# STUDIES ON TREATMENT AND UTILIZATION OF INDUSTRIAL WASTE

**Author**
Shivani Bhardwaj

**Supervisor**
Prof. Mukhtar A Khan
Department of Chemistry
Jamia Millia Islamia

Treatment and utilization of industrial waste in general covers the domain applicable to many industries that are responsible for environmental pollution. Lack of ecofriendly technologies, cost-effective waste management, and disinterest in utilization of waste products are few reasons behind ever growing pollution problems. Through out the world both at small scale as well as at the large scale, the treatment of the wastewater has been the area of interest. Government and non-government organizations, United Nations and some private sectors are involved in this humble task.

This work primarily deals with the treatment of pulp and paper mill wastewater i.e. black liquor followed by the utilization of waste material. Huge amount of the water required by the pulp and paper mills that is discharged almost in equal volume daily accumulates toxicity in aquatic system thereby directly affecting the living species in all forms. Work is carried out as an application of O-b phenoxyl radical coupling mechanism that in its premature stage leads to pharmaceutically active natural products.

The thesis has been categorized into introduction, followed by literature review, Chapter 1: Treatment of black liquor using adsorption, Chapter 2: decolourization from pretreated black liquor, Chapter 3: study on oxidative phenolic coupling of lignin monomers with polyphenolics and Chapter 4: utilization of waste material forming polyblends. Future scope is followed by bibliography.

## 1. Introduction and Literature Review

Introduction forms the foundation stone of the thesis that gives us brief idea about the functioning of pulp and paper industry, black liquor (the waste water generated during papermaking process), toxicity and color of the black liquor. Lignin is considered as a key reason behind the aesthetic displeasure of the wastewater. Wide range of applications of this natural aromatic biopolymer has been acknowledged and still holds a giant potential to get unfolded for more areas of research and development. The biomimetic synthesis of lignans using various catalysts and approaches also forms a niche in this preface. The introduction is followed by the literature review regarding the same. This enlightens the actual work done in this field over the decades, gives us idea about the problem and also suggests us to implement our work plan with a newer approach. Literature review is a necessary requirement for any research domain.

## Chapter 1:Treatment of pulp and paper mill wastewater using adsorption

Treatment of black liquor using adsorption deals with the treatment of black liquor using some cost friendly and simple operational methodology such as physicochemical processes like adsorption. Use of the low cost materials like coal and carbonaceous coal was studied in comparison to charcoal activated. The treatment was extended to use of polymers like PVC. Probable reasons behind the results obtained have been discussed. Different studies like effect of adsorbent dosage, effect of batch contact time, effect of dilution of the adsorbate and effect of amount of adsorbate were done. Adsorption isotherms, adsorption dynamics, intraparticle diffusion and Lagergren plots were determined leading to applicability of the work. The field stood thoroughly inviting, the reason being low cost and simple methodology. The carbonaceous material like char, coke, carbonized coals could substitute this. Carbonization if would have been followed by gasification, leaching or solvent extraction might yield a better coal product with huge amount of pores and carbon percent. The surface area is the definite factor behind the adsorption process. The coal under study had a high particle size i.e. -60 to + 120 BSS mesh when compared to powder form of charcoal activated. Therefore the results were found as expected. PVC is one of the adsorbent that has shown positive results. Yet it is difficult to say about the type of interaction between P.V.C and that of the colour. This could ion exchange, adsorption, occlusion and dissolution as well as actual dipolar interactions.

## Chapter 2:Decolourization of Pretreated Pulp and Paper mill wastewater using Adsorption

This chapter is focused on the pretreatment of the black liquor before adsorption. The pretreatment of the wastewater is a prerequisite for any type of treatment methods as it considerably reduces the coloring bodies present in the effluent. Keeping this in mind the work was carried out on pretreated black liquor. The technique and the adsorbents utilized for decolourization were same as that of the previous chapter 1. The same studies were implied here also to make comparison of the work and to determine the feasibility of the method adopted. The lignin obtained was used for its utilization as poly blends. Pretreatment of black liquor for decolourization is a necessity as this removes most of the colouring matter.

Removal of lignin also prevents photocatalyzed degradation in suspended form that gives rise to toxic components. The wastewater thus obtained with minimum colour could easily be treated by various methods and lignin obtained is a rich source of some value added chemicals and substitute of phenol in resins and other polymers. Decolourization of pretreated wastewater by charcoal activated is best option. But being cost effective it's use as an adsorbent has always been last priority. Carbonized coal has occurred as substitute to this. With pretreatment of wastewater carbonized coal is able to carry out adsorption of colour with more efficiency. Coal original is a poor adsorbent for colour but it is able to reduce other toxic contaminants from the wastewater that are yet to be investigated. PVC also has effectively reduced the colour better than untreated black liquor.

## Chapter 3: Study of oxidative coupling of polyphenolics with phenyl propene units: Synthesis of lignans

Study on oxidative phenolic coupling of lignin monomers with polyphenolics is developed to investigate the coupling of lignin monomers basically coniferyl alcohol, ferulic acid ester in addition to acrylic acid and vinyl acetate with polyphenolics. The coupling leads the formation of biologically active oligomers known as lignans. These are important moieties to pharmaceutical and nutraceutical industries. Varieties of catalysts have been examined to improve the yield of the products. The attempts were made to study amphoteric oxide as catalyst independently as well as in the presence of radical producing medium. Spectroscopic analysis was done.

Moderate to fair results were obtained opening a newer field to be investigated that could produce better results. The stereochemistry of the lignans has been deduced earlier, yet separations of the isomers of lignans are still not explored. Mild oxidants have been successfully used as catalysts for phenolic oxidative coupling. The use of amphoteric oxide can provide us a new type of catalysts to be investigated. The initiator of radical formation do seem to be necessary requirement otherwise poor yield is obtained. No attempts in the literature have been made to separate the regioisomers of the product despite the presence of chiral centers. Use of up growing field of chirotechnology could be applied on to separation of the isomers at large scale. For this purpose chiral shift reagents and biocatalyst could be used. However former is cost effective technology when compared to latter.

## Chapter 4: Utilization of Industrial Waste forming Polymer Blends

The black liquor mainly constitutes lignin and its derivatives that are responsible for the pollution along with some xenobiotic compounds. Lignin extractred from the black liquor during pretreatment procedure were blended with other polymers like PVC (polyvinylchloride) and PANI.HCl (polyaniline). Lignin was acylated with a known method to form blends with the same polymers.

PANI.HCL is a well-known conducting organic polymer. Lignin is also considered as polyanion leading to possibly of conductivity if blended with. PANI.HCl. the results were favorable. The blends were conducting. Expectedly the acylated lignin did affect the conductivityof the PANI.HCl. Except this other studies like film properties, D.S.C, IR were carried out. Lignin has been declaired as potent polymer that needs to be implemented for wide variety of applications at the technological scale. This is due to reason that it is rich source of value added chemicals, petrochemicals, energy, fuel and other polymeric applications. Homogenous blends were formed by lignin and acetylated lignin with PVC and PANI.HCl. This can be interpreted from the IR peaks that occurred at lower frequency. PANI.HCL: L / AL form dull green powder. No good films were obtained despite many coatings. With PVC: L / AL are translucent bright brown films were obtained. Film properties of the blends resulted in moderate to fair value. PANI.HCl: L blend represented considerable amount of conductivity whereas PANI.HCl: AL gave nil results for conductivity even at a high voltage. The glass transition temperature of PANI.HCl: L was found to be the highest when compared to rest of the blends

## Future Scope

The future scope of the work gives us a brief idea about the further proceedings that could be implemented for the research. Heat treatment to organic matters yields carbonized form. Coal in the original form has the potential of removal of low molecular weight and small sized colouring bodies. Poor results were obtained when applied to decolorization of larger molecules like lignin. However its carbonized form leads to significant results Removal of mineral matter from this state by leaching, solvent extraction, graphitization and increased porosity are  the few phenomenons that could lead to percentage increase in carbon contents. This in turn could enhance the declorization of high molecular weight colouring bodies. So far polyelectrolytes have been used as the substances for the removal of colour from black liquor. These include polyacrylamides

The field stood thoroughly inviting for the polymers that could produce ionic interaction with dissolve polyanion e.g. PVC. Chromotographic separation followed by spectroscopic analysis of the bottom distillate of the pretreated black liquor could produce the moieties that are the cause behind color except lignin. This otherwise seems to be difficult to predict as such. Mild oxidants, biocatalysts, photocatalysts and their combinations affect the o-beta oxidative coupling of polyphenolics with unsaturated moieties. Other coupling methods based on some pericyclic reactions like electrocyclic, sigmatropic and cycloadditons needs to be investigated. Blends of lignin with polyaniline do effects the conductivity and follow ohm's law. Other conducting polymers and doping of lignin with semiconductors stood thoroughly inviting. Blends with PVC results in possible ionic interaction that not only leads to decolourization during treatment but also forms miscible blends. Lastly, work related references have been accumulated in the bibliography.