

Teaching-learning materials compiled by the PARSEL consortium
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Cooperating Institutions and Universities within the PARSEL-Project:



For Teachers

Chitosan – Fat Magnet!?

A grade module on poly-saccharides and nutrition

Subject: Chemistry

Grade level: 12-13 graders

Curriculum content: Carbon hydrates (Poly saccharides)

Kind of activity: 1. Whole class discussion, 2. self-directed resource based learning, 3. small group lab experimentation, 4. Reflection, presentation, discussion, decision making

Anticipated time: 8 to 12 lessons of 45 minutes each

Introduction

Many nations with coastal regions involved in fishing or breeding crustaceans (crabs, shrimps) are confronted with the problem of millions of tons of waste in the form of crab shells. Intensive research has found several applications for the main ingredient chitin in form of its derivative chitosan to solve this environmental problem producing valuable products from waste. This module will give an introduction to chitosan, work out how to cope with the environmental problem of crab waste and evaluate critically the use of chitosan as slenderizing agent. The teaching approach is chosen in accordance to the cognitive apprenticeship model (see teacher notes). During the modeling phase the teacher (as an expert) introduces the students to the content of crab shells, chitosan and its application as a fat reducer, as well as to the competences and strategies of how to solve everyday life science based questions and make adequate decisions. During the group phase the students work self-directed in small groups on questions which have not been answered during the modeling phase.

Developer: Wolfgang Gräber

Institution: IPN – Leibniz Institut für die Pädagogik der Naturwissenschaften an der Universität Kiel

Country: GER

One of the most popular applications of chitosan is slimming enhancing. Chitosan: Best friend of the bodybuilder! Chitosan – gives fat a ticket out of your body! These are slogans used by producers in advertisements. But are they right? Do they tell the truth? And how should this work?

The effectiveness of Chitosan is an adequate problem to work on. Chitosan can be gained from Chitin, structural substance of crab- or shrimp shells. Following cellulose it is the second frequently met naturally produced polymeric worldwide, so it's no exotic substance but quite common and with many application opportunities. For teaching chemistry it's also important that it can easily be used to demonstrate structure-property interdependencies.

Pre-Requirement Knowledge:

Contents: The students had been taught a sequence on carbon hydrates and learned about cellulose as a poly saccharide.

Properties of glucose, composition and structure of the glucose molecule

Asymmetric C-atom, isomerism, optical activity

Some mono-saccharides and its appearance in nature

Glycosidic bonding

Starch and cellulose as polymeric compounds

Skills: The students are familiar with conducting experiments on their own. They can operate computers, and are to some extent able to google information.

Linkage to the Syllabus:

In the Schleswig-Holstein curriculum the area 3 in grade 12/13 in the field of carbon hydrates refers to the topic handled here. It can also be used in the field of analytics (area 9). The sequence can suit each of the following topics:

- Carbon hydrates
- Structure-property interdependencies

Position in the Teaching Sequence:

The Chitosan project can be taught as an advanced course deepening the knowledge on carbohydrates, but also extent it to more everyday life topics like healthy nutrition/ balanced diet.

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Teaching/Learning goals

Scientific concepts: Chemical structures of chitin and chitosan and its properties, Chitosan's possible reactions in human body, applications of chitosan in different areas (biochemistry/medicine, cleaning water, preparing fruit juice ...) and its explanations based on the substances properties

Skills: Formulating an inquiry question and a hypothesis, planning and performing an inquiry, planning and performing an experiment, communicating and presenting ideas and results, managing information and knowledge, identifying, evaluating and using information from the internet and other sources, using digital mind mapping to support one's performance, communicate with partners from industry, make own decisions based on scientific knowledge and personal values

Teaching guide

Lesson sequence

(1) During the **introduction phase** the teacher works together with the students on the following questions and introduces the students to the new content (chemistry chitosan, poly-saccharide) and (if necessary) to the strategies and tools used to work on this question (internet browser, search engine, mind manager)

- Are there any useful information about chitosan as fat blocker on the web?
- What is Chitosan?
- Which properties characterize Chitosan?
- How does Chitosan interact with fat?
- Where do we find Chitosan in nature?
- How can we produce Chitosan?

(2) The teacher leaves many open questions but has provided the students during the first phase (as a kind of advance organizer) with content knowledge and adequate strategies. During the second phase the students work in small groups on the open questions. They try to find information about chitosan as fat magnet, about the structure, production and properties of chitosan. They carry out own experiments e.g. to produce chitosan from shrimp (crab) shells and try to find out how it reacts with fat.

(3) The third phase is dedicated to answer the questions of the starting phase. The students have learned how to produce chitosan from shrimp shells, they have learnt how chitosan reacts with fat or fatty acids. They have read some papers on chitosan as fat blocker giving differing information. Does it work or does it not work? They reflect their findings, discuss them with their classmates and prepare a public presentation with posters, experiments and Powerpoints. The overall question is not only about its chemical functioning but also about should we use this substance ourselves or recommend it to friends to control weight? This question leads beyond pure science, includes general problems with drugs/ pharmaceuticals and balanced diets and healthy way of living.

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Time Frame:

The task includes three sections:

1. The introduction phase: about 90 minutes (1 double lesson)
2. The inquiry phase: about 360 minutes (4 double lessons)
3. Presenting and discussing the outputs and the inquiry conclusion (decision making process): about 90 minutes (1 double lesson)

First phase

The teacher shows how to find adequate information on the world wide web. With Google and the keywords chitosan and fat blocker there are lots of hits (26.02.2009: 93500 in English language). The internet shows us lots of advertisements with information referring to Chitosan (here two examples):

“The Chitosan fat blocker is dietary fiber supplement that is made from the shells of shrimp, crabs, and other crustaceans. It has been marketed as a fat blocker for years due to early clinical research studies that were done on lab animals back in the 1980’s. The preliminary studies showed that the product was effective in binding with fats that are ingested. These fats are usually broken down in the digestive tract by pancreatic enzymes and bile. Chitosan is designed to stop them from breaking down the fats. This in turn keeps the fats from being absorbed by the body.

The claims are that Chitosan interacts with pancreatic lipase and bile in the small intestine. This renders these enzymes inert. They cannot then actively break down fats in the small intestines as they are designed to do. The fats are then carried along with the fiber through the large intestine to be flushed from the body in the stool.

When the preliminary studies looked very promising, manufacturers jumped on the bandwagon, producing the supplement and marketing it for sale. However when further studies that were done on human subjects, different results were to be had, unfortunately. Dr Judy Stern at the University of California studied the supplement to judge its effectiveness on fat absorption in the body of humans. The results of the study showed that this supplement did not inhibit the pancreatic enzymes from metabolizing fat molecules. Therefore it was not able to inhibit fats from being metabolized by the body as earlier claims had stated. When the study was published, the manufacturer did dispute this study. Results of the dispute could not be found. However, a further study in Singapore gave the same results as Dr Stern’s study, backing up the original data from the University of California’s study.” (<http://www.weightlossnutrition.org/chitosan-fat-blocker/>)

Pharmaceutical studies show no positive effect of chitosan for weight loss (Google: chitosan Pharmaceutical studies): E.g.: “The new study, published in the September issue of the International Journal of Obesity (28, 1149-1156), is one of the largest to date. The researchers assigned 250 adults, with an average body mass index of 35.5, to receive either 3g of chitosan daily or a placebo for 24 weeks. All participants received standardized dietary and lifestyle advice for weight loss.

The researchers from the Clinical Trials Research Unit in the University of Auckland report that the chitosan group lost more body weight than the placebo group "but the effects were small". The chitosan group lost an average of

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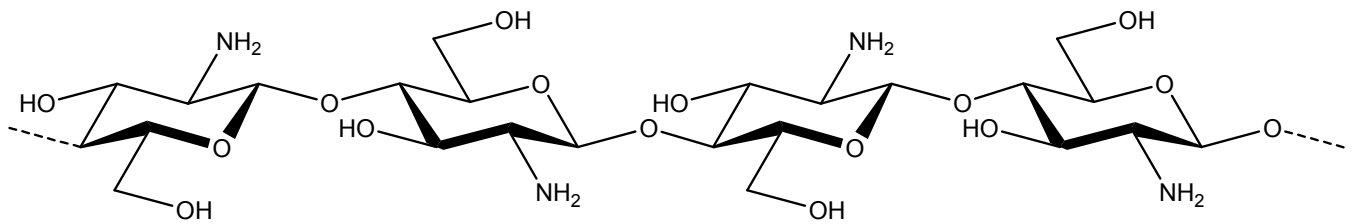
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0.4kg compared to a 0.2 kg gain in the placebo group.” (<http://www.nutraingredients-usa.com/news/ng.asp?id=54318-chitosan-fails-to>)

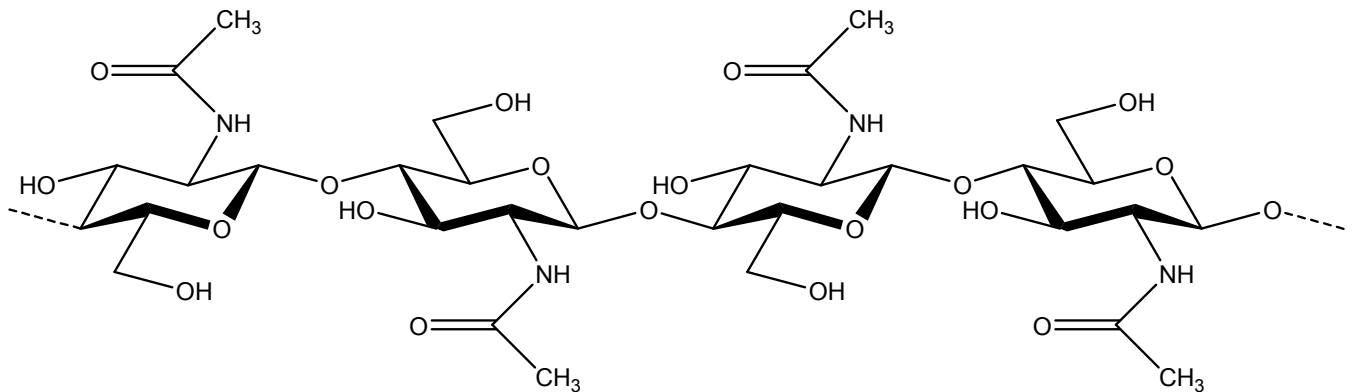
From this everyday life scenery the question arises: Does this medicine work? Can I use it for myself or would I recommend it to friends to control weight?

Second phase

So there are still differing opinions. Students should build their own opinion. They need to know more about chitosan. If you deacetelize chitin with sodium hydroxide you will get chitosan (Chitosan is a poly-glucosamin).



Chitosan: Poly-β-1,4-D-glucosamin



Chitin: Poly-β-1,4-N-acetyl-D-glucosamin

With this information we can try to explain the mode of chitosan reacting with fat by ourselves and evaluate the advertisements. In an acidic milieu the amino groups will be protonized and thus charged positively. These polykations are able to bind the negatively charged fatty acid anions, what is irreversible and the fat cannot be metabolized and leaves the body directly. But we have to consider that fats are splitted in basic solutions (intestine) and the chitosan kations exist in acidic environment (stomach). The question seems to be more complicated than primarily assumed.

In this case our class consulted experts from a company specialized on the production of chitosan from shrimp shells in Büsum, Germany. Of course this on the first glance simple process in stomach and intestine is much more complex. The experts could explain more details, but also couldn't give a simple yes or no. Our students learned more about the process of chitosan production, about the people and vocations involved and they were made aware of many other possible applications of chitosan.

A first experimental step was to produce chitosan in the school lab with the guidance by the teacher (see teacher notes) and to test its reaction with fat and fatty acids. The fat should be marked through a fat soluble dye () and the parameters pH-value, fat, fatty acid should be varied systematically.

Third phase

In the last phase students gather the results of their experiments, their research and their interviews with experts. They reflect what they have found, compare this to what they wanted to find and discuss this with their classmates. They prepare Powerpoints and posters to present their results in public. The overall goal is to make an own decision, whether to use this "medicine" for oneself or recommend it to friends for weight control. The discussion has to focus on using drugs or better to live a healthy life style with balanced diet and sporty activities. Each student is of course allowed to make personal decisions; there are no right or wrong ones. The main point is to argue in a convincing manner.