

Sustainable energy

Is water the energy of the future?

6 segments

Part 1: Motivating launch

A video Script is presented-5 to 10 seconds- of children playing on see-saws, swings and other games; afterwards the lecturer enters the class.

(Greetings): May peace be upon you

Dear students, I am Dr. Ahmad Al Ajlouni from Jordan University of Science and Technology (JUST). Our topic today is about renewable (sustainable) energy and the idea of the fuel cell. At the beginning of this presentation, you have seen children playing many games like see-saw and swings, and you might be wondering now: how is our topic (sustainable energy) related to the games of children? I'd like to ask you back this question so that you can discuss it together, and with the teacher, and try to find some connection between sustainable energy and the games of children. To make the idea clearer to you: Is it possible to use the energy flowing from children while they are playing in a useful way? Now, I'll leave you for few minutes, and return back soon.

Part 2: Innovative idea:

Greetings again, certainly, during the time of the activity, you have tried to find ways to transform the energy from kids playgrounds into useful energy, and certainly this energy is sustainable energy. Actually, Daniel Sheridan, a young man almost of your age, did this during the time he worked as a volunteer in a school in Africa. He watched the pupils playing and having fun on their playgrounds, and thought of using the energy from kids playgrounds and transform it into useful energy. So he designed a see-saw equipped with an instrument capable of transforming kinetic energy into electric energy, which is then stored in a battery to be used in the evening. Daniel estimates that the energy produced by playing on the see-saw for 10 min is enough to light the class room for few hours. For this simple invention Daniel won many prizes.

Now, let's go back to energy in our lives. All of us realize the need of energy and its importance: Development and evolution are difficult to achieve without the availability of necessary and sufficient energy. So, the developments achieved in the previous and recent centuries are the

outcome of the discovery of certain resources of energy such as petrol, coal and natural gas...etc. The question now: Is energy actually available in all places, and is it easy to attain? Are our resources of energy sustainable and safe? For example, is it possible to provide such places with energy? Places like this, poor remote areas. Before we see how to provide such places with energy, let us present the resources of energy available to us whether natural or non natural, and let us try to sort them according to their types and nature. Are they consumable or renewable (sustainable) sources? I'll leave you for few minutes to determine the types of energy available to us and sort them into consumable (unsustainable) and renewable (sustainable) sources and try to write down the advantages and disadvantages of each type. I will return back to you in few minutes.

Part 3:

Current resources of energy and challenges:

Greetings again, during the previous activity, for sure you have found that the current resources of energy which are available nowadays, and which we rely on as major sources of energy are unsustainable and consumable. Indeed, about 95% of the energy used nowadays is consumable such petrol, natural gas, and nuclear energy. Only 4-5% of the energy we use is sustainable and renewable. In addition to being unsustainable and consumable, there are many other challenges facing us as we depend on these sources of energy, such as:

- Direct and indirect pollution, like Ozone layer depletion, and global warming.
- The continuous growth of population and the increasing demand for energy, which causes the rise of its prices.
- Limited reserve of energy, which diminishes with time.
- The difficulty of attaining energy in remote or poor regions.

Therefore, we must face this problem and find a solution for it. The proper solution is to find renewable and sustainable sources of energy. So, what we should do in order to overcome these problems and challenges that are facing us, as we depend on these sources of energy as our main sources? We need to utilize permanent energy sources that are available everywhere.

I'll leave you now for few minutes, to think of natural resources of energy available in the areas shown in this photo, and try to find out ways or methods to produce electric energy using sustainable natural sources of energy such as solar energy, wind and waterfalls, and I will get back to you in few minutes.

(figure)

Part 4:

Solar energy, and how it can be utilized.

Greetings, in the previous activity, some of you have certainly thought of using natural energy sources, such as the energy of the sun, the wind or the waterfalls, in order to produce electricity in remote places, and certainly, some of you thought of transforming solar energy into other forms of energy. Before seeing how can solar energy be used to produce fuel or electricity let us demonstrate some information about solar power and how much is this energy available in our area of the world, or on earth in general, and is there enough solar energy to supply us with our need of energy?

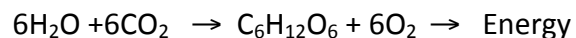
- Solar energy is estimated as 100000 Tera Watt (1 Tera watt = million –million watt)
- About 30% is reflected at the surface of the earth and its atmosphere
- Our total need of energy is estimated to be about 13 tetra watt, which means that the energy supplied from the sun is 5000 times more than our need.

In spite of the existence of many examples of utilizing solar energy such as transforming it into kinetic energy as shown in the photo, in some cars and airplanes. For instance, this plane is designed by NASA (American space agency). It uses solar energy to rotate its engines. Also solar energy is transformed into heat as in solar geezers, and it can be transformed into electrical energy as you can see in this photo; at the roof of the house, solar cells transform solar energy during the day time into electrical energy which can be stored to be used later. This technology is commonly used in Japan and Europe (as in Germany). It is also possible to convert solar energy into light using photo cells which store solar energy in the form of electricity in batteries to be used later on.

In spite of these many examples, we use no more than 1% of our total need of energy from solar energy. The question is who uses solar energy efficiently? Plants!

(Presenting a leaf from a grape tree)

Plants use solar energy efficiently in a process called photosynthesis (also called photo construction). During this process organic substances are produced, such as sugar, using solar energy and in the presence of the green substance- chlorophyll- this process is also called biomass production.



Sugar crops is one of the most efficient plants in producing biomass. It is used in Brazil to produce ethyl alcohol or ethanol, which is utilized as car fuel. So, I'll leave you for few minutes in order to discuss together how can we utilize solar energy, as plants do, to produce fuel and use it in many ways? Summarize your ideas and suggestions, and I'll get back to you in few minutes.

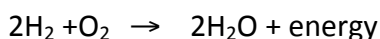
Part 5:

The idea of Hydrogen as a fuel

Greetings, in the previous activity, may be you came up with a method or methods to transform solar energy into other sorts of energy, as plants do. We saw an example of producing fuel using solar energy from sugar crops in Brazil which is used as car fuel after converting it into ethanol. Also, in the United States, ethanol is produced from corn, and may be you've noticed some time ago, that the prices of plants oils did rise as a result of the petrol price rise, because industry moved to producing fuel from plant oil, and use it as car fuel.

There is a new idea to produce hydrogen using solar energy and utilizing it as fuel. Before we see how can hydrogen be used as a fuel to produce different sorts of energy, let's get to know hydrogen, and is it a suitable fuel?

As an atom, hydrogen is the smallest element in the periodic table, and the most abundant element in the universe. As a compound, hydrogen is 30% more efficient than gasoline in producing energy. When used in a galvanic cell hydrogen 100-200% more efficient than benzene. From an environmental point of view, hydrogen does not release harmful gases such as carbon dioxide or other oxides. When burned, hydrogen produces water alone, as in the following chemical equation:

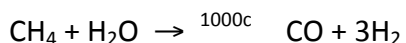


Therefore, using hydrogen as a fuel is safe and harmless to the environment and causes no pollution to it. If we take into consideration both environmental and efficiency factors, hydrogen is considered as an ideal fuel.

Now, how hydrogen can be produced?

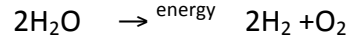
It is possible to produce hydrogen chemically in many ways:

- From Hydrocarbon compounds, as in the following formula:



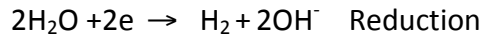
This process requires high energy, and usually occurs under high pressure.

- It is also possible to produce hydrogen from water as in the following equation:

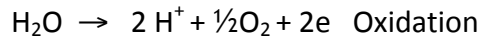


This process is called analysis of water (or water splitting), and it usually requires energy.

This process is done via electrical analysis as in the figure



(Figure)



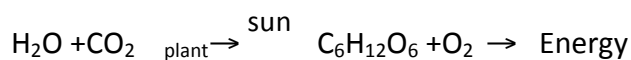
Water splitting is divided into two processes, in the first water is reduced and hydrogen is produced. In the second water is oxidized to produce oxygen.

The question now is, how can solar energy be used instead of electrical energy to analyze water?

We have seen a good example for using solar energy to produce biomass which is plant. We can follow the same model in splitting (or analyzing) water.

Before seeing how to separate water using solar power, let us see how the photosynthesis proceeds, and are the photosynthesis and the splitting of water are similar?

Photosynthesis occurs in plants in the existence of chlorophyll, which is symbolized here by P. P absorbs the solar light which causes its activation. This activated substance reduces water and carbon dioxide to produce biomass such as sugar. P is then transformed into a positively charged substance capable of oxidizing water to produce oxygen. The process is occurs completely as shown in the following chemical equation:



Is it possible to use the same method to produce hydrogen from water?

The separation of water into hydrogen and oxygen requires energy. In this process water is oxidized into oxygen, and reduced into hydrogen, as in the following figure.

(Figure)

That's why we need a substance which is capable of absorbing sunlight and able to reduce water on one hand, and oxidize it on the other hand.

That's why we need what is called a photo catalyst.

Now, after we have seen that the two processes are similar, and that we can apply the natural way of producing biomass in plants on the separation of water, and the production of hydrogen gas, or the hydrogen fuel, a suitable photo catalyst must exist.

Now, I'll leave you to think and deduce the criteria of the photo catalyst which is suitable to separate water and produce hydrogen using solar energy. Summarize your ideas and suggestions, and I'll be back soon.

Part 6:

A suitable photo catalyst, that's all what we need.

Greetings, during the activity, for sure you have inferred some of the criteria of the suitable photo catalyst to be utilized in the process of water splitting, and the production of hydrogen using solar energy, such as being stable, efficient, and capable of splitting of water to produce hydrogen and oxygen after absorbing sunlight. Also, during this process, the catalyst should suffer no chemical changes.

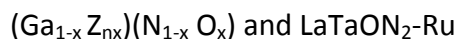
Semiconductors are substances that can work as photo catalysts. When they absorb light, the electrons jump to higher energy levels, as a result, one side of the semiconductor becomes positively charged, and the other side becomes negatively charged. The negative side reduces water to produce hydrogen, while the positive side oxidizes water to produce oxygen.

(Figure)

Examples of this type of photo-catalyst are:

solid substances containing elements such as Si, O, P, N. One of these substances is ceramic.

Other substances composed of metal oxides, and nonmetal oxides. These are usually composed of more than one compound and occur in different ratios, as in the following examples:

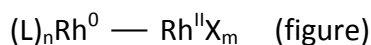


There are also some transition elements and compounds which work as photo catalysts, such as the compounds of ruthenium (Ru), titanium (Ti), rhodium (Ru), and platinum (Pt). They can be used to produce hydrogen from water using solar energy. It works as follows:

Platinum absorbs sunlight and oxidizes water into oxygen. Electrons move to the other side, the side of rhodium, so it reduces water to produce hydrogen.

(Figure)

Elements in these compounds are usually of the same type, as in the following two examples, or different types as in the previous example. In all cases one element is of high oxidation, it makes the oxidation process. The other element has low oxidation, it makes the reduction process.



In addition to these compounds and substances, there are some biological catalysts like chlorophyll itself, and they contain magnesium (Mg), iron (Fe), molybdenum (Mo), and Manganese (Mn).

After presenting how to produce hydrogen from water, let us summarize the whole process starting from producing hydrogen till using it as a fuel to produce different sorts of energy.

It can be summarized as follows:

The photo catalyst absorbs sunlight to produce hydrogen from water, then hydrogen is stored to be burned in a fuel cell to produce different sorts of energy such as heat, electric energy, mechanical energy and to be used in car engines.

Modern technology in car industry focuses on producing cars that use hydrogen fuel, for example:

HONDA, BMW, TOYOTA, MERCEDES, GM, FIAT

All these giant companies focus now on manufacturing cars that operate on hydrogen fuel. Some of these, like H5-HONDA operate on hydrogen fuel alone. Others, like BMW, called Hybrid Car operate on both hydrogen fuel and gasoline fuel at the same time.

Although there are some examples of good achievements in this field, there are many challenges facing hydrogen production and use as a fuel in cars, some of these challenges are: The existence of a photo catalyst that is efficient and stable to produce hydrogen using sunlight. Storing hydrogen fuel and transporting it from one place to another. The mechanism of burning hydrogen in a car, and its efficiency in producing energy, (what is called fuel cell technology).

For more information, you can refer to the following websites:

<http://www.hydrogencarinfo.com>

<http://www.hydrogencarsnow.com>

<http://www.fueleconomy.gov>

<http://www.transoptions.org>

They are directly related to the topic of using hydrogen as a fuel. You can do web search yourself using some keywords as *hydrogen cars* and *fuel cells*, so that you can educate yourself and follow up with the challenges that still hinder the application of the technology of hydrogen production, and use as a fuel.

At the end, I'd like to thank you all for your good listening, and remember that chemistry and other basic sciences are our aid to maintain progress and prosperity.

Sustainable energy

Is water the energy of the future?

Teacher's Guide

- In this part I'll address the teacher (chemistry teacher)
- The goal of this video presentation is to identify the role of chemistry in our lives, and to motivate our students' interest in chemistry, and boost their conception of its principles, so that they can be creative someday.
- All video scripts should be presented at the same class session, because they are related to each others.
- Within these parts, there are classroom activities to be implemented by the students who work in groups of 4-5. The activities aim at relating the previous part to the next part, they also aim at the participation and motivation of students. Try to motivate student's interest during the activity, and help them to focus on the topic, so that they become ready and curious to proceed to the next part.

Part 1: is a "motivating beginning". The activity that follows aims at the participation of students, and the stimulation of their interest.

Part 2:

- Illustrates the possibility of innovation for the students, and may be one of them will come up with a simple, yet important idea as Daniele Sheridan did (a young man almost of their age).
- This part confirms the importance of energy in our lives. It is concluded with the activity about currently used resources of energy, and sorting it into sustainable (renewable) sources, and unsustainable (consumed) sources, and summarizing the advantages and disadvantages of each, in order to figure out the challenges and problems that we face, as we depend mainly on consumable resources.

Part 3:

- Allows students to recognize the challenges and problems that we face, as we depend mainly on consumable resources, such as limited availability, cost, and the pollution caused by using it.
- Hence, sustainable, available everywhere and clean resources must be found.
- This part is concluded with a classroom activity that boosts students' participation, in finding solutions for this problem, and thinking of using natural, permanent, and available resources. They are asked to provide electricity for some remote areas, or where current resources of energy, such as petrol and gas are not available.

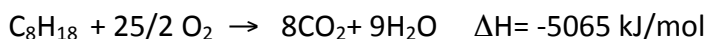
Part 4:

- This part focuses on solar energy, and its great power, and to what extent do we use it, so that we come to the conclusion that we don't use this sustainable, huge energy sufficiently and efficiently.
- Then, students' attention is directed to the efficient user of solar energy; plants in photosynthesis, to produce biomass. This process represents the best natural example of storing solar energy as fuel (biomass).
- Here, the motivating activity is introduced to stimulate students to come up with genuine ideas of using solar energy to produce fuel as plants do.

Part 5:

- The previous activity aims at guiding students thinking towards utilizing solar energy or other permanent resources of energy to produce either organic or nonorganic fuel.
- Hence, the idea of producing hydrogen from water using sustainable natural resources of energy is developed. Examples of these resources are the energy of sun, wind, and waterfalls.
- Here, we should get to know hydrogen as an element, compound, and whether it is a suitable fuel.

- It is possible to let students do some math exercise to make sure that hydrogen is an efficient fuel in comparison with gasoline which is used in cars. This is accomplished by calculating the energy that is released when 1gm of hydrogen and another gm of octane (C₈H₁₈) are burned. According to the following equations:



- Students will find out that **hydrogen is a suitable fuel, and may be considered ideal.**
- Afterwards, methods of producing hydrogen are introduced to the students. More emphasis is directed towards the process of analyzing water to produce hydrogen using sunlight.
- Then, both processes of photosynthesis and water splitting are chemically compared. The result to be inferred is that both processes are alike; in each process water is oxidized and reduced.
- As a result, hydrogen can be produced from water using sunlight in a process that resembles photosynthesis in plants.
- All we need to implement this process is the availability of **a suitable photo catalyst.**
- The concluding activity of this part allows students to infer the criteria of the photo catalyst which is suitable to convert water into hydrogen and oxygen using sunlight.

Part 6:

- In this last part, the characteristics of the desired photo catalyst are illustrated. Also, the activation of the photo catalyst via sunlight, in order to analyze water, is demonstrated. Then, chemical substances and compounds are introduced as exemplars of photo catalysts that can be used for the purpose.
- Afterwards, a synopsis of the process of producing hydrogen from water, storing and using it to produce energy in various ways as required, is presented.
- We conclude by presenting the recent achievements of car technology, cars that operate on hydrogen fuel.
- Finally, students are invited to search for the current challenges that face us in the field of producing, storing and using hydrogen in various ways, especially as cars fuel.

At the end, I'd like to thank you for choosing this video, hoping that the sought idea is conducted by you to the students. This is achieved by motivating the students, and motivates them towards chemistry and other basic and natural sciences, which is of real importance in our live in order to maintain growth and development in our societies.

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You can also refer to the website of the BLOSSOMS at:

<http://blossoms.mit.edu>