

Increasing bleach plant efficiency through control of catalase and peroxidase

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PEROXIDE BLEACHING EFFICIENCY can be compromised by several factors, one of which is the presence of bacteria in the water used for pulping recycled fibers (1, 2). A significant number of the bacteria commonly found in pulp and paper mills produce catalase and peroxidases, enzymes that effectively consume peroxide at typical mill use levels.

Aerobic organisms produce enzymes to protect themselves against naturally occurring peroxides that form biochemically during the respiratory process. Peroxides affect bacteria by producing hydroxyl free radicals, which are very reactive substances capable of attacking organic cellular materials and destroying cells. Organisms protect themselves by producing several enzymes—principally catalase, peroxidases, and superoxide dismutase—to destroy these toxic oxygen derivatives.

Although hydrogen peroxide is biocidal at high doses (>5000 ppm hydrogen peroxide), the moderate to low peroxide levels commonly used in bleaching can select for a population of microbes that produce high levels of the defense enzymes catalase and peroxidase. This makes them even more resistant to peroxide.

The presence of bacteriologically produced catalase can be easily demonstrated by adding 1.5% peroxide to bacterial colonies on an agar plate. Colonies of bacteria capable of producing catalases will “foam” as oxygen is released, as seen in Fig. 1.

Bacteria are normally found in pulp and paper mills, which provide good conditions for growth. Deinking operations provide an even friendlier environment for bacterial growth. Producers of recycled pulp use bacteriologically contaminated, post-consumer fibers, and these operations tend to reuse water at higher levels, even to the point of zero effluent for mills in urban settings. Very closed water systems help concentrate the nutrient levels in the waters and encourage microbial growth (3).

This study was carried out to determine if addition of selected proprietary biocides to pulping operations could control the catalase-producing population, thereby reducing peroxide consumption, improving bleaching efficiency, and increasing brightness.

METHODS

Samples were collected from a modern newsprint deinking facility with a 70/30 newsprint-to-magazine ratio in the furnish. The recycle plant contains a dual loop with an alkaline bleaching stage at pH 9.2–9.4. Hydrogen peroxide was fed to the pulper at the alkaline stage. The pH at the final bleaching stage was in the range of pH 4–5. The water system was moderately closed.

A modified float time procedure was used to determine if peroxide-degrading enzymes were present in the mill water system. Plate count determinations were conducted at the mill sites using standard microbiological techniques on tryptone glu-

ABSTRACT

Peroxide bleaching efficiency is adversely affected by microbial contamination. Peroxide is biocidal at high doses, but peroxide bleaching is typically carried out at doses below this threshold. Mill process waters contain many types of bacteria that produce peroxide-degrading enzymes such as catalase. Laboratory and field studies demonstrated that addition of a proprietary biocide effectively controlled the catalase-producing bacterial population, thus reducing consumption of peroxide and sodium silicate during bleaching. Even with reduced peroxide usage, brightness and peroxide residuals increased. Before the trial, peroxide residuals were undetectable in the process waters. After treatment with the proprietary biocide, the peroxide residual in the process water was 490 ppm. Brightness after treatment showed a 0.7-point increase.

Application:

Describes the benefits of using biocides to increase peroxide bleaching efficiency.

cose agar. ISO brightness was measured by mill personnel.

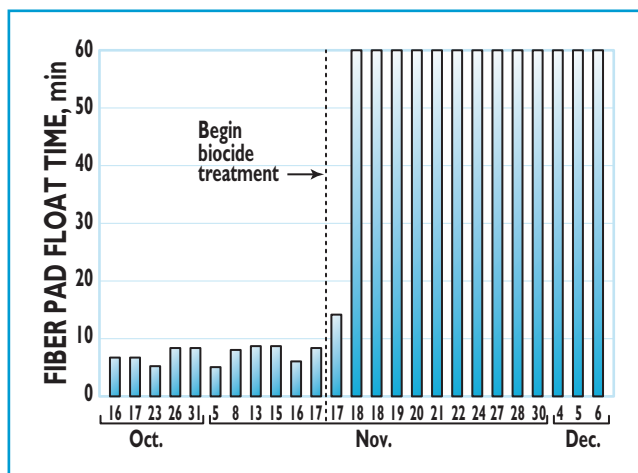
RESULTS AND DISCUSSION

High microbial catalase levels have been linked with lower brightness and greater variation in brightness levels at several North American mills. Raising the concentration of peroxide to biocidal levels (>5000 ppm) is one option. However, this may be expensive, inefficient, and it may not be practical for a mill on peroxide allocation.

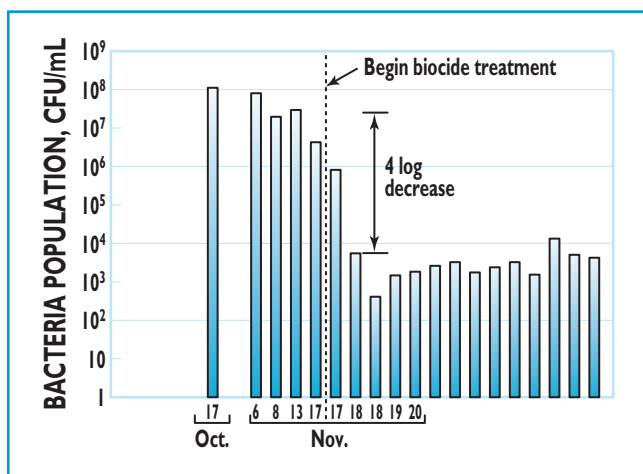
Catalase and peroxidases are produced by most bacteria and other living cells to protect them against naturally occurring, environmental peroxides. Laboratory studies have identified biocides that can inacti-



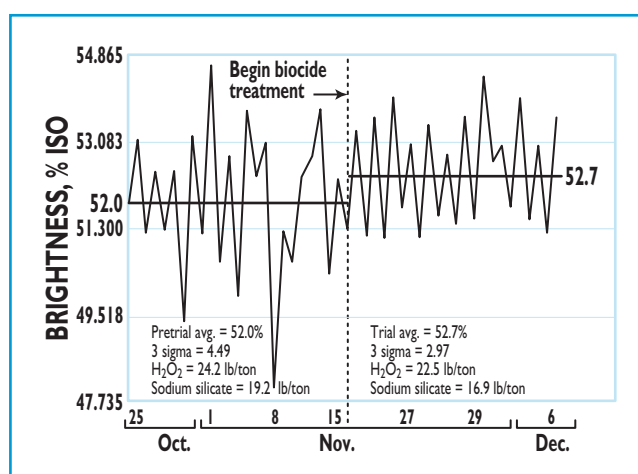
1. Bacterial colonies producing catalase foam as peroxide is added to agar plate



2. Fiber pad float times show the inhibition of peroxide-degrading enzyme activity during the mill trial



3. Change in bacterial population (measured as colony forming units (CFU) per mL) during the mill trial



4. Variation and change in brightness levels during the mill trial

vate the catalase-forming population of bacteria. However, there was concern about using biocides in the presence of peroxides. The concern was based on the discovery that low levels of peroxides can cause bacteria to “turn on” the OxyR-regulon system. This is a mechanism that increases production of catalase and other defense systems that make the bacteria more resistant to certain types of biocides (4, 5). Therefore, it was important to select biocides that remain unaffected by the OxyR-regulon system.

During the trial, the float time of filter pads increased from less than 1 min (an indication of very high catalase levels) in untreated water to

greater than 60 min (an indication of low catalase levels) in the biocide-treated water, as seen in Fig. 2. It was also found that addition of a selected proprietary biocide reduced the catalase-producing bacterial population by 4 logs or 99.99%, as seen in Fig. 3. This, in turn, reduced the peroxide demand in the mill water system.

After addition of the proprietary biocide to control the bacterial contamination of the process waters at one mill, the peroxide use decreased from 24.2 lb/ton to 22.5 lb/ton. Even with the reduced peroxide usage, brightness and peroxide residuals increased. Before the trial, peroxide residuals were undetectable in the

process waters. After treating the process water with the proprietary biocide, peroxide could be detected at 490 ppm. In addition, brightness increased by 0.7 points while variation in brightness decreased by 1.52 at a 99.73% confidence interval (3 sigma), as seen in Fig. 4. Another benefit of the treatment program was a decrease in the use of sodium silicate and chelants. Sodium silicate is added to help stabilize the peroxide, while chelants are added to stabilize transition metals such as Fe³⁺, Cu²⁺, Zn²⁺, Mn²⁺, etc., which decompose peroxide. Excess carryover of sodium silicate to the paper machine can adversely affect retention.

During the trial period, the biocide feed was temporarily disrupted,

and brightness levels decreased by 0.6 points. In addition, the catalase rise test time decreased from >60 min (an indication of low catalase levels) to 1.5 min (an indication of extremely elevated catalase levels). When biocide feed resumed, catalase levels dropped and brightness increased.

The use of microbiological control to reduce the amount of catalase and peroxidases in mill process waters reduced consumption of peroxide, sodium silicate, and chelants while increasing pulp brightness.

CONCLUSIONS

A proprietary biocide was added to the process waters of a deinking facility to reduce the population of bacteria that produce catalase and other peroxide-consuming enzymes. The following results were observed during the trial.

- A 0.7-point increase in brightness was observed at the alkaline thickener accepts. In addition, the variation in brightness decreased significantly by 1.52 at a 99.73% confidence interval (3 sigma).
- A 10% reduction in hydrogen peroxide and sodium silicate use was observed with the use of the proprietary biocide.
- Before the trial, peroxide residuals were undetectable in the process waters. After treatment with a proprietary biocide, peroxide could be detected at 490 ppm in the process waters.
- During the trial period, biocide feed was temporarily disrupted, and brightness levels decreased by 0.6 points.

Other sites using the same biocide combination have seen an increase in brightness of up to two points. Similar reductions in the consumption of bleaching chemicals have also been observed. **TJ**

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LITERATURE CITED

1. Ng, B. and Davies, D., *TAPPI 1995 Pulping Conference Proceedings*, TAPPI PRESS, Atlanta, p. 651.
2. Galland, G. et al., *Paper Technol.* 30(12): 28(1989).
3. Robertson, L. R., *TAPPI 1995 Papermakers Conference Proceedings*, TAPPI PRESS, Atlanta, p. 351.
4. Chang, H. R. et al., "A role of free radicals in the antimicrobial mechanism of electrophilic biocides," in *95th General Meeting, American Society for Microbiology Annual Meeting Proceedings*, American Society for Microbiology, Washington, DC, 1995.
5. Nunoshiba, T. M. et al., *Mutation Res.* 255(3): 265(1991).