|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| |  | | --- | | Production of fuel from waste grass | | **Proposal overview**  This proposal/research paper proposes a very viable method to produce nitrocellulose/cellulose nitrate from grass whose main constituents can be classified as \*(i). Water (ii). Pectin (iii). Lignin I am (iv). Hemicellulose and (iii). Cellulose4  Out of all these constituents, cellulose (which is present abundantly in most species of grass) may be nitrated by the procedure underlined in this paper to produce nitrocellulose or cellulose nitrate which is a chemical compound bearing high industrial value. But the prime focus of this paper is to use the said compound as a substitute for common fuels ranging from timber to advanced fuels such as petrol and gasoline. The main idea behind this method and paper is to suggest how to convert something with no economic value (waste grass) into a compound whose global market value was estimated to be \*$ 625.5 million in the year 2015 and is expected to grow by $ 1 billion14 by the end of this decade. The process is fairly simple, and by proper waste treatment, this method would not only convert waste grass to nitrocellulose but would also yield a compost based fertilizer carrier/enhancer. If deemed necessary, a converting device may also be put together which can conduct the said process to yield the maximum amount desired products in the shortest process time safely without the need of manual labor. | | |  | | --- | | ggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggggg |   By-Akshay Srivastava  Ph. No: +91 9784139472 |

Industrial value of nitrocellulose

Nitrocellulose as said above bears a very high industrial and economic value. Nitrocellulose is known to be one of the oldest film formers unequalled in properties like toughness, durability, fast solvent release capacity and solubility. The global market value of nitrocellulose was estimated to be \*$625.5 million and is estimated to cross $114 by the end of this decade. Nitrocellulose is a key element in a variety of industries such as :

* \*Printing inks: Provides gloss, fast drying capability and good adhesion to many substrates. Most gravure and flexographic inks for the packaging industry use nitrocellulose.
* Wood Lacquers: Widely used as base coat and top coat on wooden furniture and articles for high gloss, washability and amenability to spray painting.
* Auto Refinish Paint: Well known for imparting high gloss, hard film, ease of application and quick drying.
* Leather Finishing Lacquers: Preferred on leather goods both for protection and high quality finish.
* Nail Varnishes: Imparts gloss, quick drying capability to nail varnishes.
* Miscellaneous applications: Finds applications in sealants and primers that are used in painting industry. Also used in adhesives, coatings, artificial jewelry etc.
* Fuel: Remarkable detonation/propulsive properties allow it to be utilized as a propellant and rocket fuel. Less than 1.0% residual mass is left upon combustion which results majorly in pressurized gases without production of extensive amount of heat. 12

The aim of this paper as stated previously is to use the nitrocellulose produced from waste grass mainly as a fuel, but since good quality cellulose nitrate can be manufactured from grass cheaply, the nitrocellulose produced may if need be, used in other mentioned sectors of industry. A few advantages of nitrocellulose over other fuels include:

* Low heat is evolved upon it’s combustion and pressurized gases are the major products of the reaction. This will not heat the engine up as petrol does, but would be more efficient.
* Almost no solid residual mass is left upon it’s combustion which mean, if nitrocellulose is used as a fuel, the maintenance cost of the engine would reduce significantly.
* The gases produced upon combustion can be treated as easily as the gases yielded upon the combustion of petrol, to become ecofriendly.
* If the suggested method is adopted and nitrocellulose is used as a substitute fuel, it will become one of the cheapest fuel at the disposal of mankind which will greatly affect the rate at which our natural resources are being exhausted. This will inevitably allow us to reserve fossil fuels for an application that might fit them better, or allow us to avoid using fossil fuels altogether for good.

Current industrial production of nitrocellulose

The main difference between industrial production of nitrocellulose and the method suggested in this research paper is the source of cellulose used. In the industrial production of nitrocellulose, the source of cellulose utilized are wood from trees mainly obtained upon deforestation and cotton linters which are short fibers that cling to cottonseeds after the first ginning. The cellulose content in these are extensive, but the advantages of these sources are counter affected economically due to the high processing/environmental costs of deforestation or upon converting linters to bleached cotton which can then be nitrated to produce nitrocellulose. Additional costs involved in producing the initial source of linters (cotton) also adds to the economic disadvantage that goes with the utilization of linters. The premature expenses include irrigational costs, manual labor cost and land required.

But on the other hand if grass is used as the primary source of cellulose, production of nitrocellulose would be much cheaper, but equally efficient. In addition, if such a method is implemented, plantation of grass would increase dramatically, which would also be of great natural benefit (natural air purification, decrease in soil erosion and reduction of environmental heating). Though, the amount of grass required for the production of equivalent amount of nitrocellulose be higher as compared to that of cotton linters, it would also be cheap enough to overthrow the negative aspect of utilizing grass.

It is worth mentioning that the waste produced after the cellulose is extracted from the grass may be used as a biodegradable fertilizer carrier/enhancer which would make this process much more ecofriendly.

Currently, the following process is utilized in the production of nitrocellulose from cotton linters.

* Raw cotton is handpicked from cotton plantations, where is it sent to a cotton mill for ginning. There is where the raw fibrous form of cellulose ifs obtained. These are then shredded and pretreated in large ovens to reduce the moisture content to less than 1% before being blown through ducts to the nitrating building.
* Nitration of the linters is then carried as the cellulose is caused to react with the nitrating acid (a mixture of nitric acid and sulfuric acid) in the nitrating process.
* After nitration, centrifuges separate the nitrocellulose from the spent nitrating acid used in excess quantities. This spent nitrating acid is separated into nitric acid, sulfuric acid and water, and completely recycled back into the process.
* The next stage is the pre-stabilization stage where the nitrocellulose is washed with water, thus separating off any acid left on the fibers. Next, the viscosity of the nitrocellulose is adjusted by pressure boiling (heating under pressure to temperatures above 100°C).,
* This is followed by the post-stabilization stage where the nitrocellulose is washed with water and heated to temperatures below 100°C. The water is subsequently separated off to leave a water content of 35%

Proposed method of production

As said above, the main idea of behind this paper is to use waste grass as a source of cellulose. Waste grass is conventionally used in the following endeavors:

* Fuel: Dried waste grass is used as a fuel. It bears high calorific value, but burning waste grass yields alarmingly high amounts of greenhouse gases. Perennial grasses are now being used as a solid fuel in co-fired coal power plants. Despite this focus on generating electricity and producing liquid fuels, perennial grasses can also be pressed into pellets, briquettes, and cubes and used as a heating fuel to replace or complement fuels made from wood fibers. Including a thermal component in the use of solid biomass for energy increases a combustion system’s efficiency more than threefold.
* Hay: Hay is cut grass that has been cut then dried for the purpose of becoming an animal feed or food. If it’s still not to be used as food, then it can readily be stored. Hay is a common food commodity for livestock owners who raise cattle. Hay has become the standard livestock food for herbivores whenever the extreme seasons of summer and winter arrive. It will be during these occasions that grass and green pastures aren’t advisable for animal grazing.
* Compost: Compost is organic matter that has been decomposed and recycled as a fertilizer and soil amendment. Compost is a key ingredient in organic farming. Though compost is rich in nutrients, by this method the conversion of grass clippings to compost is extensively time consuming and reduces it’s feasibility on an industrial scale. Furthermore, converting grass clippings to compost requires extra labor work.

As evident from the above examples, grass (grass clippings to be precise) do not possess much economical value. So if a method could be engineered to utilize the enormous amount of grass available at ones’ disposal, society would reap a great benefit. Theoretically the outline of the plan is as follows:

* \*Treatment of grass/clippings to (i). cleaning and removing dirt and other undesired contaminants (ii). Converting grass to pulp to ensure maximum extraction of cellulose and (iii). Addition of grass pulp to reducing mixture
* The reducing mixture would comprise of sulfuric acid and acetic acid which would dissolve away the unneeded components of grass such as lignin and starch. But if, concentrated nitric acid is introduced into the reaction mixture whence the acidic decomposition of grass terminates, nitration of freshly extracted cellulose could be carried out to yield maximum amount of nitrocellulose.
* Once the insoluble nitrocellulose is obtained, the acidic pulp present alongside with it can be treated with carbonates/bicarbonates of sodium to neutralize acidity.
* The nitrocellulose can then be isolated leaving behind a compost. 1

Novelty of the proposed method

As mentioned above, production of nitrocellulose is currently carried out by utilization of cotton linters as the primary source of cellulose. The novelty of the proposed method is mentioned below:

* It suggests that the cotton linters should be replaced by a much cheaper alternative, grass/clippings. This would benefit us since it would reduce the processing costs since cotton linters are much more expensive as compared to grass (despite of considering the comparatively lower mass to cellulose content of the same) but furthermore, it is equally feasible economically and industrially.
* The abundance of grass/clippings is greater than the amount of cotton linters available naturally.
* Since this method is equally feasible but cheaper, conversion plants may be setup in remote locations where the delivery of energy is diligent which would allow the residents of such location to have a cheaper access to a reliable source of energy.
* Majority of grass/clippings are dried and burnt as a source of energy since it is considered a waste. Needless to say, it causes harm to the environment and is it not efficient either. Therefore, this method might also be considered as a better alternative to the using grass/clipping which is primarily a waste product.

Methodology

The project management and project workflow diagram below briefs up the methodology adopted:

Collection of sample

Industrial execution

Estimation of cost

Lab Tests

• Estimation of the minimum amount of reducing mixture (and it’s composition) required for the maximum extraction of cellulose and its identification •Conversion of obtained cellulose to nitrocellulose and it’s identification •Conversion of waste produced to a practically applicable fertilizer carrier.

•Check for feasibility of the proposed idea. •Implementation of the proposed idea on a small scale (for modeling to estimate the total profit made if implementation on a large scale is done)

•Estimation of the cost involved in:

(i). Collection of sample. (ii). Treatment of the collected sample. (iii). Cost of waste management (if any).

• Collection of sample of grass/clippings to analyze the percentage of extractable cellulose. • • Analyze the availability of the grass sample thus obtained on economic basis.

Description of methodology:

Description of lab tests:

Lab tests will be performed on the grass clipping after they have been collected, cleaned, and isolated from impurities such as dirt and other organic matters. The lab tests will include:

•the isolation of cellulose from grass clipping pulp for a quantitative estimation of cellulose.

•conversion of the obtained cellulose to nitrocellulose for estimation of its quality and quantity.

•conversion of the obtained waste into a practical agricultural fertilizer carrier.

The procedure, method and the theory behind the operation of the method for each of the above tasks is mentioned below:

Isolation of cellulose from grass clippings:

Isolation of cellulose from grass clipping pulp may be carried out by the either of the two mentioned processes.

* \*Chemical pulping process: In chemical pulping process, grass fiber is treated with white liquor to degrade and eliminate the two main linking components, lignin and pectin. White liquor is a mixture of sodium hydroxide (NaOH) and sodium sulfide (Na2S) in 2:1 ratio (but this ratio will be modified to reach maximum efficiency) Sodium hydroxide dissolves lignin and sodium sulfide fastens cooking reactions and decreases cellulose degradation caused by sodium hydroxide. The necessity of continuous extraction is recognized and for such reasons, continuous conversion is carried out by progressive reaction of batches of G.C.P (grass clipping pulp) in lab to check if it would be practical10. This process is used for lignin abundant substances such as wood. So to estimate the exact amount of white liquor required for the reaction, multiple such reactions would have to be carried out. The reactions that occur in chemical pulping process are mentioned below:
* \*Solution of sodium sulfite and sodium hydroxide react in water generating an equilibrium:

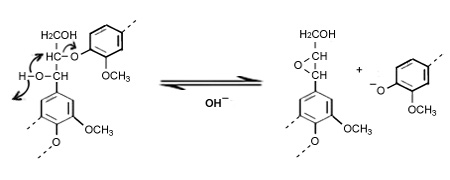
S2- + H2O ⇌ SH-+ OH-🡪(i)SH-+ OH- ⇌ S2H+ OH-🡪(ii)

The complete reaction of the interaction of the two components in a solution is defined below:

Na2S + H2O ⇌ NaOH + NaSH5

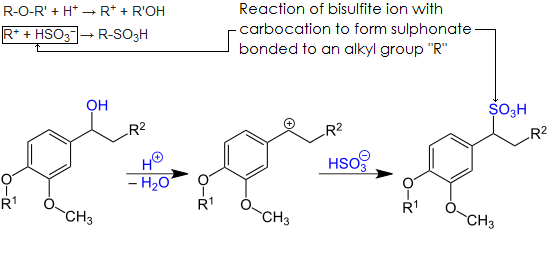
the alkali thus produced is consumed in five different ways, these are:

* \*In their reaction with lignin: The OH- ion formed in water reacts with the lignin macromolecule5



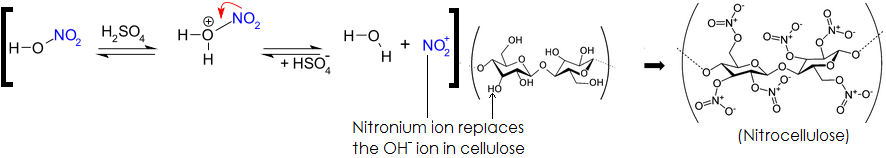
* \*Degradation of polysaccharides: The degradation of cellulose and hemicellulose by the alkali results in formation of organic acid such as saccharine acids5.
* \*In neutralization of organic acids: Most of the alkaline is consumed in the cooking process by the saccharine acids formed in the degradation of hemicelluloses. Hemicellulose is a polysacchrridic substance which includes galactoglucomannan, arabinoglucoronxylan, arabinose, arabinogalactane, glucoronxylan, glucomannan, and acids from glucorans and galactorons. The saccharinic acids formed by the degradation contains; isosaccharidic acids, milk acid, formic acid and acetic acid5.

Upon the reaction of soft wood with white liquor, a class of compounds called lignosulphonates are produced. These are formed when acidic cleavage of the ether bond in the structure of lignin occur which allows the bisulfite ion to bond with the side chain attached to the aromatic ring present in the structure of lignin as shown:

\* 16

Once cellulose has been extracted from grass, the next step would be to convert it to nitrocellulose. For this, cellulose is allowed to react with a solution concentrated in electrophilic nitronium ion. Christian Friedrich Schönbein's method for conversion of cellulose to nitrocellulose is the most practical method for this endeavor. The procedure is mentioned below:

* \*The source of nitronium ion in this process is a 2:1 mixture (by volume) of concentrated nitric acid with concentrated sulfuric acid in a beaker. The two acids are mixed carefully and they are cooled below 0°C which helps cool the mixture down which heats upon the addition of one of the component to another owing to the highly concentrated acids involved. This is done under a fume hood due to the exothermic release of nitrogen dioxide.
* Using glass rods, cellulose is immersed into the mixture. The cellulose is left to sit in the solution for 15 minutes. After that, cold water is allowed to run into the beaker to dilute the solution for a while.
* To completely neutralize the acid, a solution of sodium bicarbonate is added to the mixture. Using glass rod or gloved fingers, the nitrated cellulose lumps are removed from the beaker and washed again with cold water. After complete natural drying, nitrocellulose is obtained according to the reaction below13:



Isolation of lignosulphonates from softwood pulp:

\*Upon reaction of white liquor with grass fibers, white liquor is converted into \*black liquor whose major components are water, lignosulphonates and unreacted grass fibers17. Since lignosulphonates are water-soluble anionic polyelectrolyte polymers, they can be separated by simple methods such as filtration of \*black liquor and since the unreacted particles are of much greater size, any separation mechanism (even a simple sieve) can be utilized.2 Furthermore, to obtain dry lignosulphonate powder, water from the solution can simply be boiled off. The following text briefs up on the practicality of the idea of using the by-product as a fertilizer enhancer/carrier.7 \*Lignosulphonates are a multi-polycyclic organic polymer containing negatively charged group for which the high metal ions in soil has a strong affinity. Using lignosulphonates as a carrier of fertilizers, adsorption or parcel fertilizer, the goal of synthesizing slow-release fertilizers can be achieved. Since the lignosulphonates is a natural polymer and non-toxic in nature, it can degrade and humic acid can be generated through microbial degradation in soil, which can improve the physical and chemical properties of the soil and increase soil permeability to prevent compaction. The specific surface area of lignosulphonates is large and qualitatively light. This makes lignosulphonates act as carrier. When directly mixed with N, P, K and trace elements to obtain lignosulphonates-based carrier fertilizer, due to the nature of lignosulphonates’ slow release, nutrient utilization rate can reach more than 80% and the effects of fertilizers can last upto 20 weeks. Lignosulphonates carrier is a kind of mixed fertilizer which is pollution-free, harmless and adapts to the requirements of agricultural production.8

Identification and confirmation of cellulose

Identification of the amount of cellulose obtained by the digestion of lignin from grass fibers can be done by NMR-spectroscopically analyzing the cellulose (dried) in solvent. NMR spectroscopy can be used to match against spectral libraries of cellulose to confirm and quantify the magnitude of it’s presence in the pulp. By doing this, efficiency of chemical pulping on grass fibers to produce cellulose can be acknowledged.

Identification and confirmation of nitrocellulose

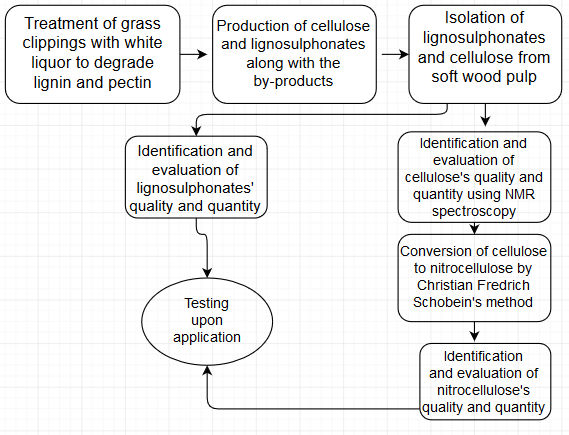
Identification of the amount of nitrocellulose obtained by the Christian Friedrich Schönbein's can also be done by NMR-spectroscopically analyzing nitrocellulose lumps obtained. NMR spectroscopy can be used to match against spectral libraries of nitrocellulose to confirm and quantify the magnitude of it’s presence in these lumps. Furthermore, the amount of nitration (presence of mono-, di- or tri- nitrated cellulose in percentages) can also be estimated by this method which will serve as a theoretical basis for calculations such as the amount of NO2 and other gases produced upon burning the obtained fuel

Identification and confirmation of lignosulphonates

Identification of the amount of lignosulphonates obtained by the digestion of lignin from grass fibers can be done by NMR-spectroscopically analyzing the lignosulphonates (dried) in solvent. NMR spectroscopy can be used to match against spectral libraries of lignosulphonates to confirm and quantify the magnitude of it’s presence.

Flowchart of the procedure:

The flowchart of the whole procedure is mentioned below:



Safety/storage measures for nitrocellulose:

\*Nitrocellulose is a dangerous compound since:

* Dry nitrocellulose is a highly flammable solid that ignites easily and burns explosively at 13ºC, the vapor from the nitrocellulose together with the oxygen in the air will catch fire if a heat source is applied to it. When the temperature is increased to 160 ºC - 170ºC and above, it will spontaneously ignite without an external spark or flame.
  + Organic solvents commonly used to damp nitrocellulose are also highly flammable. The organic solvent used also plays a part in determining when nitrocellulose will burn, whether on its own or with a heat source supplied.
  + Nitrocellulose is stable under normal temperature and pressure. However, it is shock-sensitive and will break down upon heating resulting in an explosion.
  + Both dry and damped nitrocellulose react easily with strong oxidizing agents, including strong acids and bases to produce oxides of nitrogen.
  + Inhaling nitrocellulose can irritate the nose and throat.
  + Contact with nitrocellulose can irritate the skin and eyes. It can also cause dryness of skin and dermatitis.
  + The common damping agent, isopropyl alcohol can irritate the eyes and skin. Due to its higher vapor pressure, isopropyl alcohol is more volatile than nitrocellulose and thus its vapors are easily inhaled.
  + Exposure to high concentrations of the solvents used as damping agents can cause dizziness, difficulties in breathing, and even result in unconsciousness.

Considering the above hazards, a few safety handling/storage measures are listed below:

* As dry nitrocellulose is sensitive to heat and impact, damped nitrocellulose must not be allowed to dry out. The container should be tightly sealed when not in use to prevent evaporation of the damping agent and only opened when the contents are ready to be used. All the container contents should be used each time.
* Do not subject nitrocellulose to heat through direct sunlight, impact or friction. Do not allow it to come into contact with acids, alkalis, amines or oxidizing agents. This could cause it to break down by itself or even ignite.
* Always use non-ferrous tools and materials when working with nitrocellulose. These tools can be made of copper, brass, bronze or wood. Tools made of plastic materials should not be used because they tend to produce static electricity. The tools and equipment should also be explosion-proof.
* Protect all nitrocellulose mixing and processing equipment from static electricity by grounding all metal parts. Ground all containers before transferring nitrocellulose.
* Keep the quantity of nitrocellulose stored and the period of storage to the minimum.
* If nitrocellulose has to be stored for a longer period, invert the container at regular intervals. This is to prevent the damping medium from separating from the nitrocellulose and the nitrocellulose from drying out.
* Store damped nitrocellulose in a cool, dry and well-ventilated area away from all possible sources of heat or ignition, preferably in a fire-proof area.
* Do not store nitrocellulose with incompatible substances, such as explosive substances, gases under pressure, flammable substances, oxidizing agents, acids, alkalis and amines.
* When the containers are empty, wash or wipe the with a damp rag. Clean the inside of the lid and the closure ring as well. Dispose of the used rag in the same manner as spilled nitrocellulose i.e. by damping any spilled nitrocellulose with water or alcohol immediately then collecting it while in a wetted condition in a tightly sealed container made of suitable materials (e.g. a polyethylene bag) before giving it to a licensed toxic industrial waste collector to dispose of it6.

Deliverables

The intangible product or service produced as a result of the project that is intended to be delivered to the customer or user are mentioned below:

* Nitrocellulose (produced mainly by utilization of grass) whose propellant properties are remarkable (even greater than some modern generation fuels). Such a fuel if available cheaply will be of great benefit. This fuel will find use in both our current society but also if advanced technology (such as PDE [pulse detonation engine]) are introduced.
* A fertilizer carrier/enhancer which may be used as just another organic fertilizer carrier for the enhancement of a wide variety of crops (this is a method of managing the waste product that is produced from proposed method).
* ^If this idea is further developed upon, a plant type converting mechanism may also be put together which can conduct the said process to yield the maximum amount desired products in the shortest process time safely. Furthermore, if spontaneous combustion of the freshly produced nitrocellulose could be incurred into the mechanism, then such a device may overtake the electricity generator which uses diesel and many other means of production of energy in remote location.

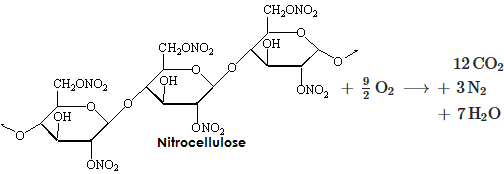
Basics of N.C converter:

The nitrocellulose converter will be a converter which will be able to perform the process of isolation of cellulose form grass clippings, isolation of lignosulphonates and conversion of cellulose to N.C. Furthermore, this machine can also convert the kinetic energy of the gases produced to electricity. Such a mechanism can find extensive use in agricultural area where a source of reliable electricity is of utmost importance. There will only ever be the need of (i)regular maintenance (ii)replace and restock the chemical reagents and (iii) removal of fertilizer enhancer manually. If implemented accordingly, such a device can revolutionize and benefit uncountable number of people

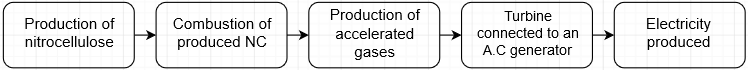
worldwide.

Application of nitrocellulose as a fuel:

The obtained nitrocellulose can be used as a fuel to replace common fuels such as petrol and diesel. This can be done since nitrocellulose upon combustion is converted gaseous compounds instantaneously.



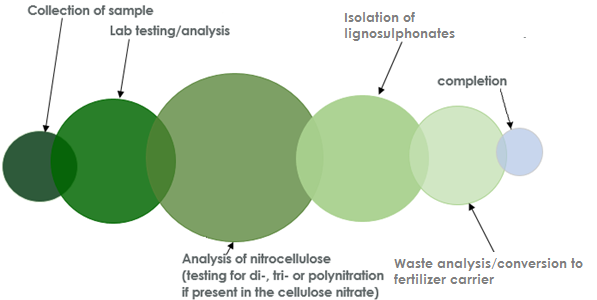
Hence for each mole of nitrocellulose, approximately 500 L of gases are produced at accelerated rates. The concept of using nitrocellulose as a fuel is to direct these gases into turbines which can utilize the high kinetic energy of these gases and convert it to electrical energy by using an ac generator. The procedure as such is represented below:



One example of a technology under development which can utilize nitrocellulose as a viable fuel without any needed modification is the Detonation engine.

Milestones

Milestone diagram for the above project is shown below where the area of the circle indicates the fraction of funding/time allotted to a given task.



* Collection of sample: Ordinary grass clippings are used so as to ensure that the practicality of this method is perpetuated due to the unavailability of a certain species of grass. Once collected, these are washed and further clipped (if deemed necessary).
* Lab testing/analysis: These tests and experiments are carried out on grass as mentioned above under the description of lab tests section.
* Analysis of nitrocellulose: Quality testing of nitrocellulose will be done by NMR-spectroscopy.
* Isolation of lignosulphonates: Isolation of lignosulphonates from the reaction mixture.
* Waste analysis/conversion to fertilizer carrier: Analysis of lignosulphonates is carried out in order to check for its feasibility as a practical fertilizer carrier.

Result showcase

The astounding fact behind this research paper is that if this idea is further developed upon, engineering a converter (which would convert batches of grass clippings directly to nitrocellulose) would be possible. This would mean, that this technology might be able to serve the great ethical cause of providing energy in rural/remote areas of the world where the requirement of energy is both crucial and unmet. Though the potentials of this idea are boundless, currently, the results will be showcased as a research publication. But if it is feasible, a converting mechanism would be designed and the prototype would then be the means of the showcasing the results thus obtained.

Resources and funding required

For the development of this project, and to commence the required testing and experiments, funding for the chemical reagents, lab equipments and NMR spectrometer is required. The total expenditure of the funding along with the designated amount and activity is mentioned below:

1. Chemical reagents required:

* Sodium Hydroxide (for making fresh white liquor in lab)
* Sodium sulfide (for making fresh white liquor in lab
* Sulfuric acid (for conversion of cellulose to nitrocellulose)
* Nitric acid (for conversion of cellulose to nitrocellulose)
* Sodium Bicarbonate (Neutralization of remaining acid in nitrocellulose after conversion

|  |  |  |
| --- | --- | --- |
| Sn. | Chemical reagents required | Price of the reagent (as mentioned of the latest catalogue of Merck life sciences ltd.) |
| 1. | Sodium Hydroxide | Rs. 1500 |
| 2. | Sodium Sulfide | Rs. 1000 |
| 3. | Sulfuric acid | Rs. 3420 |
| 4. | Nitric acid | Rs. 740 |
| 5. | Sodium Bicarbonate | Rs. 1500 |

1. Analysis/Isolation expenses:

* \*NMR spectroscopy + Solvent for dissolution11
* Filtration mesh

|  |  |  |
| --- | --- | --- |
| Sn. | Isolation/Analysis means | Expenditure |
| 1. | NMR spectroscopy + Solvent | Rs.300 + Rs.250 |
| 2. | Filtration mesh | Rs.500 |

1. Lab Equipments: Basic lab glass ware
2. \*Stipend: Stipend is requested in order to compensate for travel expenses, safety expenses etc. Considering stipends offered the official website of University Grant Commission on, the requested stipend is Rs.9000 p.m. but this value may be modified upon the preference of the funding committee. 9
3. Total expected funding: Rs.11310+Rs.9000 pm (stipend)

References/Links: -

1.Switch Grass: A potential pulp fiber source; K. Goel, R. Eisner, G. Sherson, T. Radiotis, J. Li

2.Characterization and evaluation of pulp and paper from selected Ugandan grasses for paper industry; Omar L.M.Kamoga, J.B Kirabira, J.K Byaruhanga, R.D Godiyal, Kumar Anupam (2014)

3.Potential of elephant grass fir oulp production Fernando Jose Borges Gomes, Jorge Luiz Colodette, Auphelia Burnet, Larisse Apareada Ribas Batalha and Bianca Moreira Barbosa

4.Nitrocellulose Industry: - A compendium of the history, chemistry, manufacture, commercial application and analysis of nitrated, acetates and nanthates of cellulose as applied t te peaceful arts; Edward Chauncey Worden

5.Chemical reactions in Kraft’s pulping; All K lindedahl and Co.

6.Occupational Safety and health circular: - Safe use, handling and storage of nitrocellulose; Ministry of manpower

7.Process for recovering lignosulphonates from spent sulphite liquor; Sirpa L Hamala, Tampere, Seppot. Kerava, Veli J.Sarkkinen, Pori

8.The application of lignosulphonates as fertilizer carrier; Green Agrochem (<http://www.greenagrochem.com/the-application-of-lignin-as-fertilizer-carrier/>)

9.<http://www.ugc.ac.in/oldpdf/xiplanpdf/JRFE-T.pdf>

10.The Sulphite Pulping Process : - (ied.ineris.fr/sites/default/interactive/brefpap/bref\_pap/english/bref\_gb\_sulfite.htm)

11.MNIT NMR spectroscopy facility (<http://www.mnit.ac.in/dept_mrc/facilities.php>)

12.Application of nitrocellulose (<http://www.nitrex.in/applications.asp>)

13.Condensed form of : (<https://prezi.com/o9u89mk1ckmg/cellulose-nitrate/>)

14.Market value of nitrocellulose i.e. global market values and estimates growth (<http://www.grandviewresearch.com/industry-analysis/nitrocellulose-market>)

15.Kraft’s Process of chemical pulping (<https://en.wikipedia.org/wiki/Kraft_process>)

16.Lignosulphonates (<https://en.wikipedia.org/wiki/Lignosulfonates>)

17.Composition of pulp and contents of white/black liquor produced after sulfite pulping (<https://en.wikipedia.org/wiki/Pulp_(paper))>

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final exams.

The concept of an "essay" has been extended to other mediums beyond writing. A [film essay](https://en.wikipedia.org/wiki/Essay#Film) is a movie that often incorporates documentary film making styles, and focuses more on the evolution of a theme or idea. A [photographic essay](https://en.wikipedia.org/wiki/Photo_essay) covers a topic with a linked series of [photographs](https://en.wikipedia.org/wiki/Photographs) that may have accompanying text or [captions](https://en.wikipedia.org/wiki/Photo_caption)

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final exams.

The concept of an "essay" has been extended to other mediums beyond writing. A [film essay](https://en.wikipedia.org/wiki/Essay#Film) is a movie that often incorporates documentary film making styles, and focuses more on the evolution of a theme or idea. A [photographic essay](https://en.wikipedia.org/wiki/Photo_essay) covers a topic with a linked series of [photographs](https://en.wikipedia.org/wiki/Photographs) that may h

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final exams.

The concept of an "essay" has been extended to other mediums beyond writing. A [film essay](https://en.wikipedia.org/wiki/Essay#Film) is a movie that often incorporates documentary film making styles, and focuses more on the evolution of a theme or idea. A [photographic essay](https://en.wikipedia.org/wiki/Photo_essay) covers a topic with a linked series of [photographs](https://en.wikipedia.org/wiki/Photographs) that may have accompanying text or [captions](https://en.wikipedia.org/wiki/Photo_caption)

generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final exams.

The concept of an "essay" has been extended to other mediums beyond writing. A [film essay](https://en.wikipedia.org/wiki/Essay#Film) is a movie that often incorporates documentary film making styles, and focuses more on the evolution of a theme or idea. A [photographic essay](https://en.wikipedia.org/wiki/Photo_essay) covers a topic with a linked series of [photographs](https://en.wikipedia.org/wiki/Photographs) that may have accompanying text or [captions](https://en.wikipedia.org/wiki/Photo_caption)

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final exam

The concept of an "essay" has been extended to other mediums beyond writing. A [film essay](https://en.wikipedia.org/wiki/Essay#Film) is a movie that often incorporates documentary film making styles, and focuses more on the evolution of a theme or idea. A [photographic essay](https://en.wikipedia.org/wiki/Photo_essay) covers a topic with a linked series of [photographs](https://en.wikipedia.org/wiki/Photographs) that may have accompanying text or [captions](https://en.wikipedia.org/wiki/Photo_caption)

An **essay** is, generally, a piece of writing that gives the author's own [argument](https://en.wikipedia.org/wiki/Argument) — but the definition is vague, overlapping with those of an [article](https://en.wikipedia.org/wiki/Article_%28publishing%29), a [pamphlet](https://en.wikipedia.org/wiki/Pamphlet), and a [short story](https://en.wikipedia.org/wiki/Short_story). Essays have traditionally been sub-classified as formal and informal. Formal essays are characterized by "serious purpose, dignity, logical organization, length," whereas the informal essay is characterized by "the personal element (self-revelation, individual tastes and experiences, confidential manner), humor, graceful style, rambling structure, unconventionality or novelty of theme," etc.[[1]](https://en.wikipedia.org/wiki/Essay#cite_note-1)

Essays are commonly used as literary criticism political [manifestos](https://en.wikipedia.org/wiki/Manifestos), learned [arguments](https://en.wikipedia.org/wiki/Arguments), observations of daily life, recollections, and reflections of the author. Almost all modern essays are written in [prose](https://en.wikipedia.org/wiki/Prose), but works in [verse](https://en.wikipedia.org/wiki/Poetry) have been dubbed essays (e.g., [Alexander Pope](https://en.wikipedia.org/wiki/Alexander_Pope)'s [*An Essay on Criticism*](https://en.wikipedia.org/wiki/An_Essay_on_Criticism) and [*An Essay on Man*](https://en.wikipedia.org/wiki/An_Essay_on_Man)). While brevity usually defines an essay, voluminous works like [John Locke](https://en.wikipedia.org/wiki/John_Locke)'s [*An Essay Concerning Human Understanding*](https://en.wikipedia.org/wiki/An_Essay_Concerning_Human_Understanding) and [Thomas Malthus](https://en.wikipedia.org/wiki/Thomas_Malthus)'s [*An Essay on the Principle of Population*](https://en.wikipedia.org/wiki/An_Essay_on_the_Principle_of_Population) are counterexamples. In some countries (e.g., the United States and Canada), essays have become a major part of formal [education](https://en.wikipedia.org/wiki/Education). Secondary students are taught structured essay formats to improve their writing skills; [admission essays](https://en.wikipedia.org/wiki/Admissions_essay) are often used by [universities](https://en.wikipedia.org/wiki/University) in selecting applicants, and in the humanities and social sciences essays are often used as a way of assessing the performance of students during final ex