

Research Paper

DEINKING OF NEWS PAPER PULP BY β -GLUCOSIDASE OF *PENICILLIUM PURPUROGENUM*

Mandakini B Patil^{1*} and Abhijit B Dhake¹*Corresponding Author: **Mandakini B Patil**, ✉ mbpatil@hotmail.com

Deinking of the newspaper pulp was carried out by using purified β -glucosidase produced by *penicillium purpurogenum*. The enzyme could remove ink from the pulp efficiently at the concentration 200U/g of pulp at 40°C with exposure till 90 min. The results of enzymatic treatment were comparable with chemical deinking process. The freeness of the fibers of the pulp was also retained. There was increase in the brightness and removal of lignin from the pulp which was measured by the decrease in Kappa number.

Keywords: Deinking, Enzyme, Glucosidase, Penicillium

INTRODUCTION

In the mid 1970 knowledge about the enzyme mechanism involved in the degradation of wood and its components were in infancy. It was suggested that the use of enzymes in pulp and paper making is out of reach. However, due to enormous progress made with time in the field of biosciences, the production of enzymes became economically feasible. Now a day in paper and pulp industry the enzymes are mostly used for bleaching of kraft pulp. The use of enzymes to aid bleaching of chemical pulp was introduced by (Viikari *et al.*, 1986). In the paper recycling industry, deinking is necessary to achieve minimum brightness values that are required for papers used for printing and writing purpose. A typical deinking process starts with disintegration of recycled paper. This step is generally carried out by the addition of chemicals in a strong alkaline medium in order to promote detachment of ink particles. Subsequently, washing or floatation technologies, generally in mild alkaline

media, allow ink removal from the suspension. Bio-deinking is proposed as an alternative to the use of chemical compounds at the disintegration stage. The proposed methodology uses a neutral medium, which allows the reduction of the contaminant charge (effluent containing less chemical compounds) and is comparatively more suitable for the maintenance of the environment. Different kinds of cellulase enzymes are used to facilitate ink detachment which is essential in the deinking process for the removal of the ink from cellulose fibers of the pulp (Carre *et al.*, 1995; Benington *et al.*, 1998). Application of enzyme cellulase in deinking is a recent methodology; however, contradictory results have been published for removal of ink from cellulose fibers by cellulases (Benington *et al.*, 1998). In addition to this, the proposed mechanisms of cellulase functioning in deinking process are different. According to (Woodward *et al.*, 1994), cellulase binding on pulp fiber may result in surface fiber alteration; nevertheless, other authors reported that the main effect is hydrolysis and substantial

¹ Department of Biochemistry, R.T.M. Nagpur University, Nagpur - 440033 (India).

degradation of cellulose fibers by cellulases, that implies ink removal from fibers (Eom and Ow, 1990; Lee *et al.*, 1983; Kim *et al.*, 1991). It has also been proposed that enzymic and mechanical actions are basic in the process of deinking (Jeffries *et al.*, 1994). Enzymatic deinking increases disintegration consistency caused by a higher friction between the fibers and the cellulose enzymes.

MATERIALS AND METHODS

Microorganism

Penicillium purpurogenum isolated in our laboratory and identified by I.M.Tech., Chandigarh, was used. Maintenance of fungus, production and purification of extracellular β -glucosidase was as described elsewhere (Dhake and Patil, 2007).

PULPING

Pulp of local daily English newspaper was used. Pulp was slashed at 15% in a hydropulper (Beloit Johnes Hydropulper, Germany) at 60o C for 45 min. All enzymatic treatments for deinking experiments were carried out within one week after pulping. Unused pulp was stored at 4oC until use.

ENZYMATIC TREATMENT

For deinking experiments paper pulp was mixed with purified β -glucosidase enzyme at 20, 200 and 2000 units/g of pulp and left at 40o C for 30, 60 and 90 min.

CHEMICAL TREATMENT

Alkaline hydrogen peroxide: Pulp with 15% consistency was treated with 2% hydrogen peroxide, 0.85 sodium hydroxide, 3% sodium silicate and 0.05% Magnesium sulphate at 75 to 80o C with the holding time of 1 hour (Sykes *et al.*, 1996).

PULP PROPERTIES

After the enzymatic treatment the freeness of pulp was determined by TAPPI method T227. The brightness of the pulp was measured by TAPPI

method T452. The Kappa number of the pulp for removal of lignin was measured by using standard TAPPI method (T236 os-76).

RESULTS AND DISCUSSION

Freeness

Freeness of the pulp was measured as per TAPPI T227 om-94. The deinking process performed by purified β -glucosidase of *P. purpurogenum* did not affect the freeness of the pulp. Results presented in Table 1 show the freeness of control, enzymatic and chemical based deinking process. The freeness values show variation in narrow range of 262 to 280.

| Sample | Freeness value (ml) |
|-----------------------------|---------------------|
| Control (No Enzyme) | 280 |
| A, 20 U/g of pulp, 30 min | 262 |
| B, 200 U/g of pulp, 30 min | 265 |
| C, 2000 U/g of pulp, 30 min | 267 |
| D, 20 U/g of pulp, 60 min. | 268 |
| E, 200 U/g of pulp, 60 min | 272 |
| F, 2000 U/g of pulp, 60 min | 274 |
| G, 20 U/g of pulp, 90 min | 277 |
| H, 200 U/g of pulp, 90 min | 279 |
| I, 2000 U/g pulp, 90 min | 280 |
| Chemical treatment | 278 |

Brightness

Brightness of treated & untreated pulp was measured as per TAPPI T52 om-98. The enzyme (β -glucosidase of *P. purpurogenum*) associated deinking process reflected increase in the brightness value as compared to control (untreated) and shows comparable brightness as achieved by chemical deinking process (Table 2).

Kappa Number

The Kappa number was measured as per TAPPI T236 om-96. [The Kappa number indicates the % lignin (percent lignin) content in the sample]. The kappa number is directly proportional to %

lignin content of the pulp. As kappa number decreases % lignin content also decreases. There was about half reduction in the kappa number and % lignin content as compared to blank (Table 3).

Table 2: Brightness Measurement of Selected Samples After Treatment with β -Glucosidase of *P. purpurogenum*

| Sample | Brightness (%) |
|-----------------------------|----------------|
| Control (No Enzyme) | 25.6 |
| A, 20 U/g of pulp, 30 min | 47.8 |
| B, 200 U/g of pulp, 30 min | 52.8 |
| C, 2000 U/g of pulp, 30 min | 52.8 |
| D, 20 U/g of pulp, 60 min. | 48.5 |
| E, 200 U/g of pulp, 60 min | 52.6 |
| F, 2000 U/g of pulp, 60 min | 54.1 |
| G, 20 U/g of pulp, 90 min | 48.9 |
| H, 200 U/g of pulp, 90 min | 52.8 |
| I, 2000 U/g pulp, 90 min | 54.2 |
| Chemical treatment | 53.4 |

Table 3: Kappa Number & Percent Lignin Profile of Selected Samples After Treatment with β -Glycosidase of *P. purpurogenum*

| Sample | Kappa Number |
|-----------------------------|--------------|
| Control (No Enzyme) | 40.35 |
| A, 20 U/g of pulp, 30 min | 29.21 |
| B, 200 U/g of pulp, 30 min | 25.4 |
| C, 2000 U/g of pulp, 30 min | 24.7 |
| D, 20 U/g of pulp, 60 min. | 24.13 |
| E, 200 U/g of pulp, 60 min | 22.15 |
| F, 2000 U/g of pulp, 60 min | 20.65 |
| G, 20 U/g of pulp, 90 min | 25.79 |
| H, 200 U/g of pulp, 90 min | 21.89 |
| I, 2000 U/g pulp, 90 min | 19.57 |
| Chemical treatment | 18.09 |

Results are mean of three replicates. (P value was set at > 0.05)

From the results mentioned above it is observed that the enzyme concentration of 200 U/g of pulp for 90 min. reaction was found to be the best for β -glucosidase based deinking. As it shows

comparable results with chemical deinking process and also by increasing enzyme concentration from 200 to 2000 U there was very little improvement in the clarity and quality. So the concentration of β -glucosidase at 200 U/g of pulp for enzyme treatment was considered to be the best for achieving maximum deinking of the paper pulp employed for the experiment.

Enzymatic deinking can be applied on old newsprints and office waste also (Prasad, 1993). The commercial enzymes have been shown to hydrolyze the cellulose fibers of the pulp during deinking process to release the ink particles from the pulp fibers. The loosened ink from the treated pulp can then be removed by chemical treatment or by air floatation method. A secondary benefit of the enzyme treatment is that the stripping of ink fines (ink particles) from fibers results in improved drainage that is the washings are without or with very less amount of polluting chemicals in the drainage (Rutledge et al. 1998); without reduction in the strength properties of the deinked pulp fibers which can very well be recycled for formation of new papers (Jackson et al., 1993).

Helga et al., (1998) also reported similar results for treatment with enzyme α -amylase followed by chemically aided floatation process. Pelach et al. (2003) suggested a model for cellulose assisted deinking. They postulated that fiber surface friction with the cellulase action increases with deinking efficiency. Putz et al., (1994) also found that enzymatic treatment with presoaking of pulp in solution of optimum pH was sufficient for a proper release for offset printed news paper. The efficiency of the enzymatic deinking process could potentially avoid the chemically aided floatation step and increases the yield of recovered fiber and also reduces usage of water thereby producing less effluents, which ultimately decreases the capital cost of deinking plant and ancillary equipment and reduces the sludge and its disposal cost. The freeness, brightness and kappa number values from enzymatically treated pulp are comparable to that of chemically treated pulp. Thus enzymatic deinking using β -glucosidase can be used as the

environment friendly alternative to the chemical deinking process.

All results are mean of 3 replicates. The data obtained was analyzed using ANOVA technique as given by Ronald Walpole (1982). Significance was set at $P < 0.05$.

ACKNOWLEDGMENT

Authors thank The Head, University Department of Biochemistry, RTM Nagpur University, Nagpur and Director, Lakshminarayan Institute of Technology, RTM Nagpur University, Nagpur, for laboratory facilities and encouragement.

REFERENCES

1. Bennington C P J, Sui O S and Smith J D (1998), "The Effect of Mechanical Action Waste Paper Defibering and Ink Removal in Repulping Operations", *J. Pulp Paper Sci.*, Vol. 24, No. 11, pp. 341-348.
2. Bolaski, W Gallatin A and Gallatin J C (1959), *United State Patent*, Vol. 3, pp. 041,246.
3. Call, H P (1993), *United States Patent*, Vol. 5, pp. 203, 964.
4. Carre B, Galland G and Saint Amand F J (1995), "Third Research Forum on Recycling", pp. 73-88.
5. Dhake A B and Patil M B (2007), "Characterization of Cell Wall Bound β -glucosidase from *P. Purpurogenum*", *Rom. Biotechnol. Lett.*, Vol. 12, No. 5, pp. 3441-3448.
6. Eom TJ and Ow S S K (1990), "German Patent", 262040.
7. Helga K, Zollner and Lelland R (1998), TAPPI Vol. 81, pp. 166-170.
8. Jackson L S, Heitmann J A and Joyce T W (1993), "Enzymatic Modification of Secondary Fiber", TAPPI, Vol. 76, No.3, pp. 147-154.
9. Jeffries T W, Klungness J H, Sykes M and Rutledge-Cropsey KR (1994), "Comparison of Enzyme Enhanced with Conventional Deinking of Xerographic and Laser Printed Paper", TAPPI Vol. 77, pp. 173-179.
10. Pelach M A, Pastor F J, Puig J, Vilaseca F and Mutje P (2003), "Enzymic Deinking of Old Newspapers with Cellulose", *Process Bio- chem.*, Vol. 38, pp. 1063-1067.
11. Prasad D Y (1993), "Enzymatic Deinking of Laser and Xerographic Office Waste. Appita", Vol. 46, No.4, pp. 289-292.
12. Putz H J, Gottsching L, Renner K and Jokinen O (1994), "Enzymic Deinking in Comparison with Conventional Deinking of Offset News Paper". *TAPPI Proceedings*, pp. 877-884.
13. Ronald E, Walpole (1982), "Introduction to Statistics", 3rd edition. *Macmillan Publishing Company*.
14. Sykes M (1996), "Bleachability of Recycled Fibers Deinked with Enzyme Preparations. TAPPI Proceedings", *Recycling symposium*, pp. 63-67.
15. Viikari L, Ranua M, Kantelinen A, Sundquist J and Linko M (1986), "Biotechnology in the Pulp and Paper Industry", *Stockhom, Sweden*, pp. 67-69.
16. Woodward J, Stephan L M, Koran L J Wong, K K Y and Saddler J.Mn. (1994), "Enzymatic Separation of High Quality Pulp Fibers from Recycled Newspaper". *Bitechnol.* Vol. 12, No.9, pp. 905-908.



International Journal of Engineering Research and Science & Technology

Hyderabad, INDIA. Ph: +91-09441351700, 09059645577

E-mail: editorijerst@gmail.com or editor@ijerst.com

Website: www.ijerst.com

