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GREEN CHEMISTRY IN PULP AND PAPER TECHNOLOGY

KEY WORDS: *Sustainability, Green chemistry, Pulping, Bleaching*

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ABSTRACT

Pulp and paper industry is considered to be energy intensive and polluting sectors. This sector employs conventional technologies which are highly intensive in terms of consumption of raw material, chemicals, energy and water which thereby generates higher levels of effluents. Green chemistry is an important tool in order to modify an existing process or to develop new processes with a sustainability approach. Present paper shows the new technologies used in paper and pulp industries. Green chemistry helps to reduce toxic chemicals released into the environment. It also develops nontoxic alternatives to chemicals currently which are in use. A brief idea on how different pulping and bleaching processes takes place in paper making is discussed in this paper. The fundamentals of Green Chemistry including its relationship with sustainability are highlighted.

1. INTRODUCTION:

In the last decade, various technical developments have taken place in pulping, bleaching and chemical recovery technology. Various developments have made it possible to reduce the effluents and airborne emissions. Thus there has been progress towards minimum impact mills in the pulp and paper industry. Minimum impact mill is a manufacturing concept which mainly focuses on environmental management systems, compliances with environmental laws and regulations and manufacturing technologies

Green chemistry, is also known as sustainable chemistry, is a new field that encourages the design and development of chemicals using principles that minimize the use and generation of toxic chemicals. Paul Anastas coined the term "green chemistry," Sustainability of pulp and paper industry is on trend due to the government regulations and increased awareness is developed by various environmental organisations. Sustainable pulps and paper manufacturing requires a comprehensive view of the manufacturing process

An important tool to modify the existing process is Green chemistry. It is becoming one of the new processes with a sustainability approach. It essentially enunciates the ideal principles of sustainable chemistry with basic mannerism to minimise the environmental impact of a given process.

In Green chemistry alternative to chemical development is offered that has the potential to reduce the number of new toxic chemicals released into the environment and also to develop nontoxic alternatives to chemicals currently in use. Central Pollution control Board (CPCB) identified Pulp and paper industry as one of the most polluting industries; it consumes a major quantity of water and heavy chemicals and in turn produces large volumes of effluent. Pulp and paper sector has taken a few initiatives for pollution control, but then also it is far behind the global scene, particularly the small medium industries. It is because of the diversity of the Indian pulp and paper industry with wide range of production capacities and raw materials.

During the last decade, there have been new technical developments in pulping, bleaching and chemical recovery technology. These developments have made it possible to further reduce loads in effluents and flying emissions. Thus, there has been a strong progress towards lowest impact mills in the pulp and paper industry. The minimum-impact mill is a universal manufacturing concept that encompasses environmental management systems, compliance with environmental laws and regulations and manufacturing technologies.

Green chemistry, is a philosophy of chemical research and engineering that encourages the design of products and processes with minimum use and generation of hazardous pollutants.The primary goals of green chemistry is to prevent pollution occuring at its source, rather dealing with pollution, after it has occurred. Other factors in green chemistry which play a major role are utilization of nontoxic chemicals, environmentally benign solvents and renewable materials. The key elements of green chemistry are:

- To design processes which maximize the amount of raw material that ends up in the product
- To use safe, environment-benign ssubstances, including solvents, in day to day whenever possible
- To design energy efficient processes
- To design the chemical products in a way that at the end of their function and does not persist in the environment and break down into innocuous degradation products;
- To develop analytical methodologies to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances;
- Using the ideal waste disposal strategy Green chemistry is looked as a powerful tool by researchers to evaluate the environmental impact of the processes being developed. Many attempts are being made to quantify the greenness of the chemical process but also to factor in other variables, such as, chemical yield, cost of reaction components, safety in handling chemicals, hardware demands, energy profile and ease of product workup and purification.

Pulping Process:

Pulping is the major source of effluents in the manufacturing process of pulp and paper industry. In this process separation of cellulose fibres and removal of impurities takes place. In Pulping process three types of raw materials are generally used i.e. hard wood, Agro residues and Recycled fibre/ waste paper. Qualityof paper depends on the cellulose content in pulp and the fibre length. In Hardwoods higher proportion of cellulose are shorter fibre lengths than softwoods, which are more resinous. Lignin removal is done by treating the wood chips this also improves the fibre quality. Two approaches are employed for pulping viz. chemical pulping and chemi-mechanical pulping.

- **Chemical Pulping** - Kraft Sulphate process: This process is the most important method used for the pulp production. It results in strong, long fibre with low lignin content pulp. Here in this process the wood chips are cooked at temperature of 165- 170°C along with sodium

hydroxide (caustic soda) and sodium sulphide to separate lignin and wood resins from the pulp. The pulp is later on washed and bleached. About 92-95 % of the chemicals such as sodium hydroxide, sodium sulphide and lime are recovered and reused by operating in a closed loop system.

- **Chemical Pulping – Soda process:** In Soda pulping process, pulping of agro residues like wheat and rice straw and bagasse are used. In this process these raw materials are cooked with caustic soda at a temperature of 150-160°C to separate lignin from the raw material. The pulp is obtained from soda pulping is then washed and bleached, in order, to make a bleached pulp.

- **Chemi-mechanical pulping (CMP):** In this process the wood chips are first impregnated with mild caustic soda based chemicals in order to extract resin and lignin from the fibre before mechanical refining.

- **De-inking - For recycled fibre**, for de-inking dispersion or floatation pulping process is used. The re-pulped fibre is washed and sorted out to remove solid impurities. For de-inking, chemicals such as detergents, dispersants and foaming agents are added and ink is separated from pulp with the help of foam by aeration and concentrated into sludge for disposal. The fibre yield depends upon the filler content and quality of the input fibre used.

- **Medium Consistency Pulping**- All pulping process should have in common is operation at medium to high consistency. In modern Kraft Mills, the continuous digesters, displacement washers and hot stock screening are widely used

The pulp mill of the future will operate at medium consistencies of 12-14% from the digesters to the paper machine. Medium- consistency mixers, pumps and screens have already been developed and have been tested in full scale mill trials.

- **Oxygen Pulping-**It is one of the emerging processes which have full scale development. By this pulping, pulp can be produced in the laboratory by various compositions of oxygen alkali processing steps. Both single stage and multistage process have been tried. Oxygen pulping helps in pollution control because their chemicals (oxygen and sodium base alkali) contain no source for generating odorous compound. Chemical recovery will be difficult to keep on in oxygen pulping system totally free of sulphur because sulphur compound occurs as major constituents of wood. Other benefits of the process are that less energy is needed to refine oxygen pulp.

In oxygen pulping method, two-stage Soda oxygen pulping and single stage oxygen pulping are the two cases which are often carried out. In the two- stage process the chips are cooked first in caustic soda to a point at which they can easily be mechanically separated into fibre (50- 60% yield) and after these fibre of high lignin content are dignified with oxygen to give a yield slightly better than that obtained with Kraft pulping this process used existing mill technology with the addition of an oxygen stage.

- ***Anthraquinone (AQ) Pulping***

AQ and similar compound shows a very good yield and have derived beneficial effect at very low concentration. Both **AQ** and the sodium salt of anthraquinone sulfonic acid have been found to be effective. Amounts low as 0.05 - 0.1 % on wood have been demonstrated to produce delignification rates, pulp yield strength similar to those obtained by kraft, pulping. **AQ** has also been used commercially in the Kraft process to give improvement in yield and pulp properties .It is possible to get about a 5% improvement in yield compared to that of straight better properties. The same result can be obtained with soda alone but larger amount of AQ are required. AQ seems to function somewhat as a catalyst and is not commonly considered in the cooking process. It appears to give higher yield by stopping the carbohydrate peeling reactions throwoxidation of the redacting end group to aldonic acids the mechanism of activity of AQ in the enhancing the rate of delignification has not yet been determine

Bleaching Process:

Bleaching process is to improve the brightness of the pulp. In this type of process the type of pulp involved and end use are important factors. Some of the bleaching agents used are chlorine (Cl_2), chlorine dioxide (ClO_2), hydrogen peroxide (H_2O_2), caustic, oxygen, ozone, hypochlorite, sodium bi-sulphite.

- **Chlorine Bleaching:** It is used to remove the residual lignin in the range 5- 10%. This process is followed by several stages of treatment with chlorine dioxide or hypochlorite to whiten the pulp.

- **Elemental Chlorine Free (ECF)** Bleaching: ECF bleaching technology is being used in many large mills where oxygen delignification (ODL), followed by ClO_2 and other chemical agents to achieve brightness. Other typical sequence would include chlorine dioxide, caustic soda, oxygen and hydrogen peroxide.

- **Total Chlorine Free (TCF)** Bleaching: Combination of ODL with ozone / peroxide brightening leads to TCF bleaching. The bleaching process can be enhanced by the use of enzymes and a 'chelating' agent (ethylene diamine tetra acetic acid, EDTA) is added to bind the metal ions contained in the pulp and prevent them from decomposing the hydrogen peroxide. The paper whiteness of ISO 70-85% is achieved by this method and can be improved to ISO 85-90% by using ozone bleaching.

- **Hydrogen Peroxide Bleaching:** Hydrogen peroxide is used for bleaching the pulp with high lignin content. Hydrogen peroxide alters the chemical structure of lignin by oxidizing and remains with the pulp. Though hydrogen peroxide is environmentally benign, it is expensive.

CONCLUSION:

The goal of green chemistry (GC) is to design products and develop manufacturing processes to reduce their impact on human health and the environment. Various Pulping and bleaching technologies which are utilised in paper industries are discussed. In this all new approaches carried out during pulping such as addition of anthraquinone which helps to enhance the delignification. Discussion of total chlorine free bleaching was more effective than other bleaching processes. The principles of green chemistry will helps sustainability by reducing environmental impacts and conserving natural and conserving the natural resources for future generations.

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