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Artificial Synthesis Of Butane And Propane To Make Lpg

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Abstract

According to Stanford University, fossil fuels will be replaced by other sources of energy in approximately 150 years. Also, UN has provided the world with 17 Sustainable Development Goals which are to be achieved by 2030. Also several reports state that fossil fuels will run out approximately by 2052. Thus, humanity does not have 150 years to achieve this feat. Working on the same, I have developed a paper deliberating on the steps involved to synthesise Butane and Propane artificially, without any involvement of petrochemicals. This paper provides efficient and eco-friendly methods to produce Propane and Butane mixture by simple microbial reactions and recovers the production cost efficiently by sale of by-products such as Sodium Carbonate, Phosphorous acid etc. Thus, the given paper efficiently provides works on SDG 7 (Affordable and Clean Energy) and SDG 12(Responsible Consumption and Production) and helps in poverty alleviation in middle income countries.

1.Introduction

LPG (Liquefied Petroleum Gas) is a fuel that has been in use for several years for domestic as well as commercial purposes. Currently in India, LPG is produced by the fractional distillation of Crude Oil. This leads to a major problem of depleting resources of naturally available fossil fuels. This demotes the idea of sustainability and is not in accordance with United Nations Sustainable Development Goal 7 i.e. Affordable and Clean Energy, SDG 12 i.e. Responsible Consumption and Production[1].

The supply of crude oil India majorly depends on imports from other countries. To promote the concept of "Atam Nirbhar Bharat" of the Government of India we need to focus on the resources available in our country to minimize the import

To tackle the above problems it is proposed here to make LPG artificially using saturated hydrocarbons. Out of these hydrocarbons, Butane and Propane have been used to make a mixture due to high calorific values and viable melting and boiling points. Further it uses the components such as ethanol which can be easily acquired from the crops like sugar cane. It not only helps to provide green energy but also contributes to the prosperity of the farmers of India.

Section 2 of the synopsis explains the components of proposed artificial LPG and why it is chosen so. Section 3 and section 4 explains the chosen process of synthesis of Butane and Propane respectively. Section 5 explains the composition of the mixture taken. Section 6 concludes the synopsis.

1 Components of Artificial LPG

The components of the Artificial LPG are butane and propane.

1.1 Butane

Butane is a saturated hydrocarbon (alkane) comprising of 4 carbon atoms and 10 hydrogen atoms i.e C_4H_{10}. Butane has a low melting point of -138.4° C and a low boiling point of -0.5^0 C. Adding to this, Butane also has high calorific value i.e. 49.1 MJ/kg. On a commercial basis, it is currently produced by fractional distillation of crude oil because it is produced naturally by decaying remains of animals and plants deep within the earth's crust. Fractional distillation is a process in which a mixture such as Crude Oil is separated into different components by differing the temperature at boiling points of petrochemical required.[2] As mentioned earlier, these old methods are now not of relevance with the new-age sustainable ideas.

1.2 Propane

Propane is also a saturated hydrocarbon(alkane) comprising of 3 carbon atoms and 8 hydrogen atoms i.e. C_3H_8 . Propane has a boiling point of -42°C and a melting point of -187.7°C. Also, Propane has a high calorific value of 50.4 MJ/kg. On a commercial basis, similar to butane, propane is also prepared using fractional distillation of crude oil and this method is not in accordance with Sustainable Development Goals set by UN.

1.3 Need for Propane and Butane in Artificial LPG

Though Butane and Propane both have similar calorific values, are obtained from the same source, by the same process and can be stored in liquid state, it necessary to create a mixture of both. It is in order to make an ideal fuel for the following reason. As stated above Butane has a boiling point of -0.5°C, thus, it cannot vaporize in colder temperatures such as areas near Jammu and Kashmir. Also it is known that Propane has a boiling point of -42°C. Thus making it viable in regions with colder atmosphere. Butane, in gaseous state has higher energy content of 111.4 MJ/m^3 with Propane at 93.2 MJ/m^3. Thus making it a viable option as a fuel along with propane.

2 Synthesis of Butane

With these things in mind Butane can now be synthesized without usage of any unsustainable source such as Crude Oil or Natural Gas. The following is a table of required reactants for synthesis of Butane along with their masses for better perception of practicality.

Serial No.	Name of the compound/element	Chemical Formula	Mass per mole in grams
1	Sodium Propionate	C_2H_5COONa	96 g
2	Propanoic acid	C_2H_5COOH	74 g
3	Sodium Hydroxide	NaOH	40 g
4	Ethane	C_2H_6	30 g
5	Bromoethane	C_2H_5Br	106 g
6	Sodium	Na	23 g
7	Bromine	Br_2	160 g

The catalysts used are:

1. CaO (with condition of 300°C)
2. Dry ether(Diethyl ether devoid of water)

2.1 Steps for Butane Formation

In the given following ways Butane can be synthesised without any involvement of petrochemicals:

1. Preparation of Propionic Acid
2. Preparation of Sodium Propionate
3. Preparation of Ethane
4. Preparation of Bromoethane
5. Wurtz reaction to prepare Butane

2.1.1 Preparation of Propionoic Acid

Propionoic Acid can be obtained by a microbial reaction with the help of *Lactobacillus Casei* and *Propionibacterium* that provides with Propionic and Acetic Acid when grown in an anaerobic glucose medium or in lactic acid.[3] This reaction is a more commercial version of the Fitz reaction i.e.

$$3C_4H_6O_5 = 2C_3H_6O_2 + 4CO_2 + H_2O$$

$$3C_3H_6O_3 = 2C_3H_6O_2 + CO_2 + H_2O$$

2.1.2 Preparation of Sodium Propionate

Sodium Propionate can be easily made with the help of the Propionic acid that was previously prepared along with NaOH. It's reaction is as follows:

$$C_2H_5COOH + NaOH = C_2H_5COONa + H_2O$$

2.1.3 Preparation of Ethane

Ethane also can be easily prepared with the help of Sodium Propionate that was prepared previously, although in this reaction Calcium Oxide is used as a catalyst and 300°C of temperature. The reaction is as follows:

$$C_2H_5COONa + NaOH \xrightarrow{CaO\ 300\ C} Na_2CO_3 + C_2H_6$$

2.1.4 Preparation of Bromoethane

Bromoethane can be prepared by Bromination of Ethane that was prepared previously, this provides with Hydrobromic acid as a byproduct. The reaction is as follows:

$$C_2H_6 \xrightarrow{\text{Bromination using Br2}} C_2H_5Br + HBr$$

2.1.5 Wurtz Reaction to prepare Butane

Wurtz reaction[4] is a reaction in which two R groups are joined in order to form an alkane with a longer chain which in this case is Butane along with NaX where X is a halogen(F,Br,I,Cl). It's general formula can be written as:

$$2R\text{-}X + 2Na = R\text{-}R + 2Na^+ X^-$$

Applying this general formula in our case where R-X is Bromoethane implying that halogen used is Bromine along with 2Na to form a longer chain of alkane that is Butane along with NaBr. Thus, the balanced reaction for this can be written as follows:

$$2C_2H_5Br + 2Na \xrightarrow{\text{Dry ether}} C_4H_{10} + 2NaBr$$

Following the above steps, Butane can be synthesized using sustainable means without any use of petrochemicals. Similarly Propane can be synthesized by making a few compounds from nature itself.

3 Synthesis of Propane

The following is a table which shows all the compounds and elements used as reactants for synthesis of Propane for a better understanding.

Serial No.	Name of Compound/Element	Chemical formula	Mass in Grams
1	Iodoethane	C_2H_5I	156 g
2	Iodomethane	CH_3I	142 g
3	Sodium	Na	23 g
4	Phosphorus triiodide	PI_3	412 g
5	Ethanol	C_2H_5OH	46 g

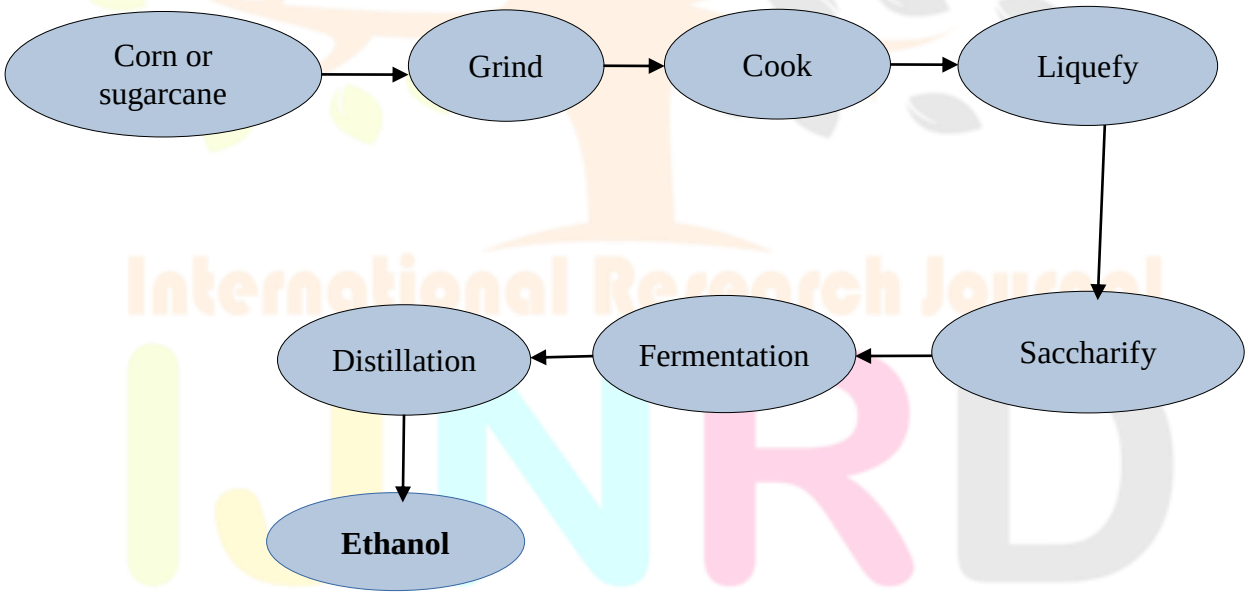
3.1 Steps in preparation of Propane

Propane can be prepared by the following steps:

- Preparation of Ethanol
- Preparation of Iodoethane
- Wurtz Coupling reaction to make Propane

3.1.1 Preparation of Ethanol

Ethanol can be easily prepared via chemical reactions but increases the cost by a significant amount, thus, to make this idea economically viable a different route can be taken to acquire ethanol which is explained through this flow chart[5].



With this, Ethanol is now acquired and Iodoethane can be prepared from it

3.1.2 Preparation of Iodoethane

Iodoethane can be simply prepared from Ethanol that was obtained naturally by reacting it with Phosphorus tri-iodide. The reaction can be stated as follows:

$$3C_2H_5OH + PI_3 = 3C_2H_5I + H_3PO_3$$

With this reaction we have acquired Iodoethane along with Phosphorous acid as a byproduct. But for this to happen we need to make PI_3 first. PI_3 can be made with the reaction of Phosphorus and Iodine in a neutral medium.

3.1.3 Wurtz Coupling Reaction to prepare Propane

Wurtz reaction involves coupling of alkyl halides using Na to obtain alkanes with longer Carbon chains. The reaction can be written as follows:

$$CH_3CH_2I + CH_3I + Na \xrightarrow{H2O} C_3H_8 + NaI$$

With this procedure, Butane and Propane can be synthesised to make a mixture suitable as a fuel.

4 Acquiring Other Raw Materials

1) Bromine

- Bromine can be acquired through Vacuum Distillation of seawater.[6]

2) Sodium Hydroxide

- Sodium Hydroxide can be easily obtained by electrolysis of brine[7]

3) Sodium Chloride

- Sodium Chloride is obtained a byproduct of vacuum distillation of seawater

5 Mixture of Propane and Butane

Different governments across the world use different percentages to mix Propane and Butane to make LPG. The factor upon which this depends is the weather conditions of a specific place, average temperature and overall topography so that it facilitates transportation of these hydrocarbons. In India, the percentage used as 60% Butane and 40% Propane. This percentage divide supports the diverse weather conditions in India supporting an equal balance of the 2 hydrocarbons to achieve maximum output from the fuel in terms of calorific value and vaporization.

6 Conclusion

In the above synopsis, it is proved that Butane and Propane can be synthesized from natural products and microbial reactions along with a few chemicals extracted from ores (such as Sodium) and can be used to prepare an ideal fuel such as LPG. With the increment in support systems LPG can be produced artificially on a large scale and the production cost can be recovered to some extent by reselling the by-products to pharmaceuticals and other private ventures that directly engage in such industrial activities. Due to this, LPG can be provided to common masses at a cheap rate thus, alleviating the poverty. Statistically, sustainable development may have tremendous impact on global market and poverty alleviation in India itself. To conclude, synthesis of Butane and Propane mixture artificially without involvement of petrochemicals has large potential in industrialization and in the scientific aspect to develop it with further accuracy and lesser expenditure.

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