

Rheological characteristics of platy kaolin

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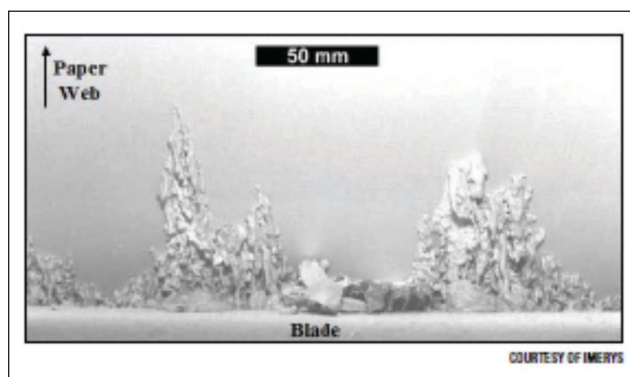
ABSTRACT: Platy kaolin can provide significant value in the coating of paper and paperboard. It can be used in multiple applications and can provide benefits such as titanium dioxide (TiO_2) extension, smoothness improvement, improved print gloss or ink set rates, calendering intensity reduction, and improved barrier properties. It is not a pigment that can be simply substituted for traditional hydrous kaolin without some adjustment to the coating formulation. These adjustments can be as simple as reducing solids, but may require binder changes as well. The coater setup may need to be adjusted because of the unique rheological behaviors these pigments exhibit.

The unique rheological characteristics of platy kaolin are explored here. Measurements of the water retention of platy kaolin containing coatings confirm that water retention is not reduced in comparison to more blocky kaolin pigments, despite the lower coating solids at which they need to be run. This means that the rheological characteristics are the most important in understanding the runnability. An extensive analysis reveals some unique behaviors that need to be understood when utilizing these materials. Viscoelastic measurements indicate that, for this binder system, $\text{Tan } \delta$ is mainly a function of solids. This may explain how weeping is initiated on a blade coater. The degree of shear thinning behaviors is investigated using the Ostwald de-Waele power law. The immobilization point was determined using the Dougherty-Krieger equation and related to the work of Weeks at the University of Maine on blade coater runnability. An indirect measure of particle shape and size synergy is also demonstrated using the Dougherty-Krieger equation parameters.

Application: This paper on the rheological characteristics of platy kaolin includes techniques that can be used to determine how to run a coating on a coater after a change in the pigment package, without running on a pilot coater. The modeling techniques outlined can also be used to reduce dependence on benchwork to evaluate a formulation change effect on the coating rheology.

Platy kaolin has unique rheological characteristics that require consideration when formulating with them. Their high shape factor, or ratio of the diameter of a particle to its thickness, means it has a larger sphere of rotation than a measurement of its particle size would indicate by use of a Sedigraph measurement. This means it takes up more space in a turbulent flow field than would be expected, but has a lesser profile in laminar flow. It also means that these platy particles will interact physically with blockier pigments like ground calcium carbonate (GCC), calcined clay, and precipitated calcium carbonate (PCC) more so than their blockier counterparts. This interaction not only results in unique rheological characteristics, but also in unique packing structures that impart enhanced optical scatter, higher coating bulk, and improved surface coverage. Even without being married to a blockier counterpart, the higher particle plate diameter gives unique coverage, smoothening, and even barrier properties.

It is well known that a blade coater's operating window depends on the viscous properties of the coating. There are several issues that can be related to the rheological characteristics of the coating, such as weeping, whiskering, coat weight control, scratches, and streaks. Stable operation of a blade coater also requires good control of the rate of dewatering of the coating. If the coating dewateres, the solids increase, which



1. Whiskering at the outgoing side of the blade tip as shown in the TAPPI's Ultimate Roll and Web Defect Troubleshooting Guide [1].

will then change the rheological behavior. Often, dewatering is associated with whiskering.

TAPPI's *Ultimate Roll and Web Defect Troubleshooting Guide* [1] lists the common causes of whiskering on a blade coater. **Figure 1** shows a photographic example at the outgoing side of the blade coater blade tip. The common causes of whiskering are:

- 1) Coating solids too high.
- 2) Poor water holding properties of the coating.

COATING

- 3) High coating line speed.
- 4) Improper blade and/or blade geometry (blade angle too low).
- 5) Blade bevel not running parallel to the web.
- 6) Overly absorbent web.
- 7) Blade pressure too high.
- 8) New blade not worn in yet.
- 9) Excessive dewatering between application and metering points.
- 10) Chamber pressure too high on a short dwell coater.

All of these issues can be related to the fundamental properties of the coating and base paper. Here, we will focus on the rheological characteristics of the coating.

Weeks [2] has recently presented a study of the coating characteristics that affect blade coater runnability based on her Ph.D. dissertation work at the University of Maine. One of the outcomes of the work was to add clarity to the understanding of what coating solids can be run on a blade coater at a given speed while avoiding such issues as streaks, weeping, whiskering, and scratching. It was clearly identified that the maximum web speed is linearly related to the difference of the immobilization solids and the coating solids. The plot shown in **Fig. 2** is from her work. This set of data was generated on a cylindrical laboratory coater (CLC) (CLC 6000, Simutech International; Kirkland, WA, USA).

Viscoelasticity is often cited as being a cause of coater runnability issues. A common method to assess it is the use of a cone and plate geometry that is oscillated at a range of frequencies. The phase shift of the force response of the oscillation input is a way of characterizing whether a fluid or material is elastic, viscous, or a combination of the two.

In this study, the Dougherty-Krieger equation [3] or method was used to determine the maximum solids of the coating. These calculated maximum solids can also be the immobilization points of the coatings. They can then be used to determine the Weeks ΔS parameter for the coatings studied. The smaller that ΔS is, as already explained by the Weeks work, the smaller the operating window is on a blade coater. It can also be speculated that this parameter can be indicative of whether there will be a runnability issue with the rod applicator on a metered size press.

The Dougherty-Krieger equation is based on the Einstein equation that accounts for particle crowding effects in a suspension. The viscosity of a suspension as a function of solids using the Dougherty-Krieger equation is:

$$\mu = \mu_0 / \left(1 - \frac{\phi}{\phi_{max}}\right)^{a\phi_{max}} \quad (1)$$

where:

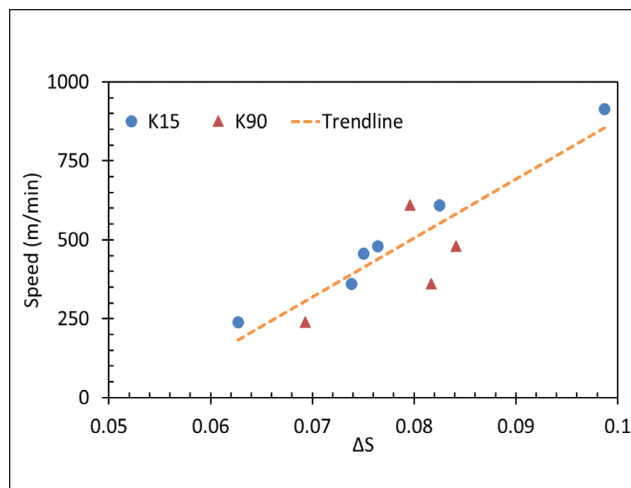
μ = apparent viscosity

μ_0 = viscosity of the suspending medium

ϕ = volumetric solids of the coating

ϕ_{max} = maximum solids

a = Einstein coefficient or the intrinsic viscosity.



2. Plot of the maximum speed without coating defects that can be run as a function of ΔS from Weeks [2]. ΔS is the immobilization solids minus the coating solids. K15 is a 15 shape factor kaolin pigment and K90 is a 90 shape factor kaolin pigment.

Using apparent viscosity versus volumetric solids data, μ_0 , ϕ_{max} , and a can be solved for in the nonlinear equation using the Solver Add-in in Microsoft Excel. To do so, a minimum of 3 sets of solids and apparent viscosity pairs are required.

Most coatings used in the production of coated papers are power law fluids of various degrees of shear thinning behavior. The constitutive viscosity power law relationship to the shear rate can be expressed as:

$$\mu = \mu_{FC} \dot{\gamma}^{(n-1)} \quad (2)$$

where:

μ = apparent viscosity

μ_{FC} = flow consistency index

$\dot{\gamma}$ = shear rate

n = flow behavior index

This power law relationship is also referred to as the Ostwald-de Waele power law [4]. This law will be applied to the cone and plate shear data.

The Dougherty-Krieger and Ostwald-de Waele relationships were investigated not only to model the data and determine the immobilization point of the coating, but also to find a method for predicting synergies between various pigment pairings. The Dougherty-Krieger parameters seem to indicate whether there is an optimum synergistic structuring of coating because of the blending of blocky (GCC) and various platy (kaolin) pigments.

MATERIALS

Table I summarizes a set of kaolin pigments that were selected for this work that has a broad range of particle sizes and shape factors. The size of the pigments was determined using a Sedigraph (Micrometrics Instrument Corp.; Norcross, GA, USA), and brightness was determined using the TAPPI Stan-

	FGCC	FK	DELK	FPK	MPK	CPK	UPK
% Solids	74.9	70.8	67.4	62.9	62.1	58.2	56
TAPPI brightness	96	88	88	89	87	88	87
Shape factor	2	14	35	58	77	83	97
pH	8.4	6.8	6.7	6.4	7.0	7.6	7.0
% < 2 μm	92	93	83	91	73	61	65
% < 0.25 μm	2	49	34	29	21	16	14
d50 in μm	0.66	0.26	0.39	0.43	0.84	1.63	2.50
FGCC = fine ground calcium carbonate; FK = fine regular brightness kaolin; DELK = typical delaminated kaolin; FPK = fine platy kaolin; MPK = medium platy kaolin; CPK = coarse platy kaolin; UPK = ultra-platy kaolin.							

I. The important physical characteristics of the pigments utilized in this work. Please note that the shape factor of the fine ground calcium carbonate (FGCC) is attributed as an approximation for analysis purposes rather than measured.

	100FGCC	100FK	100DELK	100FPK	100MPK	100CPK	100UPK
FGCC	100						
FK		100					
DELK			100				
FPK				100			
MPK					100		
CPK						100	
UPK							100
Latex, L	8	8	8	8	8	8	8
LMS	8	8	8	8	8	8	8
pH	8.1	8.1	8.1	8.1	8.1	8.1	8.0
Solids1	66.1	62.7	60.6	57.6	56.9	54.5	52.7
Solids2	64.2	60.8	58.8	55.6	55.1	52.3	50.5
Solids3	62	59	56.7	53.8	53.1	50.5	48.6
FGCC = fine ground calcium carbonate; FK = fine regular brightness kaolin; DELK = typical delaminated kaolin; FPK = fine platy kaolin; MPK = medium platy kaolin; CPK = coarse platy kaolin; UPK = ultra-platy kaolin; LMS = low molecular weight hydroxyethylated starch.							

II. Coating formulations for the comparisons of 100% of each of the pigments. The solids ladder of each formulation is also indicated.

standard Test Method T 646 “Brightness of clay and other mineral pigments.” Shape factor is a measure of the ratio of the average diameter divided by the average thickness of the particles as measured by a stop flow conductivity instrument developed by Imerys (Paris, France) [5]. The physical characteristics of these pigments are listed in Table I. FGCC is a fine GCC, FK is a fine regular brightness kaolin, DELK is a typical delaminated kaolin, FPK is a fine platy kaolin, MPK is medium platy kaolin, CPK is a coarse platy kaolin, and UPK is an ultra-platy kaolin. The pigments used in this work were obtained from Imerys. A carboxylated styrene butadiene copolymer (SBR) latex (620NA) from Trinseo (Berwyn, PA, USA) was used that has a T_g of ~10°C and a median particle size of 0.18 μm and is identified as SBR in this paper.

A low molecular weight hydroxyethylated starch (PG290) was used in this study and is identified as LMS. It is supplied by Penford (a subsidiary of Ingredion; Westchester, IL, USA). Sodium hydroxide was used to adjust the pH of the coatings.

FORMULATIONS, EXPERIMENTAL PLAN AND METHODS

The coatings were made down in a high shear mixer from pigment slurries. The starch was cooked in a laboratory batch cooker. The latex binder was used as received. **Table II** and **Table III** outline the formulations that were studied. Each grouping has a different purpose. The first group is a com-

	50:50FK	50:50DELK	50:50FPK	50:50MPK	50:50CPK	50:50UPK
FGCC	50	50	50	50	50	50
FK	50					
DELK		50				
FPK			50			
MPK				50		
CPK					50	
UPK						50
Latex, L	8	8	8	8	8	8
LMS	8	8	8	8	8	8
pH	8	8	8	8	8	8
Solids1	64.7	63.6	61.6	61.4	60.1	58.4
Solids2	62.8	61.5	59.7	59.2	58.1	56.3
Solids3	60.7	59.3	57.6	57	56	54.4

FGCC = fine ground calcium carbonate; FK = fine regular brightness kaolin; DELK = typical delaminated kaolin; FPK = fine platy kaolin; MPK = medium platy kaolin; CPK = coarse platy kaolin; UPK = ultra-platy kaolin; LMS = low molecular weight hydroxyethylated starch.

III. Coating formulations for the comparisons of the 50:50 blend combinations. The solids ladder of each formulation is also indicated.

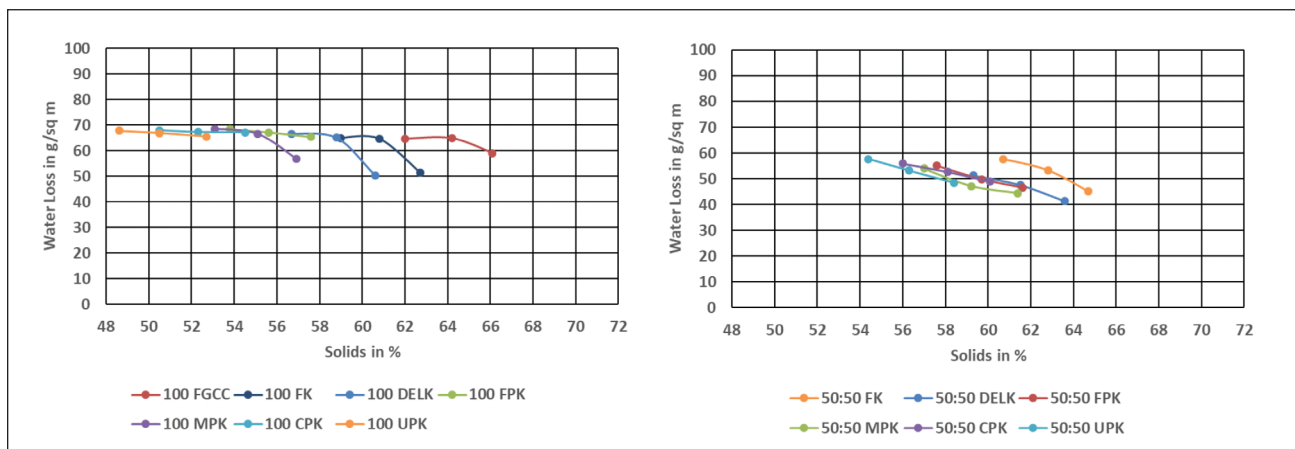
parison of each of the pigments studied as 100% of the pigment in the formulation. The second group is a comparison of the kaolin pigments combined with the FGCC at a 50:50 ratio. The purpose of these groupings is to understand how the pigment shape factor of the various kaolin pigments affects the rheological behavior and how they interact with a blocky co-pigment. All coatings were made down at the highest solids possible and then diluted twice. Each dilution was at about a 2% change.

High shear viscosity measurements were made using a DV-10 Hercules (Kalttec Scientific; Kalamazoo, MI, USA) at 4400 rpm using the E Bob. An Anton-Paar viscometer with a cone and plate configuration (Anton Paar; Graz; Austria) was

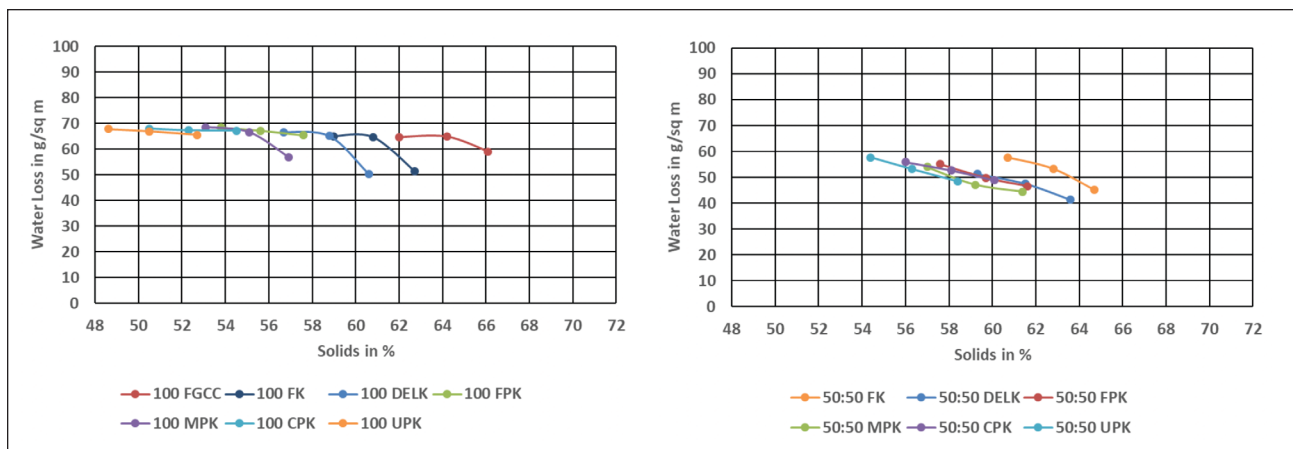
used at a range of shear rates up to 1000 s⁻¹. The Anton-Paar with a cone and plate configuration in oscillatory mode was also used to determine the viscoelastic properties. An AA-GWR instrument (Kalttec Scientific) was used to measure the dewatering of each coating over the solids range as per the Eklund method.

RESULTS AND DISCUSSION

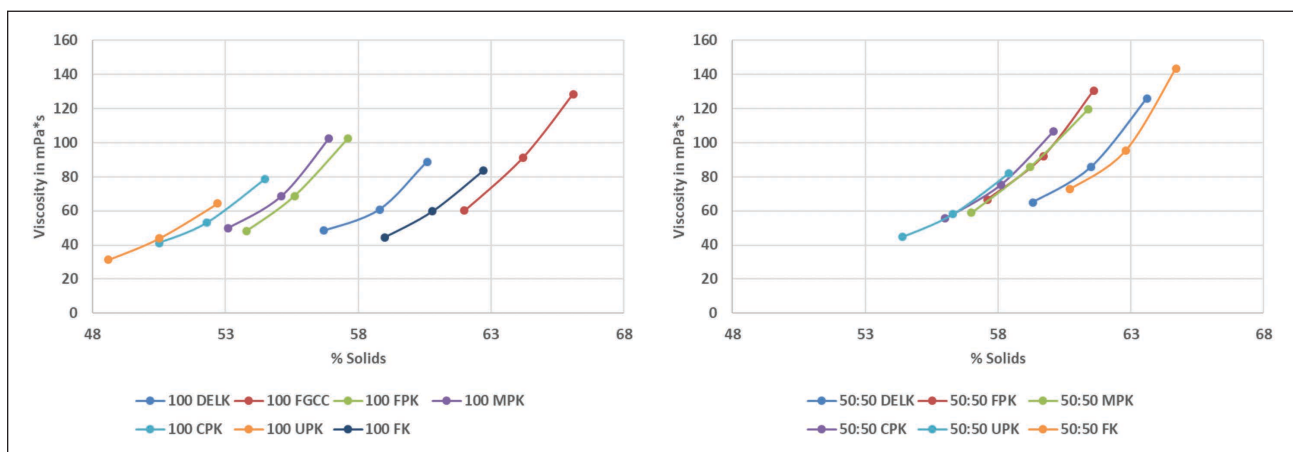
The static water retention results as measured with the AA-GWR are shown in **Fig. 3**. Interestingly, for the 100% pigment coatings, there is very little difference between the pigments. That is even while considering the pretty wide coating solids differences. The same story applies to the 50:50 blends of pig-



3. AAGWR results as a function of coating solids (FGCC = fine ground calcium carbonate; FK = fine regular brightness kaolin; DELK = typical delaminated kaolin; FPK = fine platy kaolin; MPK = medium platy kaolin; CPK = coarse platy kaolin; UPK = ultra-platy kaolin).



3. AAGWR results as a function of coating solids (FGCC = fine ground calcium carbonate; FK = fine regular brightness kaolin; DELK = typical delaminated kaolin; FPK = fine platy kaolin; MPK = medium platy kaolin; CPK = coarse platy kaolin; UPK = ultra-platy kaolin).



4. Hercules results plotted as a function of coating solids.

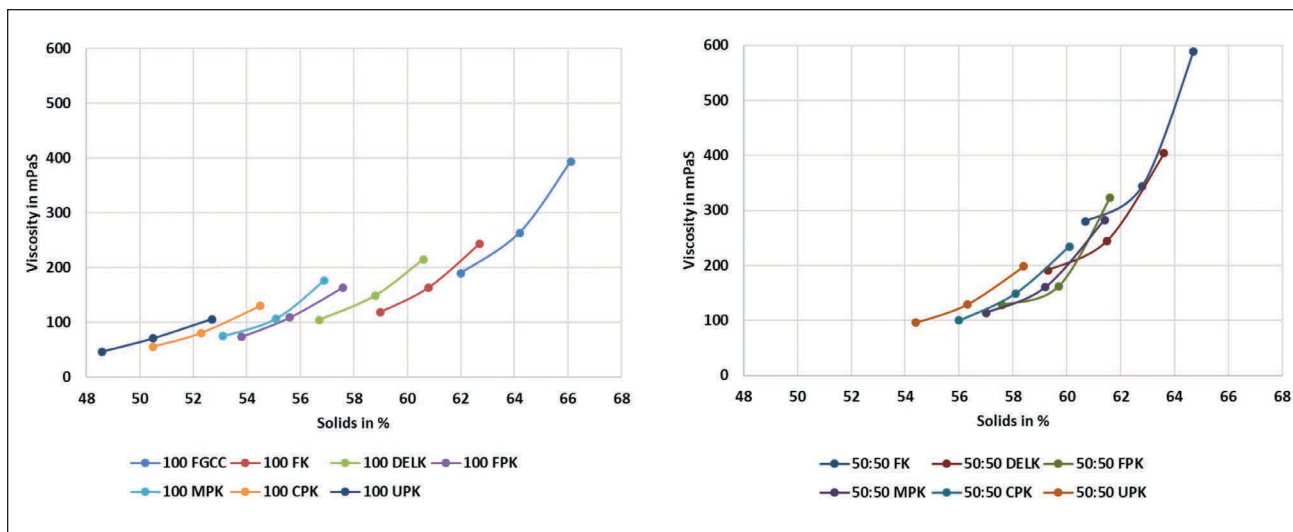
ment coatings. These results seem to indicate that there is some resistance to dewatering because of the platy nature of the kaolin pigment used. This means that the rheological characteristics of the coating are the most important factor to understand in terms of effect on the runnability of the coating.

Figure 4 shows the results for the apparent viscosity as measured by a Hercules viscometer at 4400 rpm using an E Bob. At this high shear rate of 46,288 s⁻¹, there is some differentiation between the various pigments in the 100% pigment formulations. Upon blending the various kaolin shapes and sizes with the fine GCC pigment, the coating formulation viscosity measurements appear to be more solids dependent than kaolin shape dependent. The more traditional fine and delaminated kaolin pigments appear to lie on separate lines from the platy clay data. In the Imerys laboratory, the general experience is that a coating formulation that has a higher than 75 mPa·s viscosity level will not run on a CLC-2000 laboratory coater without exhibiting banding, spitting, and scratching. That means that the highest solids coatings would not be expected to run well. This is generally not a far different experience from discussions with mill personnel on their

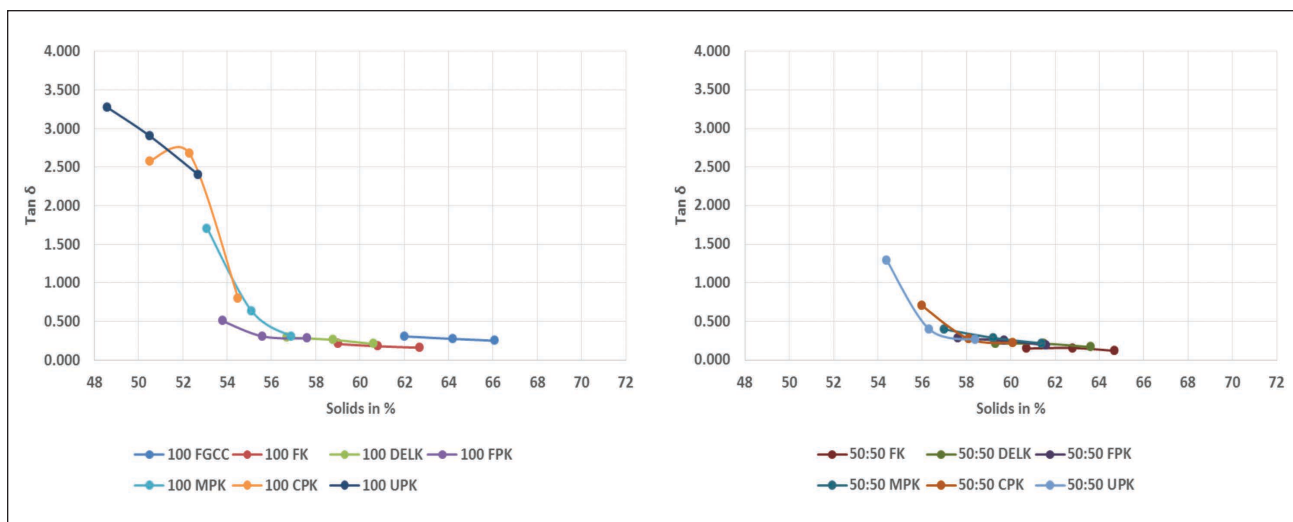
blade coaters. These results will be used with the Dougherty-Krieger equation to determine the immobilization point of the coatings.

The viscosity as a function of coating solids at a shear rate of 1000 s⁻¹ is shown in **Fig. 5** as measured with an Anton-Paar cone and plate viscometer. For the 100% pigment and 50:50 blend coatings, the major influence on the viscosity at constant levels of starch and latex are mostly the level of solids. These results across the shear rate range measured (10 to 1400 s⁻¹) will be used to obtain the Ostwald-de Waele power law parameters in order to model the viscosity behavior.

The viscoelastic behavior of the coatings was quite surprising. The oscillation results are plotted in **Fig. 6**. Tan δ at 1.1 Hz is plotted as a function of coating solids. Tan δ is the ratio of the viscous to the elastic modulus. For these coatings, this ratio looks to be a function of the solids and not necessarily of the particle shape. This was true for the 100% platy kaolin formulations and the 50:50 blends. As the solids increase, the coating formulations become more elastic- or solid-like in behavior rather than as a viscous fluid. The blockier pigments were much more elastic in behavior than the platier pigments



5. Cone and plate viscosity at 1000 s⁻¹ shear rate as a function of coating solids.



6. Oscillation results with cone and plate configuration at 1.1 Hertz oscillation. $\tan \delta$ (viscous modulus/elastic modulus) is plotted as a function of solids.

were. So, what is a good or bad level of elasticity? We have, to this point, believed that elasticity is bad, but maybe it isn't. What seems to be an issue is to have a variable response to solids.

A hypothesis that needs to be verified by further experimentation can be formed that the weeping and whiskering that is often observed for platy pigments might be caused by being in the steep response portion of the $\tan \delta$ versus coating solids curve. The platier pigments had a higher viscous component in comparison to the blockier ones, but also had a steep response to changes in the solids. Is this purely driven by the solids or the flow behavior of aligned plates as well? One can theorize that, because of the solids profile of the coating in the blade metering nip, the coating close to the blade will be lower in solids and have more viscous behavior, while the coating near the base and coating interface will be higher in solids and behave more like a solid. This will cause the more fluid coating at the blade and coating interface to squirt out, causing whis-

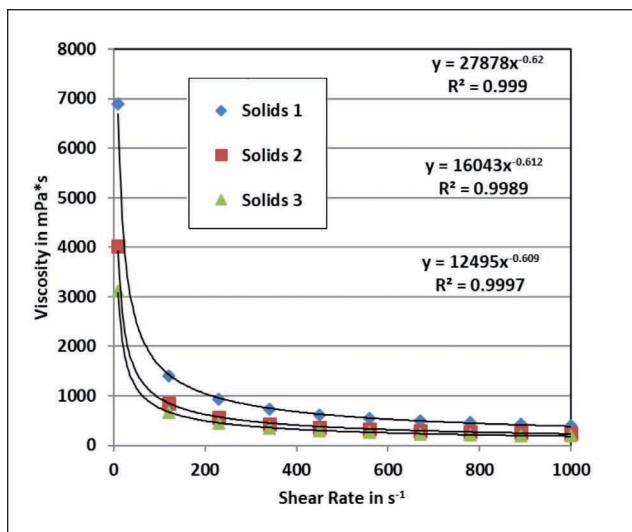
kering and weeping. The pressure behind the fluid might be higher as well since the flow channel is effectively narrowed.

CALCULATION OF THE OSTWALD-DE WAELE POWER LAW PARAMETERS

The Anton-Paar cone and plate shear results were used to determine the Ostwald-de Waele [4,6-8] power law parameters in Eq. 2 for the 50:50 blends. Excel's power function trendline data fit was used to determine flow consistency, μ_{FC} , and the power law index, n , in the constitutive equation.

Figure 7 is a plot of the data generated for the 50:50 blend of MPK and FGCC for the cone and plate data. The power law trend line fit is also shown for each solids level. This data is shown as an example of what was done for each set of viscosities.

The n index is plotted as a function of the shape factor of the kaolin pigment and μ_{FC} as a function of the solids in



7. Example of the fitting done to the cone and plate data for the 50:50 MPK and FGCC coating at each solids level. A power function was fit to each set of viscosity versus shear rate data.

Fig. 8 for all the 50:50 coatings. As the shape factor of the kaolin in each blend increases, the coating becomes more shear thickening. However, n remains less than 1 for all the coatings, so all of them are shear thinning. The degree to which they are shear thinning is all that is changing. The result for the n index seems to fit well to a second order polynomial.

The μ_{FC} parameter can be fit to a third order polynomial as a function of solids. The R^2 is a bit on the low side at 0.855. Both results show the strong influence of the kaolin shape factor on the rheological properties, as well as the effect of the solids.

DOUGHERTY-KRIEGER AND THE WEEKS ΔS

As previously discussed, the difference between the immobilization solids and the coating solids is important to how well a coating will run on a blade coater and possibly at the metering point on a rod coater. Since three solids were run for each coat-

ing, we have enough data to calculate the immobilization solids. This was applied to the 100% pigment and the 50:50 coatings.

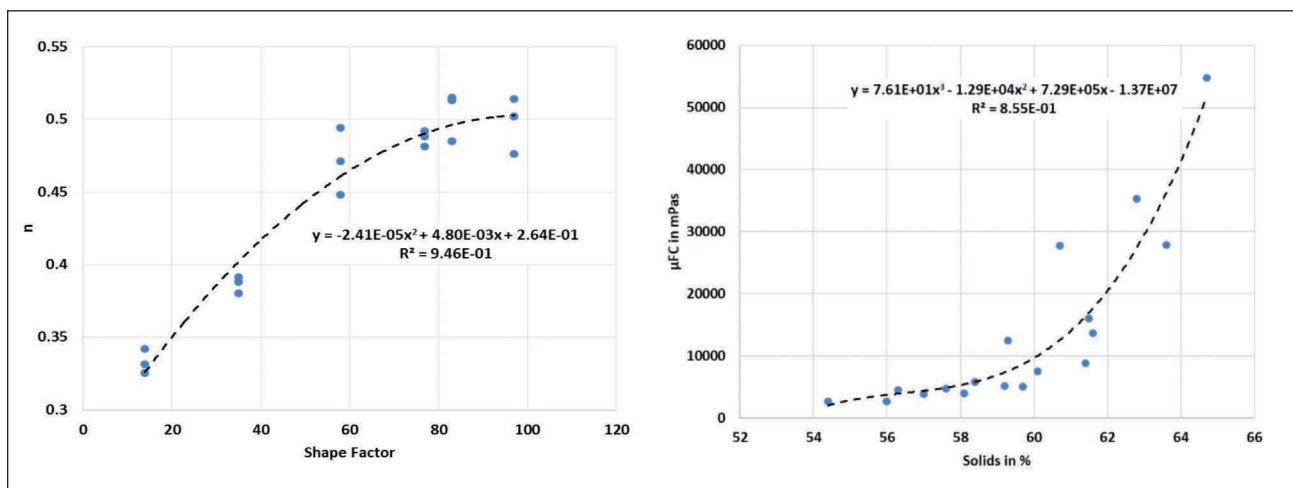
The immobilization or maximum solids calculated here can be plotted versus the shape factor. The immobilization point of the coating is also affected by the % < 0.25 μm content of the particle population. The higher it is, the lower the viscosity at high shear should be. It was expected that there should be a relationship between the immobilization solids and the shape of the particles. Both are plotted in **Fig. 9**.

In the 50:50 blend coatings, the % < 0.25 μm content of the kaolin portion of the blend and shape factor still influences the immobilization point quite strongly. The immobilization solids are plotted versus the shape factor and 0.25- μm content of the kaolin portion of the coatings in **Fig. 10**.

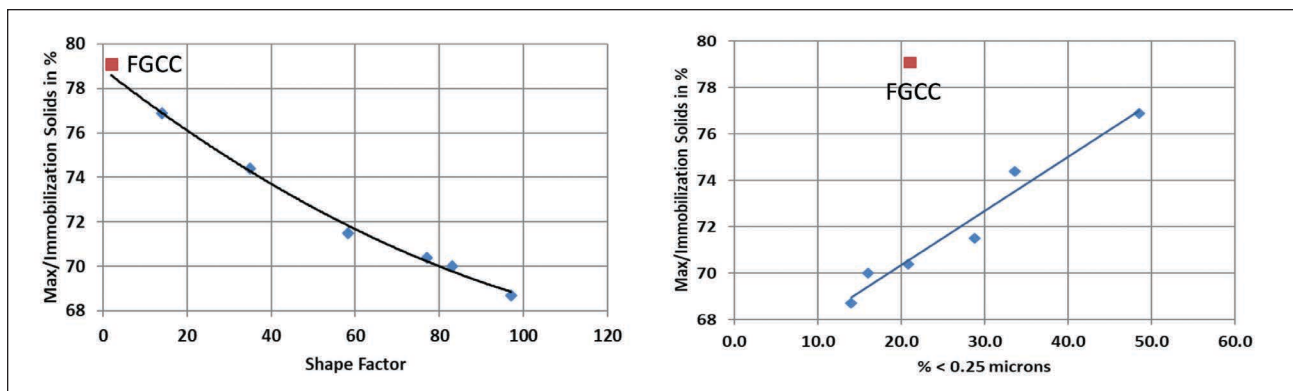
Utilizing this method to determine the immobilization solids allows one to then predict for their coater and base sheet what solids to run with a new formulation. Simply use the current ΔS to calculate the solids where the new coating needs to be run using the new immobilization solids. As an example, if the 50:50 FK coating is currently running well at 62% solids, then the target ΔS would be 76.2 minus 62 or 14.2. If there is a switch to the 50:50 FPK formulation, then the new coating would need to be run at 71.5 minus 14.2 or 57.3% solids. All of this assumes that no other changes are made to adjust the water-holding of the coating.

DOUGHERTY-KRIEGER AND SYNERGY

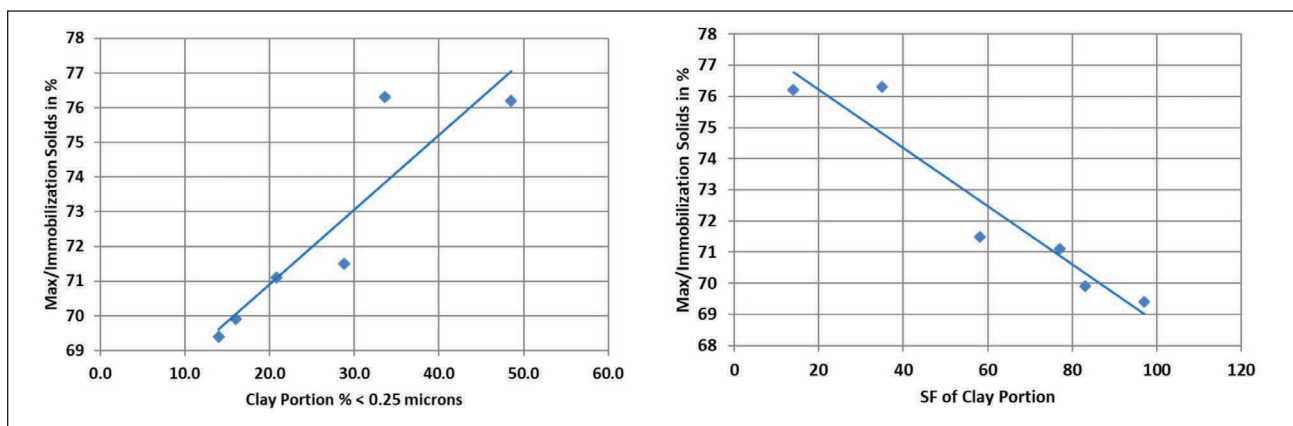
It appears that there is some relationship between the shape factor of the kaolin portion of the 50:50 coatings and α and μ_0 . These two parameters are plotted versus the shape factor in **Fig. 11**. That a parameter like α would be related to the shape of the particles makes some sense. This parameter is a multiplier in the denominator; so, as it gets smaller, so does the denominator, thus making the viscosity higher. In addition, from Einstein's theory, it is expected that α will change with particle shape. In much the same mathematical way, the μ_0 parameter maximizing at the most structured point makes



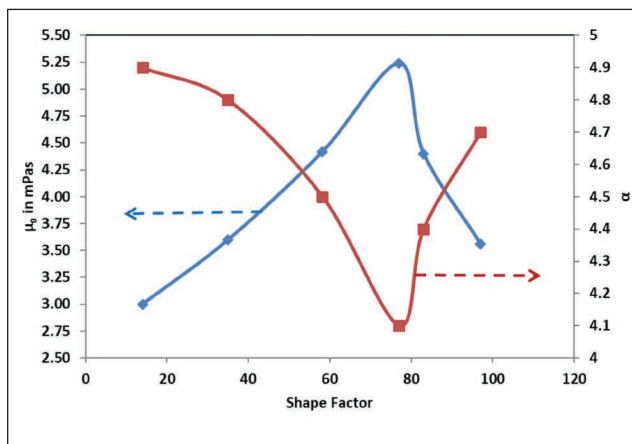
8. Plot of n versus the shape factor of the kaolin portion and μ_{FC} as a function of the solids. The higher that n is, the more shear thickening the coating becomes.



9. The maximum or immobilization solids as a function of the shape factor and % < 0.25 μ m for the 100% pigment coatings.



10. The strong influence of the kaolin portion characteristics in the 50:50 blends on the immobilization solids.



11. When μ_0 and α are plotted as a function of the shape factor, a minimum in α and maximum in μ_0 emerge, indicating an optimum in structuring synergy between the kaolin and GCC in the coating at around a kaolin shape factor of 78.

sense. However, since this parameter is supposed to be related to the suspending fluid, it requires more thought. Is it possible that the colloidal fraction that is less than 0.25 μ m in size has some influence on this parameter? Is it possibly minimized at this point so that the high shear behavior as measured by the Hercules is affected? The viscoelastic measurements seemed to indicate that the viscous nature of the

coating increases as the shape factor of the kaolin increases. Is this more evidence to this behavior?

SUMMARY AND CONCLUSIONS

The solids of a coating strongly dictate the rheological characteristics of a coating. As the shape factor of the kaolin that is used increases, the solids must shift downwards. This is true for the low shear, high shear, and viscoelastic properties of a coating. Surprisingly, even though the solids of a platier kaolin containing coating are much lower than its blockier counterpart coatings, the water-holding characteristic doesn't change very much.

Platy kaolin containing coatings tend to have a high viscous component in comparison to blocky kaolin and carbonate pigments. Does this mean that more elastic- or solid-like behavior around the coater is preferred over a more viscous dominated behavior? This bears further investigation.

It was demonstrated that all coatings in this study are shear thinning by using the Ostwald-de Waele Power Law model. The degree of shear thinning was an apparent difference between coatings.

The immobilization point of a coating can be determined using the Dougherty-Krieger equation and using viscosity measurements at three solids levels or more. A technique is demonstrated on how to calculate where to target solids as pigment

changes are made without changes in the binders and other additives using the Weeks ΔS method and Dougherty-Krieger. It was also demonstrated how the shape factor of the kaolin pigments affected the immobilization point of a coating.

A methodology is demonstrated here that deserves more investigation on the use of the Dougherty-Krieger technique to determine synergies between various pigments in terms of maximization of the bulk or porosity of the coating. This was indicated by a minimum in a plot of the inherent viscosity α as a function of the shape factor of the kaolin component in blends with a fine carbonate. There was also a maximum in the media viscosity μ_o plotted as a function of the kaolin component in blends with a fine carbonate. **TJ**

ACKNOWLEDGEMENTS AND DEDICATION

I would like to thank Perry Veal and Lisa Buttitta at the Imerys Technical Service Laboratory in Sandersville, GA, USA, for generating this data set for me. This work is dedicated to the memory of David Cummings, who was Perry's and Lisa's supervisor. David provided his excellent guidance and training in facilitating the generation of this data set. David's unfortunate passing has taught me to be even more aware of bicycle riders while driving.

ABOUT THE AUTHORS

Platy kaolin rheological behavior is unique and cannot just simply be substituted for currently used pigments without considering its differences. This work attempted to broaden our understanding and provide tools to use in reformulating and implementing their use to take full advantage of what these pigments offer.

This work is complementary to work previously done at the University of Maine in Orono on improving our understanding of the fundamental issues around the use of platy kaolin in coating formulations from a coating process perspective. This work focuses on the rheological characteristics and broadens our understanding of how these characteristics affect how the coating will run on the coater.

There were two aspects of this work that provided some difficulty. First, there was a large amount of data to generate in order to properly understand the rheological characteristics of platy kaolin in coating colors. The second was the analysis itself of the data in order to develop sound models and to tease out the important relationships and concepts that the data was confirming or not confirming in some cases.

I discovered that models and concepts that have long been in development are applicable to these very different materials. I also gained a deeper understanding of visco-elastic behaviors of paper coatings and how to interpret the data to better understand how these behaviors affect the coating

ABOUT THIS PAPER

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LITERATURE CITED

1. Smith, R.D., *Ultimate Roll and Web Defect Troubleshooting Guide*, TAPPI Press, Peachtree Corners, GA, USA, 2013, p. 280.
2. Weeks, L., "Operational limits of blade coating with high aspect ratio pigments," Ph.D. dissertation, University of Maine, Orono, ME, USA, 2017.
3. Mueller, S., Llewellyn, E.W., and Mader, H.M., *Proc. R. Soc. A* 466(2116): 1201(2009). <https://doi.org/10.1098/rspa.2009.0445>.

processability of paper coatings. The most interesting finding was that the viscous versus elastic behavior of paper coatings can vary dramatically as the coating solids changes. If one considers that the coating solids is not necessarily consistent as one observes it across the gap between the metering blade and the paper surface, this may explain the coating defects and blade deposits seen in mill operations.

It has already been demonstrated in actual mill implementations that the techniques developed in this work can indicate what to expect when a change from a current kaolin pigment to a platy kaolin is made. This helps to reduce operational issues and implementation time, and to avoid the need to run pilot coater trials just to become familiar with the operational issues that may occur.

The next step is to expand this research in scope to include a broader range of understanding in how platy kaolins interact with co-pigments in the coating formulation. This includes a broadening of the ratios of platy kaolin to co-pigments in the formulation and to vary the sizes and types of co-pigments.



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COATING

4. Ostwald, F.W., *Kolloid-Z.* 47(2): 176(1929).
<https://doi.org/10.1007/BF01496959>.
5. Gate, L.F., and Webb, T.W., U.S. pat. 5,128,606, (July 1, 1991).
6. Scott Blair, G.W., Hening, J.C., and Wagstaff, A., *J. Phys. Chem.* 43(7): 853(1939). <https://doi.org/10.1021/j150394a004>.
7. Reiner, V.M. and Schoenfeld-Reiner, R., *Kolloid-Z.* 65(1): 44(1933).
<https://doi.org/10.1007/BF01428857>.
8. Saramito, P., *Complex fluids: Modeling and Algorithms*, Springer International Publishing, Cham, Switzerland, 2016, p. 65.
<https://doi.org/10.1007/978-3-319-44362-1>.



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