of grit formation in the 100-0-16 coating is that the pH was 9.0 compared to 8.0 in the other two series.

The coatings prepared with TSPP showed less stability with respect to Brookfield viscosity and average grit size when compared to the coatings prepared with auxiliary dispersants. The 100-0-16 series was the exception again in that there was not much difference in test results between

dispersion systems.

Two of the coatings spoiled by the seventh day. The bactericide level used did not apparently give enough effect for these coatings, but no sign of spoilage was present in the other coatings.

Water retention tests and opticals on the coated paper were not run because there was not any significant or radical differences noted in the properties of the coatings tested in this study. It is surmised that differences in these properties might show up better if the dispersants were used as sole dispersants rather than auxiliary dispersants.

## SUMMARY AND CONCLUSIONS

The data obtained in this study substantiates certain claims made about the effectiveness of some of these auxiliary dispersants and the following conclusions can be made:

- 1) The acrylic related dispersants showed the most benefits when used as dispersants for domestic clay.
- 2) A dispersant system containing small amounts of acrylic-based dispersants gave better coating stability with respect to viscosity and reagglomeration than straight TSPP dispersant system.
- 3) Lower initial viscosity could be obtained when using acrylic-based dispersants as part of the dispersant system.
- 4) The other types of polymeric organic dispersants listed in Table I do not seem to have any beneficial properties when used as auxiliary dispersants with this clay.

## LITERATURE CITED

1. Tamol SN Technical Bulletin and Tamol 850 Technical Bulletin, Rohm & Haas Company.
2. Nopcosant K Technical Bulletin, and Nopcosant L Technical Bulletin, Diamond Shamrock Chemical Co., Nopco Chemical Division.
3. Dispex N-40 Technical Bulletin, Allied Colloid, Inc.
4. Lytron Resins Technical Bulletin No. 1023 C, Monsanto Company.
5. J.V. Robinson and R.N. Thompson, "Paper Coating Additives," Monograph No. 25, Tappi, Atlanta, Ga., 1963.
6. A.L. Johnson and F.H. Norton, J. Amer. Ceram. Soc. 24, 189-203 (1941).
7. J.W. Swanson and G.A. Hemstock. Tappi 39, 30 (1956), No. 1.
8. M.E. Rohman. Tappi 57, 96 (1974), No. 5.
9. A.S. Michaels, Ind. Eng. Chem. 50, 951 (1958).

10. J.F. Hern and J.H. Fritz. Tappi 49, 77A (1966),  
No. 12.
11. S.R. Dennison and G.L. Toms. "Minutes of the 18th  
Tappi Coating Conference of 1961."
12. R.D. Athey, Tappi 58, 66 (1975) No. 9, and 55 (1975)  
No. 10.
13. H.K. Salzberg and W.L. Marino. "Protein Binders in  
Paperbound Coating," Monograph No. 36, Tappi, Atlanta,  
Ga., 1975.
14. W.F. Hamann. Pulp Paper Int., p. 56, July 1965.
15. H.K. Salzberg, L.E. Georgevits and R.M.K. Cobb.  
"Protein and Synthetic Adhesives for Paper Coating,"  
Monograph No. 22, Tappi, Atlanta, Ga., 1961.
16. Karl-Kraupa. Anal. Chem. 28, 1091 (1956).

TABLE III

## Auxiliary Dispersants

Dispersant and Manufacturer	Physical Structure	% Solids	Chemical Type
1) TSPP	white granules (dry)	-- 100%	polyphosphate
2) Tamol 850 Rohm & Haas Co.	light brown liquid	30% solution in water	sodium salt of polymethacrylic acid
3) Goodrite K-702 Goodrite Chemical Co.	light brown liquid	22.2% solution in water	polyacrylic acid (NaOH neutralized)
4) Dispex N-40 Allied Colloids, Inc.	light brown liquid	40% solution in water	sodium polyacrylate terpolymer
5) Nopcosant K Nopco Division Diamond Shamrock	light brown liquid	34% solution in water	polymethacrylic copolymer
6) Tamol SN Rohm & Haas Co.	brown powder	-- 100%	napthalene sulfonate
7) Arco SMA1440H Arco	light brown liquid	30% solution in water	styrene-maleic anhydride copolymer

TABLE IV

Viscosity of 70% Clay Slurry vs. % Dispersant  
(Brookfield, 25 rpm. 78-80F)

Dispersant Level	TSPP	Tamol 850	Goodrite K-702	Dispex N-40	Nopcosant K	Tamol SN	Arco SMA1440H
.2 %	22500*	22500	22500	22500	22500	22500	22500
.025%	2250	5000	7000	600	4620	--	--
.05 %	71.5	140	2070	125	1330	14000	14200
.1 %	64.5	145	1250	128	350	5900	9200
.2 %	61	330	710	370	330	6900	4850
.3 %	65	600	1820	1420	320	6800	1600
.55 %	--	--	--	--	--	--	840
.8 %	--	--	--	--	--	--	990

\* Average value for several batches. There seems to be a variance of several thousand centipoises from batch to batch.

TABLE V

Brookfield Viscosity vs. Storage Time  
viscosity in centipoises at 20 rpm

Sample	1 Day	4 Days	7 Days
100-8-8			
TSPP	8460	15800	17300
Tamol 850	4740	6750	7340
Dispex N-40	7220	7900	--
Nopcosant K	7560	10100	12800
100-4-12			
TSPP	3730	6000	7130
Tamol 850	3100	4440	5060
Dispex N-40	2730	3700	--
Nopcosant K	2620	5240	5940
100-0-16			
TSPP	182	460	512
Tamol 850	160	344	386
Dispex N-40	186	376	424
Nopcosant K	170	758	886



TABLE VI

## Agglomerate Size vs. Storage Time

largest particle size in mils / average particle size in mils

Sample	1 Day LP / AP	4 Days LP / AP	7 Days LP / AP
100-8-8			
TSPP	3.75 / --	2.8 / 1.0	3.1 / 1.25
Tamol 850	.6 / --	1.5 / .5	1.6 / .5
Dispex N-40	1.6 / --	3.1 / .75	-- / --
Nopcosant K	2.5 / --	2.1 / .75	3.4 / .75
100-4-12			
TSPP	3.1 / --	1.9 / .7	2.2 / .8
Tamol 850	2.1 / --	2.8 / .4	2.4 / .5
Dispex N-40	2.5 / --	3.5 / 1.0	-- / --
Nopcosant K	2.6 / --	2.8 / .4	2.8 / .5
100-0-16			
TSPP	1.4 / --	2.1 / 1.25	2.0 / 1.25
Tamol 850	1.1 / --	2.4 / 1.0	2.4 / 1.25
Dispex N-40	1.25 / --	2.25 / 1.3	2.5 / 1.5
Nopcosant K	1.4 / --	2.4 / 1.7	2.9 / 1.5

Fig. 1  
Basic Unit  
Acrylic Acid

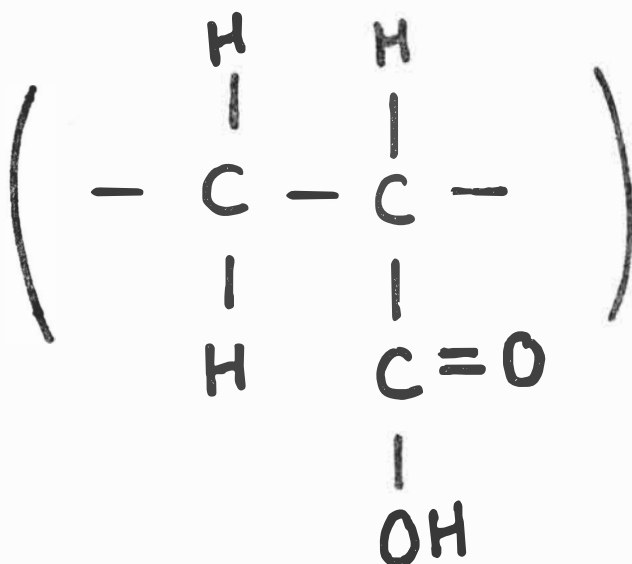


Fig. 2  
Basic Unit  
Methacrylic Acid

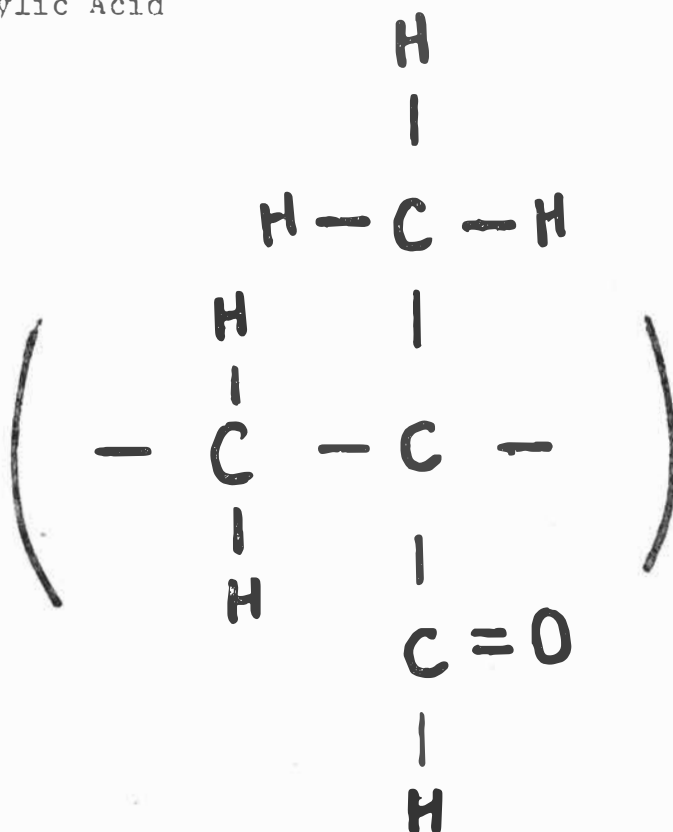


Fig. 3  
Double Layer Effect

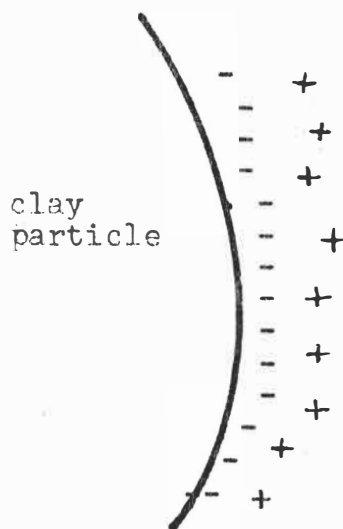


Fig. 4  
Ionic Alignment

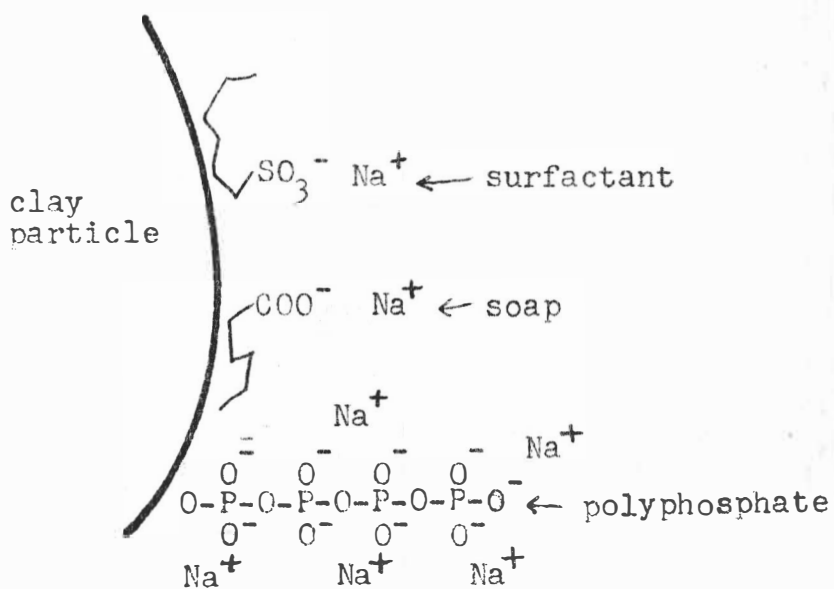


Fig. 5

Brookfield Viscosity vs. Dispersant Level  
@ 20 rpm for 70% clay slurry

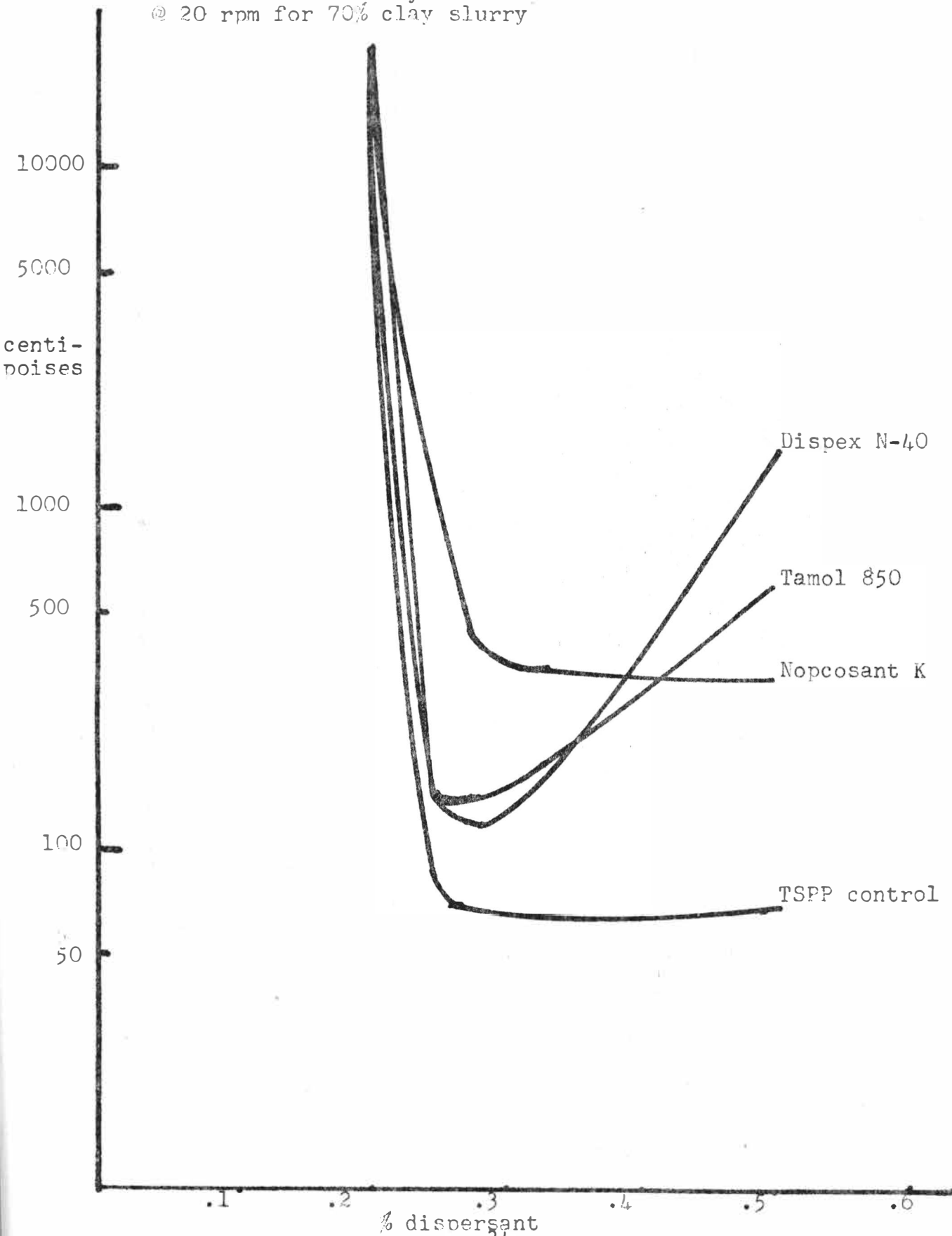


Fig. 6

Brookfield Viscosity vs. Dispersant Level  
@ 20 rpm for 70% clay slurry

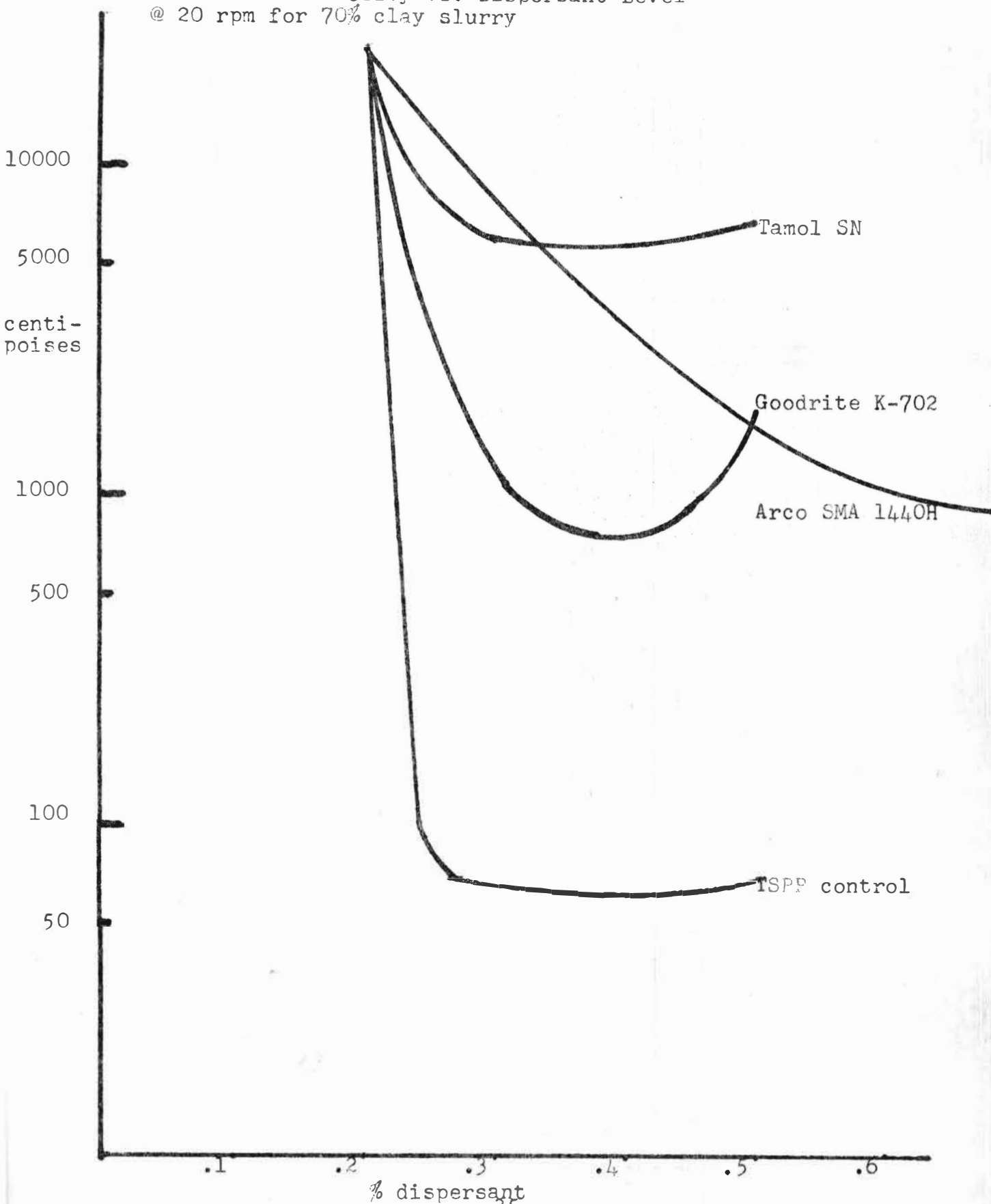
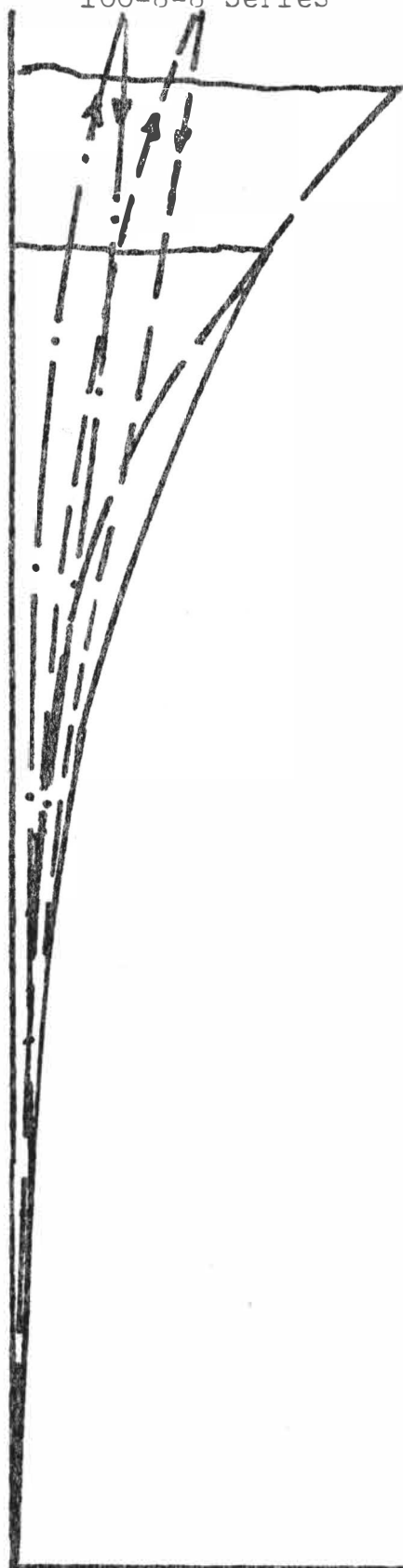


Fig. 7  
Hercules High Shear Viscosity  
100-8-8 Series

shear  
rate



400,000 dyne/cm spring

E bob

TSPP

" + Tamol 850

" + Dispex N-40

" + Nopcosant K



shear resistance

Fig. 8  
Hercules High Shear Viscosity  
100-4-12 Series

shear  
rate

100,000dyne/cm spring

E bob

TSPF

" Tamol 850

" Dispex N-40

" Nopcpsant K

shear resistance

Fig. 9  
Hercules High Shear Viscosity  
100-0-16 Series

hear  
ate

50,000 dyne/cm spring,

E bob

TSP

" Tamol 850

" Dispex N-40

" Nopcosant K

shear resistance  
- 38 -