Lesson Plan: Electrochemistry: Use of Electrolysis to Reduce Global Carbon Emissions

Teacher-contributed lesson plan by Dr Richa Arora (Shivaji College) and Dr Upasana Issar (Kalindi College), University of Delhi, India.

As a **high school** or **introductory undergraduate Chemistry** or **Environmental Sciences** teacher, you can use this set of computer-based tools to help you in teaching the **basics of electrochemistry** and how the **application of electrolysis** can potentially reduce the global carbon dioxide emissions.

This lesson plan includes an interactive classroom activity to teach about **electrochemical reactions**, **electrolysis**, and **electrolytic cells**. It also includes resources to explain to your students how electrolysis may be used to reduce global carbon dioxide emissions from large-scale processes such as **world-wide cement production**. Global cement production contributes significantly to increasing levels of atmospheric greenhouse gases such as carbon dioxide resulting in global warming and climate change.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in **Chemistry** or **Environmental Sciences**.

Use this lesson plan to help your students find answers to:

- Give examples to illustrate the use of electrochemistry in daily life.
- What are the differences in voltaic and electrolytic cells?
- Explain how electrolysis may be used in large scale cement production to reduce global carbon dioxide emissions.
- Describe some possible applications of electrochemical processes to reduce carbon emissions.

About the Lesson Plan

Grade Level: High School, Introductory Undergraduate

Discipline: Chemistry, Environmental Sciences

Topic(s) in Discipline: Electrochemistry, Reduction and Oxidation (Redox) Chemical Reactions, Half-cells, Salt Bridge, Electrolysis, Electrolytic Cells

Climate Topic: Climate and the Atmosphere, Climate and the Anthroposphere, Climate Mitigation and Adaptation

Location: Global

Access: Online, Offline

Language(s): English

Approximate Time Required: 70-100 min

1 Contents

https://soundcloud.com/mitnewsoffice/audio-article-new-approach-suggests-path-to-emissions-free-cement

4. Optional: Reading (30 min)

A reading to describe the commercial application of electrochemical carbon dioxide reduction technologies.

This can be accessed at:

https://www.sciencedirect.com/science/article/pii/S2451929418303711#sec5

5. Suggested questions/assignments for learning evaluation

- Give examples to illustrate the use of electrochemistry in daily life.
- What are the differences in voltaic and electrolytic cells?
- Explain how electrolysis may be used in large scale cement production to reduce global carbon dioxide emissions.
- Describe some possible applications of electrochemical processes to reduce carbon emissions.

2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Topic introduction and discussion

Use the teaching module, 'Electrochemistry' by Libretexts™ to teach your students the basics of electrochemistry. Navigate to the relevant sub-sections to explain electrochemical processes such as oxidation-reduction (redox) reactions and electrolysis. Use the tool to teach about voltaic/galvanic cells and electrolytic cells, and their differences. Describe Faraday's law of electrolysis, cell potentials, Half-Cell reactions, Nernst Equation, thermodynamics of electrochemical reactions, and details of redox chemistry. Finally, describe a few applications of electrolysis such as electroplating and batteries using galvanic cells.

This can be accessed at:

https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry

2. Classroom/Laboratory Activity

Use the interactive simulation, 'Electrolysis', provided by University of Oregon, to extend your students' understanding of the process of electrolysis. Note the 'Learning Objectives' to teach your students about the various aspects of electrolysis and electrolytic cells. Download the attached 'ElectrolysisCellStudentActivity' word document as a guide to conduct this activity in the classroom. Use the link given within the tool to launch the simulation to enable your students to understand the quantitative and qualitative aspects of electrolysis and to visualize how it works at the macroscopic and microscopic levels. Use the built-in demonstration to explain how the simulation can be used to experiment with the variables involved in operating an electrolytic cell. Direct your students to run the simulation for different electrolytic conditions and note their observations. Use the list of questions given under the 'Learning Outcomes' tab and in the student activity sheet to assess your students' understanding of the topic. Finally, discuss how electrolytic cells are used in real life.

This can be accessed at:

https://chemdemos.uoregon.edu/demos/Electrolysis-Computer-Simulation-New-HTML5-Version#

3. Discuss further

Play the video, 'Calcium Carbonate- Disintegrating Quicklime' by the Royal Institute, London, to explain how producing cement results in the release of carbon dioxide through heating and slaking processes, thus adding to atmospheric greenhouse gases that can cause global warming.

This can be accessed at:

https://www.youtube.com/watch?v=TOCV3fYY-_c

Use the audio podcast, 'New approach suggests path to emissions-free cement' by the MIT News Office, to explain how the world-wide large-scale cement production significantly contributes towards global carbon emissions. Use the tool to describe a new process involving electrolysis, developed by MIT researchers, to eliminate carbon emissions from cement production. The scientific paper detailing this study can be accessed separately in the additional resources section of this lesson plan.

This can be accessed at:

https://soundcloud.com/mitnewsoffice/audio-article-new-approach-suggests-path-to-emissions-free-cement

4. Optional Reading: Homework Assignment (30 min)

Use the scientific review, 'Progress toward Commercial Application of Electrochemical Carbon Dioxide Reduction' by Chi Chen et al., Chem, to enable your students to understand how various electrochemical processes are being developed to reduce global carbon emissions that contribute towards global warming and climate change.

This can be accessed at:

https://www.sciencedirect.com/science/article/pii/S2451929418303711#sec5

5. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- Give examples to illustrate the use of electrochemistry in daily life.
- What are the differences in voltaic and electrolytic cells?
- Explain how electrolysis may be used in large scale cement production to reduce global carbon dioxide emissions.

- Describe some possible applications of electrochemical processes to reduce carbon emissions.

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- understand the basics of electrochemistry
- learn about electrolysis, electrolytic cells, and their applications in real life
- describe the use of electrolysis in commercial processes to reduce global carbon emissions

4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

1. **Reading; 'Toward electrochemical synthesis of cement- An electrolyzer-based process for decarbonating $CaCO_3$ while producing useful gas streams'**

A research paper by Leah Ellis et al., PNAS, that details the development of an electrolytic process that could be used in commercial cement production to eliminate the release of carbon emissions.

This can be accessed at:

https://www.pnas.org/content/early/2019/09/10/1821673116

2. Reading; 'Q&A: Why cement emissions matter for climate change'

A reading by Carbon Brief with multiple links to further readings and visualizations about how the carbon emissions from global large-scale cement production affects global warming and climate change.

This can be accessed at:

https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and
ownership details for each tool by following the individual links provided.
We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. Teaching Module; 'Electrochemistry'

Published by Libretexts™

2. Interactive Simulation; 'Electrolysis'

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3. Video; 'Calcium Carbonate- Disintegrating Quicklime'

By the Royal Institute, London.

4. Audio Podcast; 'New approach suggests path to emissions-free cement'

By the MIT News Office.

5. Reading; 'Progress toward Commercial Application of Electrochemical Carbon Dioxide Reduction'

By Chi Chen, Juliet F. Khosrowabadi Kotyk, Stafford W. Sheehan, Chem, Volume 4, Issue 11, 8 November 2018, Pages 2571-2586.

6. Additional Resources

Leah D. Ellis, Andres F. Badel, Miki L. Chiang, Richard J.-Y. Park, Yet-Ming Chiang, Proceedings of the National Academy of Sciences, Jun 2020, 117 (23) 12584-12591.

Carbon Brief