

The mechanism of premixing rosin sizes for neutral-alkaline papermaking

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ABSTRACT: This investigation of the mechanism of premixing alum-rosin size for neutral-alkaline papermaking conditions focused on the mixture solution charge and particle size distribution. The effect of the mixture concentration, temperature, and ratio of alum to rosin on the rosin-alum size efficiency was studied theoretically.

Application: This study may help in developing new technologies for rosin sizes to be used in neutral-alkaline papermaking.

In papermaking, internal sizing helps paper and paperboard resist liquid penetration and absorption. The sizing agents used cover a wide range of chemicals, including rosin size, synthetic resin, starch, and cellulose derivatives. Rosin sizes and synthetic resins are the two principal materials used, of which rosin sizes remain, by far, the most important internal sizing agent [1-2].

Traditionally, rosin sizes are widely used in acidic papermaking systems, for the following reasons:

- They are fairly inexpensive
- They are abundant and easy to operate
- Their sizing response curve is gradual, not steep
- They are readily compatible with other wet-end additives
- They do not depend on covalent bond formation
- They do not have on-machine size development problems.

During the past decade, neutral-alkaline papermaking systems have developed considerably. More and more mills have shifted from acidic to neutral-alkaline papermaking to be able to use calcium carbonate fillers in printing paper, to enhance paper strength, and to increase the longevity of archival papers. It is, however, still valuable to explore high-efficiency technologies for rosin sizes used under neutral-alkaline papermaking conditions.

Neutral-alkaline papermaking systems use various technologies for rosin sizes. The premixing process is simple, very efficient, and useful from a commercial standpoint [3]. However, only a few papers discuss the process [2, 4-6], and literature on the process mechanism is scarce [5-6].

The aim of this work was to investigate the mechanism of the premixing process for the rosin-alum sizing. We used experimental data on alum-rosin mixture solution charge and particle size under different conditions. The results reveal optimal technological conditions of the process, which may benefit mills and assist with further research and the development of new sizing agents.

EXPERIMENTAL

Materials

We obtained the rosin size, alum, and a retention agent from MeadWestvaco Corp.

A recycled high filler pulp was obtained from Rand-Whitney Group LLC.

Preparation of handsheets

To prepare handsheets, we diluted the pulp to 4% solids pulp slurry in a pulper. The chemicals were added premixed or separately into the pulp slurry. Following chemical addition, the pulp slurry was diluted to 0.25% solids for sheet forming. We formed 12-by-12 inch hand sheets using an M/K Systems automatic sheet former. For molding sheet forming, the sheets were made with 4% solids stock by direct dewatering on a screen. These sheets were pressed at 50 psi and dried on a drum drier with a surface temperature of 120°C. Following a single pass around the drum drier, the sheets were placed in a convection oven at 125°C for 10 min. The sheets were conditioned at TAPPI standard conditions before property testing.

Analytical methods

The charge and pH value of the 4% solids pulp slurry before and after chemical addition were determined using an Electrokinetic charge analyzer, Model ECA 2000P, by Hemtrac System, Inc., and a pH

meter, Model 8005, by VRW Scientific, respectively.

The premixing solution we used—Ross-ME100LC—is made by Charles Ross & Son Co. We measured the charge, particle size, and viscosity of the solution with the Model ECA 2000P Electrokinetic charge analyzer, the Hemtrac System Horiba LA-910 laser scattering particle size analyzer, and the Model-RVT viscosity meter by Brookfield Engineering Laboratories, Inc., respectively.

We measured the paper wicking by determining the water migration distance at 30 min. Cobb value and water absorption were determined according to TAPPI Standard T441-om-90 and T433-cm-84.

RESULTS AND DISCUSSION

Effect of premixing process for rosin-alum size

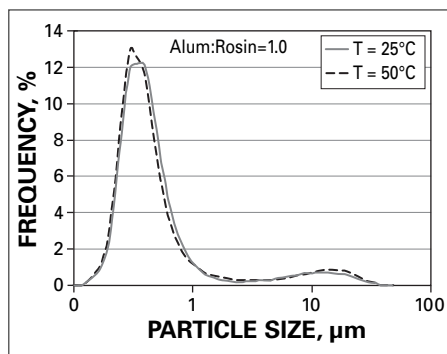
Studies have reported that alum-rosin and polyaluminum chloride (PAC)-rosin were greatly improved in neutral-alkaline papermaking systems through the premixing process [4-6]. **Table I** lists the results for the recycled high-filler pulp from Rand-Whitney.

Our results agreed with Katz's report [5-6]. The premixing sizing method produced paper with a lower Cobb number and wicking value and longer water absorption time than paper made with a conventional sizing method.

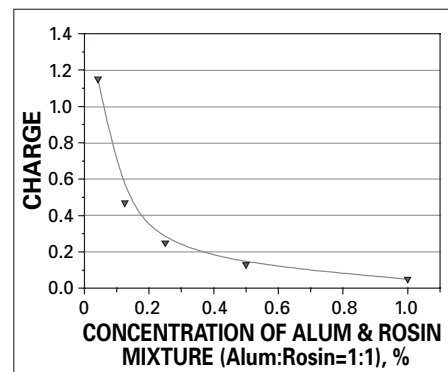
Effect of temperature

Katz and colleagues reported [5-6] unfavorable results when the temperature of the sizing mixture (alum-rosin) was increased. **Table II** lists the experimental data of charge, viscosity, and mean particle size of the mixture at two temperatures. **Figure 1** shows their particle size distributions.

From Fig. 1, it is obvious that the two curves are almost the same, with a slight difference in the highest frequency of particle size distribution. The particle size in that area increased with increasing temperature; therefore the mean particle size is increased (see Table II). Meanwhile, Table II shows that the mixture positive charge and viscosity decreased at the higher the temperature. As the temperature is increased, the particle size increased and the charge decreased, so the rosin-alum size efficiency is decreased, which means increasing the temperature is unfavorable for rosin-alum size.



1. The particle size distribution of the mixture at 25°C and 50°C.

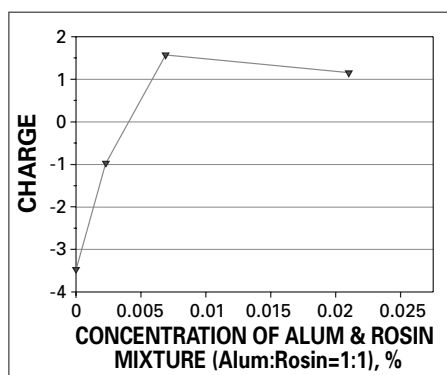


2. Effect of concentration of rosin-alum mixture on the solution charge.

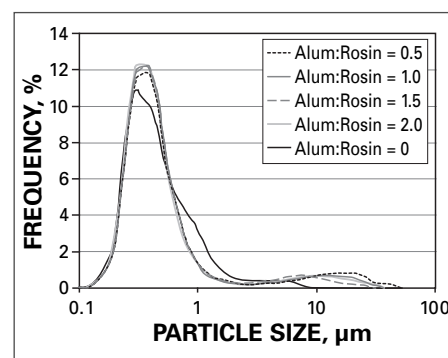
Effect of concentration

Katz and coworkers also reported [5-6] that sizing treatment at a low concentration of the mixture (alum-rosin) solution is preferable. Figures 2 and 3 show the effects of concentration on the solution charge.

Figure 2 shows that the lower the concentration, the more positive the solution charge, which is favor to rosin-alum size. When the concentration is too low, however, and nears zero, the charge becomes negative (Fig. 3). When the concentration is too low, the particle size will be too small to be sized, which is unfavorable for rosin-alum size (a very small particle size means that the compound will be a solution and go into the white water, and cannot be deposited into the fiber; therefore it will lose the size efficiency.) Therefore the optimal concentration is based on particle size, charge, and mill commercial requirements.



3. Effect of rosin-alum mixture on solution charge as concentration nears zero.



4. The particle size distribution of the mixture at different ratio of alum to rosin.

Effect of the ratio of alum to rosin

Katz et al. also reported [5-6] an optimal ratio of alum to rosin for rosin-alum mixture sizing. Table III lists the experimental data of charge, viscosity, and mean particle size of the mixture at different alum-to-rosin ratios. Figure 4 shows their particle size distributions.

Table III shows that, through the premixing process, the alum-rosin mixture has become cationic, although the rosin was anionic; the particle size of the rosin itself is too small to be sized.

Figure 4 shows that alum and rosin really formed a new material: aluminum rosinate. The particle size distribution of alum-rosin and pure rosin are not identical. The particle size in the best possible distribution area (0.3 µm) is increased for alum-rosin compared to rosin itself. There is also a second peak in the alum-rosin system, which is very important.

If aluminum rosinate were *not* formed, the figure should have an obvious distribution line for alum. In Fig. 4, for all rosin and alum conditions, compared to rosin itself, there is a second peak. The first peak is almost the same as rosin; therefore, the second should be aluminum rosinate, otherwise, where is the alum? The second peak position depends on the ratio of alum:rosin

| | Wicking, mm | Cobb No., g/m ² | Water absorption, min | pH |
|---------------------|-------------|----------------------------|-----------------------|------|
| Conventional sizing | 10 | 831 | 25 | 7.13 |
| Premixing sizing | 5 | 680 | 106 | 7.21 |

I. Effect of premixing process.

| Temperature | Charge | Viscosity, cps | Mean Particle Size, µm |
|-------------|--------|----------------|------------------------|
| 25°C | 0.05 | 17 | 1.363 |
| 50°C | 0.04 | 12 | 1.551 |

II. The mixture properties at 25°C and 50°C.

| Ratio, Alum:Rosin | Charge | Viscosity, cps | Mean Particle Size, µm |
|-------------------|--------|----------------|------------------------|
| 0 | -1.54 | 6 | 0.592 |
| 0.5:1.0 | 0.11 | 17 | 1.84 |
| 1.0:1.0 | 0.05 | 17 | 1.363 |
| 1.5:1.0 | 0.03 | 17 | 0.992 |
| 2.0:1.0 | 0.01 | 17 | 1.241 |

III. The mixture properties at different ratios of alum to rosin (25°C).

and rosin. Such as here is ~0.7 to ~0.75 µm (lg particle size) because the aluminum rosinate is a very complex compound.

SIZING

We also observed a particular phenomena in the alum-rosin system. The order of the particle size in the best possible distribution area is: alum:rosin = 2.0 > alum:rosin = 1.0 > alum:rosin = 1.5 > alum:rosin = 0.5. The next best possible distribution area is: alum:rosin = 0.5 > alum:rosin = 1.0 > alum:rosin = 2.0 > alum:rosin = 1.5. As shown in Table III, the order of average particle size for the alum:rosin system is: 1.84 μm (alum:rosin = 0.5) > 1.363 μm (alum:rosin = 1.0) > 1.241 μm (alum:rosin=2.0) > 0.992 μm (alum:rosin = 1.5), which is the same as in the second peak. From practical experience, if the particle size is $\sim 1 \mu\text{m}$, it generally will provide the best size efficiency for the same type size agent (such as alkylketene dimer [AKD]). Therefore alum:rosin = 1.5 is the optimal ratio of alum to rosin for the rosin-alum mixture sizing system, which correlates perfectly with the experimental results of Katz et al.

CONCLUSIONS

This study of alum-rosin premixing confirmed that the premixing process can greatly improve rosin size efficiency in neutral-alkaline papermaking systems. It was first found that the alum-rosin mixture becomes cationic through the premixing process. We also verified, theoretically, that there is an optimal ratio of alum to rosin and an optimal concentration of alum-rosin mixture. Finally, we explained, theoretically, that alum-rosin size efficiency declines at higher alum-rosin mixture temperatures. **TJ**

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INSIGHTS FROM THE AUTHORS

This study is part of our efforts to develop anionic resin and rosin with other sizes, such as AKD, to be used in neutral-alkaline papermaking conditions.

In the study, we explored the mechanism of the premixing process for rosin and alum. The results confirmed that the premixing process can greatly improve rosin efficiency in neutral-alkaline papermaking systems, and theoretically verified an optimal ration of alum to rosin (1.5).

The most difficult aspect of this research was to determine how to completely understand the mechanism of the premixing process. We decided to focus on the mixture solution's particle size, charge, and product physical properties.

We have found that the alum-rosin became cationic, although the rosin was anionic rosin. We also theoretically verified that there is an optimal ration of alum to rosin and an optimal concentration of alum-rosin mixture in the alum-rosin system. In addition,

we explained theoretically that alum-rosin size efficiency suffers at higher mixture temperatures.

Our next step is to develop a new anionic resin to be used in neutral-alkaline papermaking, and to blend rosin or anionic resin with other size agents to be used in neutral-alkaline systems.

Mills can directly use the premixing process for rosin or new anionic resin used in neutral-alkaline systems, and potentially achieve optimal conditions for maximum cost efficiency.

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