International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-5, January 2020

De-Inking of ONP Paper by using Different Surfactants: In Dissolved Air Flotation Process

Surjya Narayan Panda, Susanta Kumar Biswal

Abstract*: Meeting the demand of paper and paper product requirement and at the same time decreasing the availability of fibrous raw materials, keeping an eye on cost effectiveness is challenging. Thus, recycling of paper is an alternative. Corrugated box, old newspapers and office waste papers are the sources of raw materials for paper and paper product industries. Deinking is an important step for recycling of old waste writing, printing and newsprint papers. The efficiency of ink separation in the process of waste paper recycling depends on the ink properties, kind of the additives, surfactants used, age of waste papers, the printing techniques and printing conditions. In general, deinking process consumes a large amount of chemicals which makes this method expensive, pollution intensive and even quality is compromised. In this study the effectiveness of surfactants like benzene dodecyl sulphonate, lauryl benzene sulphonate and sodium carbonate for cost effective deinking process by optimizing the chemical doses has been studied. The physical strength and optical properties of the paper after deinking was also explored. The surfactant better for both physical strength properties and optical properties of paper is identified to be the sodium dodecyl benzene sulfonate.

Keywords: Deinking, Flocculants, Recycled fiber, Coagulant, Ink, Office waste, Newsprint.

I. INTRODUCTION

Despite an increase in digitalization, technology development, faster communication process, paper is equally essential for every nation irrespective of developed, developing and underdeveloped status in order to strengthen their literacy rate to an extent which would result into heightened economy. Paper is the cheapest and easiest way to full fill that. Currently environment experts consider the forest stewardship council (FSC) certification to be the most robust and comprehensive. It is important when choosing paper to ensure that any virgin fiber is FSC certified, but it is even more important to maximize recycled content first. Recycled pulps require less bleaching than virgin pulps. Primarily, recycling facilitates in reducing the production of methane from landfills. Seventeen trees are spared for recycling a ton of paper and nevertheless, 3.3 cubic yards of landfill space is also conserved. Use of recycled fibers add raw material cost saving2. As for wood heat value is 14-20 MJ/Kg and for deinking sludge it can be about 7-10MJ/Kg3. The final pulp and paper brightness is maintained by close monitoring of the pulper brightness, process optimization and appropriate choice of chemicals4. Light contaminants will self-drained to a solid content of 10-20% in the absence of fiber, particularly ink and ash removed by flotation cells5. There are challenges in processing secondary fibers particularly when using cheaper, highly contaminated waste paper sources but profitably by adding a value6. Cellulose is hydrophilic with a high surface energy. The porous structure of paper acts like a sponge in the presence of liquid. High reactivity of ASA molecules provide some of its major advantages7. The effect of modified Kaolin, a deinking agent in flotation acts as a collector for these fine particles. This de-inking reagent gives more efficient separation and removal of the ink, dirt and strikes particles from the waste paper being recycled8. Currently, paper production in India is approximately 17 million tonnes. Around 9.8 million tones (58%) of production is from recycled fibers. It is expected at this growth the share of recycled fiber will reach more than 65% in next 5 years1. India's per capita consumption of paper and board which stands at a little over 13 kg, is way behind the global average of 57 kg. pulp and waste paper import rose by 2.43%2. There are 800 units engaged in manufacturing paper, paper board and news print. The installed capacity in India is 25 million tones. it is expected to rise to 30 million tone by the year 2030. Out of the 25 million tone 80% of paper and board is manufactured by using waste paper recycled fibre3. India is one of the fastest growing paper markets with a growth rate of about 7.5% annually4. In enzymatic deinking use of Lipase and different enzymes along with chemicals like peroxidase, magnesium hydroxide are also critical. In enzymatic de-inking process temperature is a factor which creates hindrance and chemicals are also needed to act as surfactant or catalyst for better deinking 13-17. Pulping is always the 1st step of the deinking process. During pulping, fibers are separated and all the additives added to the paper during the printing and converting process are separated from the fibres9. After detachment of ink particles from fiber surfaces, it is necessary to separate these detached ink particles from pulp slurry using any of the conventional methods – floatation, washing, screening, centrifugation etc10. In this study we are using different surfactants in flotation stage and studied their efficiency on deinking (optical properties) and physical strength properties (Table 1).

Manuscript published on January 30, 2020.
* Correspondence Author
Surjya Narayan Panda*, Centurion University of Technology and Management, Odisha, India
***Susanta Kumar Biswal**, Centurion University of Technology and Management, Odisha, India

II. MATERIAL AND METHODS

Table 1. Optical properties of the recovered fibers

Pulp type	ONP
Brightness % ISO	45.89
Yellow ness	7.72
Opacity	99.99

Chemical pulping of recovered papers:

In this study six months old news print papers were made pieces of dimension of size 3 x 4cm2. These pieces were soaked in water half an hour in a beaker. Then converted into pulp in a disintegrator at 10% consistency for 15 minutes using tap water (Fig 1-3). In pulping, Sodium silicate, H2O2 and EDTA are used at PH 9 (Table 2). The main reason of adding hydrogen peroxide is to prevent the yellowing of paper that occurs at PH 8. The hydrogen peroxide generates perhydroxyl anion (HOO-) which attacks the phenolic and chromophoric groups. The reason for adding sodium silicate is to stabilize the hydrogen peroxide by inactivating the metal ions. All chemicals were added based on oven dry paper basis.

Table 2. Chemical treatment condition for recycling of recovered papers

Chemical type	Consumption based on oven dry weight of pulp %
H_2O_2	1%
NaOH	1%
EDTA	0.2%
Na_2SiO_3	2%

Washing and flotation deinking:

In flotation deinking three different surfactants were used (1) Sodium dodecyl benzene sulfonate (2) Sodium stearate, and (3) Sodium lauryl sulfate at a constant pH 8. Surfactants play three roles in flotation deinking; (1) as a dispersant to separate the ink particles from the fiber surface and prevent the re deposition of separated particles on fiber during flotation, (2) as a collector to agglomerate small ink particles to large ones and change the surface of the particles from hydrophilic to hydrophobic, (3) as a frother to generate foam layer at the top of a flotation cell for ink removal. The resultant pulps from different treatments were washed with tap water through a 200 mesh, were screen and subjected to flotation (capacity 20 liter equipped with an aerator at 4Kg pressure) for 30 minutes at temperature 400^{o}C at pH, consistency 1% and using 0.25% surfactant. During flotation foam with ink particles was continuously skimmed away from the cell surface. In all furnishes a washing stage was implemented before flotation in order to increase the brightness. After flotation, the pulp was prepared to make hand sheet.

Determination of hand sheet properties

The brightness pads are made for brightness, and hand sheets of 60 GSM are made to TAPPI T205 SP 95, The optical properties measured according to TAPPI 452OM-02 and physical properties of papers were measured accordingly to TAPPI T414 OM04. Instruments like stirrer (Fig 4), vacuum pump (Fig 5), tensile tester, tearing tester, Mullen model Bursting strength tester, Micrometer, Schopper folding endurance tester were used to test the physical properties. The optical and physical properties of papers were compared by using different surfactants in flotation deinking.

Fig 1. Waste papers cut in small size

Fig 2. Soaking of small size papers

Fig 3. Disintegrator used for pulping purpose

The brightness was measured by using ISO Brightness tester in accordance ISO standard 457nm, at light source. SEM analysis was done by using the instrument Scanning Electron Microscope (Fig 6; JEOL model No-JSM-651OLV).

Fig 4. Stirrer for uniform consistency

Fig 5. Pad formation vaccum pump

Fig 6. SEM instrument

III. RESULTS AND DISCUSSION

Keeping EDTA, H_2O_2 and sodium silicate concentration constant in pulping and using different surfactants in flotation stage, data were observed. In the deinking process, physical and optical strength properties were recorded. Different surfactants in recycled papers were found to have a significant effect on paper brightness as compared to the control pulp. The brightness is maximum for sodium dodecyl benzene sulfonate both after pulping and flotation which are 37.34% and 40.80% (Fig 7). The cleanliness in terms of number of ink particles was studied. The result is at the pulping stage ink particles detached from their fire attachment but the ink particles together covered as a coating of surface. The result is prominent and effective flotation onwards (Fig 8)

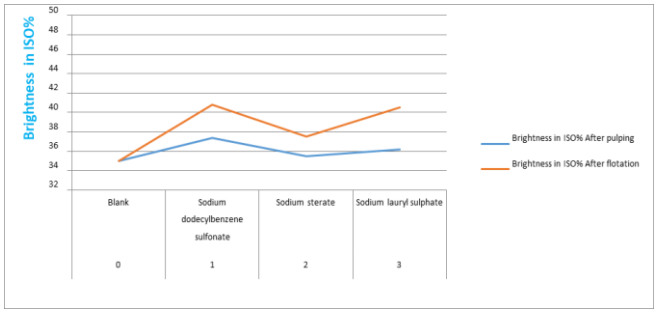

Fig 7. Variation of brightness by using different surfactants

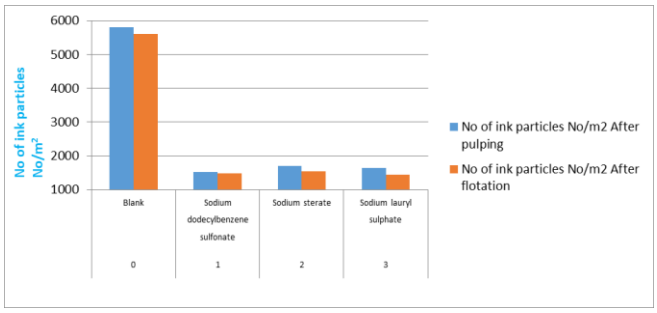

Fig 8. Variation of ink particles by using different surfactants

Physical strength properties like Tear factor, tensile strength maximum by using sodium dodecyl benzene sulfonate but Burst factor and bulk density is maximum in case of sodium stearate. The acidic group in case of stearic acid might increase the bond strength and the presence of some ink particles might be as used as filler which caused the maximum value in burst factor and bulk density. The below figures expressed the improvement of physical properties of hand sheets after de inking. As the ink removal efficiency increases the physical properties also increases because the ink content caused weakening of inter fiber bond formation. The best surfactant for improving optical properties may not improve the physical strength properties. Primarily, sodium dodecyl benzene sulfonate is more efficient as compared to the other surfactants used in the study.

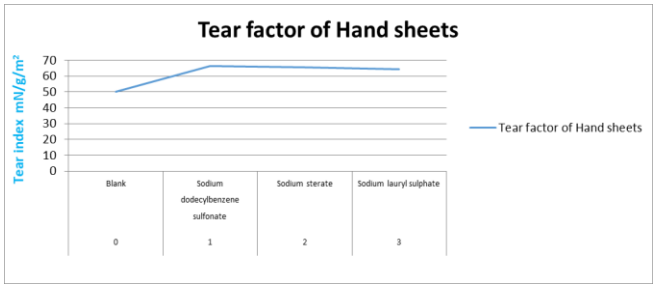

Fig 9. Variation of Tear factor with additives

The tensile force or breaking force required to produce a rupture in a strip of paper measured in machine direction or cross direction expressed in meter. Breaking length is indicative of fiber strength, fiber bonding and fiber length. It is used as a potential indicator of resistance to web breaking during printing.

As recycled fiber can be used in making printing of newspapers again, in case of using sodium dodecyl benzene sulfonate the tensile strength of recycled paper is maximum value.

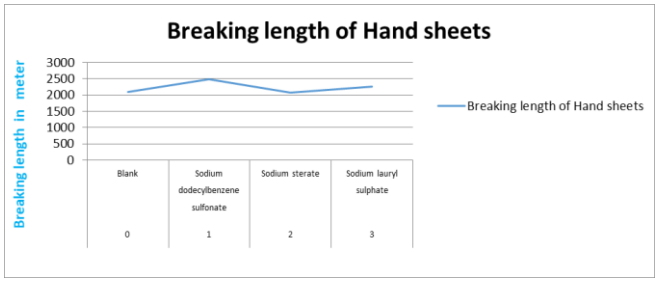

Fig 10. Variation of Breaking Length

Bursting strength indicates how much pressure a paper can tolerate before rupture. Bursting strength is measured as the maximum hydrostatic pressure required to rupture the sample by constantly increasing the pressure applied through a rubber diaphragm on 1.20-inch diameter sample. Bursting strength in case of using sodium dodecyl benzene sulfonate is maximum because removal of ink particle is maximum causing the fiber bond strength is strongest.

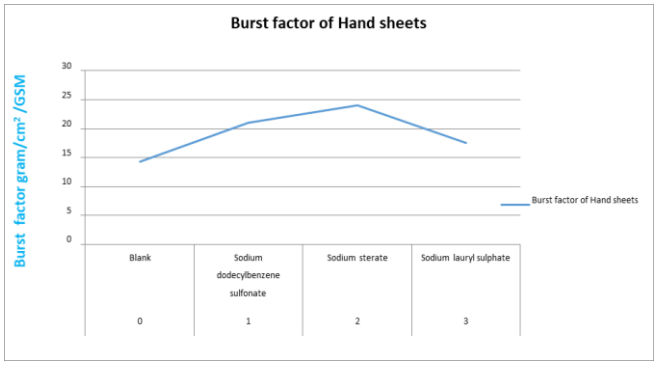

Fig 11. Variation of Burst factor with different surfactants

Bulk is another physical strength property of paper particularly for printers. It is calculated from caliper and basis weight. Decrease in bulk or in other words increase in density makes the sheet smoother and lower in strength. High bulk is desirable in absorbent paper while lower bulk is preferred from printing papers particulars[11], which is observed in case sodium dodecyl benzene sulfonate and sodium lauryl sulfate

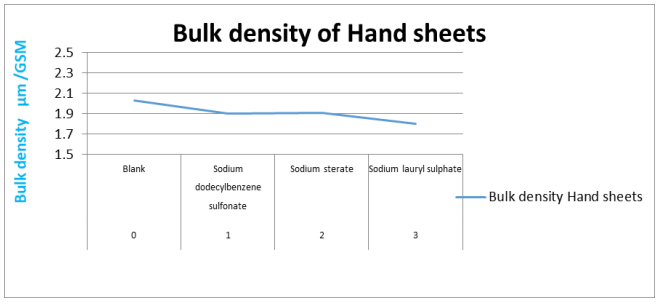

Fig 12. Variation of Bulk density with different surfactants

Double fold is the paper's capability of withstanding multiple folds before it breaks. It is defined as the number of double folds that a strip of 15mm wide and 100 mm length can withstand under a specified load before it breaks. In case of using sodium dodecyl benzene sulfonate, it is nearly similar to that of sodium lauryl sulfate but in case of sodium stearate it is minimum double fold value

Strength property	Sodium dodecyl benzene sulfonate	Sodium stearate	Sodium lauryl sulfate
Double fold value	3	2.8	2

The SEM figures of the different deinking hand sheet samples are shown in figure 13-16. From the SEM figures it is clear that the blank sample contains high percentage of ink particles as shown in Fig 13.

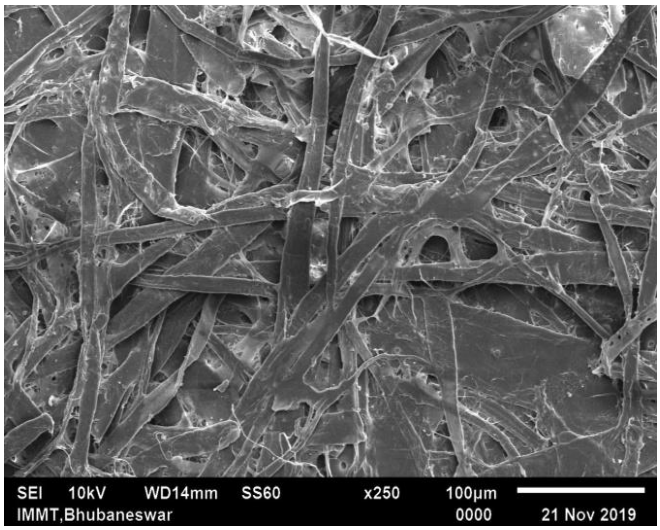

Fig 13. 10KV, 100µ (Blank)

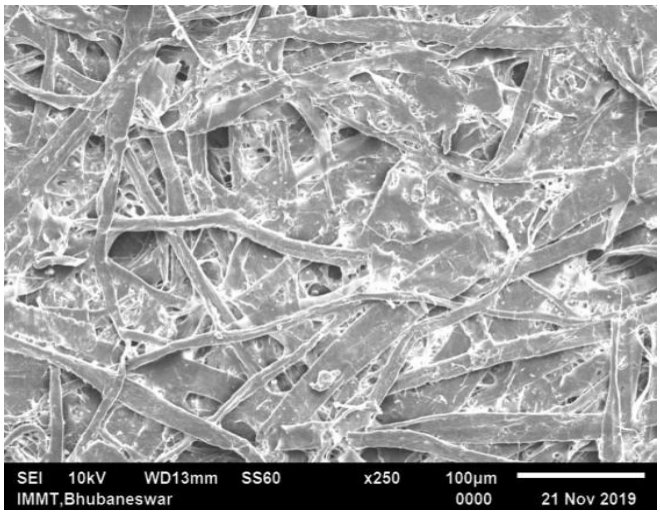

Fig 14. 10KV,100 µ(Sodium dodecyl benzene sulfonate)

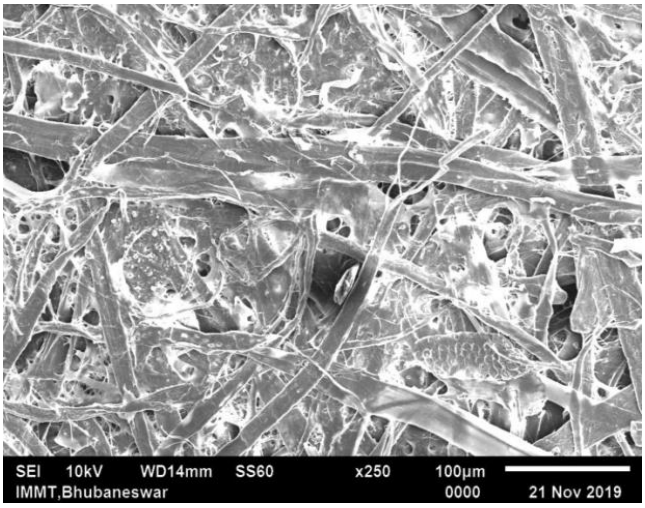

Fig 15. 10KV, 100µ (Sodium lauryl sulfate)

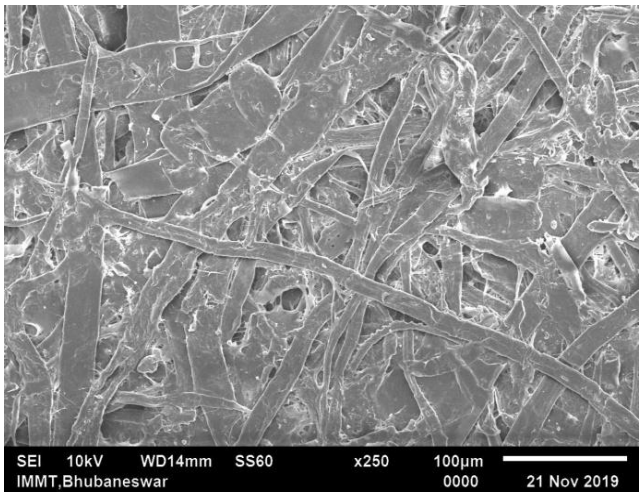

Fig 16. 10KV, 100µ (Sodium stearate)

The presence of ink particles modified the surface, making the fiber rough and heterogeneous. Small micro fibrils appeared on the surface, producing crack, peeling, swelling and external fibrillation. Sodium dodecyl benzene sulfonate facilitated the maximal removal of ink and resulted in better defibrillation of pulp fiber. The optical properties of paper are maximum in case of Sodium dodecyl benzene sulfonate followed by Sodium lauryl sulfate and Sodium stearate

IV. CONCLUSION

Sustainable development is always being a key challenge for the human race and treated as the highest priority across the globe. Achieving this goal, mainly depends on the way we deal with our environmental resources. Recycling of paper, which is environmentally healthy and ecofriendly practice contributes to waste management, thus leading to efficient use of natural resources. In India, to fulfill the demand of paper consumption for every individual, recycling of waste paper must be triggered. The present research work highlights a comparative study of different chemicals available as surfactants in deinking process. The removal selectivity of ink in DAF (diffused air flotation) cell is effective. In this process, removal of ash, long and short fibers are minimum. Because of hydrophobic nature of ink in the froth, ink particles get separated. Visual assessment of the hand sheet surface images revealed that brightness in % ISO increased to a higher value for Sodium dodecyl benzene sulfonate as compared to other two surfactants used in this study. The physical properties like tear, tensile strength, double folding is maximum for Sodium dodecyl benzene sulfonate.

REFERENCES

1. Miller M, Roberto M and Naik C. 2019. Optimum refining of recycledd fibre, challenges and success. Paper India. 22.1, 14-24.
2. Government press release. 2019. Paper India. 22.1, 30.
3. Mukundananda P G. 2019. Green energy in indian paper industry. Paper India. 22.1, 3.
4. Mukundananda P G. 2019. Need for accurate data on waste paper recovery. Paper India. 22.2, 3.
5. K S K Viswanathan. 2018. Go green and become competitive,Wires and fabriks, 22.1, 1-2.
6. Christian J R. 2014. Global challenges for the paper industry paper making cost optimization strategies. In paper, I, 22-27.
7. Heimonen J, Goyal M, Aho T and Jain N K. 2010. A state of the art deinking separation process for maximum yield ,IPPTA, 22.1, 141-145.
8. Tyagi S, Mohan V, Roy C K and Nair M B S. 2013. Effective recycling of waste paper for production of good quality news print.IPPTA, 25.3, 41-47.
9. Desarada S. 2013. Fibre and water reclaiming in waste paper recycling system. IPPTA, 25.3, 65-71.
10. Alexande S. 2015. Recycled fibre more more contamimants but potentially more value. Paper India, 18.5, 16-26.
11. Sharma A, Karkkar S, Chauhan V S, Bharadwaj N K and Vardhan R. 2013. Role of AKD and ASA emulsions in improving hydrophobicity of recycled fibre based paper. IPPTA, 25.3, 91-96.
12. Dr Basilio S. 2015. Novel Kaolin based deinking reagent for improved deinking of waste paper. Inpaper international, 17.3, 20-24.
13. Yum N and He B. 2019. Effect of enzyme treatment on surface properties of Mg(OH)2 based peroxide bleached deinked pulp.Bio resources. 14.2, 2861-2872.
14. Biswas P, Bharati A K, Kadam A and Dutta D. 2019. Wheat bran as substrat for enzyme production and its application in the bio deinking of mixed office waste paper. Bioresources 14.3, 5788-5806.
15. Amiri E,Rahamaninia M and Khosravani A. 2019. Efeect of Chilosan molecular weight on the performance of Chitosan silica nanoparticle system in recycled pulp. Bioresources 14.4, 7687-7701.
16. Biswas P,Bharati A K, Dutta D and Kadam A. 2019. Horseradish and Potato Peroxidase biobleaching of mixed office waste paper. Bioresources. 14.4, 8000-8013.
17. Vinod Kumar N,Rani M E, Gunaseeli R and Kannan N D. 2018. Paper pulp modification and deinking efficiency of cellulose-Xylanase complex from Escherichia coliSD5.International journal of biological macromolecules.111, 289-295.