ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 35, E3, 2023, p. 52-55

GREEN, BIOBASED TECHNOLOGIES FOR RECYCLED PAPER INDUSTRY

Dr. Manish V. Petkar
Head R&D and QC

Dr. Sivaramakrishna Pillai
Director Technical

Chandrasekar B
Director

Radhika B S
Business head Pulp & Paper

**ProKlean Technologies Pvt. Ltd., TICEL Bio Park, Taramani, Chennai 600043.*

Abstract:

Paper is an important part of our daily lives and is a necessity which we are unlikely to do away with. Paper making from trees is the most common practice even now. Today, preserving the environment has become the major concern and more emphasis has been placed on planting more trees than its consumption. Reducing, reusing and recycling paper is the way for sustainability. The recycled paper industry is the key contributor in sustainability and help in reducing environmental concerns. Any technological attempt to make recycled paper processing more efficient will contribute to protecting the eco system in a better and efficient way.

The technologies presented in this paper focus on bringing in higher productivity, better paper quality and improved water quality by-

1. Reducing the consumption of chemicals- By enhancing the performance of key process stages such as bleaching (oxidative and reductive)
2. Improving process efficiency- By reducing the paper breaks, improving the machine runnability and enhancing the paper quality
3. Enhancing the recycled water quality- By reducing the unwanted microbial growth and associated problems
4. Improving the final paper quality- By reducing the odor in paper, deposits and improving the strength

The novel technologies presented in this paper are biobased and the developed products are readily biodegradable. The key technologies include-

1. Stickies and deposit control (Non enzymatic, biobased technology)
2. Oxidative and reductive bleaching enhancer
3. A microbial based odor control program

These technologies at their optimum dosing concentration, dosing frequency and at appropriate dosing points, effectively reduce the consumption of chemicals by 20-30%, paper breaks by 25-30%, unwanted microbial growth by >95% and volatile fatty acids (VFA) by >60% and improves the paper quality and productivity at reduced process cost.

Keywords: Oxidative bleaching, reductive bleaching, stickies, deposits, paper breaks, VFA, Slime and biofilm, biocides, probiotics, bio-dispersant

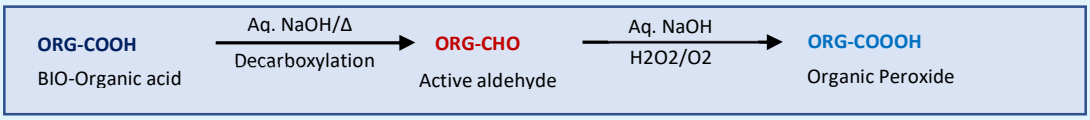
Technology at glance

Research studies presented in the article have been focused on using a unique combination of biobased technologies. The different product technologies are developed using a combination of fermentation compounds and plant-based ingredients. The development has focused on making non-enzymatic technologies considering the limitations in use of enzymes in paper industry. All the developed product technologies are truly natural and completely biodegradable. The different chemistries and mechanisms of action are described below-

1. Live probiotic microorganisms
    a. They produce organic acids and help suppress the unwanted bacterial growth responsible for slime and biofilm formation.

b. Their competitive inhibition mechanism reduces the growth of unwanted microorganisms1.

2. Biobased dispersant
   a. Non-ionic surfactants formulated during proprietary fermentation process.
   b. Reduces the surface tension and facilitates faster penetration.
   c. Eradicates slime and biofilm.
   d. Converts macro stickies into micro stickies by dispersion.
3. Oxidation booster
   a. The organic acids form peracids2 which work as the micro catalyst for oxidation boosting mechanism.
   b. This effectively lowers the active consumption of oxidation chemicals.



Results and Discussion

The different technologies have been developed and optimized in the lab conditions followed by the field trials. The lab trials and field trial results are summarized below.

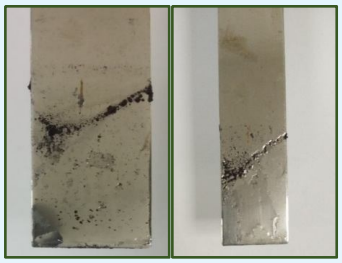
1. Stickies and deposit control in recycled mills

This unique technology offers a sustainable solution with its bio-based surfactant combinations which are completely bio-degradable. Two product formulations, namely 'FK' and 'F80 (ProSC)' were prepared in the lab based on the presented technology approach and tested under lab conditions. The products have been formulated considering all the characteristics of stickies – it acts as a solvent, surfactant, and a powerful dispersing agent. Out of the two product formulations, 'F80 (ProSC)' was found to be better in terms of the performance & further considered for detailed lab studies and mill trials.

Lab scale studies

The presented lab studies are conducted with the product formulation 'F80 (ProSC)' with the pulp samples prepared in the lab using 60% of the old newsprints (ONP) and 40% of old magazines (OMG). Dispersion of stickies in presence of the 'F80 (ProSC)' and reaggregation/ redeposition in presence of a coagulant by 'coupon deposition method' was done. The results obtained are presented in figs. 1 and 2.

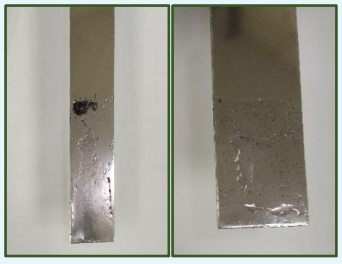
(i) Performance without coagulant



Blank 'F80 (ProSC)'

Figure 1: Coupon deposition after one hour of treatment with out coagulant

(ii) Performance with coagulant



Blank 'F80 (ProSC)'

Figure 2: Coupon deposition after one hour of treatment in presence of coagulant

The quantum of stickies redeposited in case of the application with 'F80 (ProSC)' was found to be lower as compared to the blank. The redeposition was found to be very low or nil in presence of a coagulant. The study has helped in understanding the redeposition behavior of stickies in presence of 'F80 (ProSC)'.

The quantitative conversion of stickies from macro to micro was studied by DCM extractive method. The study was conducted at various dosages of 'F80 (ProSC)' ranging from 200 to 600 g/t. A graph has been plotted with dosages vs percentage of stickies in the rejects at different dosages. The data is presented in figure 3.

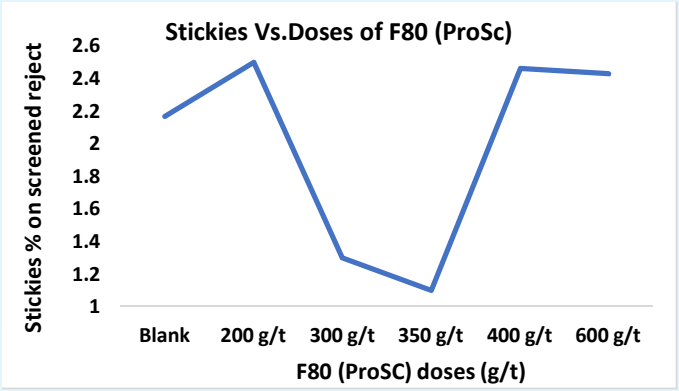


Figure 3: Effect of product dosage on macro to micro stickies formation

The stickies conversion from macro to micro is found to be optimum in between 300-350 g/t dosages whereas below and above these dosages it was found to be inferior.

The biobased technology is found to be an effective dispersant for stickies and facilitates conversion from macro to micro in the dosage range of 300 – 350 g/t at 100 gpl of dilution. The 'F80 (ProSC)' is also found to be effective against the reaggregation of the stickies in presence of any coagulant.

Mill scale study

The successful lab scale studies were followed by mill trials wherein the product efficiency is evaluated at dynamic process conditions. The selection of product for mill trial was done based on the lab data obtained for microstickies conversion and turbidity of process water. The results obtained are summarized in Table 1.

Both the products namely, 'FK' & 'F80 (ProSC)' are found to be working good at lab scale conditions. Product 'FK' was found to reduce the macro stickies by 64.5% at 400 g/t dose as against 55.5% reduction in case of 'F80 (ProSC)'. The turbidity increase was higher in case of the 'F80 (ProSC)' as compared to the 'FK'. The ISO brightness of deinked pulp was increased by 0.7 & 0.6 points with 'FK' & 'F80 (ProSC)' respectively. Product 'F80 (ProSC)' was found to

Table 1: Effect of 'FK' & 'F80 (ProSC)' and dosages on pulp parameters

S.No.	Chemicals (dose)	Parameters	After Treatment			
			Macrostickies	Brightness	ERIC	Process water turbidity
		Unit	mm^2/kg	% ISO	ppm	NTU
		Test method	Instrumental method (Pulmac master screen)	IS-1060 part-I	Tappi T-567	Instrumental method (Turbidity meter)
1.	Control (0 g/t)		17583	65.5	1668	79.7
2.	FK (200 g/t)		12461 **(-29.1%)**	65.6	1641	80.0 **(+0.4%)**
3.	FK (400 g/t)		6237 **(-64.5%)**	65.8	1621	82.4 **(+3.4%)**
4.	FK (600 g/t)		5635 **(-68.0%)**	66.2 **(+0.7 pt.)**	1617	91.0 **(+14.2%)**
5.	F80 (200 g/t)		15063 **(-14.3%)**	65.6	1672	107.4 **(+34.8%)**
6.	F80 (400 g/t)		7823 **(-55.5%)**	65.8	1630	109.2 **(+37.0%)**
7.	F80 (600 g/t)		5744 **(-67.3%)**	66.1 **(+0.6 pt.)**	1621	110.6 **(+38.8%)**

Note: Minus sign (-) denotes %age reduction and positive sign denotes %age improvement/ increase with respect to control.

be superior in terms of the turbidity gain of the filtrate water. Based on the results Product F80 was found to be better and was selected for the further mill trials.

The break analysis results of the actual mill trial obtained with product 'F80 (ProSC)' is summarized in figure 4.

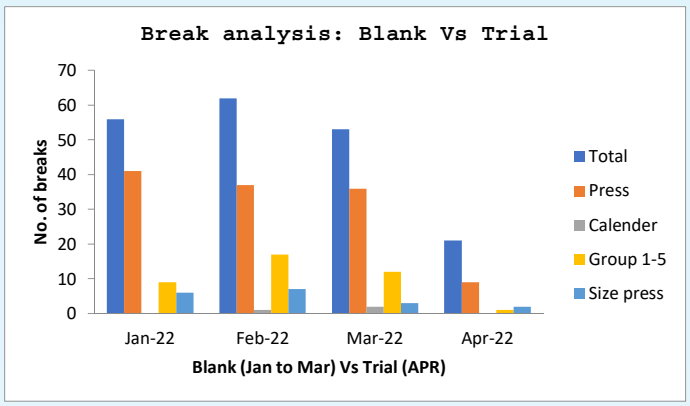


Figure 4: Break analysis across various process points with and without 'F80 (ProSC)'

The trial period (April 22) break analysis report was compared with the blank data (Jan-Mar22) for three months. The trial period was observed to reduce the number breaks by more than 50% when compared against the blank. The boil out was found to be extended by a period of 30-45 days with improved runnability of machine.

2. Oxidative bleach enhancement for recycled paper

Different experiments were carried out in lab conditions with 60% ONP and 40% OMG screened pulp using various dosage conditions. 1% caustic, 2% peroxide and 2% sodium silicate was used for the bleaching study. 'Probleach ADV', a product developed under this technology was studied at lab followed by mill conditions. The study was conducted at various dosages ranging from 150-350 g/T of the pulp. The optimum results are obtained at 350 g/t of the dosages. The initial brightness of the pulp was measured and found to be 49.65 %ISO whereas the post oxidation brightness was found to be 53.5 %ISO. Based on the lab data, further studies were conducted at dynamic mill conditions. Evaluation of effective brightness gain across dump tower to polcon tower and dump tower to final tower was performed. The results obtained are summarized in figure 5.

The effective gain in the brightness has been achieved with a reduction in bleaching chemicals during the trial and compared against the blank chemical consumption. The data obtained is summarized in figure 6.

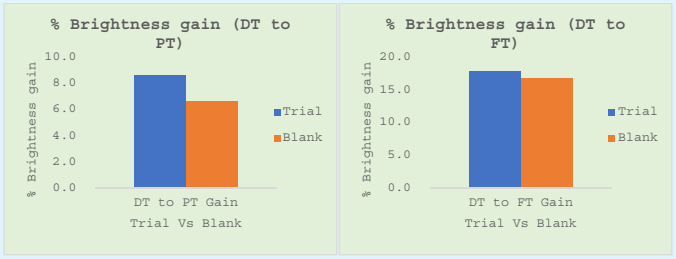


Figure 5: Brightness improvement with and without 'Probleach ADV'

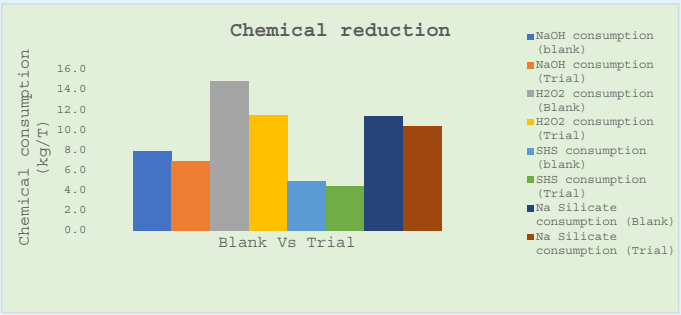


Figure 6: Bleach chemical reduction with and without 'Probleach ADV'

It was seen from the brightness and chemical consumption graph that the effective gain in brightness has been achieved at reduced chemical consumptions. The technology has been proven to work on enhancing the oxidative conditions at reduced chemical consumptions.

3. Biobased odor control for recycled kraft mills

Biobased odor control is a novel technology which works with a probiotic based odor control mechanism. 'Prosolve' A live microbe-based product formulation was developed under this technology. Different trials were conducted at the mill conditions to replace toxic chemicals such as hypo and biocide. The technology works by reducing the microbial load in the process water and eventually on the final paper. It reduces the population of microbes which produce volatile fatty acids. Oxidation reduction potential (ORP) is an important parameter of water which indicates the type of microbial contamination. The key parameters recorded during the mill trials are ORP of the process water and VFA on the final paper to monitor the effectiveness of the technology. The results obtained are presented in figures 7 and 8.

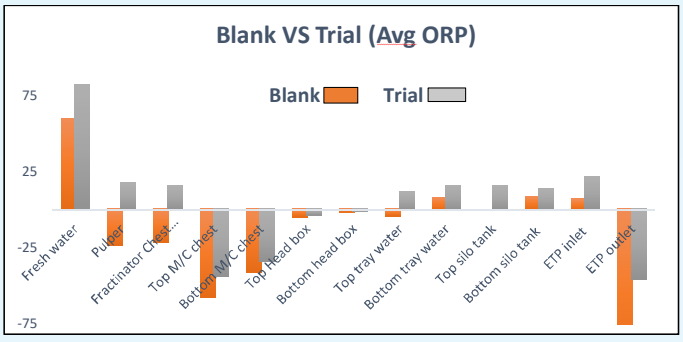


Figure 7: ORP of the water at different process points in a mill

Improvement in ORP

Figure 7 shows the ORP data for both blank and trial run. It is seen from the graph that the trial run has effectively increased the ORP values indicating better health of the water in terms of the unwanted microbial growth. The ORP values were found to be above -50 in

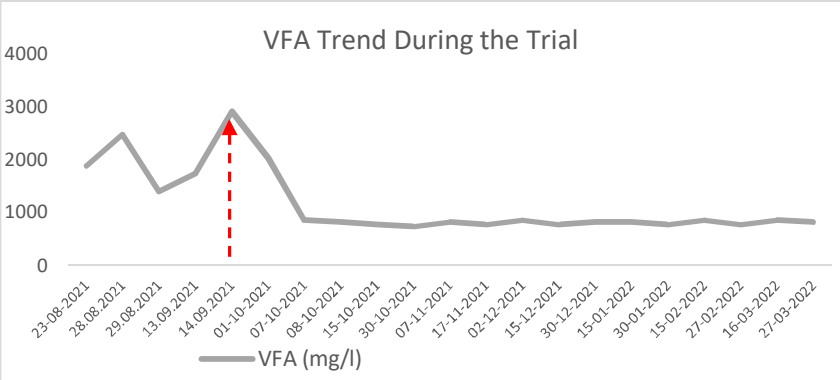


Figure 8: VFA on the paper with and without 'Prosolve'

presence of the 'Prosolve'. The increase in the ORP values have reflected in corresponding reduction in the VFA values.

Reduction in VFA

Figure 8 represents the VFA data for both blank and trial run. It is seen from the graph that the VFA has reduced from an average value of 2000 ppm to 700 ppm. The significant reduction in the VFA was achieved due to the improved ORP conditions of the water. The technology have been found to be effective in controlling the microbes which produce VFA, due to the competitive inhibition mechanism of the probiotic bacteria. The non-ionic surfactants formulated during proprietary fermentation process has functioned as biodispersant used in the treatment protocol and has helped in wiping out the existing clusters of the unwanted microbes aiding the effectiveness of the probiotic microbial consortium.

Conclusion

Biobased technologies have proven to be an effective solution for recycled paper industry. The issues occurring because of furnish, water, high chemical usage and the processing methodologies are the key drivers for inefficient paper manufacturing. The green technologies presented in this paper are found be a gateway for reducing or eliminating the use of hazardous chemicals which impact the environment and water. The novel technologies provide a sustainable and biodegradable option for the recycle paper industry to improve its environmental footprint and produce good quality paper in an eco-friendly way. It is an attempt to help the paper industry move towards cleaner and greener processes by improving their water quality and hence environment. Water is a key resource on the earth and any attempt towards cleaning and recycling water will be an effort towards making the mother earth safer. The technologies presented in this paper offer a promising solution for paper industry to make it cleaner and sustainable.

References

1. Jason M. Neal-McKinney, Xiaonan Lu, Tri Duong, Charles L. Larson, Douglas R. Call, Devendra H. Shah, and Michael E. Konkel. Production of organic acids by probiotic Lactobacilli can be used to reduce pathogen load in poultry, PLOS ONE, 2012: 7(9), page 1-11.
2. R. George. The oxidation of sodium lactate by hydrogen peroxide, 1924, Department of Physiology, Harward School of public health, Boston.