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Novel Biosurfactant Derived From Natural Sources And Its Application In Deinking Of Waste Paper.

ABSRACT

The present research addresses the influence of biosurfactant developed by Texbiosciences, offers eco- friendly alternative to chemical surfactant for the removal of ink particles in the waste paper. The effect of biosurfactant treatment was studied on the laboratory scale with the objective of reduction in conventional chemicals used in the deinking process. Biosurfactant with the combination of enzyme treatment eliminated 100% hydrogen peroxide, 100% sodium silicate and biosurfactant alone eliminated 100% chemical surfactant and 50% reduction of hydrogen peroxide and sodium silicate with the same level of brightness without affecting the strength properties and yield in the waste paper deinking process. The result showed that the biosurfactant acts as dual character both as bleaching agent and as surface-active agent.

Application: Recycled mills can apply biosurfactant to reduce the total consumption of chemicals in the deinking process in an ecofriendly and cost effective manner.

INTRODUCTION & REVIEW OF LITERATURE

The usage of paper is increasing day by day; ultimately the demand for the raw material like wood, Bagasse and secondary fiber for paper production is also increasing. In the world, 40% of total paper production is based on secondary fiber. There are several advantages in recycling paper processing. The rate of used paper has steadily increased in recent decades as part of the effort to preserve forest resources. The use of recycled fiber has been an economic and environmental necessity. Replacement of virgin pulp with recycled fibers reduces the exploitation of old forests and wood. For instance for production of 1 ton of paper, mills use raw materials ranging from 2 to 3 tones, energy from 1000 to 2000 kWh, water from 75 m^3 to 125 m^3 / t of paper, and labor / manpower from 5 to 30. Considering consumption of all these basic inputs, it is difficult to achieve the cost effective production and compete in the open economy [(1)]. Primary fiber is usually bleached by chlorine compounds where as recycled paper is rebleached with oxygen. Greater utilization of recycled fiber is expected in the future. However, several problems are associated with the recycling of secondary fiber. The recycled paper is divided into different categories like Old News Print (ONP), Old Magazines (OMG), Mixed Office Waste (MOW), Paperboard and corrugated fiberboard, etc. The composition differs but key components are fiber (70-90%), filler material (5-30%) and strength agents, whitening agents and inks. Ink consists of pigments or dye, a binder to attach the ink to the paper and other components. Most of the inks are hydrophobic which is prerequisite for deinking chemistry to work [(2,3)]. Recycling of old newspapers and office waste papers will be more economical and environmentally sound if deinking of old paper is done chemically or biologically. The chemical & mechanical processes involved in a deinking mill are pulping, flotation, washing, disperging, etc. Most of the chemicals used for deinking are standard products like caustic soda, hydrogen peroxide and sodium silicate. Some others are quite complex like surfactants and polymers. Chemistry plays a role in fiber swelling, ink removal, wetting, dispersion, oxidation-reduction of chromophores, etc. Each and every chemical has some unique function. Table 1 lists some of the chemicals used in the recycled paper industry [(4)]. Not all of these chemicals are used at a time, which depend on the furnish and the finished product.

The function of the pulper in a deinking operation is to defiber the paper and to detach the ink and other contaminants. Deinking and contaminant removal are major barriers in paper recycling. Toners are particularly difficult to remove. These are resilient, plastic polymers that are fused to fibers. Unlike dispersible inks that occur in newsprint or offset printing, laser and xerographic inks don't disperse. The residual ink decreases the brightness and the toner particles create a conspicuous background. The flotation unit also referred to as the heart of the deinking system [(5)]. Current deinking technology is being stretched by the following factors. Main technique for recycling paper is deinking flotation. Flotation is a process to selectively separate the hydrophobic ink particles from the hydrophilic fiber, stickies and the coloured dyes present in unsorted

Table 1. Chemicals used in processing of recycled paper

Sl No.	Chemical	Point of Application	Approximate percentages used
1	Sodium hydroxide	Pulper, bleaching	0.8-1.5
2	Hydrogen peroxide	Pulper, bleaching	0.5-2.0
3	Sodium silicate	Pulper, bleaching	1.0-3.0
4	Chelating agents	Pulper, bleaching	0.15-0.4
5	Surfactant/collector	Pulper, flotation, washing	0.25-1.5
6	Sodium hypochlorite	bleaching	0.5-1.0
7	Sodium hydrosulfite	bleaching	0.25-0.75

MOW. The deinking process is either wash flotation or a combination of wash and flotation [6, 7, 8]. Experts in the field of deinking have observed that "the washing deinking process is essentially a laundry process" [9]. Interfacial tension (IFT) and surface tension are the properties behind the study of deinking.

Biodegradation of these chemicals is becoming more of an issue, as the environmental impact laws get tougher. The biodegradation question has a high profile in developing countries. The growing concern about the release of these undesirable materials into the environment is leading researchers to seek ways of eliminating or at least reducing. Applying biotechnology in the pulp and paper industry has become an area of increasing research [10]. Advances in biotechnology have occurred rapidly. Biotechnological processes are receiving greater attention as industry seeks to reduce its impact on the environment [11,12]. Increasing awareness among consumers for bio-based products will give rise to new markets for Enzymes and Biosurfactants. The development of papermaking processes with low environmental impact finds the use of biological treatments.

USE OF BIOSURFACTANT/ENZYME IN DEINKING

Among various biotechnological applications in deinking process are 1) enzyme and 2) biosurfactant. Enzyme alone or enzyme/surfactant combinations in deinking, could enhance toner removal from xerographic and laser printer papers [13,14]. The problem associated with the use of chemical surfactants pose some environmental risks because they form harmful compounds from incomplete biodegradation in water or soil [15,16]. Biosurfactants are superior ecofriendly replacements for chemical surfactants; exhibit characteristic physical and chemical properties. Biosurfactants, due to their biodegradability, are becoming more attractive for use in all Industrial applications. A biosurfactant has been successfully derived from biological sources (phospholipids, glycolipids, lipo-peptides) resulting in low material and processing costs making the biosurfactant attractive to large scale applications. The biosurfactant which exhibit characteristic physical and chemical properties with low surface tension (28 dynes/cm at CMC of 0.2 g/L). Due to their biodegradability, it is becoming more attractive as deinking agent for use in recycled paper industry. Additional reasons for selecting this biosurfactant are: (1) produced from waste material & its biodegradabilty and (2) surface active properties are comparable to popular synthetic surfactants. The main feature of this biosurfactant is that it can be used as wetting agent for pulping and deinking, dispersants for washing deinking of recovered paper and collectors for flotation deinking. It will also enhance the bleaching, efficient removal of ink and good buffering character. Both enzymatic and biosurfactant treatments can improve deinking efficiency and decrease the chemical consumption, which ultimately reduces total treatment cost [17].

MATERIAL & METHODS

For this work, the furnish consists of 40% ONP, 40% OMG and 20% MOW. This sort of paper was torn into small pieces of approximately 2 x 2 cm shredded and dry mixed before each trial. Pulping was performed in a lab hydrapulper with the chemicals dosage as per Table 2. Ordinary tap water was used for all the trials. After pulping, the ink was removed using flotation process using Lab Deinking cell (Laboratory model). After filling the pulp suspension at 1% consistency in the flotation unit, air flow of 7 L/min was injected in the cell and the froth removal was done. The flotation time was around 12 min for all flotation trials. The pulps were subsequently floated and washed. The fiber content in the flotation reject was measured along with the pulp and froth consistencies. The washed pulp was collected and sheet pads were formed to evaluate brightness (%ISO) and residual ink (ERIC) parameters. Hand sheets were made at 60 gsm by usual standard procedure to evaluate burst, tear and tensile strengths. The variables in question are temperature, dosages, pH, consistency, slushing time, pulping time and flotation time. Texzyme I (an enzyme having cellulase and hemicellulase activities), Luna DS (a non-ionic chemical surfactant) and Texbiosurf (a biodegradable biosurfactant) were used in this study. Texzyme I, Luna DS and

Table 2. Dosage of Chemicals and conditions of Pulping and Deinking

PARTICULARS	UOM	Set 1	Set 2	Set 3	Set 4
A RAW MATERIAL					
a. Old News Paper (ONP)	%	40	40	40	40
b. Old Magazine (OMG)	%	40	40	40	40
c. Mixed Office Waste (MOW)	%	20	20	20	20
B PULPING					
1 Chemicals Dosage					
a. Hydrogen Peroxide	%	0.5	Nil	Nil	0.25
b. Caustic Soda	%	0.8	0.4	0.4	0.4
c. Sodium silicate	%	1.2	Nil	Nil	0.6
d. Surfactant	%	0.03	Nil	Nil	Nil
e. Biosurfactant	%	Nil	0.03	0.01	0.03
f. Texzyme I	%	Nil	Nil	0.02	Nil
2 Conditions					
a. Consistency	%	5	5	5	5
b. pH		10.5	10.7	10.8	10.75
c. Temp	°C	50	50	50	50
d. Retention time	min	60	60	60	60
C FLOTATION					
1 Chemicals Dosage					
a. Surfactant	%	0.02	Nil	Nil	Nil
b. Biosurfactant	%	Nil	0.02	0.02	0.02
2 Conditions					
a. Consistency	%	1	1	1	1
b. Airflow rate	LPM	7	7	7	7
c. Time	min	12	12	12	12

Texbiosurf have been developed in-house. Other chemicals like hydrogen peroxide, sodium hydroxide and sodium silicate are the usual chemicals used in paper industries.

RESULTS & DISCUSSION

The trial results in Table 3 indicate that treatment with biosurfactant improved the final brightness. The biosurfactant (TexBiosurf) helps to release ink particles in the pulping as well as in the flotation stage. In Set 2, even though there was 0.6% decline in brightness when compared with Set 1 (control), there was a possibility of complete elimination of hydrogen peroxide and sodium silicate by 100%. But in Set 4 biosurfactant treatment, it is possible that the brightness level achieved was at or near the brightness ceiling of 63, with the reduction of 50% of hydrogen peroxide, 50% caustic and 50% sodium silicate as compared with the control.

The best results in brightness were obtained in Set 3 experiment. The increase in brightness was 0.8 units with the combination of biosurfactant and enzyme. This is due to the enzymatic hydrolysis of cellulose by enzyme (Texzyme I), facilitating the deinking process. It is observed that the use of enzyme with biosurfactant combination improved brightness values in pulp as well as deinking process indicating that enzyme treatment activated the pulps. At the same time there was 100% reduction in hydrogen peroxide and sodium silicate, 50% caustic in comparison with the control. It appears that in addition to biosurfactant, enzyme also has potential to eliminate regular chemicals used in the recycled paper industry.

As far as the strength properties are concerned, the tear factor decreased by 2, 3, 2.5 units in Set 2, 3, 4

Table 3. Deinking performance results

	PARTICULARS	UOM	Set 1 Control	Set 2 Blosurfactant	Set 3 Blosurfactant + Enzyme	Set 4 Blosurfactant
	a. Total Surfactant b. Total Biosurfactant c. Enzyme	kg/t kg/t kg/t	0.5	0.5	0.3 0.2	0.5
A	YIELD	%	80.7	80.9	80.5	80.7
B	BRIGHTNESS a. After Pulping b. After Flotation	 % %	 51.06 63	 52.2 62.4	 53.9 63.8	 52.6 63
C	EFFECTIVE RESIDUAL CONCENTRATION (ERIC) a. After Pulping b. After Flotation	 Ppm Ppm	 520 179	 532 182	 515 174	 526 173
D	STREGTH REDUCTION a. Tear Factor b. Burst Factor c. Breaking length	 m	 64.71 17.6 3000	 62.5 19.2 3196	 61.7 19.6 3263	 62.2 18.7 3221
E	CHEMICALS REDUCTION d. Hydrogen Peroxide e. Caustic soda	 % %		 100 50	 100 50	 50 50

experiments when compared with Set 1 control whereas the burst factor increased by 1.5 to 2 units. Breaking length also simultaneously increased.

The overall properties are comparable or superior to the conventional pulp (without any major impact on the pulp quality). Better understanding of this effect is needed to facilitate optimization of biosurfactant treatment. The commercial use of biosurfactant is a fairly recent development in the waste paper processing. The ability of biosurfactant treatment to increase the brightness ceiling also is a positive effect on the success of the treatment when limited chemical substitutions are being used.

CONCLUSIONS

The overall results of biosurfactant and biosurfactant plus enzyme treatment were positive and suggest that the mill may be capable of producing the required brightness pulp without much difficulty. Simultaneously it holds the promise that treatment with biosurfactant may be able to significantly reduce or potentially eliminate the use of hydrogen peroxide and sodium silicate. The incorporation of biosurfactant into the recycled system has proved to be relatively simple and easy process, which is most economical and pollution free. It is a possible and competitive strategy to deink recycled pulps. But a thorough optimization of the process is needed in order to obtain a good quality of the paper. Different pulps may react differently with the character of the biosurfactant.

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