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ADDIS ABABA UNIVERSITY

ADDIS ABABA INISTITUTE OF TECHNOLOGY

SCHOOL OF CHEMICAL AND BIO ENGINEERING

"Optimization and Characterization of Carbon black and Lye Production using Prosopis plant"

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Process Engineering

By

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CERTIFICATION BY BOARD OF EXAMINERS

This thesis has been read and approved as meeting the requirements for the award of Master of Science (M.Sc) degree in Process Engineering in the School of Chemical and Bio Engineering, Addis Ababa Institute of Technology, Addis Ababa University.

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CERTIFICATION

This is to certify that Haregewoin Roba has carried out her research work on the topic entitled "Optimization and Characterization of Carbon black and Lye Production using Prosopis plant" under my supervision. This thesis has been submitted for the verdict of board of examiners with my approval as M.Sc thesis for the award of degree of M.Sc in Process Engineering.

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<u>Dr.Ing. Belay Woldeyes</u> Advisor	_________________	______________

DECLARATION

I, Haregewoin Roba declare that this thesis study entitled "Optimization and Characterization of Carbon black and Lye Production using Prosopis plant" is my work. I have carried out the research work under the supervision of Dr.Ing. Belay Woldeyes, School of Chemical and Bio Engineering, Addis Ababa Institute of Technology, Addis Ababa University, Addis Ababa and presented here, in partial fulfilment of the requirements for the degree of M.Sc. in Process Engineering.

I further declare that this research work has not been submitted to any other University or Institution for the Award of any degree or diploma.

Haregewoin Roba	Signature	Date
Student	_________	________

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ABSTRACT

In Ethiopia, rangelands and farming areas within altitudes of 450 m to ~1000 m above sea level are being invaded by Prosopis Juliflora plant. Because of its abundance and government plan to eradicate through utilization, prosopis plant is used as an input for Carbon Black and Lye production. Carbon black is a black powder made by burning hydrocarbon in a limiting supply of air and it is used in the manufacture of automotive tires, color printing ink, painting etc. Lye is a liquid obtained by leaching ash and used in fertilizers, alkaline batteries, dyes etc. Hence the carbon black and lye production optimization, its yield characterization and determination is investigated, material and energy balance is calculated and its production feasibility is studied. Before the experiment, the prosopis plant is collected, dried and crushed in small size 10nm. The pyrolysis method is applied for CB production and optimum result is obtained at 500°c and 1hr whereas white ash is mixed with water and filtration method is applied, and optimum lye concentration with 14.50 pH value is obtained at a temperature 85°c for 24 hr. The feasibility study conducted for CB and Lye production using prosopis plant indicated that its cost effectiveness. The overall result of this study shown the highly invasion of prosopis plants in the country and worldwide guaranteed its abundance for small scale production.

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LIST OF ABBREVIATIONS AND ACRONYMS

CB	Carbon Black
NAOH	Caustic Soda
KOH	Caustic Potash
M	Mass
N	Normal
L	Liter
ha	Hectare
hr	Hour
gm	Gram
UV	Ultra Violet
ASTM	American Standard Test Method
nm	Nanometer
Kg/m^3	Kilogram per meter cube
m^2/g	Meter square per gram
v/w	Volume per weight
℃	Degree centigrade
%	Percentage

1. INTRODUCTION

1.1 Background

Ethiopia is one of the fast growing sub Saharan countries located at the horn of Africa. Currently the country set the second five year growth and transformation plan to precede its development in the better way. And also focused to transform the economy of the country from agricultural based to industry based economy. As a result, most of industries starting from micro-industry to huge investments are facilitated and supported by the government of Ethiopia to strengthen and assure sustainable development. The raw materials used by the most of these industries were imported from abroad. This also incurred high foreign currency. But now a day's there is a little improvement in assessing locally available raw materials by the industries and used for their further processing. The most of imported items are chemicals like carbon black, Lye (caustic potash or caustic soda) etc, which are used as inputs for chemical industries. These two chemical products are studied in this thesis for their vast applications.

Prosopis species is one of the highly invasive plants in the world. *Prosopis* has invaded millions of hectares of land in the arid and semi-arid continents of Asia, Africa, Australia and Americas. In Africa alone, *Prosopis* is believed to have invaded over 4 million hectares, threatening crop and rangeland production, desiccating water resources and displacing native flora and fauna; including Sudan, Kenya, Ethiopia and so on[4]. In the Afar region of Ethiopia, where *P. juliflora* is having dramatic impacts across the landscape, its spread and impacts on resources has been ranked as one of the leading threats to traditional land use, exceeded only by drought and conflict. Thus nationally it is the most problematic plant invader in Ethiopia [4]. Expensive and unsuccessful eradication efforts around the world have led the Ethiopian Government, and some NGO's, to follow a strategy of controlling *P. juliflora* through utilization.

Carbon black is a black powder or granular substance made by burning hydrocarbons in a limited supply of air. This produces a black smoke containing extremely small carbon black particles which can be separated from the combustion gases to form a fluffy powder of intense blackness. Carbon black is used mostly as a reinforcing agent for rubber. The largest use of carbon black is in the manufacture of automotive tires. It is also used to color printing ink, painting, paper and plastics [1].

A lye is a liquid obtained by leaching ashes (containing largely potassium carbonate or "potash"), or a strong alkali which is highly soluble in water producing caustic basic solutions. Lye is commonly the alternative name of sodium hydroxide (NaOH) or potassium hydroxide (KOH) [3]. Lye (caustic potash) is mainly used in commercial such as fertilizers, alkaline batteries, potassium carbonate, agrochemicals, dyes, soap and detergents.

These two products, Carbon black and Lye, are focused in this study to saw the possibility of their production using prosopis plant, highly invasive in the country and abroad.

Therefore, the aim of this study is to provide a means to eradicating the most invasive prosopis plant (Weyane Zaf) through utilization by using it as a raw material for the local production of carbon black and Lye (caustic potash) which consumed as an input in different chemical industries.

1.2 Statement of the Problem

This thesis work focused on two well-known products (Carbon black and Lye) which were imported from the abroad for different purpose and in various nominations. Due to the vast expansions of local industries and economic growth of the country, these products indicated in the most consumed imported materials by direct use and as raw materials for various local chemical industries. Hence conducting the research in producing the carbon black and Lye from locally available inputs/resources and checking for its practical implementation in regard to the standard is mandatory. Because it's believed that the quality of products obtained after the completion of this research work might be reverse the importing system of these products to exporting and maximizing foreign currency of the country in supporting its fast growth.

Therefore as a raw material for carbon black and Lye production, the Prosopis plant species *P. Juliflora* which has fast expansions and covered broad agricultural and grass land of most pastoralist and agro-pastoralist areas of the country. Currently the regional state and federal government of Ethiopia implemented various clearing ways, but still can't manage its expansion. As a result, utilizing this plant as an input for the production of Lye and Carbon black from a single process of burning of firewood, hoped to be profitable socially, economically and technologically.

Thus the aim of this research work is to produce carbon black and lye locally using Prosopis plant and optimize and characterize its product to the standard.

1.3 Objective

1.3.1 General Objective

The main aim of this thesis work is to optimize and characterize the production of carbon black and Lye locally using prosopis plant.

1.3.2 Specific Objectives

The specific objectives are to:

- ❖ Optimize the production of carbon black and lye
- ❖ Determine and Characterize the carbon black and Lye yield
- ❖ Propose a feasibility study

1.4 Significance of the Study

The production of Carbon black and Lye using prosopis plant which is locally available resource has economic and social advantage for the country as stated below.
Most of these advantages are:

- ✓ make the local entrepreneurs and societies as the whole beneficiaries by exploring locally available resources

- ✓ Save money and time spent to import the Lye and carbon black (in minimizing foreign currency)
- ✓ use as a road map for the future researchers and encourage them to conduct their work on the quality improvements of local lye and carbon black production
- ✓ Proper utilization of prosopis trees in clearing from agricultural sites covered by plant (Afar, Ethio Somali, Dire dawa, etc)
- ✓ support the growth and transformation plan of the country, Ethiopia, in providing best inputs(Lye) for local micro-industries work on detergent production
- ✓ benefit the local societies that having low income by minimizing production cost(in case of Lye) because it is possible to produce at home

1.5 Scope of the Study

This thesis work covers the optimization and characterization of the product of carbon black and lye using prosopis plant. And also determine the yield of the products and its mass and energy balance. The feasibility study of the products also considered.

2. LITERATURE REVIEW

2.1 Carbon Black

2.1.1 Definition of carbon black

Carbon black (CB) is an ancient material and has been produced for over a century by several traditional processes. The raw materials have been mainly residual oils from refineries and from natural gas [1]. CB is the name of a group of manufactured fine-particle products that have a variety of different trade names and physicochemical properties, but share a chemical composition of nearly pure elemental carbon (EC). CB as shown in figure 2.1; has been commercially produced for over 100 years, and with 2008 worldwide production totaling approximately 9.8 million metric tons. Rubber applications tire-related automotive uses (tires, tubes, tread), rubber automotive products (e.g. belts, hoses, miscellaneous), and non-automotive industrial rubber products including industrial molded and extruded products dominate worldwide CB use patterns, consuming approximately 90% of CB used in the US, Western Europe, and Japan. The remaining 10% is divided among other special CB applications that include uses as a pigment, UV absorbing, and/or conducting agent in inks, coatings, and plastics [2].

Figure 2.1: Carbon black [4]

Carbon black is a form of amorphous carbon that has a high surface-area-to-volume ratio, although its surface-area-to-volume ratio is low compared to that of activated carbon. With surging demand, the carbon black industry is in growth mode. A growing number of producers are increasing capacity by building new production lines. Carbon black producers are also undertaking projects to increase capacity on their existing lines [3].

2.1.2 Development state of Carbon black

World demand for carbon black is forecast to rise 4.3 percent per year through 2013 to 11.6 million metric tons, bolstered by a healthy global rubber market over the same period. Gains will be exaggerated to some extent by the fact that growth will be rising off a relatively weak base in 2008, when a significant part of the world experienced the beginnings of recession. The vast majority of carbon black finds use as reinforcement material in vulcanized rubber goods, with over 60 percent devoted to motor vehicle tires alone. Carbon black demand from the tire sector is projected to increase 3.7percent per year through 2013 to 6.9million metric tons. The non-tire rubber carbon black market will expand 4.8percent per year through 2013 to 3.6million metric tons [8].

2.1.3 Technologies for Carbon Black

Carbon black is a product of incomplete combustion. It is the dark component of smoke and in fact all CB processes start with the production of a "smoke." In the process, the first step is to produce an intensely hot combustion zone with a convenient raw material. After combustion is complete, a feedstock in excess of stoichiometric quantities is injected into that intensely hot zone. With this injection, carbon black will be produced; the art comes with assuring that the required properties are attained. Following the feedstock injection, the reaction is stopped after some time by either injection of water or by allowing the temperature to decay with time. The carbon particles thus produced are separated from the process gas stream or "smoke" by conventional means and pelletized to increase the bulk density [6].

As stated in [7] there are five processes currently used to make carbon black

i) Furnace Black

The furnace process generates > 95% of all carbon black produced in the world. It was developed in 1943 and rapidly displaced previous gas-based technologies because of its higher yields and the broader range of carbon blacks that could be produced. It also captures particulates effectively and has greatly reduced their release into the environment around carbon black plants. The oil-furnace process is based on the partial combustion of residual aromatic oils. Because residual oils are widely available and are easily transported, the process can be carried out with little geographical limitation, which has led to the construction of carbon black plants all over the world. Plants are typically located in areas of tire and rubber goods manufacture. Because carbon black has a relatively low density, it is far less expensive to transport feedstock than to transport the carbon black [7].

The basic process consists of atomizing preheated oil in a combustion gas stream that is formed by burning fuel in preheated air. Some of the atomized feedstock is combusted with excess oxidant in the combustion gas. Temperatures in the region of carbon black formation range from 500 to 600 °C. The gases that contain carbon black a requenched by spraying water into the stream as it passes through a heat exchanger and into a bag filter. The bag filter separates the agglomerated carbon black from the by-product tail gas, which comprises mainly nitrogen and water vapor. The fluffy black from the bag filter is mixed with water to form wet granules that are dried in a rotary dryer and bagged or pelleted. This method is suitable for mass production due to its high yield, and allows wide control over its properties such as particle size or structure. This is currently the most common method used for manufacturing CB for various applications from rubber reinforcement to coloring [7].

The Preferred feedstocks for the oil-furnace process are heavy fuel oils such as catalytic cracker residue (after removal of residual catalyst), ethylene cracker residues and distilled heavy coal-tar fractions. Other specifications of importance are absence of solid materials, moderate-to-low sulfur content and low alkali metal content [7].

The furnace walls lined with bricks become very hot because the oxygen and raw material combust. By varying the amount of raw material and air, the internal temperature of the furnace can be altered, which permits manipulation of the particle size and particle connections of the carbon black being produced [4].

The pyrolysis reactor has four main parts: the feeding system, the reactor, the vessel for carbon black collector and the condensation system. Pyrolysis reactor is heated by external electrical furnaces. During reaction, the raw material move through the reactor while decomposing in to a char and volatiles. The carbon black leaves the reactors falling down by gravity in to the vessel for solid collection as shown in figure 2.2.

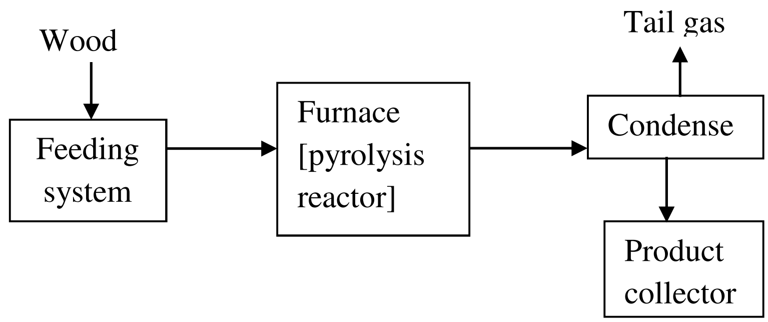


Figure 2.2: Carbon black production description by furnace black [pyrolysis] process

ii) Thermal Black

Thermal black is made by the thermal decomposition of natural gas, coke-oven gas or liquid hydrocarbons in the absence of air or flames. Its economic production requires inexpensive natural gas. Today, it is among the most expensive of the carbon blacks that are regularly used in rubber goods. Because of its unique physical properties, it is used in some rubber and plastics applications such as O-rings and seals, hose, tire inner liners, belts, other mechanical goods and in cross-linked polyethylene for electrical cables.

The thermal black process, which dates from 1922, is cyclic and uses two refractory lined cylindrical furnaces or generators. While one generator is heated to about 1300°Cwith a burning mixture of air and hydrogen off-gas, the other pre-heated generator is fed with natural gas which ‘cracks’ to form carbon black and hydrogen. The effluent gas, which comprises approximately 90% hydrogen, carries the carbon black to a quench tower where water sprays lower its temperature before it enters the bag filter. The CB collected from the filters is screened, hammer-milled and then bagged or pelleted [7].

iii) Lamp Black

The lampblack process is the oldest and most primitive carbon black process that is still being carried out. The ancient Egyptians and Chinese employed techniques similar to modern methods that collect the lampblack by deposition on cool surfaces. Basically, the process consists of burning various liquid or molten raw materials in large, open, shallow pans under brick-lined flue enclosures with a restricted air supply. The smoke from the burning pans passes through low-velocity settling chambers from which the carbon black is cleared by motor-driven ploughs.

In more modern installations, the carbon black is separated by cyclones and filters. Lampblacks have similar properties to the small-surface area oil-furnace blacks. The main use of lampblack is in paints, as a tinting pigment in which a blue tone is desired and in some special applications in the rubber industry [7].

iv) Acetylene Black

The high carbon content of acetylene (92%) and its exothermic decomposition to carbon and hydrogen make it an attractive raw material for conversion to carbon black. Acetylene black is made by a continuous decomposition process at atmospheric pressure and 800–1000 °C. Acetylene is fed into reactors where, at temperatures above 800 °C, the exothermic reaction is self-sustaining and requires cooling by water to maintain a constant reaction temperature. The carbon black-laden hydrogen stream is then cooled followed by separation of the carbon from the hydrogen tail gas. Acetylene black is very fluffy with a bulk density of only 19 kg/m^3, is difficult to compact and resists pelletization. Commercial grades are compressed to various bulk densities of up to 200 kg/m^3. The unique features of acetylene black result in high electrical and thermal conductivity, low moisture adsorption and high liquid absorption [7].

v) Channel Black

Between the First and the Second World Wars, the channel black process produced most of the carbon black used worldwide for rubber and pigment applications. The last channel black plant in the USA was closed in 1976. The demise of channel black was caused by environmental problems, cost, smoke pollution and the rapid development of oil-furnace process grades that were equal or superior to channel black products, particularly for use in synthetic rubber tires.

The name channel black derived from the steel channel irons used to collect carbon black deposited by small flames of natural gas that impinged on their surface iron channels. Today, coal-tar fractions are used as raw material in addition to natural gas and, in modern installations; channels have been replaced by water-cooled rollers. The carbon black is scraped off the rollers, and the off-gases from the steel box-enclosed rollers are passed through bag filters where additional carbon black is collected. The oils used in this process must be vaporized and conveyed to the large number of small burners by means of a combustible carrier gas, such as coke-oven gas. The yield of rubber-grade carbon black is 60% and that of high-quality color grades is 10–30%. The characteristics of carbon blacks from roller process impingement are basically similar to those of channel blacks. The grades of smaller particle size are used as color (pigment) carbon blacks and the larger (~30 nm) grade is used in rubber [7].

2.1.4 Raw materials for production of Carbon Black

Carbon Black is produced from petrochemical feedstocks, from vegetable carbon products (also referred to as vegetable black) that are produced from materials of plant origin, including wood, cellulose residues, peat, and coconut and other shells. In addition to their different source materials, commercial vegetable carbon products have markedly larger characteristic particle size distributions than CB that are distinguished by the general absence of particles with diameters of less than 275 nm[2]. During production of carbon black the parameters affecting carbon black is temperature and time.

2.1.5 Fundamental Properties of Carbon black

The most important properties of carbon black include the surface area, primary particle size, structure (complexity of composition), surface chemistry and binder chemistries used in the pelletization process [5].

Structure: is the degree to which a carbon black provides reinforcement to an elastomeric compound and is a measurement of particle aggregation. Types of structure are classified as high structure, moderate structure and low structure.

High structure is the particle size of CB is very fine, elongation is very low and the Moderate structure is the particle size of the CB is neither fine nor big it is in between the elongation is greater than high structure the last structure is Low structure the elongation is large and the size of particle is large.

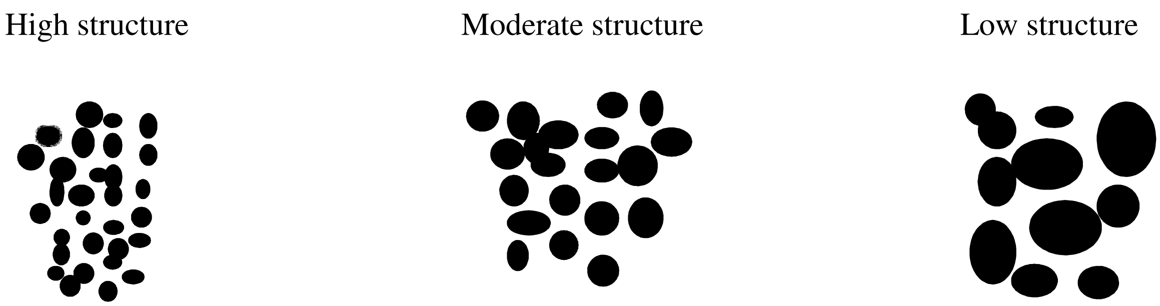


Figure 2.3: Types of structure of carbon black [18]

Surface Chemistry: Various functional groups exist on carbon black's surface. The affinity of carbon black with inks or paint varnishes changes depending on the type and amount of the functional groups. Carbon black, with a large amount of hydroxyl group given with oxidation treatment, has a greatly enhanced affinity to print inks or varnishes, showing an excellent dispersibility. The influence of the surface area and the structure of CB production on the properties and performance describe in table 2.1 and table 2.2. In table 2.1the surface area of CB is increase the properties of the CB and the performance of CB is shown and in table 2.2 the structure of CB is increase the properties of the CB and the performance of CB is shown.

Table 2.1: when surface area of the carbon black increases

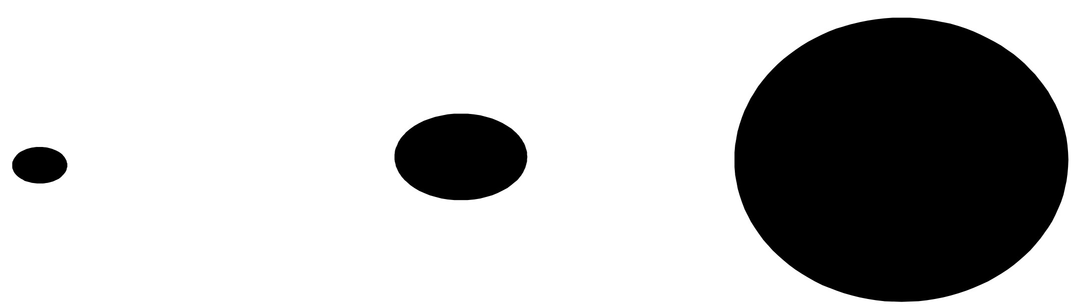
Property of CB	**Performance of CB**
Particle Size	Decrease
Aggregate Size	Decrease
Iodine Number	Increase
Elongation	No Change Significantly
Hardness	Increase
Impact Resistance	Decrease
Abrasion Resistance	Increases

Table 2.2: when structure of the carbon black Increases

Property of CB	**Performance of CB**
Particle Size	No Effect
Aggregate Size	Increase
Iodine Number	No Effect
Elongation	Decrease
Hardness	Increase
Impact Resistance	No Significant Effect
Abrasion Resistance	Increases

Primary Particles: The smallest unit of a carbon black particle, the primary particle, has dimensions of size, graphitic content, shape and crystallinity. Although the majority of processes manufacture near-spherical shaped primary particles some processes produce primary particles having aspect ratios higher than those of true spheres. The higher aspect ratio leads to higher surface area per unit volume and provides more wetable surface area improving ease of dispersion and increasing electrical conductivity. Primary particle attributes influence color, electrical conductivity and UV blocking performance of the CB [5].Carbon black particles are usually spherical in shape and less regularly crystalline than graphite [4].

Carbon black can be graded in terms of particle size



(a) (b) (c)

Figure 2.4: different sizes of carbon black; the size of (a) is N110 (15nm), (b) is N767 (80nm) and (c) is N990 (280nm)

The table 2.3 shows the impact of particle size and structure on the characteristic properties of carbon black. The specific surface becomes larger as particle diameters decline. For this reason carbon black with smaller particles absorbs greater amounts of oil [4].

Table 2.3: Particle size & structure characterize the properties of CB

Property of CB	**Small Particle**	**Large particle**
Structure	High	Low
Surface	High	Low
Oil absorption	High	Low
Viscosity	High	Low
Electricity of the final product	Low	High

Since small particles also aggregate more easily than large ones, a smaller particle size results in increased viscosity.

Table 2.4: Particle range of rubber-grade carbon blacks

Group number	Typical average primary particle size (nm)	Average surface area (m^2/g)
0	0–10	>150
1	11–19	121–150
2	20–25	100–120
3	26–30	70–99
4	31–39	50–69
5	40–48	40–49
6	49–60	33–39
7	61-100	21–32
8	101-200	11–20
9	201-500	0-10

Aggregates: Carbon black aggregates are complex clusters of fused primary particles. Aggregates have dimensions of size, shape, void volume and structure. Each of these dimensions determines the ultimate utility of the carbon black and goes to provide competitive grade differentiation among carbon black manufacturers. The size of the aggregate influences the color aspect of the carbon black and its tinting strength. The shape and structure influence dispersibility and to some extent electrical conductivity. Void volume influences wetability and is a critical concern in applications where the carbon black will be used in a liquid medium such as a coating, paint or ink.

Inter-particle Attractions and Agglomerates: Carbon black particles are small. For example, large aggregates are the size of red blood cells and aggregates composed of small primary particles are roughly the size of tobacco mosaic virus. Primary particles can be as small as 5nm and aggregates can be as small as 50nm. It is this small size that makes carbon black so useful in pigmentation – a little goes a long way. The small size of carbon black and its triboelectic properties results in carbon black obeying laws of bi-polar particle physics. Carbon black is subject to Vander Waals forces.

Color Properties: Owing to the variety of shape and size, carbon black can exhibit a range of color properties. Important color properties include jetness, mass tone and tinting strength. The delicate interaction between primary particle size, surface area and aggregate size determines the ultimate color, whereas, structure influences the dispersibility of carbon black and thus determines the level of color achievable in the host matrix. An important property of carbon black is its ability to modify the visual appearance of other colors.

- ✓ *Jetness:* Carbon black is added to plastics to impart a black color the measurement of which is referred to as "jetness." More jet blacks appear blacker than those having less jet characteristics. Jetness is a complex function of surface area, primary particle size and degree of dispersion. Carbon blacks possessing smaller primary particle sizes tend to impart a higher degree of jetness than those having larger primary particles.
- ✓ *Masstone:* When compounded into plastics carbon black can impart colors ranging from a bluish black to a brown/black undertone. This color range is referred to as the masstone of the black and is strongly correlated to particle size and the scattering of light in the host plastic matrix. Owing to differences in refractive index and light scattering for different plastics two different plastics containing well-dispersed carbon black can have the same jetness but differ greatly in masstone.
- ✓ *Tinting Strength*: An important property of carbon black is its ability to modify the visual appearance of other colors. The tinting strength is a measure of the effectiveness of the carbon

black. There are a variety of methods used in measuring tinting strength but the most prevalent is ASTM D 3265. In this method, carbon black is added to a mixture of zinc oxide in dispersion medium (soy oil for example) and the reflectance values are measured relative to the zinc oxide standard. Tinting strength increases with decreasing primary particle size and decreases with aggregate structure complexity. Tinting strength reaches a maximum for primary particle sizes of less than 20nm.

2.1.6 Product Description and Application of Carbon Black

Carbon black has been used as a reinforcing agent in tires. Today, because of its unique properties, the uses of carbon black have expanded to include pigmentation, ultraviolet (UV) stabilization and conductive agents in a variety of everyday and specialty high performance products [5].

Tires and Industrial Rubber Products: Carbon black is added to rubber as both filler and as a strengthening or reinforcing agent. For various types of tires, it is used in inner liners, carcasses, sidewalls and treads utilizing different types based on specific performance requirements. Carbon black is also used in many molded and extruded industrial rubber products, such as belts, hoses, gaskets, diaphragms, vibration isolation devices, bushings, air springs, chassis bumpers, and multiple types of pads, boots, wiper blades, fascia, conveyor wheels, and grommets.

Plastics: Carbon blacks are now widely used for conductive packaging, films, fibers, moldings, pipes and semi-conductive cable compounds in products such as refuse sacks, industrial bags, photographic containers, agriculture mulch film, stretch wrap, and thermoplastic molding applications for automotive, electrical/electronics, household appliances and blow-molded containers.

Electrostatic Discharge (ESD) Compounds: Carbon blacks are carefully designed to transform electrical characteristics from insulating to conductive in products such as electronic packaging, safety applications, and automotive parts.

High Performance Coatings: Carbon blacks provide pigmentation, conductivity, and UV protection for a number of coating applications including automotive (primer basecoats and clearcoats), marine, aerospace, decorative, wood, and industrial coatings.

Toners and Printing Inks: Carbon blacks enhance formulations and deliver broad flexibility in meeting specific color requirements.

2.1.7 Environmental Impact Assessment on carbon black

The major environmental impact in relation to carbon black production process using the furnace black technology is dust pollution. The dust pollution shall be controlled by employing different dust arresting technologies such as cyclones, wet scrubber, bag filter, etc.

2.1.8 Quality Parameters of Carbon Black

Carbon black is a high-tech material with properties that conform to international standards and are crucial for determining the character of end products. For example, as a filler material, carbon black improves the mechanical characteristics of plastic, increases the abrasion-resistance of tires, and offers protection against heat and UV radiation. Depending on their characteristic properties, the special carbon black types are suitable for all different kinds of application [4].

Accordingly, the tire industry places the toughest requirements on the quality and properties of carbon black. Tests to determine the quality and applicability of the carbon blacks which were conducted by renowned tire manufacturers independently of one another have yielded very positive results. Tests of the characteristics (surface, structure) have demonstrated that carbon black achieves values that are similar to those of N326, and that it can replace N660 and N772. As shown in table 2.5, carbon black is between the so-called hard and soft carbon black type, which gives it a very broad application range. N indicates that the carbon black has the normal vulcanization rate and the next digits indicate the typical average particle size. And it is grade determined by particle size.

ASTM Grade	Tint strength	DBP Absorption	Iodine adsorption	N2SA Miltipoint Adsorption	STSA Adsorption	24M4 DBP Adsorption	Heat loss	Pour Density	300%Mod. (w.r.t IRB 7)
	%ITRB	Cc/100g	g/kg	M2/g	M2/g	Cc/100g	% max	Kg/m3	Mpa
	D 3265	D 2414	D 1510	D 4820	D 5816	D 3493	D 1509	D 1513	D 3192/D 412
N110	123	113	145	127	115	97	2.0	345	(-)3.2
N115	123	113	160	137	124	97	2.0	345	(-)3.1
N121	119	132	121	122	114	111	2.0	320	(-) 0.1
N134	131	127	142	143	137	103	2.0	320	(-) 1.5
N219	123	78	118	120	-	75	1.5	440	(-) 6.0
N220	116	114	121	114	106	98	1.5	355	(-) 2.0
N231	120	92	121	111	107	86	1.5	400	(-)4.6
N234	123	125	120	119	112	102	1.5	320	(-) 0.1
N299	113	124	108	104	97	104	1.5	335	(+) 0.7
N326	111	72	82	78	76	68	1.5	455	(-) 3.6
N330	104	102	82	78	75	88	1.5	380	(-) 0.6
N339	111	120	90	91	88	99	1.5	345	(+) 0.9
N347	105	124	90	85	83	99	1.5	335	(+) 0.5
N351	100	120	68	71	70	95	1.5	345	(+) 1.1
N358	98	150	84	80	78	108	1.5	305	(+) 2.3
N375	114	114	90	93	91	96	1.5	345	(+) 0.4
N539	-	111	43	39	38	81	1.5	385	(-) 1.3
N550	-	121	43	40	39	85	1.5	360	(-)0.6
N650	-	122	36	36	35	84	1.5	370	(-) 0.7
N660	-	90	36	35	34	74	1.5	440	(-) 2.3
N762	-	65	27	29	28	59	1.5	515	(-)4.6
N765	-	115	31	34	32	81	1.5	370	(-)0.3
N774	-	72	29	30	29	63	1.5	490	(-)3.8

2.2 Lye (Caustic Potash)

2.2.1 Definitions of Lye

Lye is a powerful base (alkali) that can be created using rain water and wood ashes. Lye created from wood ash is potassium hydroxide (KOH) whereas commercial lye is composed of sodium hydroxide (NaOH). Modern chemical engineering has all but replaced the traditional method of producing lye. For many homestead applications the difference in chemical formulae are inconsequential, but there are exceptions [10].

A lye is a liquid obtained by leaching ashes (containing largely potassium carbonate or "potash"), or a strong alkali which is highly soluble in water producing caustic basic solutions. Lye is commonly the alternative name of sodium hydroxide (NaOH) or historically potassium hydroxide (KOH) [3]. And also stated in [9] Lye is an aqueous solution of caustic soda or potash and by the chemical decomposition of the fat and its conversion to soap is affected.

Lye is a strong alkali that is used in soap making, among other things. It is also known as caustic soda or sodium hydroxide. Largely forgotten by the modern world, lye is still important to those interested in self-sufficiency. Historically, lye has been used to make many foods like hominy, lutefisk, German pretzels, and Chinese noodles. Animal fats or vegetable oils are combined with lye to make homemade soap. Lye can also be used to chemically pulp plant matter for making paper. The modern world wouldn’t be the same without lye either; oven cleaner, drain opener, and biodiesel production all use lye [10].

2.2.2 Technologies for Lye

2.2.2.1 Traditional Method of Making Lye using a Wooden Barrel

Traditionally making lye is possible using a wooden barrel in considering the following steps:

- Take an old barrel and make sure that it is clean and steaming it will give good results. Elevate it and then place a bucket or similar underneath the leaching hole at the bottom of barrel to collect the lye water when it is ready to emerge. Place a bung in any existing opening in the barrel, and drill a smaller hole into the barrel that is only $1/8^{th}$ inch wide. The aim is a hole wide enough for the water to drip through but small enough for the ashes not to fall out. Keep this hole closed up with a small bung until it goes out. Now, pack the bottom of the barrel with clean river stones. Make sure that a good mix of both large and small stones is work as a filtration system. If stones are not available, instead a thick layer of charcoal used.

- After a good layer of stones a generous layer of straw needed to be placed on the top of the stones. The straw should take up at least half way up the barrel. Shovel the ashes until the barrel is as full as it wanted. After that, pour over some hot rain water in small amounts so that the whole contents are wet and soaking but not flooding. Using hot water is important as the hot water draw out more potash from the wood ash than cold water, making the lye stronger.

- Traditionally, a little lime was mixed with the ashes to 2 - 5% which then guaranteed that would have good lye. On day 2, add more ash and water after allowing the ash from the previous day to settle. On day 3, make sure the receptacle is ready under the opening on the barrel, remove the bung and wait for the lye water to slowly trickle out.

2.2.2.2 How to Test the Strength of Lye Traditionally

To make the lye successful for soap making, the lye has to be at the right strength. Therefore, there are 2 ways to check its strength.

Test-1: This is a simple test. Take a chicken feather and place it in the lye. If the feather dissolves, the lye is strong enough. If not, the lye water has re-boiled when it emerges and repeats the process until the chicken feathers dissolve.

Test-2: This test involves using a fresh, whole egg or a potato works just as well. Take the egg or potato of similar size and place it in the cold lye water. If it sinks, the lye is not strong enough and the process has to repeat until it does.

If the potato floats with just a little of the lye water above it; about an inch showing above the water, or the head of the egg sinks to just half-way down, then the strength is just right. If the potato or egg floats too high, almost on top of the lye water, then the strength is too strong. It can be compensated by adding a little bit of fresh water to the lye water and try again.

2.2.2.3 Modern Method of Making Lye using a Plastic Bucket

It also possible to make lye using a plastic bucket rather than wooden barrel as a modern method as follows:

- Using cold wood ash, take a spade and carefully place the ash into the stopped-up bucket. The place in the bucket is fine, white ash, as opposed to any charcoal bits. The ash is well compacted in the bucket.

- Boil water half of the capacity of the bucket and pour gently over the ashes. As soon as the water makes contact with the ash it will start hissing and bubbling. This is perfectly normal. At this stage the water is just sitting on top of the ash, without it appearing to do anything. Just leave it, without disturbing it, and after a time add the rest of the water.

- Once all the water used to elevate the bucket so that place a glass or plastic container under the hole that previously drilled and stopped up with a flap. The receiving containers placed under the hole and remove the flap. Let them stand for 12 - 24 hours, or until the liquid is clear, then carefully pour off the clear lye. The flap is used to stop up the hole after having enough lye water.

- At this stage as the lye is caustic and if it splashes onto the skin and into the eyes it will burn. It will need protective wear gloves and safety glasses at this point. To strengthen the produced lye, the lye water is heated up and backs it to bucket and carefully pour it back over the ashes in the bucket.

The process of lye production is that, the wood is burned in the stove and becoming white ash. Unburned wood and white ash is separated using the sieve. The white ash is mixed with distilled water and left for an hour till the ash is settled. Finally the clear lye is filtered from the residuals using filtration process as shown in figure 2.5.

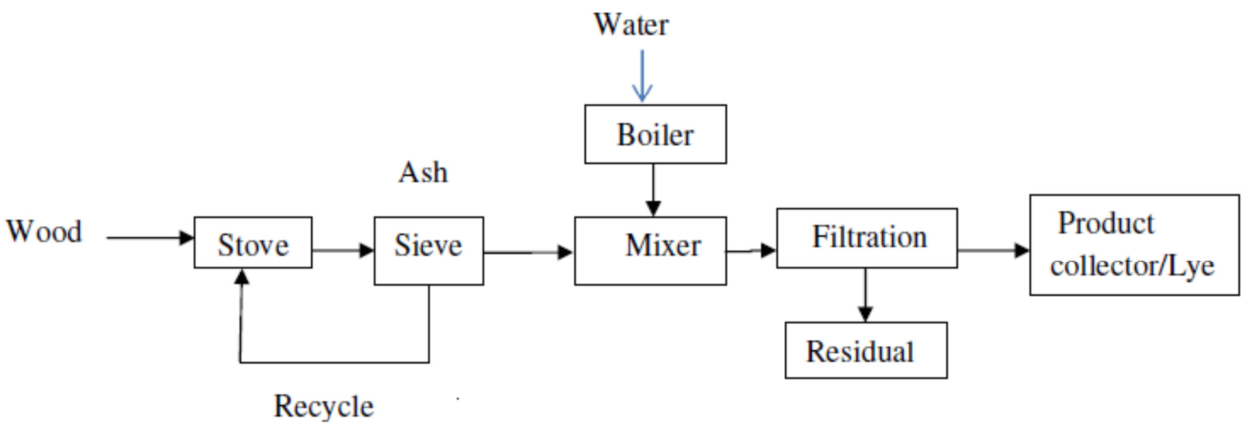


Figure 2.5: Production description of Lye process

2.2.3 Raw materials for production of Lye

Only two ingredients needed to make lye: wood ash and water. Collect rainwater - it should be free of chemicals and excessive mineral levels that are found in city and well water. Using wood ash from broad-leaved hardwood trees gives better quality lye than soft woods or conifers. Lye is very dangerous and extreme caution should be used when making or handling lye - whether commercial or homemade [10].

As described in [9] the common alkalis used in soap making are sodium hydroxide (NaOH) also called caustic soda and potassium hydroxide (KOH) known as caustic potash. Wood ash is about 25% calcium carbonate and contains about 10% potash (K_20), 1% phosphate and trace amount of micro-nutrients. Potassium hydroxide or caustic potash, potash-lye, potassium hydrate or lye can be locally produced from agricultural wastes like wood.

2.2.4 Fundamental Properties of Lye

Lye should never come in contact with aluminum as it will react with the metal. Lye can cause chemical burns if it comes in contact with skin and blindness if it gets in eyes. In fact, when skin gets lye, the lye will begin reacting with the fatty acids on skin and begin making soap. Always make and use lye in a well-ventilated area, and keep pets and children at a safe distance. Pants, a long sleeved shirt, rubber gloves, and eye protection should be worn when making or using lye. If skin gets lye, use vinegar to neutralize the solution [10].

2.2.5 Verify the Concentration of Lye

The concentration of lye is determined by using iteration by hydrochloric acid the simple reaction is

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Titrate with hydrochloric acid solution till the first color change [20].

2.2.6 Product Description and Application of Lye

As described in [10] there are numerous ways to make lye from wood ash. Some instructions suggest that mix ash with hot water and let it set before filtering out the ash. Others drill holes in the bottom of a barrel, cover with straw, and then fill with ash. Water is poured over the ash and lye is leached as the water filters thru the barrel and is collected by a pan underneath the barrel. This works, but lye is likely to be discolored by the straw. When lye reacts with lignin in the straw, the bonds are broken down and the fibers are left behind. After enough leaching, the remaining straw fibers work as an effective filter, but will no longer discolor the lye.

Animal fats or vegetable oils are combined with lye to make homemade soap. Lye can also be used to chemically pulp plant matter for making paper, oven cleaner, drain opener, and biodiesel production all use lye [4].

2.2.7 Environmental Impact Assessment of Lye

The major environmental impact in relation to lye production process is contamination. The contamination shall be controlled by employing use different plastic material during process like eye glass and glove.

2.3 Prosopis Plant (Prosopis-Juliflora)

2.3.1 Local Names

Arabic (mesquite); Creole (bayawonn, bayawonnfran); English (ironwood, algarroba, honey mesquite, mesquite, mesquite bean); Filipino (aroma); French (bayahonda, chambron, bayarone,bayahondefrancais); German (mesquitebaum); Hindi (vilayatikhejra,vilayatibabul, gandababul, vilayatikikar); Swahili (kikwajukwaju) [12].

2.3.2 Definition of Prosopis Juliflora plant

Prosopis Juliflora is one of the most economically and ecologically important tree species in arid and semi-arid zones of the world [15]. They came originally from the Americas, the genus Prosopis is highly adapted to dry lands and has about 45 species. Prosopis Juliflora (Figure 2.6) is among species in Prosopis genus that has been widely introduced in various parts of the world including Ethiopia [14].

Figure 2.6: Prosopis Juliflora [13]

There are serious problems associated with exotic invasive species for they spread so fast colonizing the native species where it becomes difficult to eradicate or manage them. Prosopis is now a serious topic in Ethiopia, especially in Afar and Dire-Dawa. It has invaded large areas of mostly grazing land in these regions and elsewhere, and is the national number one invasive plant. Avoid problems of Prosopis spread by exploiting all its potential uses; neither blames nor exaggerates it, just utilize it as a resource [16].

2.3.3 Distribution of Prosopis Juliflora

P. Juliflora was introduced in the 1970s through collaborative projects involving local governments and outside agencies. This is very likely to be the case for Kenya and Ethiopia, but other reports suggests that introduction to the Sudan took place as early as 1917. Although P. Juliflora, P. Pallida and P. Chillines are present in neighboring Sudan and Kenya, only P. Juliflora has been reported in Ethiopia. In the Afar region of Ethiopia P. Juliflora is having dramatic impacts across the landscape. Its spread and impacts on resources has been ranked as one of the leading threats to traditional land use exceeded only by drought and conflict. Nationally, P. Juliflora has been ranked as the most problematic plant invader in Ethiopia [13].

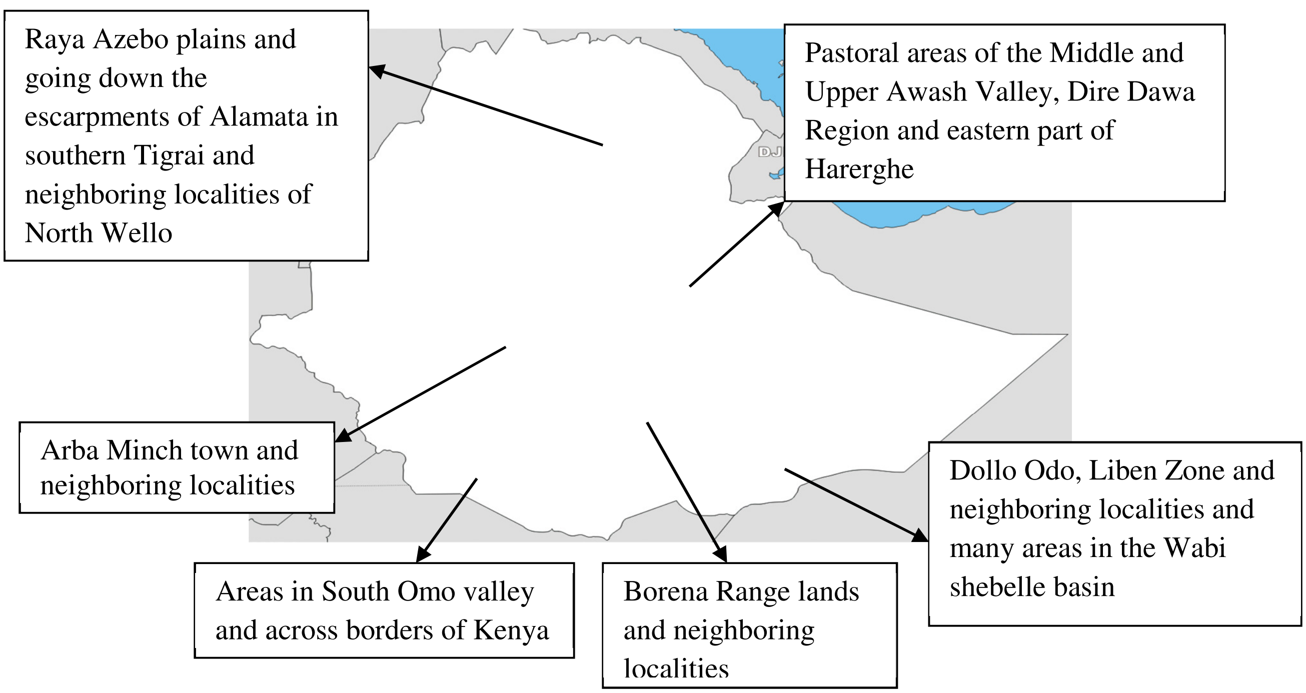


Figure 2.7: Distribution of Prosopis Juliflora plant [17].

2.3.4 Prosopis Juliflora Clearing mechanism in Ethiopia

The clearing mechanism of prosopis plant is through direct fire at land or through utilization. Through utilization prosopis Juliflora has used for different purpose [13]. Such as;

- For *animal feed*: P. Juliflora has become a major source of dry season feed for goats, camels and donkeys. In Ethiopia, 10 and 20% inclusion of ground P. Juliflora pods was found to reduce feed production costs without compromising biological performance. At 30%, however, the positive results of P. Juliflora diminished with the growth and feed intake of poultry.
- For *energy production*: Energy from Prosopis can be obtained through several ways that include, direct burning, carbonization, gasification, pulverization, and fermentation. Prosopis trees are good sources of fuel wood around the world; in Ethiopia, the trees are made into charcoal which are then transported and sold in urban areas.
- Prosopis *wood products*: Studies indicate that good quality lumber can be produced from Prosopis wood. Prosopis lumber compares favorably in color, hardness and shrinkage values to the world's finest timbers. And also used in construction industries.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Optimization of the Carbon Black and Lye production

Material and equipment used for optimize the productions of CB and Lye is listed below;

3.1.1.1 Materials and equipment used for Carbon Black production

One major raw material was used during the experiment, which is Prosopis Juliflora plant. The other materials and equipment used during the experiments were safety dress (Glove and Shoes), furnace (tubular reactor), weight balance, sample collector bag, spatula, and stopwatch and so on.

3.1.1.2 Materials and equipment used for Lye production

Prosopis Juliflora plant is used as a major raw material during the experiment. The prosopis trees collected Afar regional state, around logia city; some materials and chemicals purchased from Addis Ababa (Aster Neway chemical supply PLC)and the left materials &equipment was used from school of Chemical and Bio-Engineering of Addis Ababa Institute of Technology (AAiT), Addis Ababa, Ethiopia.

The equipment used during the experiments were safety dress (Glove, Eyeglass, Shoes, Garb, and others), Stove (kesel mandeja), Beakers, Glass Stirrer, Distilled Water, Weight Balance, Pipette, Conical flasks, Collecting bag, Burette and filter paper and cutter.

3.1.2 Determination and Characterization the carbon black and Lye yield

Material and equipment used for determine and characterize the productions of CB and Lye is listed below;

3.1.2.1 Determination and Characterization the Carbon Black yield

Material and equipment used for determine and characterize the production of CB yield is weight balance, spatula, product collector bag, sieve and furnace.

3.1.2.2 Determination and Characterization the Lye Yield

Material and equipment used for determine and characterize the production of Lye yield is labeled cylinder, pH meter, HCl (11.32 M), methyl orange

3.2 Methods

3.2.1 Optimization of the Carbon Black and Lye Production

3.2.1.1 Optimization the Product of Carbon Black

The carbon black is manufactured by burning p. Juliflora plant in furnace (tubular reactor). Its process is optimized using the temperature range of 500-600^{o}c for time range of 1-5 hours.

3.2.1.2 Optimization the Product of Lye

The lye is manufactured by burning prosopis trees in open air to have white ashes and mix with water. The lye product is optimized using temperature range of 25-85^{o}c, sample weight of ash/ concentration/range of 5-15gm and time range of 12-24 hours.

3.2.1.3 Sample Preparation for Carbon Black and Lye Production

3.2.1.3.1 Sample Preparation for Carbon Black Production

The sample was collected from Logia city, Afar regional state. And then it was crashed using cross beater mill at the size of 10 mm. Its moisture was predicting using oven. Wash the crucible and dry it. After it dry measure the weight of crucible and then measure the weight of crucible with sample. And also measure the weight of crucible having sample after 24hr staying in the oven. Finally the moisture content of the collected sample is determined using the following formula.

$$m = \frac{S_1 - S_2}{S_1} * 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3.1)$$

Where;

m: Moisture content

S_1: Sample collected before dry

S_2: Sample with crucible weight collected after dry by using oven at 110^{o}c for 24 hr.

The Crucible weight is 39.0gm and Sample weight is 5.0gm is used for the production CB. Then, the total weight is crucible weight plus sample weight which means (39.0gm + 5.0gm) and total weight of 44.0gm is obtained.

After 24hr staying in oven, the total weight of crucible with sample becomes 43.12gm. Therefore, the moisture content of the sample in percentage calculated using Eq. 3.1 is;

$$m = \frac{S_1 - S_2}{S_1} * 100 = \frac{44 - 43.12}{44} * 100 = 2\%$$

3.2.1.3.2 Sample Preparation for Lye Production

The P. Juliflora plant sample having the same moisture content that was already determined above, which means 2% moisture content is used for ash production. The wood was burned in the open space for the presence of oxygen. Thus the prosopis wood was burned until the ash color is become white and gets cooled. Finally the produced ash collected using collector bag.

3.2.1.4 Methods for Carbon Black and Lye Production

3.2.1.4.1 Carbon Black Production

In this process, the small size of prosopis plant was cut by cross beater mill at 10mm and having 2% amount of moisture. The sample was measured 20gm of crushed sample using digital balance and take the sample by spatula entered to clean by brush tubular reactor and then adjust the temperature to 500, 550 and 600^{o}c for 1,3 and 5 hours.

The setup of carbon black production in this work is shown schematically in Figure 3.1tubular reactor is used in pyrolysis reactor. The pyrolysis reactor is heated by external heat source (electric socket plug). Then after, put 20gm of the sample inside the tubular reactor and close it. One end is connecting to the nitrogen gas which used as carrier gas and the other end is open partially and adjusts the temperature. Once the temperature adjusted, the time is recorded till allotted hours. Then, switched off the power of the reactor and wait for 2 to 3 hours still it became cooled and measure the weight of end product using digital balance.

Figure 3.1: Carbon Black production setup

3.2.1.4.2 Lye Production

Using a spatula and weight balance, the weight of cold wood ash sample is measured to 5, 10 and 15 gram and carefully puts into the stand-up beaker and 100ml of distilled water is added into the beaker. And stand the mixture in water bath with 25, 55 and 85^{0}c for 12, 18 and 24 hours. The water stirred the ash and it would start hissing and bubbling. After it was stayed in water bath for 12, 18 and 24 hours filtered using a filter paper to and clean lye obtained. Using central composite 20 experiments was run.

3.2.2 Determination and Characterization of the Carbon Black and Lye Yield

3.2.2.1 Determination the Carbon Black and Lye Yield

3.2.2.1.1 Determination of the Carbon Black Yield

Carbon black yield was determined as the ratio of the mass of the carbon black collected to the mass of the raw material used by the reactor.

3.2.2.1.2 Determination of Lye Yield

To determine the maximum yield product of lye production within the ranges 25-85^{o}c temperature, 5-15gm and 12-24 hours was measured with a cylinder (v/w).

3.2.2.2 Carbon Black and Lye Characterization

3.2.2.2.1Carbon Black Characterization

The properties of collected carbon black product were characterized. The extensively characterized properties were particle size, ash content and heat loss of carbon black. Standard methods used for the Carbon black characterization are presented in Table 3.1.

Table 3.1: Standard methods used for the carbon black characterization

Property of Carbon black	Test Method
Particle Size	Sieve analysis
Ash Content	Furnace

3.2.2.2.1.1 Determination of Particle Size

The carbon black produced was used to determine the particle size of carbon black. The particle size of carbon black was characterized using sieve analysis method. Measure the sample of carbon black product, put on the sieve and shake for 10 second. And then, measure amount of sample remains on the sieve. Thus, the size of the particle was in between the remaining and passes through the sieve.

3.2.2.2.1.2 Determination of ash content

The ash content of the product was determined by furnace. At the first step measured the sample of the product 1gm and washed the crucible and dry it. Then add the sample to the crucible and at 300^{o}c of temperature for 30 second stand in the furnace. Finally measure the weight of the crucible with sample and subtract the weight of the crucible, the result was the weight of the ash content.

3.2.2.2.2 Lye Characterization

3.2.2.2.2.1 Determination of pH value

The pH value is determined using pH meter and also it is standardized using buffer solution. The electrode is immersed in to the sample and the pH value is recorded.

3.2.2.2.2.2 Determination the value of concentration

The property of Lye produced from prosopis wood ash was characterized. The extensively characterized property of lye was its concentration. Titration method is applied for the Lye characterization. The titration was carried out using HCl (11 M). After filtering the lye product, 25% of HCl is added and iterate until the color of the solution become pink.

4. RESULT AND DISCUSSION

4.1 Optimization of the Carbon Black and Lye Production

4.1.1 Optimization of the Carbon Black Product

As shown in table 4.1 for temperature range 500-600^{o}c and for time range 1-5hr, the average products of carbon black with yield 22.5 to 32.5 in percentage was obtained. From these ranges of carbon black production, the product having maximum yield with short time in low temperature is selected as optimum. Therefore, the CB product having value of 32.5% yield produced in 500^{o}c temperature within 1 hr time is an optimum production.

Table 4.1: Average result of the carbon black yield

Temperature (^{o}c)	Time (hr)	Yield (%)
500	1	32.5
500	3	32.5
500	5	30
550	1	32.5
550	3	32.5
550	5	25
600	1	22.5
600	3	27.5
600	5	30

4.1.2 Optimization of the lye product

As it can be seen from table 4.2, the average products of lye having yield 53.8 – 94 gm/ml produced in temperature 25-85^{o}c and sample weight 5-15 gm within 12-24 hr was obtained. Thus, the Lye product having value of 53.8gm/ml yield produced in 85^{o}c temperature and sample weight 15 gm within 24 hr time is an optimum production.

Table 4.2: Average result of the lye yield

Temperature (^{o}c)	Sample weight (gm)	Time (hr)	Yield (gm/ml)
25	5	12	84.16
25	15	12	77
25	5	24	89
25	10	18	78.4
25	15	24	73
55	5	18	89
55	10	18	78.4
55	15	18	67.3
55	10	24	78.4
55	10	12	73.5
85	5	12	94
85	5	24	79
85	15	12	57.69
85	10	18	78.4
85	15	24	53.8

4.2 Determination and Characterization of the Carbon Black and Lye Yield

4.2.1 Determination of the Carbon Black and Lye Yield

4.2.1.1 Determination of the Carbon Black Yield

The production of carbon black for temperature 500^{o}c to 600^{o}c is given in table 4.3.The yield of the product could be determined by dividing the weight of sample with reactor after a process with the weight of sample with reactor before a process.

$$\text{Yield} = \frac{\text{sample with reactor weight after a process}}{\text{sample with reactor weight before a process}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots \quad (4.1)$$

Table 4.3: carbon black yield description

Std	Run	Temperature (^oc)	Time (hr.)	Yield (%)
27	1	600	5	25
8	2	600	1	30
16	3	600	3	65
11	4	500	3	90
6	5	550	1	90
26	6	600	5	30
7	7	600	1	90
13	8	550	3	30
12	9	500	3	30
25	10	600	5	30
4	11	550	1	35
14	12	550	3	80
21	13	500	5	30
9	14	600	1	15
24	15	550	5	25
1	16	500	1	80
18	17	600	3	30
5	18	550	1	30
2	19	500	1	35
23	20	550	5	25
22	21	550	5	25
19	22	500	5	30
17	23	600	3	25
3	24	500	1	40
10	25	500	3	30
15	26	550	3	35
20	27	500	5	35

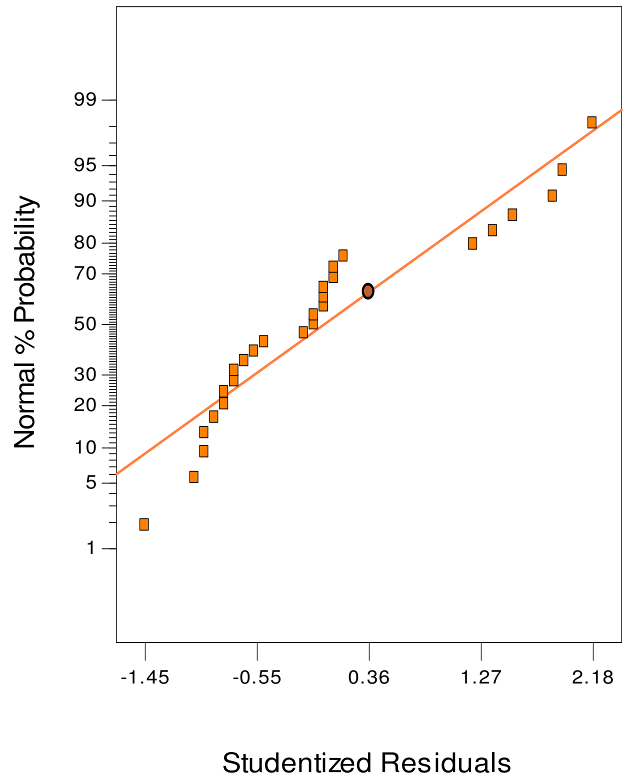


Figure 4.1: Normal plot of residual

The normal probability plot (Fig. 4.1), indicates the residuals following a normal distribution, in which case some points follow a straight line and called optimum point.

4.2.1.2 Determination of the Lye Yield

The production of lye from 5 to 15gm for 12 to 24hr and 25 to 85^{o}c was described in table 4.4. The yield could be measured using leveled cylinder which means the amount of clear lye.

5gm of sample is mixed with 100 L of distilled water the leveled was 101v/w

10gm of sample is mixed with 100 L of distilled water the leveled was 102v/w

15gm of sample is mixed with 100 L of distilled water the leveled was 104v/w

The yield of the product is determined by dividing the weight of sample after a process with the weight of sample before a process.

Table 4.4: Lye yield description

Std	Run	Sample weight (gm)	Temperature (^oc)	Time (hr)	Yield (%)
12	1	10	85	18	78.4
20	2	10	55	18	78.4
4	3	15	85	12	57.69
15	4	10	55	18	83.3
1	5	5	25	12	84.16
2	6	15	25	12	77
14	7	10	55	24	78.4
6	8	15	25	24	73
5	9	5	25	24	89
18	10	10	55	18	78.4
9	11	5	55	18	89
8	12	15	85	24	53.8
3	13	5	85	12	94
17	14	10	55	18	78.4
19	15	10	55	18	78.4
10	16	15	55	18	67.3
13	17	10	55	12	73.5
16	18	10	55	18	73.5
7	19	5	85	24	79
11	20	10	25	18	78.4

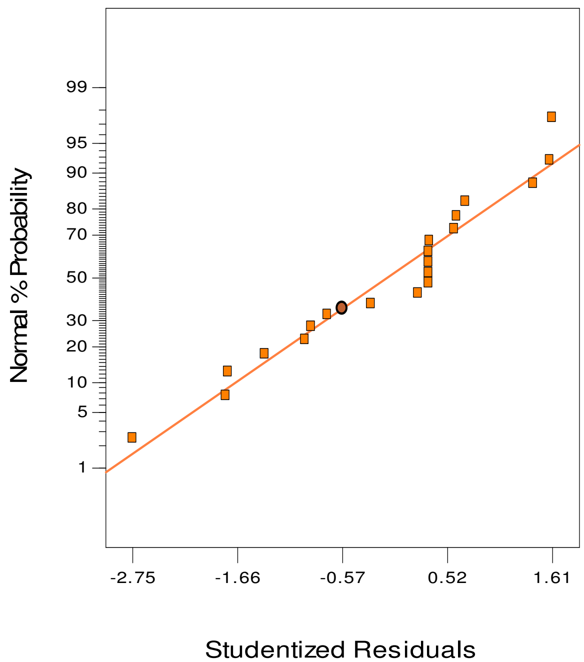


Figure 4.2: Normal plot of residual

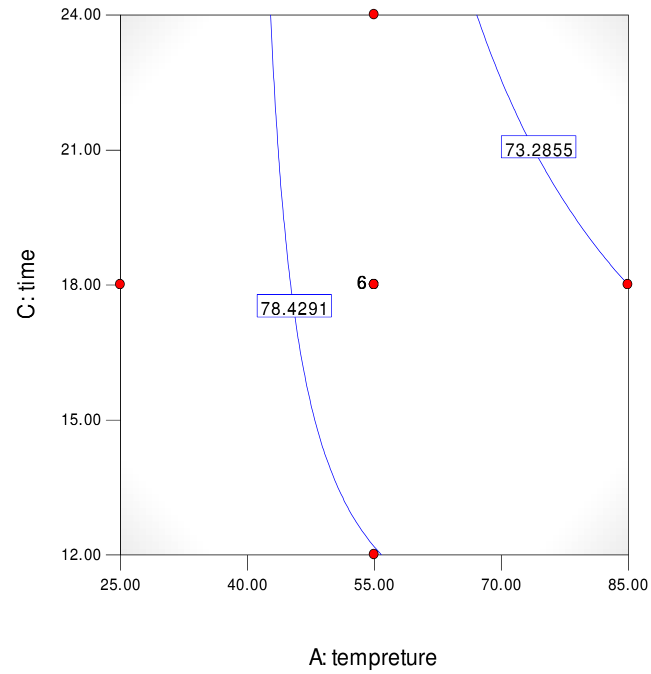


Figure 4.3: the relation between time and temperature

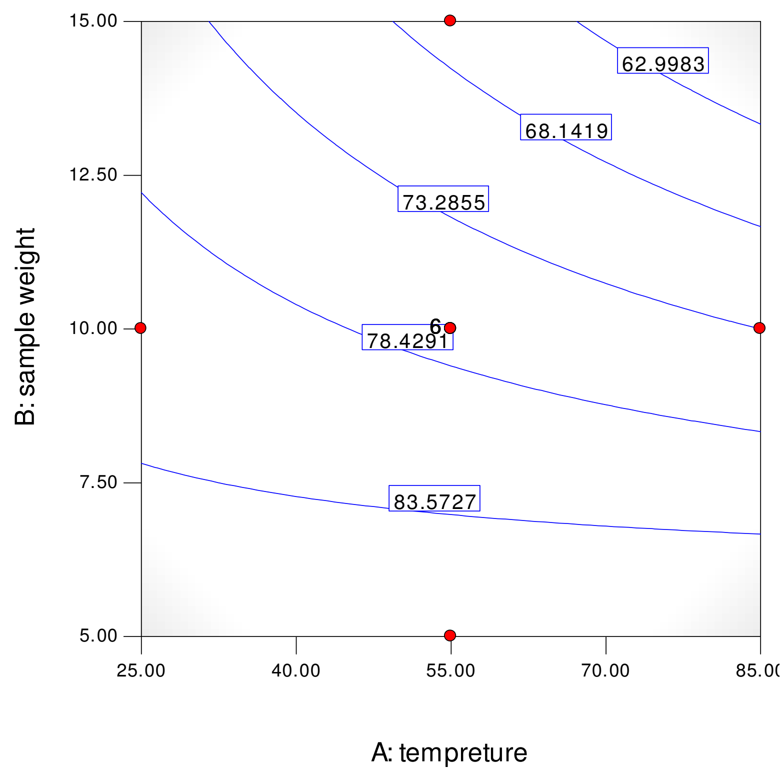


Figure 4.4: the relation between temperature and sample weight

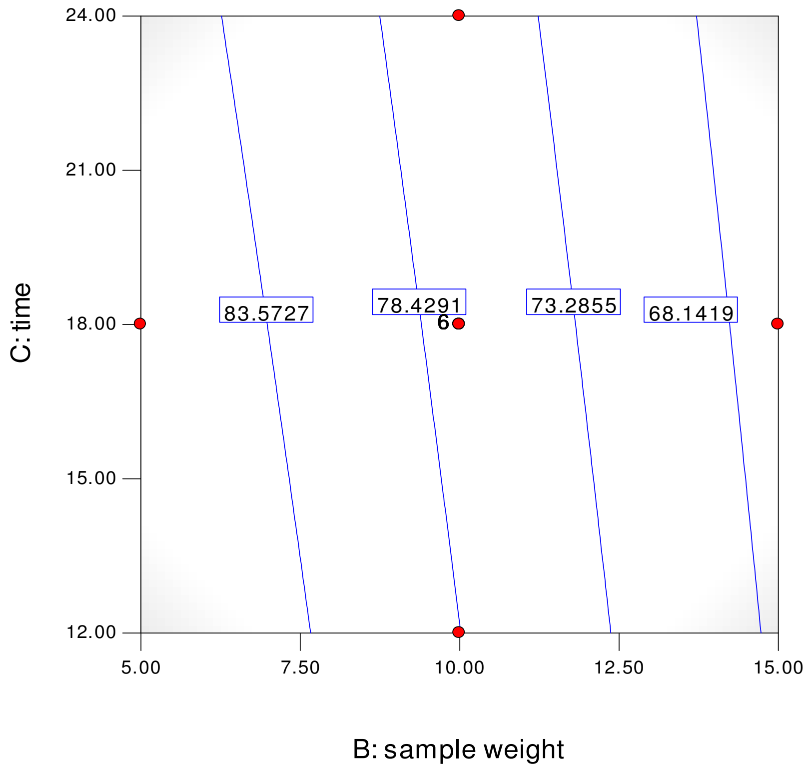


Figure 4.5: the relation of time with sample weight

The result of ANOVA is shown that where the relation between the factors increases, the yield decrease but its concentration increase. Therefore, the amount of sample weight, time of contact and temperature of the distilled water increases the concentration of the lye increase.

4.2.2 Characterization the Carbon Black and Lye production

4.2.2.1 Carbon Black Characterization

4.2.2.1.1 Determination the particle size

The particle size of carbon black was characterized using sieve analysis method. As it can be seen from table 4.5, the particle size analysis result is obtained by considering the sample size passing through the sieve and remains after shaking. Therefore, the size of the particle was fall in between those remaining and passing through the sieve.

Table 4.5: particle size analysis

Size of sieve (μm)	Weight of sieve (gm)	Weight of sieve with sample (gm)	Net weight (gm)
>100	335.6	336.6	1.0
100	255.7	256.4	0.7
125	274.2	274.3	0.1
150	242.2	242.5	0.3
180	262.5	265.8	3.3
500	274.5	274.6	0.1
710	290.0	291.1	1.1

4.2.2.1.2 Determination the Ash Content

As it can be seen from the table 4.6, the ash content of carbon black product that determined by furnace in a given time and temperature is indicated.

Table 4.6: Ash content of the CB product

No	Time (hr)	Temperature (^{o}c)	Ash content (gm)
1	1	500	6.39
2	1	550	6.59
3	1	600	8.26
4	3	500	11.82
5	3	550	9.79
6	3	600	8.92
7	5	500	7.22
8	5	550	7.94
9	5	600	7.85

According to the result obtained from Horizon Addis tire shown, the ash content of CB is 3-7gm. Thus, the result of the project at 1hr and 500^{o}c is optimum value.

4.2.2.2 Lye Characterization

4.2.2.2.1 Determination of pH value

The result of lye product pH value at given sample weight, temperature and time is shown in table 4.8. As it can be seen from the table, the higher pH value of 14.50 is recorded at 12 run. The higher concentration is obtained at the long time contact of sample weight and solvent.

Therefore, the result obtained indicated that the Lye produced from the prosopis wood ash is strong alkali (strong base). The pH of the lye is varied with its concentration.

Table 4.7: analysis of pH value

Std	Run	Sample weight (gm)	Temperature (°c)	Time (hr)	pH
12	1	10	85	18	13.87
20	2	10	55	18	13.70
4	3	15	85	12	13.05
15	4	10	55	18	13.89
1	5	5	25	12	13.05
2	6	15	25	12	13.60
14	7	10	55	24	13.88
6	8	15	25	24	13.95
5	9	5	25	24	13.60
18	10	10	55	18	13.99
9	11	5	55	18	13.05
8	12	15	85	24	14.50
3	13	5	85	12	13.80
17	14	10	55	18	13.82
19	15	10	55	18	13.89
10	16	15	55	18	13.89
13	17	10	55	12	13.09
16	18	10	55	18	13.89
7	19	5	85	24	13.65
11	20	10	25	18	13.86

4.2.2.2.2 Determination the value of concentration

As it can be seen from table 4.9, the titration result of lye concentration is obtained after the lye product characterized using the titration method. During characterization the variables: sample weight, temperature and time were considered. As it can be understood from the table 4.9, the concentration indicator color result is dark pink which is strong alkali, at run 12 with variable value of 15gm, 85°c and 24hr.

Table 4.8: the result of the concentration

Std	Run	Sample weight (gm)	Temperature (^oc)	Time (hr)	Concentration Indicator color
12	1	10	85	18	Pink
20	2	10	55	18	Light pink
4	3	15	85	12	Pink
15	4	10	55	18	Light pink
1	5	5	25	12	less pink
2	6	15	25	12	less pink
14	7	10	55	24	Light pink
6	8	15	25	24	Less pink
5	9	5	25	24	Less pink
18	10	10	55	18	Light pink
9	11	5	55	18	Light pink
8	12	15	85	24	Dark pink
3	13	5	85	12	Less pink
17	14	10	55	18	Light pink
19	15	10	55	18	Light pink
10	16	15	55	18	Light pink
13	17	10	55	12	Light pink
16	18	10	55	18	Light pink
7	19	5	85	24	Less pink
11	20	10	25	18	light pink

5. MATERIAL AND ENERGY BALANCES

5.1 Material Balance

5.1.1 Material Balance for Carbon Black Production

Basis:

- ✓ total need of CB in Ethiopia is 2800 ton, taken from the literature
- ✓ Ethiopia consumes 2800 tons per annum of Carbon Black
- ✓ 700,000 hectare of prosopis plant growth in Ethiopia within a year

From the experiment:

- ✓ 32.5% of CB was collected
- ✓ 2% are moisture content of prosopis plant used
- ✓ 65.5% of gas are removed during the process of CB production
- ✓ 1 bar N_2 gas

Assumption:

- ✓ Within 1ha = 6400 tree grow
- ✓ From total number of hectare 30% is used
- ✓ The mass of one tree is between 50-200 kg = 125kg is used
- ✓ In the cutter 99% of the product is collected
- ✓ The nitrogen gas is used as a carrier (In = Out)
- ✓ In the condenser there is only heat change

The conservation law of mass balance is;

Input + Accumulation + Generation - Consumption =Output ………….(5.1)

1 -Feeding system/ cutter

From 700,000ha 30% is used in this calculation. The total mass of prosopis plant was determined as:

$$H_{used}=0.3\ H_{total}$$

Where;

H_{used}: the total hectare used

$$H_{used} = 700000 * 0.30 = \underline{210000\ ha}$$

Total number of prosopis plant growth

1ha = 6400 tree

210000 ha = ?

210000 ha * 6400 tree/1ha = 1,344,000,000 tree

From assumption 99% of product is collected from the cutter and from equation 5.1 is

Accumulation = Generation = Consumption = 0

Therefore; Input = Output

$$M_{in} = M_{out} \quad ,$$

Where:-M = mass

Prosopis tree = Small size of prosopis + Leaf

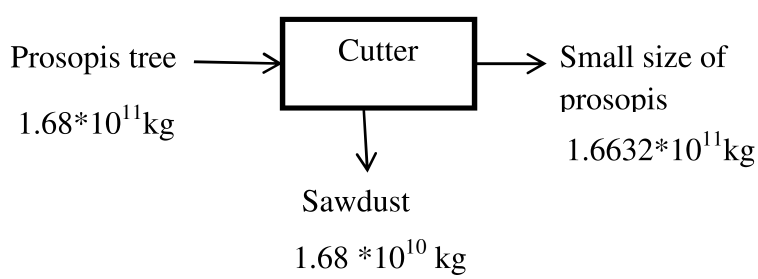
Prosopis tree = 1,344,000,000tree

= 1,344,000,000tree *125kg/tree= $1.68*10^{11}$kg

Small size of prosopis = $0.99*1.68*10^{11}$kg

= $1.6632*10^{11}$kg

Sawdust = $0.1*1.68*10^{11}$kg = $1.68*10^{10}$ kg



2-Pyrolysis reactor: from the experimental 32.5% of CB was collected, 2% are moisture content and 65.5% of gas is removed during the process of CB production and using eq.5.1.

Accumulation = Generation = Consumption =0

Therefore; Input = Output

$$M_{in} = M_{out}$$

Where:-M = mass

Small size of prosopis + N_2 gas = $CB_{product}$ + Other gas + N_2 gas

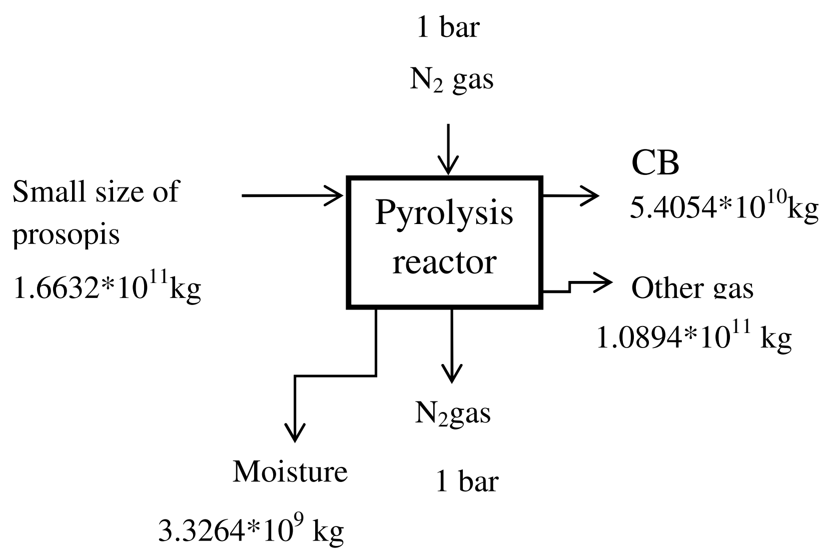
Small size of prosopis = $1.6632*10^{11}$kg

N_2 gas = 1bar of N_2 gas

CB product = $1.6632*10^{11}$kg * 32.5% = $\underline{5.4054*10^{10}\text{kg}}$

Other gas = $1.6632*10^{11}$kg * 65.5% = $\underline{1.0894*10^{11}\text{ kg}}$

Moisture content = $1.6632*10^{11}$kg * 2% = $\underline{3.3264*10^{9}\text{ kg}}$



5.1.2 Material Balance for Lye Production

Basis:

- ✓ total need of Lye(caustic potash) in Ethiopia is 79,504 ton from Literature
- ✓ Ethiopia consumes 79,504 tons of Lye per year

From Experiment:

- ✓ 53.8% of lye was produced in the experiment

- ✓ 46.2% is residual
- ✓ From 5kg of wood 80gm(16%) obtained where others converted to gas

Assumption:

- ✓ From total number of hectare 20% is used

1 -Stove: from the experiment 16%was converted to ash where as other 82% converted to gas and 2% moisture is content and using equation 5.1 is

Input + Accumulation + Generation - Consumption = Output

Accumulation = Generation = Consumption = 0

Therefore Input = Output

$$\mathbf{M_{in} = M_{out}}$$

Prosopis tree = Ash + moisture + other gas

From 700,000ha 20% is used in this production. The total mass of prosopis plant was determined as:

700000ha *0.20 = 140,000 ha

Total number of prosopis plant growth is calculated:

1ha =6400 tree

140,000 ha=?

140,000 ha * 6400 tree/1ha = $\underline{\underline{8.96*10^8 \text{tree}}}$

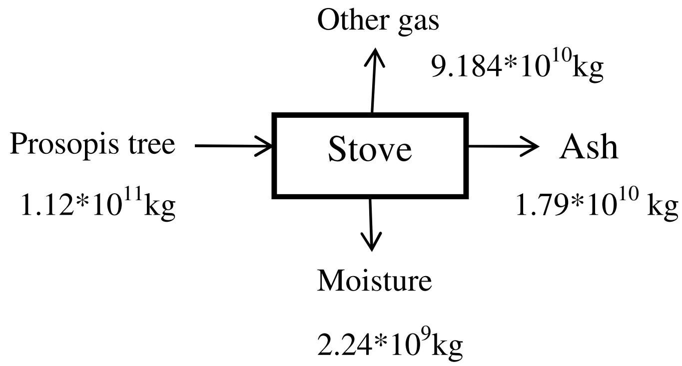
Total mass of prosopis tree is determined as:

= $8.96*10^8$tree *125kg/tree = $\underline{\underline{1.12*10^{11}\text{kg}}}$

Ash = $1.12*10^{11}$kg * 16% = $\underline{\underline{1.79*10^{10} \text{ kg}}}$

Moisture = $1.12*10^{11}$kg * 2% = $\underline{\underline{2.24*10^{9}\text{kg}}}$

Other gas = $1.12*10^{11}$kg * 82% = $\underline{\underline{9.184*10^{10}\text{kg}}}$



2 -Mixer: from the experiment 14.4% of ash was used and 85.6% was water and stand for 24 hours and using equation 5.1 is

Input + Accumulation + Generation - Consumption =Output

Accumulation = Generation = Consumption = 0

Therefore, Input = Output

$$\mathbf{M_{in} = M_{out}}$$

Ash + Distilled water = Mixed solution

Value of Ash = $\underline{\underline{1.79*10^{10}\ kg}}$ is known and the amount of distilled water used is calculated as:

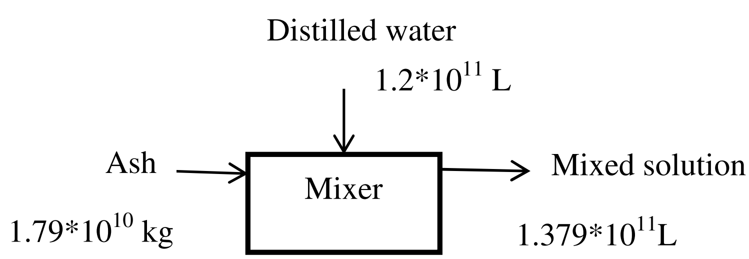
$$0.015kg = 0.1L$$

$$1.79*10^{10}\ kg = ?$$

Distilled water = $1.79*10^{10}$ kg * 0.1L/ 0.015kg

$$= \underline{\underline{1.2*10^{11}\ L}}$$

Mixed solution =$1.79*10^{10}$ kg*1L/1kg + $1.2*10^{11}$ L=$\underline{\underline{1.379*10^{11}L}}$



3-Filtration: from the experiment 53.8% of clear lye was gotten and 46.2% was residual and using equation 5.1 is

Input + Accumulation + Generation - Consumption =Output

Accumulation = Generation = Consumption = 0

Therefore, Input = Output

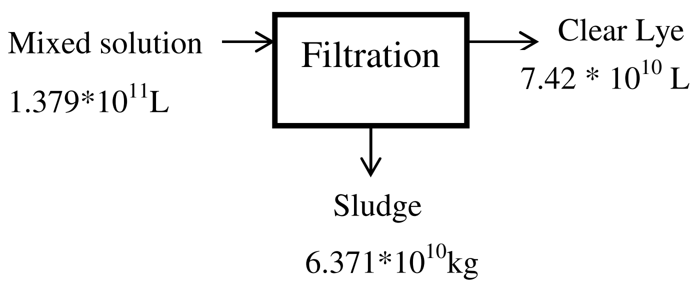
$$\mathbf{M_{in} = M_{out}}$$

Mixed solution = Clear Lye + Sludge

Mixed solution = $1.379*10^{11}$L

Clear Lye = $1.379*10^{11}$L * 53.8% = $7.42 * 10^{10}$ L

Sludge = $1.379*10^{11}$L*1kg/1L* 46.2% = $6.371*10^{10}$kg



5.2 Energy Balance for Carbon Black and Lye production

5.2.1 Energy Balance for Carbon Black

The conservation of heat is calculated by

Input + Heat generated + Heat consumed = Output …………………………………… (5.2)

Chang of heat can be calculated by

$\Delta Q = mC_P\Delta T$ ……………………………………………………….. (5.3)

1- Balance on Furnace

For producing an optimum amount of CB, the temperature inside the reactor should be maintained at $500^{o}C$. This temperature is achieved by supplying electric power from socket plug and this temperature is assumed to fall to $\pm 5^{o}c$. Therefore, the temperature inside the reactor is adjusted to the required value after charging the raw material and this can be calculating using equation 5.2 and 5.3.

Input + Heat generated + Heat consumed = Output

Assumption

- ✓ Heat generated = 0
- ✓ Heat consumed = 0
- ✓ $Q_{N2\ gas\ in} = Q_{N2\ gas\ out}$

Therefore,

$$\text{Input} = \text{Output}$$

$$Q_{prosopis} + Q_{N2in} = Q_{CB} + Q_{N2out}$$

$$Q_{prosopis} = Q_{CB}$$

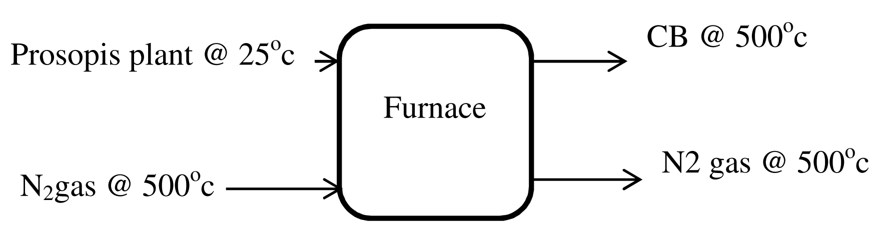
$$M_{prosopis} * cp_{prosopis} * \Delta T = M_{CB} * cp_{CB} * \Delta T$$

Specific heat of CB is at $500^{o}c$ = 1.15

$Cp_{prosopis} = M_{CB} * cp_{CB} * \Delta T_{CB} / M_{prosopis} * \Delta T_{prosopis}$

$= 5.4054*10^{10} kg * 1.15 KJ/kg\ k * 773\ k / 1.6632*10^{11} kg * 298\ k$

$Cp_{prosopis}$ = <u>0.97 KJ/kg k</u>



2- Balance on condenser:

For collecting the product of CB the temperature is adjusted to room temperature and this can be calculating using equation 5.2 and 5.3.

$$\text{Input} + \text{heat generate} - \text{heat consumed} = \text{Output}$$

Assumption

- ✓ Heat generate = 0
- ✓ Heat consumed = 0

Input = Output

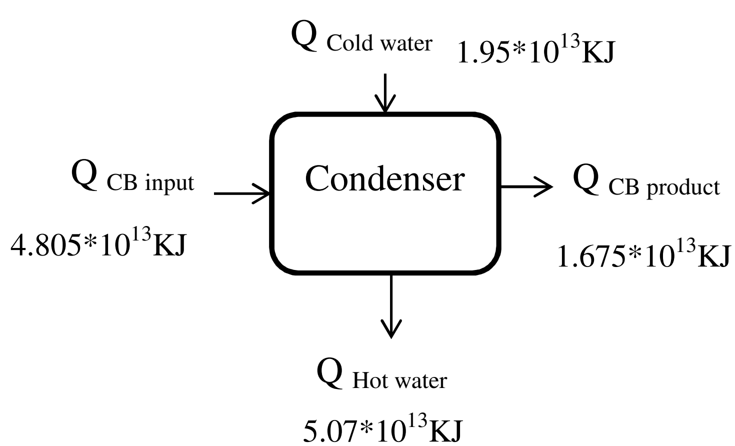
$$Q_{in\ CB} + Q_{in\ cooled\ water} = Q_{outCB} + Q_{out\ hot\ water}$$

$$(M*cp*\Delta T)_{in\ CB} + (M*cp*\Delta T)_{in\ cooled\ water} = (M*cp*\Delta T)_{out\ CB} + (M*cp*\Delta T)_{out\ hot\ water}$$

$$(5.4054*10^{10}kg * 1.15KJ/kg\ k *773\ k)_{in\ CB} + (M*4.182\ KJ/kg\ k * 298k) = (5.4054*10^{10}kg *1.04KJ/kg\ k *298\ k)_{out\ CB} + (M * 4.203KJ/kg\ k *773\ k)$$

$$4.805*10^{13}KJ + 1246.24MKJ/kg = 1.675*10^{13}KJ + 3248.92MKJ/kg$$

M_{H2O} = $\underline{\underline{1.562*10^{10}\ kg}}$



5.2.2 Energy Balance for Lye

1. **Balance on stove :**

Input + heat generate - heat consumed = output

Assumption

- ✓ The ash become white from 70 – 80°c=75°c is used as average value
- ✓ Heat consumed = 0

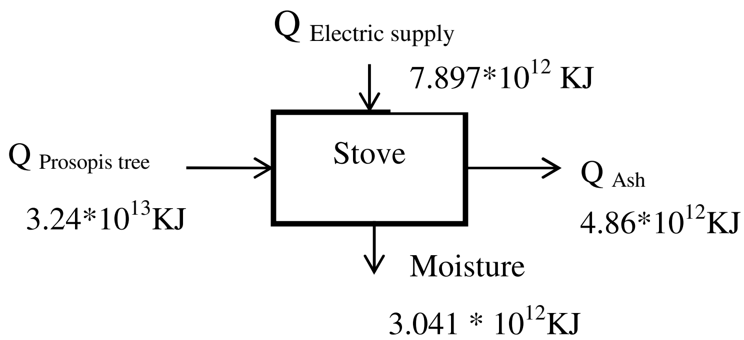
Input + heat generate = Output

$$Q_{Prosopis\ tree} + Q_{electricsupply} = Q_{Ash} + Q_{Moisture}$$

$$(M*cp*\Delta T)_{Prosopis\ tree} + Q_{electric\ supply} = (M*cp*\Delta T)_{Ash} + (M*cp*\Delta T)_{Moisture}$$

$(1.12*10^{11} kg* 0.97 KJ/kg.k * 298) + Q_{\text{electric supply}} = (1.79*10^{10} kg * 0.84 KJ/kg k * 323 k)_{Ash} + (2.24*10^{9} kg * 4.203 KJ/kg k * 323 k)$

$Q_{\text{electric supply}} = \underline{\underline{7.897*10^{12} KJ}}$



2- **Balance on Boiler:**

Input + heat generate - heat consumed = output

Assumption:

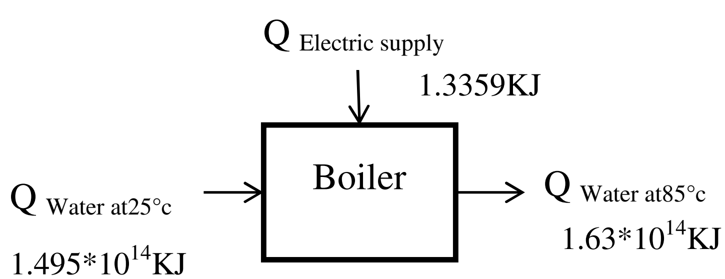
- ✓ Heat consumed = 0
- ✓ Heat generate = 0

Input + $Q_{\text{Electric supply}}$ =output

$(M * cp * \Delta T)_{\text{Water in}} + Q_{\text{Electric supply}} = (M * cp * \Delta T)_{\text{Water out}}$

$(1.2*10^{11} L * 1kg/L * 4.182 KJ/kg k * 298 k)_{\text{Water in}} + Q_{\text{Electric supply}} = (1.2*10^{11} L * 1kg/L * 4.203 KJ/kgk * 323k)_{\text{Water out}}$

$Q_{\text{Electric supply}} = \underline{\underline{1.3359 KJ}}$



3- Balance on Mixer:

Input + heat generate - heat consumed = output

Assumption:

- ✓ Heat generate = 0
- ✓ Heat consumed = 0

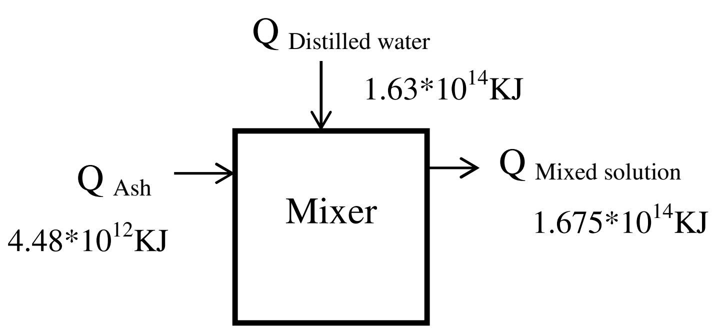
Input = Output

$$Q_{\text{Ash}} + Q_{\text{Distilled water}} = Q_{\text{Mixed solution}}$$

$$(M * cp * \Delta T)_{\text{Ash}} + Q_{\text{Distilled water}} = Q_{\text{Mixed solution}}$$

$$(1.79*10^{10}\ \text{kg} * 0.84\text{KJ/kg k} * 298\ \text{k})\text{Ash} + 1.63*10^{14}\text{KJ} = Q_{\text{Mixed solution}}$$

$$Q_{\text{Mixed solution}} = \underline{1.675*10^{14}\text{KJ}}$$



6. FEASIBILITY STUDY OF CARBON BLACK AND LYE PRODUCTION IN ETHIOPIA

6.1 Plant Capacity and Operation Program

Production capacity of the CB and Lye is $5.4054*10^{10}$kg and $1.79*10^{10}$kg respectively. The CB and Lye plant will be set into operation for 330 days per year, working in three shifts (8 hours each) per day. Assume production will start at 75% in the first operation.

6.2 Raw Material and Auxiliary Inputs Required

A. Raw Material

The main raw material of CB and Lye production is from prosopis Juliflora plant. And also distilled water is required in case of lye production.

Table 6.1: Annual Raw Materials Requirement and Cost at 75% Production Capacity of both

No	Description	Quantity	Unit Price(Birr)	Total Price(Birr)
1	Prosopis plant	$2.7832*10^{11}$kg	0.001birr/kg	278320000
2	Distilled water	$1.2*10^{11}$ L	12birr/L	$1.44*10^{12}$
Total price				$1.99664*10^{12}$

B. Utility

Electrical Power: the electric power is required from EPCO grid and the total amount that used by the plant is;

Total electric used per year = $8.03059*10^{12}$KJ/yr * 1yr/330 days * 1day/24hr *1hr/3600 s

= 281,656.496KJ/s

= 281,656.496KWh

Table 6.2: Utility

Utility	Unit	Annual consumption	Unit price(birr)	Annual cost(birr)
Electricity	KWh	281,656.496	0.4736	133,392.52

6.3 Technology and Engineering

To estimate the cost of equipment, first the size of the equipment calculated as given below.

6.3.1 Sizing and equipment listing for the productions of Carbon Black and Lye

Safety factor: is a factor to represent the amount of design that would be used to account for the change in the operating performance with time. As a general;

Safety factor = 10 % of capacity of the equipment

Storage tanks are sized depended on daily requirement; they can store and 10% safety factor for the volume.

Assumption:

- ✓ $1m^3$ contain 2000kg

i. *Storage tank for cutter*

$1m^3 = 2000kg$

$? = 1.68*10^{11}kg/330day = 509090909kg/day$

$V = (509090909kg/day * 1m^3/2000kg) + (509090909kg/day * 1m^3/2000kg) * 0.1$

$= 254545.454m^3/day + 25454.5454m^3/day$

$= \underline{\underline{279999.999m^3/day}}$

ii. *Storage tank for reactor*

Assume: the allowance is 20% because the nitrogen gas expanded if the temperature of the reactant is increase

$1m^3 = 2000kg$

$? = 1.663*10^{11}kg/330day = 503939394kg/day$

V = (503939394kg/day *1m3/2000kg) + (503939394kg/day *1m3/2000kg) *0.2

$= \underline{\underline{302363.64m^3/day}}$

iii. *Storage tank for stove*

$1m^3 = 2000kg$

$? = 1.12*10^{11}kg/330day = 339393939kg/day$

$V = (339393939kg/day*1m^3)/2000kg + (339393939kg/day *1m3/20000) *0.1$

$= 169696.97\ m^3/day + 16969.697\ m^3/day$

$= \underline{\underline{186666.67m^3/day}}$

iv. *Storage tank for mixer*

Density of any white ash is between 650-850 =750kg/m^3

$V = (m_{ash}/\rho_{ash} + m_{water}/\rho_{water}) + (m_{ash}/\rho_{ash} + m_{water}/\rho_{water})*0.1$

$= (1.79*10^{10}kg/750kg/m^3*330day + 1.2*10^{11}L*1kg/1000L*330day) +$

$(1.79*10^{10}kg/750kg/m^3*330day + 1.2*10^{11}L*1kg/1000L*330day)*0.1$

$V = \underline{\underline{479555.55m^3/day}}$

v. *Storage tank for filtration*

$1m^3 = 2000kg$

$? = 1.379*10^{11}L*1kg /L/330day$

$V = (417878788\ kg/day *1m^3/2000) + (417878788\ kg/day *1m^3/2000) *0.1$

$= \underline{\underline{229833.333m^3/day}}$

vi. *Storage tank for condenser*

$1m^3 = 2000kg$

$? = 5.4054*10^{10}L*1\ kg / L/330day = 1.638*10^8\ kg/day$

$V = (1.638*10^8\ kg/day*1m^3/2000) + (1.638*10^8\ kg/day*1m^3/2000)*0.1 +$

$(1.562*10^{10}kg/1000kg/m^3*330day) + (1.562*10^{10}kg/1000kg/m^3*330day) *0.1$

$V = \underline{\underline{142156.7m^3/day}}$

vii. *Storage tank for boiler*

$V = (M_{water}/ \rho_{water}) + (M_{water}/ \rho_{water}) *0.1$

$= (1.2*10^{11}\ L*1kg/L) /330day*1000kg/m^3 + (1.2*10^{11}\ L*1kg/L) /330day *1000kg/m^3 *0.1$

$= \underline{\underline{4*10^5\ m^3/day}}$

viii. Storage tank for clear lye

$V = (m_{lye}/\rho_{lye}) + (m_{lye}/\rho_{lye})*0.1$

$= 7.42 * 10^{10}$ L*1kg/L/330day*2.13kg/m^3+ (7.42 * 10^{10} L * 1kg/L/330day*2.13kg/m^3)*0.1

= <u>21112533.8m^3/day</u>

6.3.2 Site and Location of the Plant

Proximity to market and availability of raw material are the main factors that are considered to determine the location of the envisaged plant. The geographical location of the final plant can have strong influence on the success of an industrial venture. Considerable care must be exercised in selecting the plant site and many different factors must be considered. Primarily the plant should be located where the minimum cost of production and distribution can be obtained.

The following factors should be considered in selection a plant site.

- ✓ High labor force it means there are a lot unemployed people
- ✓ Availability of raw material (prosopis Juliflora plant).
- ✓ Availability of water and electricity
- ✓ High availability of transportation
- ✓ High market Flood and fire protection
- ✓ Community factors

Totally Logia city, Afar regional state is preferred for plant based upon the above criteria. The total area required for building the factory is 1 hectare.

6.3.3 Purchased Equipment Cost Estimation for carbon black

Table 6.3: Purchased Equipment Cost Estimation

Equipment Name	Capacity	Qty	Material	Unit cost	Total cost
Cutter	279999.999m^3	1	Carbon steel	$35,000	$35,000
Pyrolysis reactor	302363.64m3	1	Stainless steel	$100,000	$100,000
Condenser	142156.7m^3	1	Stainless steel	$50,000	$50,000
Total purchased equipment cost					$185,000

6.3.4 Purchased Equipment Cost Estimation for Lye

Table 6.4: Purchased Equipment Cost Estimation for lye

Equipment Name	Capacity	Qty	Material	Unit cost	Total cost
Stove	186666.67m^3	1	Copper alloy	$15,000	$15,000
Mixer	479555.55m^3	1	Stainless steel	$50,000	$50,000
Filtration	229833.333m^3	1	Stainless steel	$50,000	$50,000
Boiler	$4*10^5$ m^3	1	Stainless steel	$50,000	$50,000
Clear lye	21112533.8m^3	2	Stainless steel	$35,000	$70,000
Total purchased equipment cost					$235,000

6.4 Manpower and Training Requirement

6.4.1 Man Power

Table 6.5: Man power cost for CB and Lye

No	Description	Req. No.	Monthly Salary (Birr)	Annual Salary (Birr)
1	General Manager	1	9000	108,000
2	Production Department Manager	1	6000	72,000
3	Technical Department Manager	1	6000	72000
4	Quality control head	1	4000	48,000
5	Human Resource Manager	1	5000	60,000
6	Finance Department Manager	1	4000	48,000
7	Marketing Department Manager	1	4000	48,000
8	Audit Service Department Manager	1	4000	48,000
9	Senior Chemical Engineer	1	7000	84,000
10	Chemical Engineers	3	4000	48,000
11	Senior Chemist	1	4000	48,000
12	Accountant	1	3000	36,000
13	Training Section Head	1	4000	48,000
14	Boiler operator	3	2500	112,500
15	Laboratory Analyzer	3	2500	112,500
16	Drivers	3	2000	72,000
17	Ambulance Driver	3	3000	108000
18	Cleaner	3	1000	36,000
19	Druggist	3	2500	90,000
20	Laboratory clerk	2	2000	48000
21	Mechanical Maintenance Forman	3	4000	144,000
22	Electrician	3	3000	108,000
23	Guard	4	2000	96000

Continued table 6.5

24	Office Cleaner and Messenger	4	1000	48000
25	Secretary-1	2	3000	72,000
26	Casher	2	1500	36,000
27	Civil Engineer	1	5000	60,000
28	Cost & Budgets head	1	6000	72,000
29	Training Section Head	1	6000	72,000
30	Personnel	5	1500	90,000
Total				2,145,000

6.4.2 Training Requirement

The production supervisor, operators, quality controllers should be given three month on-the-job training. In addition, all workers should train by trainee about quality management, risky management and safety precautions.

The total cost of training is estimated to be Birr 100,000.

6.5 Financial analysis

6.5.1 Investment Analysis

Table 6.6: Total Capital Investment

	Component	Cost (birr/yr)
Total direct plant cost and indirect cost	Purchased equipment cost (PEC)	420,000*22= 9,240,000
	Installation	500,000
	Piping installed	100,000
	Building	2,000,000
	Land	5,000,000
Fixed-capital investment (FCI)	DC + IC	16,840,000
Working capital	Raw material cost	278,320,000
	Utility	133392.52
	Salaries	2,145,000
	Training	100,000
	Transportation	1,000,000
	Other none standing cost	50,000
Total working capital		31260392.52
Total-capital investment (TCI)	FCI +WC	48,100,392.52

6.5.2 Source of Finance

Table 6.7: Source of Finance

No	Source	Percentage	Amount in birr
1	Share-holders equity	30%	14,430,117.756
2	Bank loan	70%	33,670,274.764
Total		100%	48,100,392.52

Gross Earning/ Income

- ✓ Total income from product for CB

  = unit selling price × Quantity of product manufactured

  = 10 birr/kg * $5.4054*10^{10}$kg

  = 108,108,000,000birr

- ✓ Total income from product for Lye

  = unit selling price × Quantity of product manufactured

  = 10 birr/L * 7.42 * 10^{10} L

  = 742,000,000,000birr

- ✓ Total income from sawdust = unit selling price × Quantity of by product

  = 0.01 birr/kg *$1.68*10^{10}$kg/yr

  = 8,400,000,000birr/yr

Total Income = Income of product CB + Income of product Lye + Income of sawdust

= $5.4054*10^{12}$ birr +$1.855*10^{12}$ birr +$1.68*10^{10}$ birr

= 7,277,200,000,000 birr

6.6 Cash Flow

Table 6.8: Cash Flow Description

"000"birr

Year	0	1	2	3	4	5	6	7	8	9	10
Capital U.%	-	75	85	95	100	100	100	100	100	100	100
Investment	293,885	-	-	-	-	-	-	-	-	-	-
I- Cash inflow	-	$5.4579*10^9$	$6.185*10^9$	$6.91*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^{12}$	$7.277*10^9$	$7.277*10^9$
Revenue	-	$5.4579*10^9$	$6.185*10^9$	$6.91*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$	$7.277*10^9$
Salvage value(0.1PEC)	-	-	-	-	-	-	-	-	-	-	924000
II- Cash outflow	-	1,091,822,000	1,240,293,000	1,380,318,000	1,450,329,000	1,450,327,000	1,450,308,000	1,450,308,000	1,450,308,000	1,450,308,000	1.450,308,000
RM	-	208740	236572	264404	278320	278320	278320	278320	278320	278320	278320
Utilities	-	100	113	127	134	134	134	134	134	134	134
Factory overheads (20%Sell)	-	$1.09158*10^9$	$1.24*10^9$	$1.38*10^9$	$1.4555*10^9$	$1.4555*10^9$	$1.4555*10^9$	$1.4555*10^9$	$1.4555*10^9$	$1.4555*10^9$	$1.4555*10^9$
Depreciation &Amort.(10%)	-	29389	29389	29389	29389	29389	29389	29389	29389	29389	29389
Int. (12%) = $1/(1+r)^n$	-	4041	26842	23965	21392	19131	-	-	-	-	-
Gross Profit= (I -II)	293,885	$4.366*10^9$	$4.95*10^9$	$5.53*10^9$	$5.89*10^9$	$5.89*10^9$	$5.89*10^9$	$5.89*10^9$	$5.89*10^9$	$5.89*10^9$	$5.89*10^9$

6.7 Profitability Analysis

A. Present Value

Table 6.9: Present Value

Year	Cash flow	DCF (10%)	PV
0	-293,885	1	-293,885
1	$4.366*10^9$	0.909	3.97*109
2	$4.95*10^9$	0.826	4.1*109
3	$5.53*10^9$	0.75	4.15*109
4	$5.89*10^9$	0.68	4*109
5	$5.89*10^9$	0.62	3.7*109
6	$5.89*10^9$	0.56	3.3*109
7	$5.89*10^9$	0.51	3*109
8	$5.89*10^9$	0.466	2.8*109
9	$5.89*10^9$	0.42	2.5*109
10	$5.89*10^9$	0.38	2.3*109

B. Net Present Value

$$NPV = \Sigma\, PV$$
$$= \underline{\underline{3.382*10^{10}}}$$

C. Net Present Value Ratio

$$NPVR = \Sigma\, NPV / NPVI$$
$$= 3.382*10^{10}/293{,}885{,}000$$
$$= \underline{\underline{115.07}}$$

6.8 Implementation Schedule

Table 6.10: Implementation Schedule

Activity	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Prototype model design	■											
Purchase of construction materials		■	■									
Construction			■	■	■	■	■	■	■	■	■	
Manufacture of proto model			■	■	■	■	■					
Purchase of material								■	■	■	■	
Initial production run											■	
Staff training										■	■	
Sales training												■
Advertising activities												■

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The carbon Black is produced by burning the well dry and crushed (10nm) prosopis plant wood in furnace (pyrolysis method) by high temperature of 500°c and for 1hr time, optimum production was obtained. And whereas the dry prosopis wood 15gm is burned in open air of temperature 85°c for 24 hr time to produce white ash and mixed with water in the beaker and then filtered to have lye product in different concentration, 14.50 pH value is the optimum.

The result of characterization and the CB and Lye yield obtained shows the opportunity to produce CB and lye at large. The material and energy balance of CB and Lye production is also determined. The feasibility study conducted for CB and Lye production foreseen that producing CB and Lye in small scale is cost effective by using prosopis plant as inputs. The overall result of this thesis study shows the highly invasion of prosopis plants in the country and worldwide assure its abundance for small scale production.

7.2 Recommendation and Future Work

- ✓ This thesis report has shown the possibility to produce the Lye (caustic potash) using prosopis Juliflora plants and it's an opportunity job seeking youth that living around the areas (Afar, Dire Dewa, Somali region, etc) of expansion rate of prosopis tree is higher. And also there is a huge demand for caustic potash (lye) due to its different application in different chemical and related industries.

- ✓ Other opportunity for lye producers from prosopis plant is that those charcoal produced in illegal way would be collected from producers/ charcoal sellers before get in to market by the government to protect deforestation because they use protected trees in the name of prosopis and burned in open air at large. So it is possible to produce lye in large quantity by collecting white air after burning.

- ✓ The application of carbon Black is growing from time to time because of chemical industries increment in the country. The CB used in the country is mostly imported. To minimize its imported quantity many graduates and researchers tried to produce CB from locally available inputs, but there is no organized lab to identify and analyze its elements to the standard. On this regard its better if further study will be done in future.

- ✓ Removing the prosopis plant from agricultural land by using the prosopis trees for production of lye and carbon black, has to be considered by the government in the long plan removing the fast invasion of prosopis through utilization.

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