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Biodegradation of Lignocellulosic Material

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ABSTRACT

In pulp and paper industry use of chemicals for pulping of raw material creates lot of pollution. Hence, we should move to bio pulping which is an eco-friendly process. In nature, cellulose, lignocelluloses and lignin are major sources of plant biomass; therefore, their recycling is indispensable for the carbon cycle. Each polymer is degraded by a variety of microorganisms which produce enzymes that work synergically. Large amount of cellulose waste (many billions of tons) are produced worldwide as residues from agricultural activities and industrial food processing. The use of microorganisms in order to remove, reduce or ameliorate these potential polluting materials is a very environmental challenge, which could be solved by focused research on biological degradation of these wastes. In the near future, processes that use lignocellulolytic enzymes could lead to new, environmentally friendly technologies. Pigeon pea (canjanus cajan) stem is characterized by shorter fibre compared to hardwood species. The objective of present study biodegradation of lignocellulosic material by using pigeon pea (canjanus cajan) pods & its stem which is commonly known as toor daal. The analysis of sample before and after degradation is given in experimental analysis.

Keywords: Biodegradation, Pigeon Pea (Cajanus Cajan), Cellulose, Lignocelluloses, Lignin, Micro-Organisms.

1. INTRODUCTION

The word ‘paper’ itself has acquired an aura of being something over the period which is defined and worthwhile. Paper gets its name from papyrus a sheet made by pressing together the core material or pith of the Egyptian papyrus plant. Papyrus as a writing material was first developed about 4,000 years ago. It was 2,000 years back about the time of Jesus Christ that a scholar from China named Ts’ai Lun invented paper which is known today. There is no doubt that paper is called are symbol of knowledge and nothing is wrong in calling it as symbol of civilization because it has been there in different forms so as to have a track of our existence as a whole. We can’t imagine our progress of pervious journey of modern world without paper [1].

But despite all these, now a days the chemicals used for paper making processes (pulping and bleaching) are creating environmental issue. Hence we have to overcome by means of new alternative to these chemicals and the solution is biotechnology and its attractiveness lies in its potential to provide processes where nonbiological processes are unable to increase specificity in reactions. Also it provide less environmentally deleterious are processes to save energy decrease cost.

Raw material used for paper making is forest based i.e. wood and its components. Wood contain cellulose, hemicelluloses and lignin. Cellulose is used for making paper because it is a long fiber that can be easily dispersed in water and easily forms entangled mats when dried. Hemicellulose is like cellulose, but it is made of much shorter fibers. Lignin is a large molecule that forms crosslinks with hemicelluloses and gives wood its hardness. Paper is made from cellulose by breaking down the lignin that makes it possible to extract pure cellulose and hemicelluloses from a whole wood mass. Traditionally, wood pulp was treated with sodium hydroxide and sodium sulfide to break down the lignin. Both of these chemical are dangerous , and many of the byproducts of this pulp treatment are

smelly , environmentally hazardous , toxic and carcinogenic .paper manufacture are trying to remove lignin without using harmful chemicals. The main problem in designing new process for delignification so that the chemical bond between hemicelluloses and lignin are stubborn and complicated .[2]

The pulp and paper industry has been investigating biological replacement for the chemicals used paper making process that creates pollution and also to reduce capital and operating costs and minimizing its environmental impact. Use of biological treatment that has been of interest, is for reducing refining energy consumption in mechanical. pulping. Process shown that certain fungal treatment can achieve this end without damage to the resulting fiber and possible with better quality fiber in the end. There has also been some success in retreating wood chips for chemical pulping processes. In this type of retreatment, our main aim is to obtain uniform delignification, high yield and chemical usage reduction. Research into chip treatment with cellulose and hemicelluloses enzymes is just beginning. Pre-treatment of hard wood chips with Pseudomonas Chrysosporium shows an improvement in Kraft pulp yield after 20 days, bus is more pronounced after a period of 30 days. The resulting pulp compared at the same Kappa number has a higher tensile strength and corresponding lower tear strength. The pulps also refine faster, thus saving refining energy to achieve the same pulp properties, the use of environment friendly process is becoming more popular in the pulp and paper industry. biotechnology encompasses a diverse array of activities such as fermentation ,immobilized cell and enzyme technology ,cell and tissue culture, monoclonal antibody techniques for genetic transfer and DNA manipulation namely genetic engineering . [3]

Biotechnology is define as the area of biology which used living system and microorganism or biological system. the microorganisms do this by making a type of molecule called an enzyme. At that time , when biotechnology was developed for the pulp and paper industry in the mid 70's , knowledge about the enzyme mechanisms involved in the degradation of wood and it's component was in it's infancy . the suggestion , at that time , to use enzymes in pulp and paper making seemed out of reach .production of the required enzymes quantities at a price that would have been close to economic feasibility was impossible .however, since then enormous progress has been made in the bioscience in general in genetic ,molecular biology, biochemistry and microbiology .this has allowed for production of enzymes at economically feasible process , which has made them technically interesting for the industry. Enzymes from alkaliphilic and thermophilic microorganisms can now be cloned into efficient production system and enzymes for bleaching, enzymatic deinking and other papermaking processes can be produced at costs we could hardly 10 year ago. Now, microorganisms can be genetically modified to make them ideal for specific purposes and enzymes can be designed to better catalyze industrially important reaction .the massive amount of effort devoted over the past few decades to a better understanding of the enzymes produced by wood degrading microorganisms for conversion and degradation of lignin, cellulose and hemicelluloses have provided a fresh base for successful developed of biotechnology in pulp and paper industry.[4]

Biopulping is the application of biotechnology at industrial level where natural fungus are used for conversion of wood chips to pulping. Basically there are two types of processes for pulp manufacturing i.e chemical and

mechanical. The problem faced by chemical and mechanical processes can be overcome by biopulping process where it uses fungi present in wood naturally the alter the lignin in the cell wall of wood. After lignin removal ,wood chips become soft .Hence , the already softened wood chips require less energy in the further process and chemical usage can be reduced therefore reducing pollution. Biopulping reduces electrical energy needed by an average of 25%-30% , it also save about $9-$20 per ton of pulp .The fungus used in biopulping is ceriporiopsis subvermispora and is fairly easy to maintain .treating the wood with steam and creating a ventilation system provides a good environment for fungi to thrive in .overall ,we can utilize the knowledge obtained from naturally occurring microorganism in wood ,to manufacture better quality of paper thereby reducing the adverse effect of chemical on environment . [5]

Fungal pre-treatment of wood chips removes some of the lignin and modifies other lignin ;these changes might make it easier to remove lignin in the subsequent pulping process .fungal treatment causes softening and swelling of wood cells. It is possible that these fungus induced changes and the removal or modification of lignin may result in improved chemical penetration during pulping operations, which could result in more easily bleachable , lower kappa pulps; reduced cooking times and temperature ; reduced pulping chemical needs ; and reduced effluent waste load.

Biopulping is a simple concept, but harnessing lignin degrading fungi in a commercially attractive process has not been simple. Many biological variables had first to be examined and optimized; major ones include fungus species and strains, inoculums from and size, wood species, chip pre-treatment, incubation time, aeration, and nutrients. each variable had to be examined independently of the others, To get to the current process out of the many biological variable. Three were paramounts: (i) fungus selection, (ii) chip surface decontamination and (iii) inoculums.[6]

2. PROCEDURE

The sample of pigeon pea (cajanus cajan) had taken . Then it was washed, dried, and grinded. Grinded sample was weighed about 35gm and transferred into a conical flask. In that, distilled water was added such that the sample should well dipped in it. The beaker was then covered with cloth , so that should passed inside .It means the system is aerobic .then we kept the sample for observation and every day checked the status of the sample .

3. RESULTS AND DISCUSSIONS

The results of the experimental analysis indicated in Table 1.

Table 1: experimental analysis of given sample before and after degradation

Sr.no	Experiment	Sample A (before degradation)	Sample B (after degradation)
1.	Moisture content (%)	9.4	8.6

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2.	Ash content (%)	5.2	2.9
3.	Cold water solubility (%)	18.02	9.78
4.	Hot water solubility(%)	26.2	15.5
5.	1 % NaOH solubility (%)	37.85	27.9
6.	72% acid soluble lignin	20.6	23.68
7.	Kappa no	37	23.2

Note: all the experiments are performed according to TAPPI standards .

Moisture content of dry sample is less than that of dry sample. Ash content of sample B is less than that of sample A it means that after degradation inorganic material had decreased. Also cold water and hot water solubility of sample A is more which shows that water soluble components had been removed after degradation. As NaOH solubility is more of sample A it means that alkali soluble component i.e lignin is more before degradation .it means micro-organisms had degraded lignin. Kappa no determines the amount of lignin present. Kappa no is less of sample B therefore lignin content is less which shows that micro-organisms had effectively removed lignin.

Wood and other fibrous raw material are of all biological in origin and readily decompose in nature. Biological pulping puts to use the same process of degradation to remove lignin and hemicellulosic materials. Hence, these experimental evidences showed that these micro-organisms show their acceptance in future for biopulping. But the process is show and time consuming ,which cannot cope up with the today's competitive world .however , if it's application before curtail the pollution load produced by hazardous chemical and will certainly prove an economically feasible and environmental friendly process.

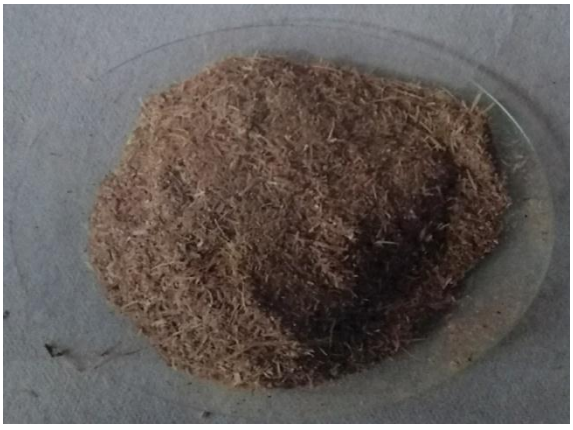

Figure no -1 pigeon pea (cajanus cajan) pod before degradation

Figure no-2 wet sample kept for degradation

From our observation come to know that in anaerobic sample also degradation also occurs but the rate of degradation is more than that of aerobic sample. Sample had kept the under observation at temperature range 30°- 40°C in which bacteria and fungi cannot sustain .also from literature data we come to know that

actinomycetes can sustain this temperature. Hence the biological agent responsible for lignin degradation is actinomycetes.

Figure no- 3 sample A at intial stage
i.e. before degradation
sample B at final stage
i.e after degradation

Figure no-4 degraded sample after drying

4. CONCLUSION

From our experimental analysis come to know that lignin is removed from the sample after degradation and it was aerobic biodegradation. Hence, bio-pulping can be utilized for pulp making which is an eco-friendly method. Bio-pulping can reduce chemical consumption and reduce pollution. It can save energy and decrease the capital cost. Also, the sample had used pigeon pea (cajanus cajan) which is not commercialized yet for making of paper. But, literature evidence shows that pulp of cajanus cajan can be mixed with normal pulp to make paper.

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