

Polyelectrolyte Multilayers

Structure-Function-Properties Series

Instructor's Guide

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CHEM 101

RESOURCES

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DEVELOPED BY THE TEACHING AND LEARNING LABORATORY AT MIT
FOR THE SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Introduction

When to Use this Video

- In Chem 101, at home/in class/in recitation, after lecture number 27.
- Prior knowledge: the concepts of pH and pK_a , be able to recognize common chemical functional groups.

Learning Objectives

After watching this video students will be able to explain how the concepts of pH and pK_a are useful in the design of materials via layer-by-layer assembly.

Motivation

Often, traditional introductory chemistry instruction limits students' exposure to pH and pK_a to buffer calculations. This video highlights the utility of pH and pK_a in a research application.

Student Experience

It is highly recommended that the video is paused when prompted so that students are able to attempt the activities on their own and then check their solutions against the video.

During the video, students will consider whether particular functional groups on given polymers will be positively or negatively charged at given conditions.

Key Information

Duration: 10:55

Narrator: Nisarg Shah

Materials Needed:

- paper
- pencil

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Video Highlights

This table outlines a collection of activities and important ideas from the video.

Time	Feature	Comments
1:21	Chapter 1: The structure of polyelectrolyte multilayers (PEMs)	Explanation and lab footage of the dip method used to create polyelectrolyte multilayer films.
4:32	The pK_a s of the functional groups on two polymers are given.	Students are asked to consider what the charge on each polymer would be (positive or negative) given that the film is being assembled at a pH of 4.
5:24	Chapter 2: Designing PEMs with function and properties in mind	The challenge of effective therapies for large bone defects is posed as a motivation to engineer scaffolds coated with a multilayer film to encourage bone growth.
8:52	Chapter 3: Testing it out	Preliminary results indicate that the coated scaffolds encourage the deposition of bone minerals and collagen.
9:58	To Review	

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Video Summary

In this video, students learn about layer-by-layer assembly of polyelectrolyte multilayer films. They see how the chemical structure of the macromolecules used in the films affects the function and properties of the film. Students learn how these films have been used to regenerate bone tissue components in rats.

Chem 101 Materials

Pre-Video Materials

When appropriate, this guide is accompanied by additional materials to aid in the delivery of some of the following activities and discussions.



1. Group review: What do K_a and pK_a tell you?

Help students recall the physical significance of the acid ionization constant, K_a . Then have them consider how knowing an acid's pK_a might give us useful information. You may wish to formally list the ideas that students come up with on the board. Push students to support their statements with reasoning. For example, if a student says “The lower the pK_a , the stronger the acid,” check for understanding by asking the student to explain how they know this.



2. Elicit students' prior knowledge of polymers



Students may or may not be familiar with polymers. The following activity can be used to gain insight into what students already know about polymers, what the gaps are in their understanding, and what misconceptions they may have.

Have students work in groups of 3-4. Give each group an item from the following list (or a similar everyday item) and ask them to discuss how the item(s) are “like a polymer” and “not like a polymer”. Allow groups 3-4 minutes to discuss and then ask groups to share out to the larger class.

Possible items: (You may substitute other items. Consider the possible responses students may come up with and what descriptions/properties of polymers you wish to highlight. If you have a very large class, more than one group can receive the same object.)

- 5-6 paperclips linked together
- pinecone
- small, plastic bottle containing shampoo or lotion
- packet of sugar
- twist tie
- plastic baggie
- small, rigid plastic container

Post-Video Materials



Reflection

Have students think back to the list of ideas they generated on the utility of pK_a before watching the video. Do they have any new ideas to add? Did the video help them see pK_a differently?

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Additional Resources

Going Further

Students going on to study organic chemistry will continue to use the concept of pK_a when studying and designing chemical reactions. The paper by Rossi, below, discusses many of the useful aspects of pK_a in organic chemistry.

References

- Hammond, P. T. (2012). Building Biomedical Materials Layer-by-Layer. *Materials Today*, 15(5), 196-206.
- Rossi, R. D. (2012). What Does the Acid Ionization Constant Tell You? An Organic Chemistry Student Guide. *Journal of Chemical Education*, 90(2), 183-190.
- Shah, N.J.; Macdonald, M.L.; Beben, Y.M.; Padera, R.F.; Samuel, R.E.; Hammond, P.T. (2011). Tunable Dual Growth Factor Delivery from Polyelectrolyte Multilayer Films. *Biomaterials*, 32, 6183-6193.

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RES.TLL.004 STEM Concept Videos
Fall 2013

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