Lesson Artificial Photosynthesis

Subject Area(s) Biology, Chemistry

Associated Unit

Lesson Title Artificial Photosynthesis

Header

Grade Level 11(10-12)

Lesson # __ of __

Lesson Dependency

Time Required 20 minutes

Summary

Alternative energy is a hot topic among scientists and politicians. While many people know about solar energy, they are unaware of artificial photosynthesis and how they differ. This lesson is an introduction into utilizing photosynthesis as an energy source.

Engineering Connection

Scientists engineer catalysts that can be used for artificial photosynthesis. Engineers are also responsible for designing energy conversion systems and household conversion systems.

Engineering Category = # 1 & 3

Choose the category that best describes this lesson's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

catalyst, energy, metal-complex, photosynthesis, research

Educational Standards

Choose from http://www.jesandco.org/asn/viewer/default.aspx.

ITEEA

Standard 4. Students will develop an understanding of the cultural, social, economic, and political
effects of technology. Grades 9-12:

I. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.

Standard 5. Students will develop an understanding of the effects of technology on the environment. Grades 9-12:

H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.

J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.

State/national science/math/technology (provide source, year, number[s] and text):

TEKS BIO 9B: The student knows the significance of various molecules involved in metabolic

processes and energy conversions that occur in living organisms. The student is expected to compare the reactants and products of photosynthesis and cellular respiration in terms of energy and matter;

Pre-Requisite Knowledge

It is best if the students already understand photosynthesis and related pathways. A brief overview of photosynthesis is given however the students should already understand major concepts. It is also necessary that the students understand chemical energy and electrical energy. Students do not need to understand solar energy however it is helpful for comparison.

Learning Objectives

After this lesson, students should be able to:

- **Explain artificial photosynthesis**
- **Explain the difference between solar chemistry and artificial photosynthesis**
- **Argue for or against total conversion to solar energy for the community**

Introduction / Motivation

This lesson follows a power point presentation.

Last class we studied photosynthesis. Plants use the sun as a food source. We, humans, can't utilize this process as an energy source. Or can we? Everyone has seen solar cells on roof tops, the school zone warning light, toys, or on cell phone recharging devises. So what is solar power? [Pause for student's responses. Change slide] Solar power is the process of changing the energy of the sun into electrical energy. Does everyone remember their chemistry and physics and the different types of energy: electrical, chemical, mechanical, potential, and kinetic. So what is electrical energy? [Pause for student's responses. It is the flow of electrons through a system which we use as our main source of energy for lights, heating, everyday lives.] So how do we turn sun rays into air conditioning or power for our TVs? [Pause for student's responses.] We use photovoltaics, semiconductors to turn light into electrical energy, or concentrate solar light via mirrors to heat up a system. Photovoltaic systems are the most common and are seen everywhere. A concentrating solar power plant uses mirrors to redirect the sun's rays to a single point where it heats up a source converting solar into electrical energy. [Change slide.] So how exactly does solar power and photosynthesis differ? They both use the sun's energy as a fuel source. The biggest difference between the two is the type of output energy. Solar power creates electrical energy and photosynthesis creates chemical energy. Remember plants produce sugar which is used as a fuel source. [Change slide.] So what about artificial photosynthesis? If plants can do it, why can't we? Scientists are harvesting sunlight to split water molecules which provides a chemical energy source, hydrogen. The oxygen-hydrogen bond of water is a high energy bond meaning the breaking of the bond is endothermic. However the potential of hydrogen as a fuel source is greater than the energy needed to split water. Sugar is great for cookies but not for powering a car. So we must change the output of artificial photosynthesis to produce chemicals we can utilize in our cars and homes. Methanol and ethanol are carbon based molecules that we can use as a fuel source. [Change slide.] The main hurdle scientists are working on is powering the reaction. Remember splitting water is endothermic, it requires energy to proceed. One molecule of water requires more energy than a AA batter! So why do this? Why are scientists using artificial photosynthesis instead of other forms of alternative energy? [Pause for student's responses. Change slide.] The answer is catalysts. Scientists are using catalysts to reduce the energy of activation for the splitting of water. Just as plants use enzymes, we're using catalysts. These catalysts will aid in producing hydrogen and methanol.

The problems are solved! Or are they? [Change slide.] What happens when it's cloudy outside? Or at night? Here is a diagram, which is very possible. Solar panels and artificial photosynthesis panels would be on your roof or in a sunny spot away from trees. The sunlight would be stored as hydrogen and oxygen then recombined to power the daily needs of the household. Remember the true value is in the hydrogen. So, solar photovoltaics could power everything in the day time while artificial photosynthesis is creating energy for night time. We'd never run out of fuel, assuming it is sunny every day of the year. But what about the costs? Technology is only getting cheaper however it is currently a little expensive.

Lesson Background & Concepts for Teachers

Articles for further information:

Gust, Devens; Moore, Thomas A.; and Moore, Ana L. "Solar Fuels via Artificial Photosynthesis." Chem. Res. Volume 42, No. 12, Pages 1890–1898, 2009. doi: 10.1021/ar900209b

McConnell, Iain; Li, Gonghu; Brudvig, Gary W. "Energy Conversion in Natural and Artificial Photosynthesis." Chemistry & Biology. Volume 17, Issue 5, Pages 434-447, 28 May 2010. doi:10.1016/j.chembiol.2010.05.005

Regalado, Antonio. "Reinventing the Leaf." Scientific American. Volume 303, No. 4, Pages 86 - 89, 2010. doi:10.1038/scientificamerican1010-86

Image

Vocabulary / Definitions

Word	Definition
Endothermic	Requires heat/energy

Associated Activities

Lesson: Photosynthesis - Life's Primary Energy Source

Basic lesson on photosynthesis and how plants use sunlight to make sugar.

TE Activity: Corn for Fuel?!

Students perform an experiment that studies the effect that a variable of their choice has on plant growth. They use the result to inform decisions about designing a biofuels refinery.

Lesson: Renewable Energy

Introductory lesson on using solar, wind, and water as an energy source.

TE Activity: Solar Power

Students learn how solar energy is used to heat buildings by investigating the thermal storage properties of some common materials: sand, salt, water and shredded paper. Students then evaluate the usefulness of each material as a thermal storage material to be

used as the thermal mass in a passive solar building. This lesson plan helps students learn how the sun can be used for heating.

Lesson Closure

Comparing solar power to artificial photosynthesis, which is better? [Pause for student's response.] Current technology is a little expensive, but you would buy into solar-fuel? [Pause for student's response.] If nature has figured out how to use the sun for energy, what other lessons can we learn from nature? [Pause for response.] What else can we engineer that resembles items nature has already figured out?

Assessment

Pre-Lesson Assessment

Ask the students what they know about solar energy and alternative energy.

Post-Introduction Assessment

Be sure to include every student during the introduction. Let each student answer the questions asked during the introduction.

Lesson Summary Assessment

Ask the students to think of an alternative fuel source other than solar, wind, and water.

Homework

None. This is an introduction lesson to artificial photosynthesis.

Lesson Extension Activities

Additional Multimedia Support

References

Power point image references

http://inventorspot.com/articles/sun_your_engine_or_photosynthesis_without_plants

http://sohowww.nascom.nasa.gov/

http://gotpowered.com/2010/photosynthesis-as-an-energy-source-whether-natural-or-artificial/

Tom White, MIT. http://www.geoisla.com/2008/08/18/major-discovery-from-mit-primed-to-unleash-solar-revolution/

http://gigaom.com/cleantech/dye-sensitized-solar-scores-morgan-stanley-backing/

http://trendsupdates.com/how-useful-would-nocera%E2%80%99s-artificial-photosynthesis-be/

Attachments

Artificial Photosynthesis (pptx)

Artificial Photosynthesis (pdf)

Other

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Supporting Program
NSF GK-12 Program, College of Engineering, University of Houston, Houston, TX.

Version: September 2010