For students

What is worse, cigarettes or narghile?

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Country: Israel

Subject: Science for all, Chemistry.

Grade level: 9-12.

Curriculum content: Acids/bases, solids, gases.

Kind of activity: Laboratory activity.

Anticipated time: 3 lessons of 45 minutes each.

Task description

In the following activities we will analyze what substances enter the human body when someone smokes cigarettes and water-pipes (narghiles) – active smoking, or when standing near someone smoking – passive smoking.

Background: The harmful effects of smoking cigarettes and narghiles have been confirmed in many scientific studies. Eighty percent of all lung cancer cases develop among smokers. Smoking is the main factor for developing other types of cancer. Smoking also causes other severe diseases in the respiratory system, e.g., asthma and bronchitis. Smoking harms the brain and the kidneys, and immediately reduces physical fitness. Smoking harms the fertility of humans, leads to the acceleration of aging processes and the development of face wrinkles and other skin deformations.

What is there in cigarette smoke that causes such varied health hazards? In this laboratory activity we will try to characterize part of the components inhaled into the human body while smoking in order to understand how and what substances cause various diseases as a result of smoking.

At the end of the activity we will be asked to write a justified assay regarding the questions in the title: What is worse, cigarettes or narghile? And to hand over this lab report, after you answer all the questions. It is recommended to fill it up during the lab session.

Station 1- The acidity of the smoke

In this station we will gather the substances present in cigarette smoke, and check the acidity that developed in the lungs of smokers.

First, we will learn about acidity. Many substances around us are characterized by a specific acidity level. Substances such as lemon and vinegar are termed **acidic** substances. There are other substances that are not acidic; in the language of chemists they are called **bases**. And there are **neutral** substances that are neither acidic nor basic.

With the help of indicators a substance can be identified as acidic, basic, or neutral. Indicators are substances that change their color according to the acidity level of the tested solution. Bromothymol blue is an indicator that changes its color in the presence of a base and has a different color in the presence of acid.

From this point until the end of the activity, all students must wear safety goggles.

- Acquaintance with the indicator: Take 4 tubes and fill them with the indicator solution. To the first tube add one drop from the flask containing a base, to the second tube add a drop of strong acid, and to the third tube add a drop of weak acid. What is the color in each tube? Fill in the table below.

Tube #	Acidity level	Color
1	Base	
2	Strong acid	
3	Weak acid	
4	Neutral	

- Below are some substances that can be found in every home. Drip them inside the tube containing the indicator solution. Record your observations in the following table.

Substance	The color of the indicator	Acidic/Basic/Neutral
Vinegar		
Baking soda*		
Vitamin C*		
Cola		
Lemon		
Baking powder*		

* These substances should be first dissolved in a small amount of water, and only then can they be added to the indicator solution.

- On the basis of your observations, decide whether each of the substances is acidic, basic, or neutral (the last column in the table).
- Now we will build the system that will smoke cigarettes and transfer the smoke via the indicator solution.
- Assemble the "smoking machine" illustrated in Figure 1.

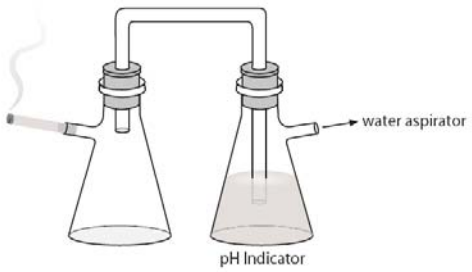

Figure 1: Smoking machine for analyzing the acidity of the cigarette smoke

The following procedures should be performed in well-ventilated fume hoods, with a glass shield separating the students from the smoking machines.

- Connect the cigarette to the first flask.
- Connect the second flask to the water aspirator.
- Fill the second flask with 200 ml of the indicator solution.
- Turn on the water in the water aspirator.
- Light the cigarette.

Describe what happens in the system: _____

What is the color of the indicator? _____

What is the acidity of the smoke? _____

What happens to the lungs as a result of exposure to the acidic smoke: _____

_____

_____

Station 2- Solid particles in the smoke

The cigarette smoke consists of a gaseous and solid phase. Each cubic mm of smoke contains as much as 5x109 particles of 0.2–10 micron diameter (one micron equals one millionth of a meter). Nicotine is present in the solid phase, and it is considered to be the main factor in becoming addicted to smoking. Besides nicotine, the solid phase contains additional organic compounds; most of them are one-ring and multi-ring aromatic hydrocarbons. The mixture of these solid compounds is called “tar”; the majority of substances in tar are carcinogenic.

As already mentioned, smoking cigarettes is the main factor for developing lung cancer. The substances present in the cigarette smoke are the main reason for these diseases. These substances (composing the tar) cause paralysis of the cilia in the epithelium of the respiratory system. Paralysis of the cilia can cause contamination of the lungs. The substances in the tar also cause irritation and increased secretion of saliva

from the epithelial gland. The combination of both these factors can cause partial or complete occlusion of the respiratory system. In the absence of absolute ability to remove waste from the lung, the human body activates an alternative emergency mechanism – the well-known cough of chronic smokers.
At this station we will collect the solid particles existing in the cigarette and narghile smoke and compare them.
What are the properties of tar (color, solubility, smell, etc.)? _____
_____
Why is it harmful to the lungs? _____
_____

- Assemble the smoking machine for the collection of solid particles as it is illustrated in the Figure 3.

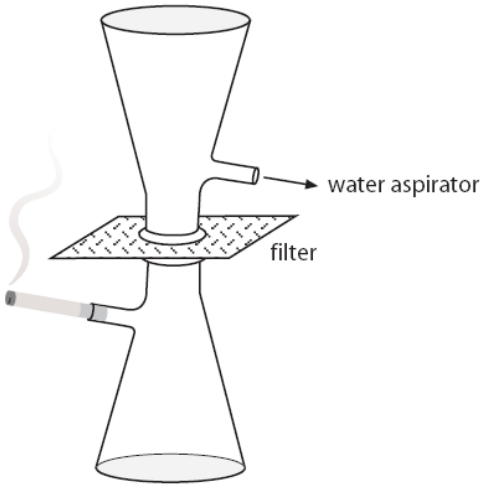

Figure 3: Cigarette and narghile smoking system for collection of solid particles in smoke

- Fold twice the filter paper and place it between the 2 flasks fixed as it is illustrated in Figure 3.
- Connect the 2 flasks properly with "plasticine", so that they will not fall down and the smoke will not escape from the system.
- Insert the cigarette into the system's opening.
- Turn on the water aspirator.
- Light the cigarette.
- Measure the pumping time of a cigarette. Duration of burning 1 cigarette: _____
- Turn off the water aspirator.
- Remove the filter paper and put it on the plastic plate.
- Mark the plastic plate so that you will be able to know the source of the filter paper.
- Repeat the action with the narghile: insert clean filter paper.
- The duration of smoking the narghile should be identical to the burning time of 1 cigarette.

What is the color of the filter paper? _____

Which filter paper is darker? _____

- Insert the filter paper (that collected the cigarette's tar) in water.
- Do you observe that the tar dissolves in water? _____

Methanol is a toxin! Next step should be performed inside the hood; students should use it only wearing protective gloves and safety goggles.

- Insert the filter paper in methanol
- Do you observe the tar dissolves in methanol? _____

Explain your observations in term of intermolecular forces? _____

_____

Try to guess, what would be the color of a smoker's lungs? _____

Is it possible to rinse off the tar and remove it from the lungs (explain why)? _____

_____

Station 4 will demonstrate the answer to these questions.

Station 3- Vapor phase substance in the smoke

According to the report of the World Health Organization, tobacco and cigarette and narghile smoke are composed of approximately 400 different chemical substances. Some of these chemical substances are dangerous toxins. We will determine whether the cigarette and narghile smoke really contain substances dangerous to health as is published in the report. At this station we will test only the components of the gaseous phase (we will not deal with the components that are particles – we qualitatively checked them at station 2).

The main dangerous components of the gaseous phase are carbon monoxide (CO), oxides of nitrogen (NOx), ammonia (NH3), sulfur dioxide (SO2), volatile sulfur compounds, volatile nitrogen compounds (such as cyanic acid), hydrocarbons, alcohols, and other organic substances. Such substances are toxins; some of them are highly toxic.

What gases are you familiar with? _____

_____

What gases are present in the air? _____

_____

What is an organic substance? _____

What are the products in the chemical reaction of burning an organic substance? _____

_____

When carbon monoxide is also created in a chemical reaction? _____

_____

Why is carbon monoxide a toxin? _____

_____

Have you heard about people dying as a result of exposure to carbon monoxide?

_____

What well-known toxin is present in smoke? (Hint: It is one of the substances on the list of dangerous substances on the previous page)

_____

At this station we will analyze the existence of carbon monoxide, oxides of nitrogen, and sulfur dioxide in the cigarette and narghile smoke. We will perform quantitative analysis to identify these substances by the indicators specific for these toxins, and compare the results received in the analysis of the cigarette and the narghile smoke.

- Assemble the smoking system like it is illustrated in Figure 3.

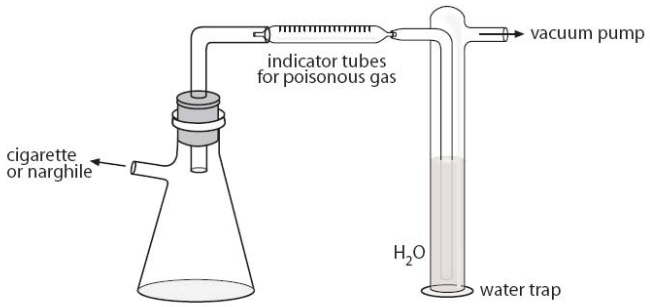

Figure3: Smoking system for the analysis of the cigarette and narghile smoke

- Connect the flask to a cigarette.
- Open both sides of the indicator tube.
- Connect the indicator tubes between the flask and the water trap.
- Connect the water trap to a vacuum pump.
- Turn on the oil pump.
- Light the cigarette.
- Measure the duration of burning the 2nd cigarette: _____
- Read the quantitative analysis to identify the following gases: carbon monoxide, oxides of nitrogen, and sulfur oxides.

Amount of carbon monoxide in the cigarette smoke: _____

Amount of oxides of nitrogen in the cigarette smoke: _____

Amount of sulfur oxides in the cigarette smoke: _____

- Repeat the experiment, but connect the narghile instead of a cigarette to the pumping tubule. It is important to be precise regarding the same period of time that you measured for the cigarette. Otherwise we will not be able to compare the results of the toxins from cigarette smoke and narghile smoke.

Amount of carbon monoxide in the narghile smoke: _____

Amount of oxides of nitrogen in the narghile smoke: _____

Amount of sulfur oxides in the narghile smoke: _____

Organize the results of the toxins gases from cigarette and narghile smoke in a table:

What are the differences between the contents of the gases you analyzed in the cigarette and in the narghile? _____

_____

_____

Raise assumptions for the cause of differences: _____

_____

_____

Station 4- Observation and demonstration of ventilation of lungs of a "healthy pig" and a "smoking pig", simulating the effect of smoking on human lungs

In front of you there are two mechanisms of preserved pig lungs that can be inflated – healthy lungs and lungs simulating a smoker's condition. From an anatomical and physiological point of view, it is almost impossible to distinguish them from the lungs of human beings of average weight.
Besides this, you see in front of you slices of lung that have undergone a drying out process. These slices will make it possible to observe in detail the anatomical internal structure and to demonstrate the spongy texture of the lung.

It is forbidden to touch the lungs with your bare hands. Wear protective gloves and in case of direct contact you should thoroughly wash your hands with water.

At this station the instructor will explain the structure of lungs and demonstrate the differences between a healthy lung and a smoker's lung.