Teaching Biomass Energy in Secondary School Chemistry: A Stimulus for Achieving Sustainable Energy

N. M. Eya[1], Attah F. O.[2] & Umate, B. A.[3]

[1, 2] & [3] Department of Science Education, Faculty of Education, University of Nigeria, Nsukka, Nigeria

Abstract: **The continuous increase of energy consumption has generally improved the standard of living but it has also caused serious environmental problems. There is therefore the need for sustainable energy sources. Sustainable energy involves increasing production of renewable energy, making safe energy universally available, and energy conservation. Sustainable energy is of great importance in Nigeria considering the broad and growing nature of energy use. Burning of fossil fuels to generate energy has resulted to many negative environmental problems on the climate, natural environment and the society at large. There is the need o change to other renewable and environmental free sources of energy. Biomass is a renewable energy source used to reduce our overdependence on fossil fuels and to help reduce air pollution. Secondary school chemistry students need to be taught about this biomass and biomass energy at the early stage of their educational pursuit even as they are the future scientists. When the students are best informed about these concepts at the early stage of their education and they develop interest in learning them, they will be in a better position to enhance their utilization as good sources of renewable energy in future as they are the hope of the nation as future scientists The paper therefore examined the concept of biomass and biomass energy, conversion of biomass to energy, advantages of biomass energy over fossil fuels and the implication of teaching biomass and biomass energy to secondary school chemistry students.**

Keywords: **Biomass, Sustainable, Energy, Chemistry & Teaching**

I. INTRODUCTION

Energy is sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable energy is a form of energy that can be utilized again and again without putting the source in danger of being depleted (Mark &Aida,2022) Sustainable energy is a significant and focal aspect of sustainability and an important consideration for human development. Developing new energy sources to produce reliable, affordable, energy while respecting the environment is one of today's most compelling needs. Of late, much attention is being focused on identifying suitable alternative and renewable energy sources, which can provide high-energy outputs, to replace conventional fossil fuel energy sources (Ogwo, Dike, Mathew,& Emmanuel,,2012). The authors also stated that the total energy stored in terrestrial biomass is not only enormous but is also highly available and renewable and that if biomass is properly harnessed, it can form a substantial part of future energy sources which will reduce the pressures on the global energy crises. The quest for biofuels in Nigeria is no doubt, a reasonable ambition. This is so because the focus on biofuel production has assumed a global dimension, and the benefits that may accrue from such effort may turn out to be enormous if the preconditions are adequately satisfied (So;kan ,Adeagba & Ann ,2015). The researchers also stated that as a member of the global community, it has become necessary for Nigeria to explore other potential means of bettering her economy Biomass refers to the diverse materials obtained from plants and animals, which can be used as raw materials for the creation of useful energy in various forms and for diverse purposes

Biomass is fuel that is developed from organic materials, a renewable and sustainable source of energy used to create electricity or other forms of power [Sharma,2016). Some examples of materials that make up biomass fuels are: scrap lumber; forest debris; certain crops manure; and some types of waste residues (Simonyan1 & Fasina, 2013). . With a constant supply of wastes – from construction and demolition activities, to wood not used in papermaking, to municipal solid wastes , bioenergy production can continue indefinitely. Biomass is a renewable source of fuel to produce energy because: waste residues will always exist – in terms of scrap wood, mill residuals and forest resources. Also, properly managed forests will always have more trees ;these trees will always have crops and the residual biological matter from those crops will also continue to exist. Biomass fuels come from things that once lived: wood products, dried vegetation, crop residues, aquatic plants and even garbage. It is known as *'Natural Materials'*. Plants used up a lot of the sun's energy to make their own food through photosynthesis. They stored the foods in the plants in the form of chemical energy. As the plants died, the energy is trapped in the residue. This trapped energy is usually released by burning and can be converted into biomass energy (American Chemical Society ,2019)

Biomass is such a widely utilized source of energy, probably due to its low cost and indigenous nature, that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, mostly for cooking and heating (American Chemical Society ,2019). In biomass power plants, wood waste or other waste is burned to produce steam that runs a turbine to make electricity, or that provides heat to

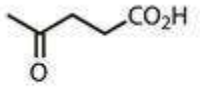
industries and homes [Sharma,2016).. Fortunately, new technologies — including pollution control and combustion engineering — have advanced to the point that any emissions from burning biomass in industrial facilities are generally less than emissions produced when using fossil fuels (coal, natural gas, oil).

Advancements in technology have allowed biomass energy to be used in a wide variety of applications, including liquids and gases used for biofuels to power transport (Demirbas, 2009).. Biofuel is any fuel that is derived from biomass—that is, plant or algae material or animal waste organisms. Biofuels are either liquid or gaseous fuel. They can be produced from any source that can be replenished rapidly, e.g. plants, agricultural crops and municipal waste. Current biofuels are produced from sugar and starch crops such as wheat and sugar cane, which are also part of the food chain (Moreira, Moraes, Aquino & Heinrichs, (2019)**.** One of the key targets for energy researchers is a sustainable route to biofuels from non-edible lignocellulosic (plant) biomass, such as agricultural wastes, forestry residues or purpose grown energy grasses (Anwar, Gulfraz, & Irshad,(2014) . These are examples of so-called advanced biofuels.

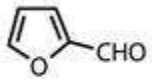
Current biofuels, such as ethanol, have a lower energy contet biomass (volumetric energy density) compared with conventional hydrocarbon fuels, petroleum and natural gas (Gnansounou, & Dauriat, 2005). The aim is to produce fuels that have a high carbon contentt /and therefore have higher volumetric energy density. This can be achieved by chemical reactions that remove oxygen atoms from biofuel chemical compounds. This process produces a so called 'drop-in biofuel', i.e. a fuel that can be blended directly with existing hydrocarbon fuels that have similar combustion properties (Karatzos,,Vandyke, McMillan, &Jack, (2016)

Efficient synthesis of renewable fuels remains a challenging and important line of research.

Levulinic acid and furfural



Levulinic Acid



Furfural

are examples of potential 'platform molecules', *i.e.* molecules that can be produced from biomass and converted into biofuels (Kakasaheb, Vishwakarma, Rathod, Simakova, & Bokade, (2020). According to the authors, Levulinic acid can be produced in high yield (>70%) from inedible hexose bio-polymers such as cellulose, which is a polymer of glucose and the most common organic compound on Earth while Furfural has been produced industrially for many years from pentose-rich agricultural wastes and can also act as a platform molecule. Recent reports have highlighted the use of organic chemistry to convert platform molecules like levulinic acid and furfural into potential advanced biofuels by specifically, changing parts of the molecules that are responsible for their structure and function. This process is called 'functional group interconversion and is part of the toolkit of organic chemistry basic (http://www.rsc.org/Membership/Networking/InterestGroups/OrganicDivision/organic-chemistry-case-studies/organic-chemistry-biofuels.asp)

Organic chemistry is the study of the structure , properties, composition, reactions, and preparation of carbon-containing compounds, which include not only hydrocarbons but also compounds with any number of other elements, including hydrogen , nitrogen, oxygen, halogens, phosphorus, silicon, and sulfur (American Chemical Society, 2019). The range of application of organic compounds is enormous and also includes, but is not limited to, pharmaceuticals, petrochemicals, food, explosives, paints, and cosmetics. Organic chemistry is a highly creative science in which chemists create new molecules and explore the properties of existing compounds. It is a popular field of study for chemists. Organic compounds are all around us. They are central to the economic growth of many counties in the areas of rubber, plastics, fuel, pharmaceutical, cosmetics, detergent, coatings, dyestuff, and agrichemical industries, to name a few.

Considering the importance of knowledge of organic chemistry in the production of biofuels, it is expedient that chemistry teachers should in the process of teaching this branch of chemistry to secondary school students try to incorporate the concept of biomass as an important source of energy. They should also link the study of organic compounds to include those chemical compounds found in biomass. The different methods of obtaining bioenergy from biomass and the main advantages of bioenergy over fossil fuels should also be taught to students. By so doing , chemistry students will become aware of the need for using biomass as a major source of energy early enough.

II. CONCEPT OF BIOMASS AND BIOENERGY

The term "biomass" refers to organicz matter that has stored energy through the process of photosynthesis. It exists in one form as plants and may be transferred through the food chain to animals' bodies and their wastes, all of which can be converted for everyday human use through processes such as combustion, which releases the carbon dioxide stored in the plant material . Many of the biomass fuels used today come in the form of wood products, dried vegetation, crop residues, and aquatic plants. Biomass has become one of the most commonly used renewable sources of energy in the last two decades, second only to hydropower in the generation of electricity. It is such a widely utilized source of energy, probably due to its low cost and indigenous nature, that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, mostly for cooking and heating (U.S Energy Information Administration ,2018)..

Biomass can be used as a source of biofuels (a renewable energy source) to reduce our dependence on fossil fuels, and to help reduce air pollution (Spanwar, Kaushik, & Kothari,2011). The authors considered biomass as carbon neutral, due to the fact that the amount of carbon released is equivalent to the amount absorbed during its life time. Biomass has been widely considered as major source of energy in both developed and developing nations Examples of biomass and their uses for energy according to Spanwar et al (2011) include:

- Wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to generate electricity
- Agricultural crops and waste materials—burned as a fuel or converted to liquid biofuels
- Food, yard, and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills
- Animal manure and human sewage—converted to biogas, which can be burned as a fuel

Biomass energy is a relatively clean, renewable energy source involving the use of organic matter which collected energy from the Sun and converted it into chemical energy when it was alive. It is a renewable source as this matter is continually growing and absorbing the Sun's energy, particularly where biomass crops are farmed. Most biomass energy is sourced from plants which have gathered energy from the Sun through the process of photosynthesis. This form of energy has been used by humans for thousands of years, since humans began to burn wood for heat. Advancements in technology have allowed biomass energy to be used in a wide variety of applications, including liquids and gases used for biofuels to power transport. The main uses of biomass energy today are for producing electricity through driving turbines and providing biofuel for transportation such as biodiesel and ethanol (UN-Energy,2007). The acceptance of bioenergy has increased together with many modern ways to utilize it, especially in many of the industrialiszed countries. The use of bioenergy instead of fossil fuels is an attractive option to reduce fossil-fuel dependency and mitigate global climate change.. Biofuels are either liquid or gaseous fuel. They can be produced from any source that can be replenished rapidly, e.g. plants, agricultural crops and municipal waste [3]. Current biofuels are produced from sugar and starch crops such as wheat and sugar cane, which is also part of the food chain The continuous increase of energy consumption has generally improved the standard of living but it has also caused serious environmental problems. Since the beginning of the pre-industrial revolution, burning fossil fuels during energy production processes has been the main source of anthropogenic emissions of greenhouse gases (GHGs), causing global climate change with potential negative impacts on climatic systems, natural environment, and human society (International Energy Agency (IEA) 2008., IPCC, 2007]. In this context, renewable energies (REs) have emerged as sustainable and environmental friendly sources of energy, which can satisfy our current and future socio-economic needs SPanwar, Kaushik,. & Kothari .(2011).

Three main categories of bioenergy resources globally used are forestry biomass, agricultural biomass and wastes biomass (McCormick &, Kåberger(2007) According to the authors,there exist forest and agriculture-based highly developed bioenergy sectors in countries such as Finland, Sweden, Germany, Austria, Brazil, and the United States of America. The spread of the modern bioenergy sector is, however, still in its primary stages in many of the developed and developing countries in the world.

III. CONVERTING BIOMASS TO ENERGY

Solid biomass, such as wood and garbage, can be burned directly to produce heat. Biomass can also be converted into a gas called biogas or into liquid biofuels such as ethanol and biodiesel. These fuels can then be burned for energy (U.S Energy Information Administration, 2018).

Biogas forms when paper, food scraps, and yard waste decompose in landfills, and it can be produced by processing sewage and animal manure in special vessels called digesters. Ethanol is made from crops such as corn and sugar cane that are fermented to produce fuel ethanol for use in vehicles. Biodiesel is produced from vegetable oils and animal fats and can be used in vehicles and as heating oil. . Some examples of biofuels and how they can be pricesssed is shown Table 1 (U.S Energy Information Administration (2018).

	Processing	**Use**
Biogas	Bacteria break down sewage in a digester	The methane in biogas can be used as a fuel for heating homes
Bioethanol	Yeast breaks down the sugar in sugar cane to produce alcohol	Bioethanol is used in Brazil to fuel cars
Fast-growing timber	Trees such as willow can be burned in power stations	Electricity is generated using renewable biomass instead of fossil fuels

The methods involved in the conversion of biomass to energy according to Selman & Hasan (2013) include the following;

1) Burning:

This is a very common way of converting organic matter into energy. Burning stuff like wood, waste and other plant matter releases stored chemical energy in the form of heat, which can be used to turn shafts to produce electricity. A simple illustration of how biomass is used to generate electricity. is shown as follows:

1. Energy from the sun is transferred and stored in plants. When the plants are cut or die, wood chips, straw and other plant matter is delivered to the bunker
2. This is burned to heat water in a boiler to release heat energy (steam).
3. The energy/power from the steam is directed to turbines with pipes

4. The steam turns a number of blades in the turbine and generators, which are made of coils and magnets.
5. The charged magnetic fields produce electricity, which is sent to homes by cables.

Other ways in which organic matter can be converted into energy include:

2) Decomposition:

Things that can rot, like garbage, human and animal waste, dead animals and the like can be left to rot, releasing a gas called biogas (also known as methane gas or landfill gas). Methane can be captured by a machine called Microturbine and converted into electricity. Sometimes, animal waste (poop) can also be converted into methane by a machine called 'Anaerobic Digester'

3) Fermentation:

Ethanol can be produced from crops with lots of sugars, like corn and sugarcane. The process used to produce ethanol is called gasification

Advantages Of Biomass Energy Over Fossil Fuels (Ecavo.com 2016)

A major advantage of biomass energy is that it produces a smaller amount of harmful greenhouse gases than fossil fuel alternatives produce (Bamisile , Abbasoglu, Dagbasi & Garba 2018; Halder, 2016).. Bioenergy derived from biomass is a promising energy alternative that can reduce the greenhouse gas emissions generated from non-renewable fuels.. Renewable energy from biomass is environmentally friendly when compared to fossil fuel resources; hence they are agent of sustainable development (Perea- Moreno, Sameron-Manzan & Alberto-Jesus,2018) Levels of the greenhouse gases methane and carbon (iv)oxide could be reduced through the use of biomass energy sources as these gases are produced by organic matter if left to decay without being used for a purpose such as this. Another environmental benefit of biomass energy is that it produces lower levels of sulfur (ivi) oxide which is a major component of acid rain. Biomass energy is easily sustainable if crops are farmed and managed effectively and is available wherever plants can be grown. Biomass energy can also be used for a range of different purposes, including heat production, fuel for cars and the production of electricity.Biofuels play an essential role in reducing the carbon emissions from transportation. The development of 'drop in' fuels produced from lignocellulosic raw materials will increase both the availability of biofuels and the sustainability of the biofuel industry".

Biomass is a renewable source of fuel to produce energy because:

- waste residues will always exist – in terms of scrap wood, mill residuals and forest resources; and
- properly managed forests will always have more trees, and we will always have crops and the residual biological matter from those crops..

Biomass power is carbon neutral electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as fodder for forest fire (Kalidasam,Srvas & Shankar,2015). The environmental benefits of biomass power generation – using biomass fuel – are clear. By using waste material for fuel in our green energy plants, we prevent that waste from burdening our landfills even more, or being left to decay on the forest floor or urban lot.

Implication of Teaching Biomass and Biomass Energy to Secondary School Chemistry Students

The importance of chemistry in national development cannot be ruled out. Chemistry has generally led to improved living conditions of mankind. Research has shown that the teacher's mode of presentation of various science concepts in the class affects performance and achievement (Bankole, Opasima,and Ige ,2010). The role of the teacher in chemistry teaching is to provide varied opportunities for students to engage in activities that will enable them make sense of the world around them, make new discoveries, solve problems and develop skills that are sustainability driven (Egolum (2013).

The concept of organic chemistry is introduced to secondary school students at the senior secondary II (SS2) class where they are taught coal, hydrocarbons petroleum and petroleum products. In their SS3, they are also taught organic chemistry II which includes alkanols, alkanoic acids, esters carbohydrates, amines, amino acids etc (Federal Ministry of Education, 2009) Many scholarly studies tried to explore awareness and perception of biomass energy among chemistry students and teachers and the findings of these studies appeared to be mixed. Some of these studies reported that students have little or negative perception of biomass energy being produced from biomass (Popp et al, 2014; Halder, Havu-Nuutinen, Pietarinen & Pelkonen, 2011; Miet., Sebastien, Gilbert & Steven ,2017;). Some studies on the other hand reported that students have positive or high perception and awareness towards biomass and biomass energy (Halder, 2016; Emmanuel, 2014; Kapasaa, Abeliotis & Scoullos, 2013).

In teaching the concept of organic chemistry to SS2 students, teachers should not limit it to studying about coal, petroleum and petroleum products as if they are the only sources of fuels to the country. The teacher should include several activities to teach the students the concept of biomass and biomass energy as a renewable source of fuel and energy, differences between fossil fuels and bioenergy resources and how the depletion of fossil fuel is a serious global issue The teaching of alkanols, carbohydrates, cellulose etc should also incorporate the current methods of obtaining biofuels like bioethanol ,biogas(methane) from biomass and also their uses as bioenergy sources. The teaching of chemical industries in SS3 should include biofuel industries –their products and the hazardous effects. Through these delivery approaches, the chemistry teacher will help to create more awareness of the concept of biomass and biomass energy to chemistry students.

When the students are best informed about these concepts at the early stage of their education and they develop interest in learning them, they will be in a better position to enhance their utilization as good sources of renewable energy in future as they are the hope of the nation as future scientists.

IV. CONCLUSION

The purpose of teaching is learning. When a lesson is prepared, we need to understand what the students want to know and what they need to know in order to encourage them to become lifelong learners. Teaching the concept of biomass and biomass energy to secondary school chemistry students will go a long way to change the students' perception positively towards the utilization of biomass as a renewable energy resource in Nigeria Considering the depletion of fossils and the serious environmental hazards associated with their use as energy resources, there is the need for a greater awareness to be created among secondary school chemistry students as they are our future scientists

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