Natural Reduction Agent For Indigo Dyeing Process

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Abstract- *This project provides a brief overview of natural reducing agent for indigo dyeing process. The reduction process of indigo dyes with sodium dithionite produces a lot of harmful byproducts that cause hazard to health as well as environmental pollution. A new reduction method should be introduced to reduce the impact of chemical reduction agent. In this project indigo dye is extracted from the leaves of Indigofera tinctoria plant by fermentation method. For dye extraction a setup was made which consist of 3 tanks such as fermentation tank, coagulation tank and waste water collection tank. The leaves are fermented for 48 hours in the fermentation tank, and then it was aerated for 1hours using stirrer in the coagulation tank. The dye is extracted from the coagulation tank in sludge form which was dried at room temperature. The natural reducing agents are obtained from fruit by product such as orange peel, banana peel, citron peel and grape peel. The 100% pure cotton fabrics are dyed with chemical and natural reduction agent and their color fastness were tested. The test result shows that cotton fabric using banana peel as reduction agent have good resistance to fading than other reduction agent. By using natural reduction agent, it is possible to replace chemical reducing agent and to get satisfactory color fastness property. Theeffluent parameters such as BOD, COD, pH, Total Dissolved Solids, Suspended Solids, Sulphate Content, Chloride content are also tested to prove that natural reduction agent is saferthan chemical reduction agent.*

Keywords- sodium dithionite,Colorfastness,Natural Reduction agent,BOD,COD,pH,Total Dissolved Solids, Suspended Solids, Sulphate Content, Chloride content.

I. INTRODUCTION

Indigo is a known dye extracted from the Indigofera tinctoria plant. Due to synthetic dye usage the natural Indigo is one of the oldest indigo dye extraction from Indigofera tinctoria is not currently used. However, the synthetic dye is causing various health as well as environmental problem which lead to the growing interest on natural indigo dye. Indigo is insoluble in water but it must be converted into water- soluble form before using it as a dye. It can convert into soluble form by undergo reduction process in which the reduction agent is added. The chemical reduction agents like sodium dithionite is currently used but the by-product generated during the process are harmful to human as well as to environment. So it is essential to find out a substitution for chemical reduction agent. In this project I am trying to develop natural reduction agent obtain from the natural resources like banana peel, orange peel, citron peel and grape seed. The color strength and effluent of natural reduction agent is compared with the chemical reduction agents to find the best eco-friendly reduction agent and to promote environmental safety.The main objectives of this project are as follows to find out the eco-friendly reduction agent that promote environmental and health safety.

NEED FOR NATURAL REDUCING AGENT:

- Sodium dithionite produces large amount of sodium sulphate, and also toxic sulphite and thiosulphate as by-products
- Thiosulphate may cause gastrointestinal irritation, mutagenicity and carcinogenicity.
- High amount of hydrogen peroxide and alkali are required for the effluent treatment which will increase the cost of the project

II. LITERATURE REVIEW

GENERAL

The natural indigo dye extracted from the *Indigofera tinctoria* plant is insoluble in water to convert it into water - soluble form chemical reduction agent are used. The main objective of the project is to convert the dye into water - soluble by using natural reducing agent to promote environmental safety.

REVIEW OF PREVIOUS RESEARCH ON REDUCING AGENT FOR INDIGO DYEING PROCESS

DONG YOO (2020) discussed the application of persimmon peel extract in indigo dyeing as an Eco -friendly alternative reluctant. The persimmon peel was dried at room temperature then it is crushed and stored in refrigerator. Refluxing persimmon peel in distilled watered at 100°c for 60 minutes the extract is obtained which is concentrated in rotary evaporator and shock frozen followed by freeze dyeing to get extract the powder. The sugar content and its functionalities are determined then the colour strength, redox potential of fabrics is tested. The result shows that the reduction potential and colour strength is increased by increasing the concentration of permission peel extract so the persimmon peel extract can be used as reducing agent as substituent for sodium dithionite.

YOUNSOOK SHIN (2020) discussed the development of Eco- friendly indigo dyeing system by using Baker's yeast. Activated dried yeast is taken as reduction agent, the buffer solution is prepared with NaHCO3 and Na0H then the indigo is added with yeast,and it is incubated at 30°c. The pH control, bath reuse, repeated dyeing of different fabric like Cotton, Nylon, Wool is tested.by using platinum electrode andsilver chloride electrode (reference electrode) along with potassium chloride electrolyte the red ox potential is examined**.** And spectrophotometer is used to measure the colour strength of dyed fabric. The result shows that if the pH is maintained then the colour strength is increased. The deep blue colour is obtained by repeated dyeing process.So, it is possible that yeast can be used as substituent to replace chemical reduction agent

MIN CHOI (2019) discussed the utilization of fruit By-products for organic reducing agent in indigo dyeing. The banana peel is used as reduction agent and its reduction potential is compared with chemical reduction agent. Banana peel is dried at room temperature, the dried peel is boiled in water for 60 minutes to obtain liquid extract. The liquid extract was converted into powder by vacuum, shock frozen and frozen dried at -50°c.The banana peel extract powder is added to indigo dye-bath and ramie fabric are dyed. The reduction potential is measured with Bio-analytical system CV-27 voltamograph as well as the color strength spectraphotometer; result shows higher color strength was extracted by using banana peel and the toxic effect of chemical reduction agent are completely eliminated.

HERRY PURNAMA (2017) discussed the effect of initial treatment in the preparation of natural indigo dye from Indigofera tinctoria. The initial treatment by soaking the plant in cold water for 48 hours is carried out. Indoxly in the fermented leaves are oxidized with aquarium air pump to form pigment of indigo. Lime is added to solution which acts as reduction agent form indigo paste. The result shows that the shocking treatment in cold water produces high amount of dye rather than the initial treatment by both hot water and grounding method. 48 hours-soaked leaves have maximum dye yield.

LAKSANAWADEE SAIKHAOL (2017) compared the usage of sodium dithionite and glucose as reducing agent for natural indigo dyeing on cotton fabrics. The reduction potential of sodium dithionite and glucose was analysed by measuring reduction potential. To measure the reduction potential, the platinum electrode and silver chloride electrode (reference electrode) along with potassium chloride electrolyte is used. Optimum reduction temperature of 70°c is maintained for both the reducing agent, spectrophotometer is used to measure the value of colour strength and the dyed sample is tested for wash fastness according to ISO 105-C05:1994. The result shows that the sodium dithionite have higher colour strength than glucose but the wash fastness of fabric sample from glucose is slightly better than sodium dithionite .so, it is possible to use glucose as green reduction agent in natural indigo dyeing.

EMMANUEL S. E (2011) discussed the extraction of indigo dye from the leaf of Indigofera tinctorial plant. Fresh plant leaves are pre-dried in sunlight and oven dried at 60 °c for 6 hours, then it was ground and sieved. The fermentation process was replaced by alkaline solution (sodium hydroxide) and acidified hydrogen peroxide in combination with oxygen to form indigo concentrated blue pigment. The dried crushed samples of leaves are added with different concentration of sodium hydroxide solution and are stirred well for 5minutes. Then the mixture is filter with filter paper. The filter liquid is added with glacial acetic acid solution of hydrogen peroxide to precipitate the dye -stuff. the dye stuff is filtered and dried in oven at 110°c to obtain the powder form dye. The various proportion of sodium hydroxide is mixed in order to find the optimum value. The result shows that the pH of dyestuff obtained is 5.5, the volume of acidified hydrogen peroxide solution need to precipitate the dyestuff from sodium hydroxide extract mixture is proportional to the concentration of sodium hydroxide solution used**.**

NITTAYA CHANAYATH (2002) discussed powder dye extraction techniques from the leaves of Indigofera tinctorial plant and chemical structural analysis of major compound". Three type of sample such as fresh, semi-dried and dried plant are investigated. The plants is dried at 30°c for 3days to get semi dried material and are dried for 7 days to get totally dried material. The plant materials is cut into smaller material and are fermented for different period in water then calcium hydroxide is added and air blow for 15 minutes to get precipitated indigo. The optimum condition for effective extraction of dye wereinvestigated,and it was found that by cutting raw material into smaller pieces and cover it by a cotton bag before soaking in water for fermentation can reduce the unpleasant smell,and it easy to remove the waste. The result shows that maximum amount of indigo dye is extracted in 24 hours fermentation process and the semi dried as well the dried indigo plant have very low dye extract. After 24 hours fermentation from the semi dried plant 32mg of dye is extracted, in dried plant only 8 mg is extracted but by using fresh plant 330mg is extracted.

III. EXPERIMENTAL

MATERIAL

INDIGO LEAVES

The leaves are collected from agricultural college and research institute,Madurai

Natural reduction agent

The fruits such as orange peel, citron peel, banana peel, grape seed are brought from local fruit market and the peels were separated and dried at room temperature. The dried peel is ground into powder form and is stored.

METHODS

Dye extraction

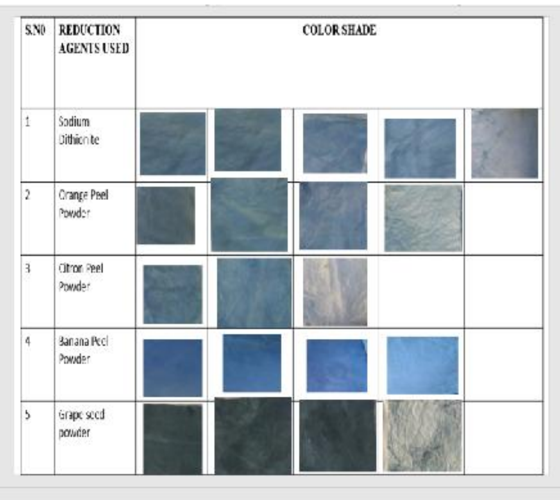
The 1 kg of leaves are cut into small pieces and are placed in the grid chamber. Then the chamber is placed in the fermentation tank, and it is filled with 5 liters of water.The leaves get fermented by the microorganisms present in the air naturally.After 48 hours of fermentation, the fermented leaves in the grid chamber are removed and the fermented water is allowed to get collected in the coagulation tank .In the coagulation tank the oxygen is supplied by continuous stirring for 1 hours and left undisturbed for 30 minutes during which the small dye particle gets attracted towards each other and settle at the bottom of the tank.The waste water at the top of coagulation tank is separated and stored in the waste water collection tank

The sludge is separated, filtered and dried to obtain indigo dye

Amount Of Fresh Leaves	Duration Of Aeration	Amount Of Powder Dye Extracted

DYEING

Add 5 grams of indigo dye powder and 150 grams of reduction agent (sodium dithionite, orange peel, banana peel, citron peel, grape Seed powder) in 1 liter of water in a pot.Then the temperature is raised to 60°c, during which the reducing sugar in the natural reduction agent react with the indigo dye and convert the dye into water -soluble form.Then cotton fabrics of 30 x30 cm are immersed in the dye bath for 30 seconds, and are oxidized in the air for 90 seconds.The process was repeated for three times in the same dyebath to achieve the desired color yield.



S.NO	REDUCTION AGENTS USED	COLOR SHADE
1	Sodium Dithionite	
2	Orange Peel Powder	
3	Citron Peel Powder	
4	Banana Peel Powder	
5	Grape seed powder	

COLOR FASTNESS TEST

•The dyed sample is examined according to ISO standards. The specific test is

•Colorfastness to rubbing test method: ISO 105 X12

•Colorfastness to perspiration test method: ISO -E04

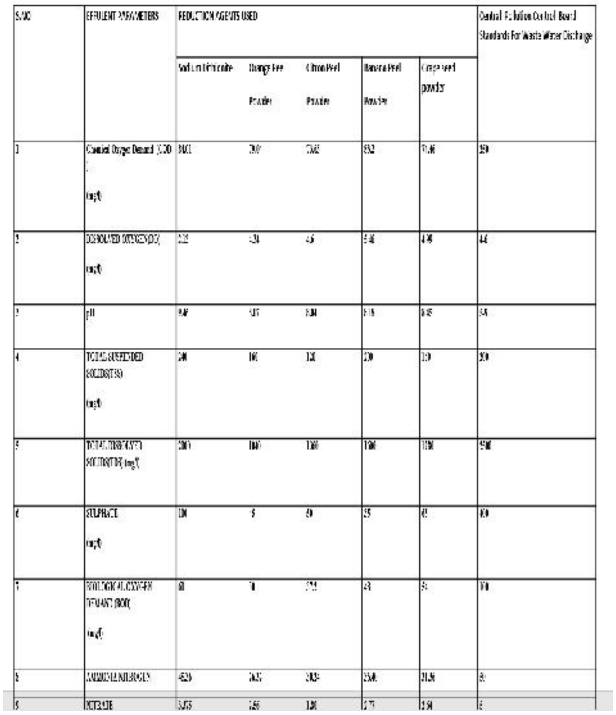
•Colorfastness to washing test method: ISO B02

The sample are tested by AZO TEXTILE TESTING LABORATORY AT TIRUPUR

Reduction Agent Used	Color Fastness Test
SODIUM DITHIONITE	PASS
ORANGE PEEL	PASS
BANANA PEEL	PASS
CITRON PEEL	PASS
GRAPE SEED POWDER	FAIL

EFFULENT TEST

Various effluent parameter such as pH, BOD, COD, total suspended solids, total dissolved solids, total nitrogen, sulfates, and chloride content is tested.



S.NO	EFFULENT PARAMETERS	REDUCTION AGENTS USED					Central Pollution Control Board Standards For Waste Water Discharge
		Sodium Dithionite	Orange Peel Powder	Citron Peel Powder	Banana Peel Powder	Grape seed powder	
1	Chemical Oxygen Demand (COD) (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	DISSOLVED OXYGEN(DO) (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	pH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	TOTAL SUSPENDED SOLIDS(TSS) (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	TOTAL DISSOLVED SOLIDS(TDS) (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	SULPHATE (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	BIOLOGICAL OXYGEN DEMAND (BOD) (mg/l)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	AMMONICAL NITROGEN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	NITRATE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

V. RESULT OF TESTING

The result of tested sample are as follows:

- In the chemical oxygen demand test both the chemical and natural reduction agent are within the standard LIMITS and it is found that cod of effluent with sodium dithionite is reduced to 12.35% when citron pee powder is used a reduction agent..
- In the pH test the pH value of sodium dithionite is above the standard but the pH values of natural reduction agent are within the range.
- In the Dissolved Oxygen (D.O) test, the D.O value of sodium dithionite is very lesser than standard which indicate that it should be treated before discharge the effluent otherwise the aquatic life will be affected, but the values of natural reduction agent are within the range of the standard.
- In the measurement of Total Suspended Solids (TSS) test,the TSSvalue of sodium dithionite is more than standard which indicate that it should be treated before discharge the effluent otherwise the aquatic life will be affected, but the values of natural reduction agent are within the range of the standard and 51.21% of TSS is decreased while using orange peel powder as reducing agent.

In the measurement of Total Dissolved Solids (TDS) test, the TDS value of sodium dithionite is more than standard which indicate that it should be treated before discharge the effluent otherwise the aquatic life will be affected, but the values of natural reduction agent are within the range of the standard and 82.60% of TSS of sodium dithionite is decreased while using banana peel powder as reducing agent

VI. CONCLUSION

From testing results the following conclusions are made

- In the effluent test the values obtained by using natural reduction agent are within the Central Pollution Control Board Standards For Waste Water Discharge**,** but the effluent obtained by using sodium dithionite as reduction agent is not within the limit**.**
- In the Total Dissolved Solids (TDS) test, 82.60% of TSS of sodium dithionite is decreased while using banana peel powder as reducing agent.

6.3 FUTURE SCOPE ;

The dye will be extracted from*Indigo fera arrecta* (tandi), *Indigofera suffruticosa* (vibiti) plant and are also tested with natural reducing agent. The colourfastness and effluent from the dye bath will be tested from which the effective plant and reduction agent for indigo dyeing process will be found.

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