Interactive Blossoms Lesson

Lesson Title

Plastics and Chemical Bonds

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Part I: (2 minutes) A picture of plastic wastes and the difficulty of their decomposition, if possible. Location: Dammam or Khobar beach contaminated with the remains of plastic materials such as plastic bags and water bottles.

Peace be upon you. My name is Hana Thieban, a chemistry teacher in Al-Saad National School, Khobar, Kingdom of Saudi Arabia.

As we know, humans have depended over the past centuries (until the early twentieth century) on materials made from natural sources in the environment to make their own food and personal tools. These include dishes, spoons, and cups made of plants or animals and materials like wool, silk, rubber, wood, porcelain.

(Pictures of these things from the environment are displayed)

But in the beginning of the last century, the discovery of oil was followed by new man-made materials that had numerous uses capable of competing with natural materials and therefore replaced them in many industries.

One of the most favored materials is plastic. We all know how we appreciate them, especially plastic bottles and dishes because they are light to carry and use. We prefer them compared to paper dishes that are easily torn or glass dishes that break when accidentally falling from our hands.

(Scene of the beach contaminated with remains of plastics)

But much of the organic waste from natural products is biodegradable which means they can be decomposed easily by bacteria within days or months or a few years at most. Most types of bacteria, however, are unable to biodegrade plastic waste.

Nevertheless, we use, recycle, and reuse them in purposes such as: refilling bottles of drinking water.

* The question here is:

How do we make these plastics that we enjoy yet fear their accumulation due to lack of decomposition?

In groups think about what plastic materials are made of and I will come back to you.

Part 2: (3 minutes) Location: Scitech -Organic materials that show carbon atoms.

Hello. I expect you have tried hard to find the answer. Let us see.

Plastic materials are polymers, a word which is composed of two syllables. ‘poly’ meaning ‘many’ and ‘monomers’ which means ‘small molecules’. These small molecules combine with each other by chemical bonds and form what are known as polymers.

These bonds are unsaturated. This means that not all the bonds of the carbon atoms are bonded to other elements such as hydrogen, chlorine or fluorine. As a result, these small organic molecules can bond to each other through the unsaturated bonds to form saturated macromolecules that can be very useful for a variety of industrial purposes.

As we know, the carbon atom is the basis of the organic compound structure.

Remember that a carbon atom has unique properties compared to the rest of the atoms. Among these properties is its ability to form distinctive long chains.

The carbon atom is the basis required for the formation of any organic compound. The organic compound, in turn, is the basis of plastic polymer formation. So let's start exploring the structure of the carbon atom together.

Work in groups as you always do, illustrate the electrical configuration of the carbon atom. Then distribute the electrons according to the Aufbau principle and predict the number of bonds that can be formed by the carbon atom. I will come back shortly.

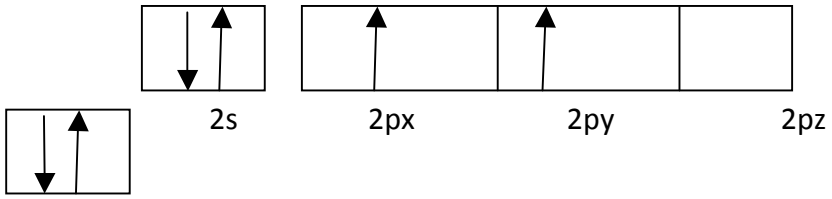
We are back again. Thank you for your wonderful efforts.

(The periodic table appears as a background during explanation)

The carbon atom, which is found at the top of the periodic table, has 6 electrons. This is known as the atomic number and is located above the chemical symbol. When distributing these electrons in the atomic levels and sublevels, we get the following figure: $1S^2 2S^2 2P^2$

(Preferably PowerPoint)

When the electrons are distributed into their energy levels and orbitals, we get the following orbital diagram:

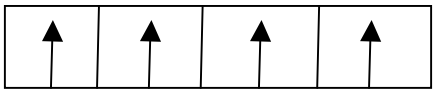


$1s^2$

Perhaps you expected carbon atom to form two bonds due to the presence of two unpaired electrons

Found in the orbitals $2p_X$ and $2p_Y$. In fact, this does not really happen. Instead, there is a transfer of one electron from the 2s orbital to the $2p_Z$ orbital in a process called hybridization in which the 2s orbital is hybridized with the 2p orbitals to form four hybridized orbitals of the type sp^3 with the same length, type and strength and forming this shape

sp^3



Now, what are your expectations about the type of organic material which contains carbon atoms and forms the plastic materials?

Think about the answer and I will see you shortly.

Part III: (3 minutes) The previous question is displayed on the board and I read it without appearing on the screen.

Our question was: what type of organic materials can form the plastic materials?

We know that the basic unit to form plastic is an organic molecule composed of two carbon atoms with a double bond between them. A large number of these molecules combine with each other to form enormous long chains.

This small organic compound by which plastic materials are made is known as ethylene $H_2C=CH_2$.

This is the first material from which polymers were manufactured and it belongs to the group of unsaturated hydrocarbons known as alkenes. Ethylene is also the smallest alkene to be used in making polymers.

Let's explore the composition of the ethylene molecule.

(A display of atoms present in the molecules)

An ethylene molecule contains two carbon atoms covalently bonded together by a double bond.

One of these bonds is known as sigma, which is given the symbol, and the second one is known as pi and is given the symbol π.

Chemical researchers have found that the pi bond is the key to many chemical reactions by which the small molecules are converted to a large number of new industrial materials such as plastics, rubbers and synthetic fibers. In addition, organic materials that contain double covalent bonds are used to produce chemical fertilizers, detergents, soap and other powders. Note, that without this bond, none of these wonderful materials would have existed and plastic materials in particular.

Let’s think together about the following question: How is the pi bond formed between two carbon atoms?

Think about it and I will see you later.

Back again

Part IV: (5 minutes)

Thank you for your genuine efforts to find the answer to my question. Let me share my answer with you.

At the beginning of our lesson, we identified the properties of the carbon atom and how the electron in the orbital 2s transfers to the $2p_z$ orbital. The only difference will be in type of hybridization and the orbitals that need to be mixed.

(View the atoms of a molecule to explain this part.)

An ethylene molecule consists of two carbon atoms, and each one of them needs three electrons. One electron to bond with the second carbon atom and two electrons to bond with two hydrogen atoms to make the total number of required electrons three for each carbon atom. The carbon atom makes four bonds as the number of valence electrons in the outermost energy level indicates. How does this happen? Let's see how.

(The slides for the first phase appear)

We can see that the carbon atoms are in a grounded state. We start distributing the electrons to their energy levels according to Hund's rule.

In the second phase, an electron transfers from the 2S orbital to the empty 2Pz orbital and the carbon atoms are in the excited state.

In the third phase, the process of mixing the 2P orbitals with 2S orbitals to produce three hybridized orbitals of the type sp^2 which have the same length, strength, type, and shape. The carbon atom at this stage is hybridized. The second carbon atom undergoes the same process.

In the fourth phase, the process of making bonds starts like this: the two carbon atoms start forming a covalent bond of the type sigma between the hybridized orbitals as we notice, followed by the formation of a pi bond between the unhybridized orbitals and then the two hydrogen atoms bond with unpaired electrons in the hybridized orbitals

The first carbon atom and the two hydrogen atoms bond with the hybridized orbitals in the second carbon atom.

The molecule of ethylene forms by a vertical overlapping between the hybridized orbitals sp^2 to form a sigma bond. The overlapping in the unhybridized orbitals is parallel from the sides to form a pi bond that does not bond with hydrogen atoms. Then a vertical overlapping for the rest of the hydrogen atoms establishes a sigma bond between hydrogen atoms and carbon atoms to form the ethylene molecule.

(A question is introduced as an exclamatory question)

But think with me, aren't plastics polymers? And polymers are organic compounds, which are based on ethylene, a non-saturated molecule which in turn combines with other identical molecules by breaking the pi bond.

What do you think causes the breaking of the unsaturated pi bond and not the saturated sigma bond? I think you know why.

(View only the fifth tranche to show only how the pi bond was formed.)

Note that in the case of lateral overlapping of the pi bond, the bond is longer compared to the Sigma bond, which makes the pi bond weaker and easily broken and this is the reason why chemists use ethylene as a basic material to make polymers.

Now, since we know that plastics are polymers, why are there different types of plastic materials? There is a hard type of plastic and a flexible type. In your opinion, what distinguishes each type when both have the same chemical composition? Think about the reason and I'll be back shortly.

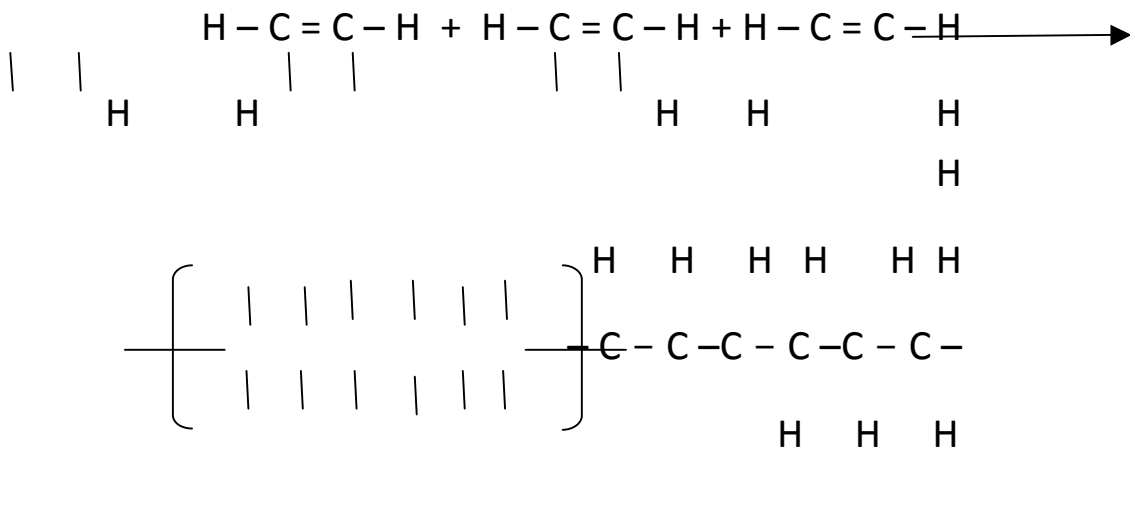
We will come back again to answer the previous question.

Part V (4 minutes)

Let us have a look at ethylene polymer.

(display a picture of an ethylene polymer pointing out the name of carbon and hydrogen atoms on the picture or the molecule.)

When ethylene molecules starts combining with each other, the pi bonds break and the small molecules of ethylene combine to form a very large molecule known as ethylene polymer.



These compounds are used to produce flexible and transparent polymers which are used in plastic synthesis for making packaging bags, electric wire insulations, toys and plastic water bottles.

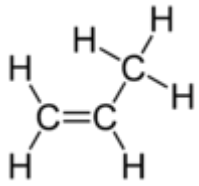
Display pictures of some factories for manufacturing plastic water bottle, factories for plastic bags used in food packaging, and trash bags.

The impressive products of plastic materials have encouraged researchers to discover new plastics with properties better than previously produced. How do you think the type of polymer was improved to make products such as CD, and plastic chairs? Think about that until we meet again.

Part VI: (3 minutes)

Welcome, again. Thank you for your cooperation in looking for the correct answer. But before we discuss the answer, I want you to replace the first letter in the word “habl” (which means rope) with the letter ‘ j’.

We get a new word which is “jabl” (which means mountain). As we have seen, replacing one letter has changed the meaning completely, and this is what happens in polymers when we replace a hydrogen atom in the ethylene molecule with a group of atoms such as the methyl group ($-CH_3$), a molecule with more strength and hardness called propene is produced.



These polymers are used to produce materials with more hardness and heat resistance such as CDs for storing computer files, plastic ropes, plastic cups for drinking cold or hot water, cutting boards, plastic files, bags, and containers.

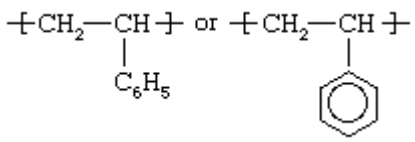
I hold a piece of polystyrene in my hand and say:

We are all familiar with this kind of material known as polystyrene. Let's try to burn it. Do you expect it to burn? In your opinion, which group has been added to the ethylene molecule and formed this compound known as polystyrene?

Think about it and I hope you will find the answer.

Part VII: (3 minutes)

Thank you for your answers. As you expected, such a strong and incombustible material must be made of strong molecules, where the weak hydrogen atom was replaced with a group of atoms forming a complex ring-shaped known as a benzene ring, which has increased the molecule strength in the polymer. A picture of the polymer is displayed.



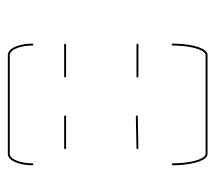
Additional pictures of the styrene polymer are displayed, which is used in the manufacture of thermal insulators for buildings, plates and cups used for hot drinks.

(A display of a picture of an egg fried and sticks in a pan of aluminum, and an egg fried in a non-stick Tefal pan)

Ask why the egg did not stick in one pan, while it did in the other. It must have been coated with a special substance. In your opinion, what is this wonderful material made of? Think about it. There is very powerful and active atom in group seventeen of the periodic table that belongs to the halogen family, have you identified this atom? It is the fluorine atom.

When it replaces hydrogen atoms in a molecule of ethylene, a powerful, durable, heat resistant and non-stick material is created and used in coating cooking pots and pans.

Do you expect that fire-resistant clothing is made of the same polymer? Yes, it is. They are made from **tetrafluoroethylene**.

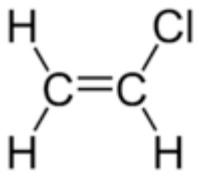


-C = C- -

F F

But, if a hydrogen atom is replaced and with a chlorine atom in the ethylene molecule, a very strong polymer known as vinyl chloride commercially known as P. V. C. It is used in the manufacture of water pipes instead of steel pipes since they are do not corrode,

It is also used in the manufacture of raincoats and car furniture. This is how vinyl chloride is formed.



As much as possible, I have mentioned examples of materials that can be produced from unsaturated organic compounds, which was the main point in this lesson. We have been blessed by Allah with a variety of materials that were not available to our ancestors, such as plastic materials.

Despite the importance of plastic materials in our daily life and their role in satisfying our needs, they do not decompose easily. This has led forbidding the use of plastic bags in some countries and replacing them with paper bags. These bags can decompose readily and have the ability to dissolve in water if they were accumulated in water bodies.

Recent research findings identified types of bacteria capable of decomposing polyethylene materials. Find more information and conduct theoretical and applied researches to solve the problem of plastic wastes and the preserve the environment from pollution.

We can contribute to environment preservation through the wise use of plastic materials by keeping it to a minimum and using plastic products that can be used several times instead of single- use plastic products. We can also reuse plastic bags more than once, rather than throw it away after one use.

We have identified the relationship between the unsaturated petrochemicals and plastic materials, and therefore we have answered the question we introduced at the beginning of the lesson. I hope that you have enjoyed the lesson and I encourage you to have a deep look at the materials that we use in our daily life. Look for more information about the types of bacteria capable of decomposing some types of plastics and conduct research that enlighten others.