



## A CASE STUDY ON

### *Carbon Nanotubes*

by

Mrs Vanya Gunova, 2<sup>nd</sup> Secondary school 'Akad. Emilian Stanev', Sofia, Bulgaria

#### **BASIC INFORMATION:**

Vanya Gunova is a teacher in 2nd secondary school "Emilian Stanve" in Sofia, Bulgaria. The lesson "Carbon Nanotubes" was implemented with 12th grade students.

The school is in the capital city of Bulgaria – Sofia.

#### **INTRODUCTION/BACKGROUND**

The "Carbon Nanotubes" lesson(2 periods) provides an opportunity to explore and understand the carbon nanotube which is an allotrope of carbon.

#### **(DEFINITIONS/NOTIONS/TERMINOLOGY)**

Nanotechnology, Carbon Nanotubes(CNTs), Allotrope, Fullerenes, Graphene, Buckyball; Single Walled Carbon Nanotubes(SWCNTs): "Armchair", " Zigzag" and "Chiral"; multi walled CNTs(MWCNTs); Tensile strength; Stiffness; Hydrophobic;

#### **PURPOSE**

The lesson is aimed to help students visualize CNTs which they cannot see by naked eye and to raise their interest in both CNTs and nanotechnology.

#### **OBJECTIVES**

The lesson activities are designed for the sixth *form students*(12<sup>th</sup> grade in Bulgaria), English lesson. The objectives are: Students will learn about the structure of carbon nanotubes, their properties and the application areas of CNTs.

The proposed activities allow students to understand the term "nanotube", to comprehend the application areas of CNTs and why they are used.



## LEARNING RESULTS

Students learned about different types of nanotubes, the production methods and a variety of application areas. Students' interest in nanotechnology was raised.

## CLASSROOM MANAGEMENT & SEQUENCE OF EVENTS

Class preparations include designing the room to watch the experiment videos and preparing a presentation (in Prezi) and the materials needed in the activities: students' guidelines, sheets of fence wire, microfiber cloth, ordinary cloth and two measurement containers with water.

- 1. A brainstorming session attracts students' attention to the main topic.***
- 2. The teacher asks questions preparing the students to watch the first video about spider silk explaining its properties. Then there is a discussion about the possible uses of technological replication of spider silk.***
- 3. Students watch the video explaining the allotropes of carbon. They recognize carbon nanotubes as one of carbon allotropes and provide a definition.***
- 4. Students watch the video explaining the production of carbon nanotubes and some of their uses.***
- 5. The teacher shows pictures of different types of CNTs on the board and explains how to make their own CNTs out of the fence wire available on their desks. The teacher checks what type of nanotubes ("armchair", "zigzag" or "chiral") have been designed by the students.***
- 6. Students are invited to read about CNTs properties from the Student's guidelines and fill in gapped sentences projected on the board.***
- 7. Students watch an experiment video in the Virtual lab in order to recognize the water and oil absorption of materials made of CNTs. Then students discuss the amazing oil absorption property of CNTs and the possible application areas.***
- 8. Students learn about other application areas of CNTs from teacher's presentation and the next animation video, explaining how they are used in computer circuits.***
9. Finally students watch a video about space elevator and discuss the importance of carbon and its allotropes in technology of the future.
- 10. Evaluation is done at the end of the lesson.**

## RESOURCES

Teachers' guidelines available through NTSE are used to prepare a presentation (in Prezi) with videos, text and images, aiming to ensure the smooth running of the lesson. One of the videos from the Virtual lab, section Carbon Nanotubes is also watched in class. The other one is demonstrated in front



of the students by using the microfiber yellow cloth, the ordinary cloth and two measurement containers with water.

### **PROCESS (ENDING)**

The lesson incorporates a variety of teaching techniques and methods, which are aimed to make students interested in the topic and involve them into solving practical problems and tasks. Brainstorming activities and class discussion are also done in the course of events.

### **ASSESSMENT SUGGESTIONS**

There is a short test that assesses what students learn from the lesson in terms of definitions and terminology, as well as physical properties. A questionnaire for students is aimed at evaluating and collecting information and suggestions on the content, usability and pedagogical effectiveness of the NTSE Project teaching materials.

### **IMPACT ON STUDENTS**

**The students who participated in the lesson have been both satisfied from their performance and fascinated from the overall experience. The lesson raises young people's awareness of how nanotechnology can be used to improve life in the future.**

### **STUDENTS' FEEDBACK**

#### ***Expressed feedback:***

The results of the test show that students have fully comprehended the suggested concepts and terminology. Only few students have confused the properties of carbon nanotubes with those of spider silk.

The results of the questionnaire show that most of the students find the "Reading before experiment" useful and easy to understand. Only one of the students (a boy) experienced difficulty to follow the video experiment. There is another student (a girl) who didn't find the interactive animation very useful for understanding the experiment but two thirds of the class found the animation useful. Almost all the students agreed or even strongly agreed that after watching the video and doing the suggested activities, they had a better understanding of the subject matter. Only two students (from 15) felt neutral about the statement "Assignment helped me better understand



the subject matter.” Most of the students agreed that the tests and tasks reflected the lesson content. 80 per cent of the students disagreed that the tests and tasks in this lesson were difficult. The rest 20 per cent of the class neither agreed nor disagreed. There is only one student (a girl) who didn’t learn a lot in this lesson. The same girl didn’t enjoy the lesson. However, the rest of the class agreed or even strongly agreed that they enjoyed doing this lesson.

**Processed feedback (graphical results):**

.....  
.....  
.....  
(Diagrams/Graphs)  
.....  
.....  
.....

**CONCLUSION**

The lesson provides an opportunity for upper secondary students to learn about some of the latest developments in the field of technology through the medium of English.

**References**

.....  
.....  
.....

Videos

.....  
.....  
.....

Links

<http://vlab.ntse-nanotech.eu/NanoVirtualLab/>  
<http://ntse.ssai.valahia.ro/>

.....  
.....  
.....



**NANO TECHNOLOGY SCIENCE EDUCATION (NTSE)**  
**Project No: 511787-LLP-1-2010-1-TR-KA3-KA3MP**



**Images/video taken during the activity/project/lesson(s)**

.....

.....

.....