Journal of Korea TAPPI
Vol. 33. No. 5, 2001
Printed in Korea

The Choice of the Right FWA for High White Coated Papers

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1. Introduction

Optical brighteners (OBA) or fluorescent whitening agents (FWA) are widely used to improve the brightness and whiteness of textile fabrics and papers. The most common FWAs used today in paper coating are tetrasulfo type of derivatives of diaminostilbene disulphonic acid. They are quite cost-effective, but can only be used in low and medium whiteness segments due to the so-called greening (saturation) effect. Moreover, tetrasulfo FWAs have another disadvantage: there have to be a sufficiently high concentration of co-binder in the coating color, to achieve a significant effect.

Thus, tetrasulfo FWAs are not so suitable for the production of high white coated papers. Both old and novel products are available, but it is not easy to choose the right one. The aim of this paper is to ease this choice.

2. Mechanism of FWAs

All natural material, like fibers, pigments, etc. have a yellowish tint, even if they are highly bleached. For the papermaker, the usage of FWAs is one of the tools to eliminate this yellowish hue and to improve the paper quality in terms of appearance. FWAs convert invisible ultraviolet radiation to visible blue light (blue fluorescence). Using FWAs is a convenient way to increase the reflectance (and thus the lightness) of paper and simultaneously to move the shade from yellow to blue. This subtle tint change makes the paper look even whiter.

3. Whiteness segments

The effect of FWAs in paper coatings can be divided into, 4 different segments: low, medium, high and the highest whiteness. Low whiteness segment means that the whiteness improvement caused by FWA is low and, correspondingly, the highest whiteness means that the effect of FWA is extremely strong. The absolute whiteness levels of these different segments vary from grade to grade. Table 1 defines these segments more in detail and shows the typical amount of conventional FWAs.

Table 1. Whiteness segments

Segment	Description /Product type	Typical amount of convention FWA
Low whiteness	Clearly below Tetrasulfo' s saturation point	around 0.5 parts
Medium whiteness	Around Tetrasulfo' s saturation point	0.7~1.0 parts
High whiteness	Premium FWA needed (hexasulfo, Tinopal MC or SK-type)	1.0~2.0 parts
Highest whiteness	Only boosted hexasulfos (like Tinopal SHP) works well	more than 2.0 parts

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4. Tetrasulfo FAW' s saturation

Generally speaking, tetrasulfo FWA is the best choice for low and medium whiteness levels, but it can not be used in higher whiteness segments due to the so-called greening (saturation) effect. If the amount of FWA exceeds the certain limit, the product does not work properly. The shade of the paper first turns gray and then green, and it does not look white any more. The tetrasulfo FWAs are most sensitive to "greening," meaning that the "greening" starts at quite a low dosage level. This phenomenon is demonstrated in Figures 1~3 where the behavior of Ciba® TINOPAL® ABP (tetrasulfo) is compared to that of the novel FWA (TINOPAL MC).

The saturation point (i.e., the point where "greening" starts) is most easy to see from coordinates a* and b* (Figure 3). Note that above the saturation point (where "greening" has already started) the measured whiteness and especially the brightness can still increase while the visual whiteness already starts to decrease. Note also the effect of the co-binder: the lower the co-binder level, the sooner the tetrasulfo FWA reaches the saturation point.

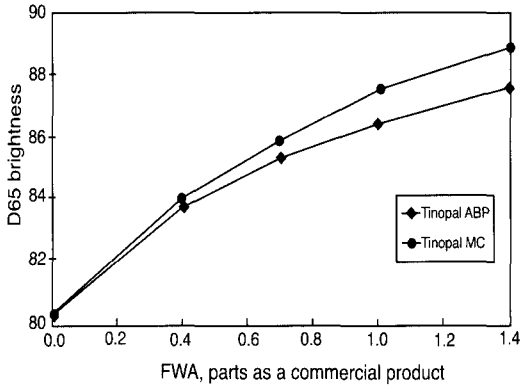

Figure 1. Tetrasulfo' s saturation - D65 brightness vs. the amount of FWA. Recipe: 60 parts $CaCO_3$, 40 parts Clay, 10 parts SB-latex and 0.9 parts CMC. Base paper: LWC.

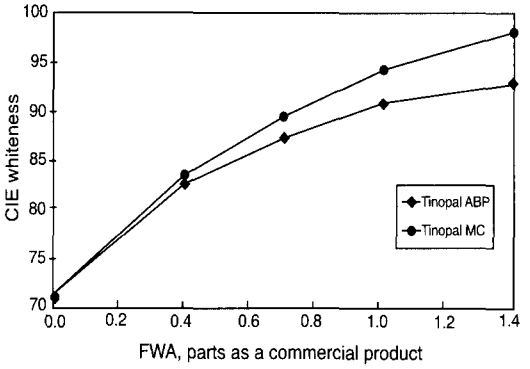

Figure 2. Tetrasulfo' s saturation - CIE whiteness vs. the amount of FWA. Recipe: 60 parts $CaCO_3$, 40 parts Clay, 10 parts SB-latex, and 0.9 parts CMC. Base paper: LWC.

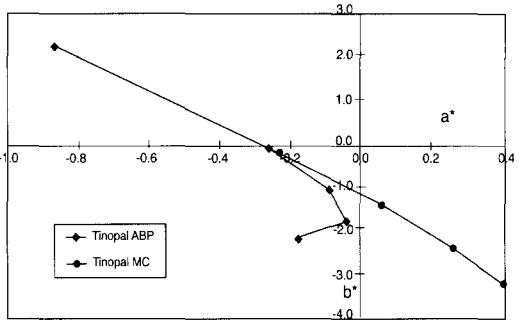

Figure 3. Tetrasulfo' s saturation, shade. Recipe: 60 parts $CaCO_3$, 40 parts Clay, 10 parts SB-latex, and 0.9 parts CMC. Base paper: LWC.

5. Tinopal FAWs for high white segment

Traditionally, hexasulfo type FWAs have been the only choice for the high whiteness segment. The use of these products is, however, very expensive, because the needed amounts are relatively high. Therefore they

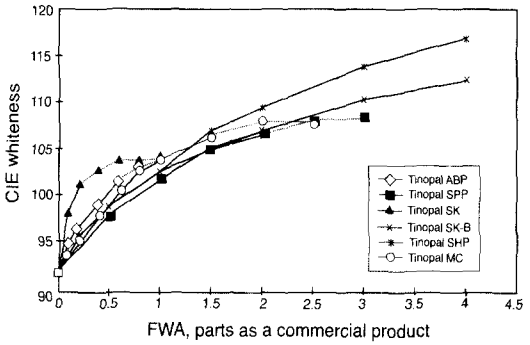

Figure 4. TINOPAL FWAs for high white segment, example 1.
Recipe: 60 parts $CaCO_3$, 40 parts Clay, 11 parts SB-latex, and 0.8 parts CMC.
Base paper: Woodfree.

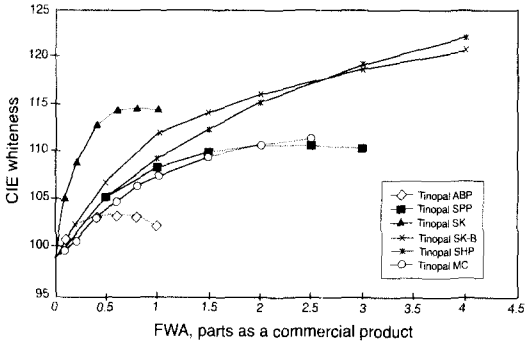

Figure 5. TINOPAL FWAs for high white segment, example 2.
Recipe: 70 parts $CaCO_3$, 30 parts Clay, 12 parts Acrylic latex, and 1 parts PVA.
Base paper: Precoated woodfree.

are not widely used. To overcome this problem, new FWAs for the high whiteness segment have been developed, such as a stilbenic FWA with a new unique structure (TINOPAL MC), and distyrylbiphenyl products (TINOPAL SK and TINOPAL SK-B). The choice of the technically and economically best FWA depends on the coating color composition and the whiteness level required. This phenomenon has been evaluated through numerous lab trials, using various coating colors and types of base paper. The main findings of the lab trials are shown in Figures 4~6. In these Figures, the dotted lines mean that the "greening" has already started.

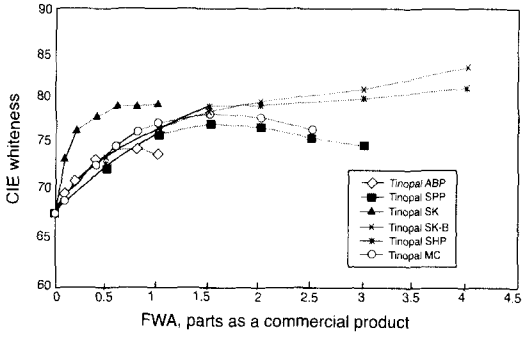

Figure 6. TINOPAL FWAs for high white segment, example 3.
Recipe: 100 parts Clay, 10 parts SB-latex, and 0.3 parts CMC.
Base paper: LWC.

Figure 4 shows an example where the base paper is woodfree and the co-binder is CMC. For the high whiteness segment the best product is TINOPAL MC and for the highest whiteness segment the best product is TINOPAL SHP (boosted hexasulfo). Note also that the efficacy of TINOPAL MC is better than that of TINOPAL SPP (hexasulfo), and the efficacy of distyrylbiphenyl products (TINOPAL SK and TINOPAL SK-B) is not very good.

The results of precoated woodfree paper with PVA as a co-binder are shown in Figure 5. This situation compared to Figure 4 is completely different: distyrylbiphenyl products (TINOPAL SK and TINOPAL SK-B) work very well, but TINOPAL MC is not suitable at all. In this case, the best choice for the high whiteness segment is made between TINOPAL SK and TINOPAL SK-B, depending on the whiteness level required. Moreover, TINOPAL SK-B can be even used in the highest whiteness segment. However, at a very high dosage level the whiteness of TINOPAL SHP was higher than that of TINOPAL SK-B.

Figure 6 shows the results of LWC paper

with a low amount of CMC as a co-binder. Due to a low amount of co-binder, the "greening" starts quite early with all products. In this case the best product for the high whiteness segment is either TINOPAL MC or TINOPAL SK. When tetrasulfo FWA (TINOPAL ABP) levels off, TINOPAL MC continues to build up. On the other hand, TINOPAL SK is not sensitive to the amount of co-binder, and therefore its efficacy is good.

6. Pilot and mill scale experience

To confirm the findings of the lab trials a couple of pilot and mill scale trials with various customers have been carried out. These trials confirmed the lab results:

- In the PVA system distyrylbiphenyl products TINOPAL SK and TINOPAL SK-B work very well, but the efficacy of TINOPAL MC is low.
- On the other hand in the case of CMC or starch TINOPAL MC is the most suitable FWA for high whiteness segment.

Moreover it was noticed that FWA does not have a negative effect on coating color properties or paper properties even at high dosage levels. Printability was also checked with industrial printing machines, and it was found that whiteness improvement with FWA could be reached without affecting the printing result.

7. Conclusions

Tetrasulfo FWAs are most cases the most economical solution for low and medium whiteness segments i.e., as long as the required whiteness levels can be reached. On the other hand they are not suitable for the high whiteness segment due to greening.

The choice of the FWA for the high white coated papers depends on the coating color composition. The two main parameters are the type and the amount of co-binder. The two most commonly used co-binders are CMC and PVA. The same conclusions can be drawn from all the results of the trials in various scales.

- In PVA systems, the best FWA for the high whiteness segment is TINOPAL SK, and the best product for the highest whiteness segment is TINOPAL SK-B.
- When using CMC or starch as a co-binder, TINOPAL MC is the best FWA for the high whiteness segment and TINOPAL SHP is the best for the highest whiteness segment.

Moreover, all these FWAs are by far less sensitive to the amount of co-binder than the tetrasulfo types. Therefore, they can be used in cases where the amount of co-binder is small, and with the TINOPAL SK types, even in cases where there is no co-binder in coating color.

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