Lesson 4: Adhesion & electronegativity

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Objectives

1. Apply the polarity of chemical molecules to the adhesive nature of resins.
2. Explore how electronegativity influences polarity of molecules.
3. Identify polar covalent bonds within molecules.

Introduction

How do adhesive materials like resins work? One of the ways is by chemical structure of the molecules in the adhesive. Mycelium, glue, varnish, and epoxy all have the capability of forming noncovalent interactions with other molecules. This causes them to adhere to them, and stick. But what makes something sticky? One of the reasons is due to the electronegativity of a molecule.

Electronegativity is the measure of an atom's tendency to attract electrons. A scale of electronegativity values was created by Linus Pauling (who also discovered the bonding patterns inside DNA in the 1950's). His scale of values is called the Pauling Scale of Electronegativity.

As you move from left to right in the periodic table of elements, the number of protons in the elements grows, and so also does the electronegativity of those elements. Electronegativity also increases as you move up the periodic table. The atoms get smaller (less atomic mass) and the valence electrons are closer to the nucleus of the atom, so they are influenced more by the pull of the nucleus.

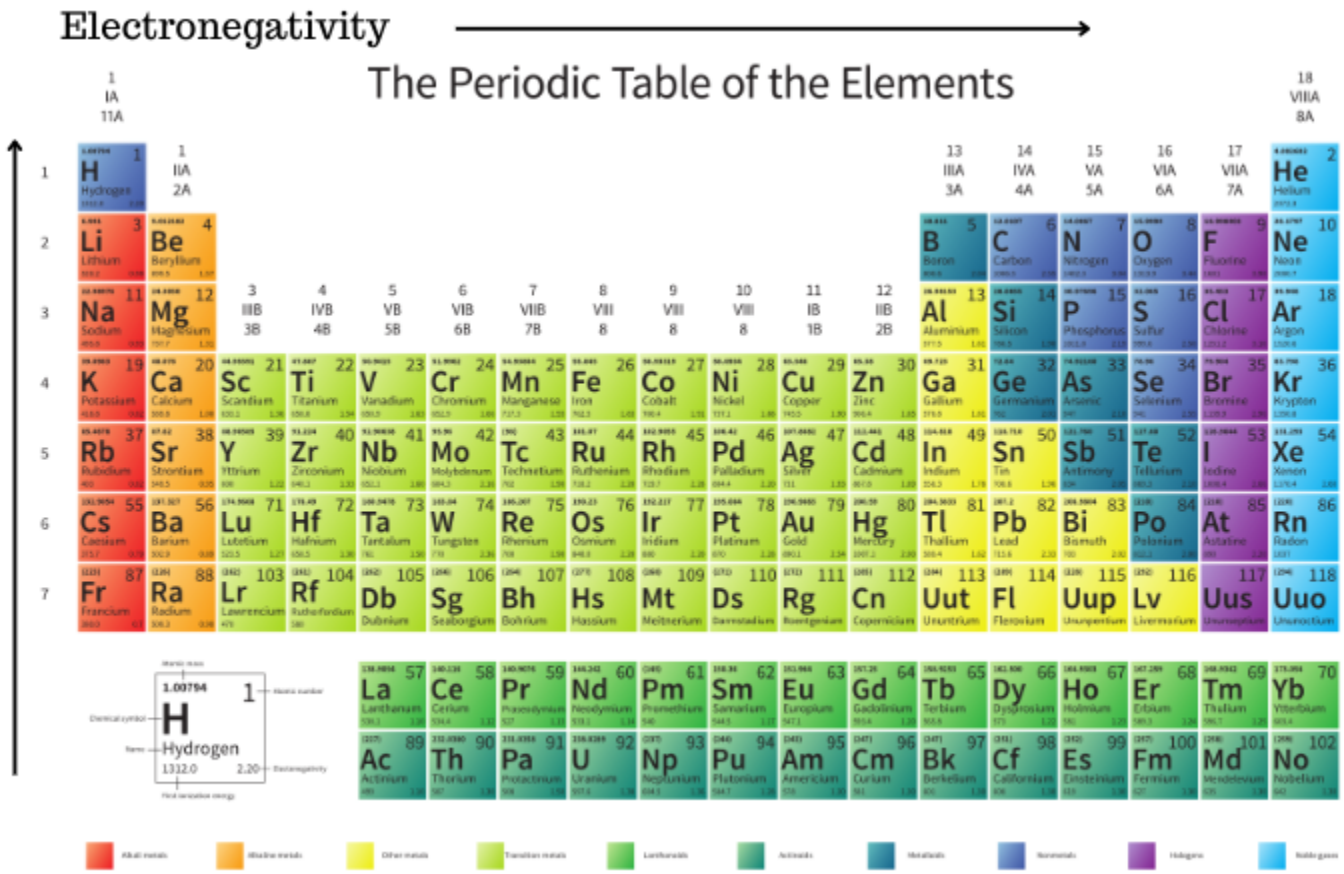


Figure 1

Electronegativity differences between atoms of the same molecule will cause it to easily form chemical interactions with other molecules, and adhere. For example, vinyl acetate is an adhesive commonly known as white glue. Below is its chemical structure.

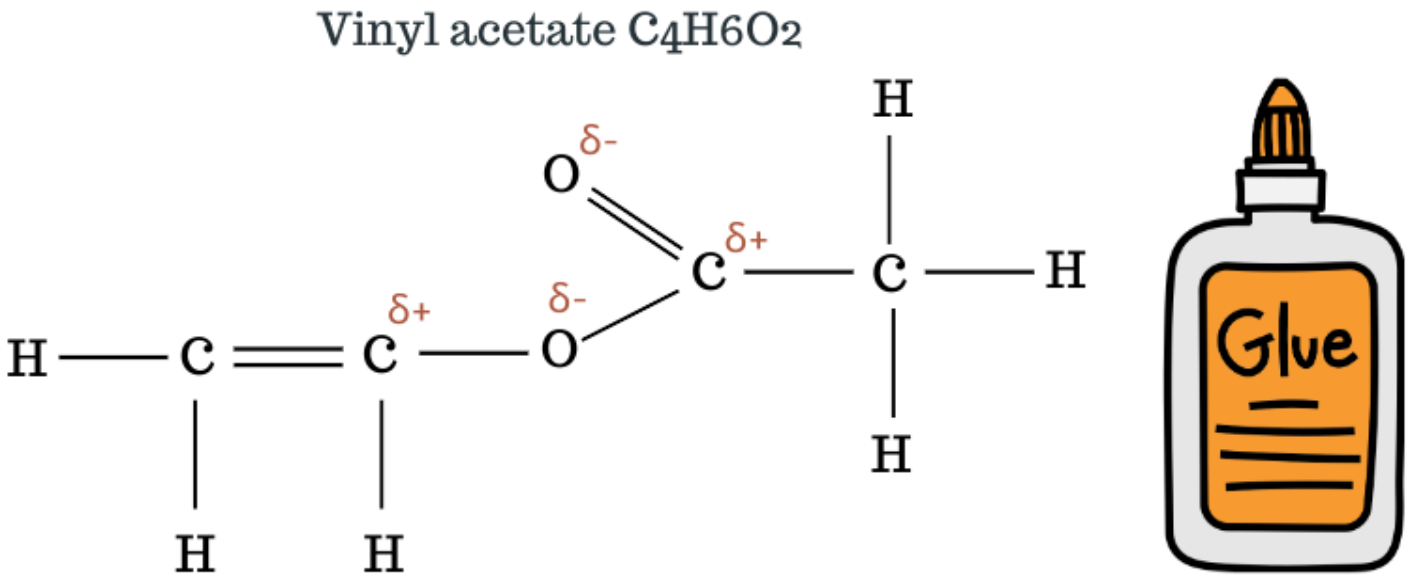


Figure 2

Notice how the oxygen and carbon atoms have partial charges. These can be expressed using the symbol lowercase delta, δ. In the periodic table above, you can see that oxygen is particularly electronegative, meaning it has a higher affinity to pull electrons towards it, than carbon. This is why oxygen has a partial negative charge and the atoms it is bonding with, all take on partial positive charges. The δ symbol illustrates where electrons are being pulled, in this case towards the oxygen atoms.

Comprehension check:

1. Which element is more electronegative, Lithium or Oxygen?
2. Which element is more electronegative, Iodine or Chlorine?
3. Which element is more electronegative, Fluorine or Cesium?
4. What is the symbol that represents a *partial charge* of an atom?

Electronegativity and polarity

This difference in electronegativity creates a polar covalent bond between the atoms. In the vinyl acetate molecule above, polar covalent bonds are formed between the C and O atoms. We can describe the molecule as having 'polar regions' because of these polar covalent bonds. Often adhesive molecules will contain these polar regions, which cause them to be slightly charged. The slightly charged regions will attract other molecules. This is what causes them to 'stick' or adhere to other substances.

Water is a polar molecule that is able to stick to other water molecules as well as other surfaces. This is what creates surface tension. Try dropping water one by one onto a penny. You'll see the water droplets start to form a convex shape around the penny as the water sticks together instead of falling down the sides. Take a look below at the polarity of a water molecule.

Below is a chart giving some electronegativity values of some common elements:

Element	Electronegativity value
Carbon	2.55
Chlorine	3.16
Hydrogen	2.20
Nitrogen	3.04
Oxygen	3.44

Figure 3

Subtract the smaller value from the larger one between two atoms to find the difference in electronegativity. For example, in water, there are bonds between oxygen and hydrogen. Oxygen has an electronegativity value of 3.4, and hydrogen 2.20. Oxygen has a higher affinity for the electrons, with a difference of 1.24. According to the chart below, this difference implies it has a polar covalent bond. Oxygen will have a partial negative charge, as the electrons that make up the covalent bond between oxygen and hydrogen are pulled slightly more towards the oxygen. The hydrogen will have a partial positive charge as the electrons get pulled slightly away.

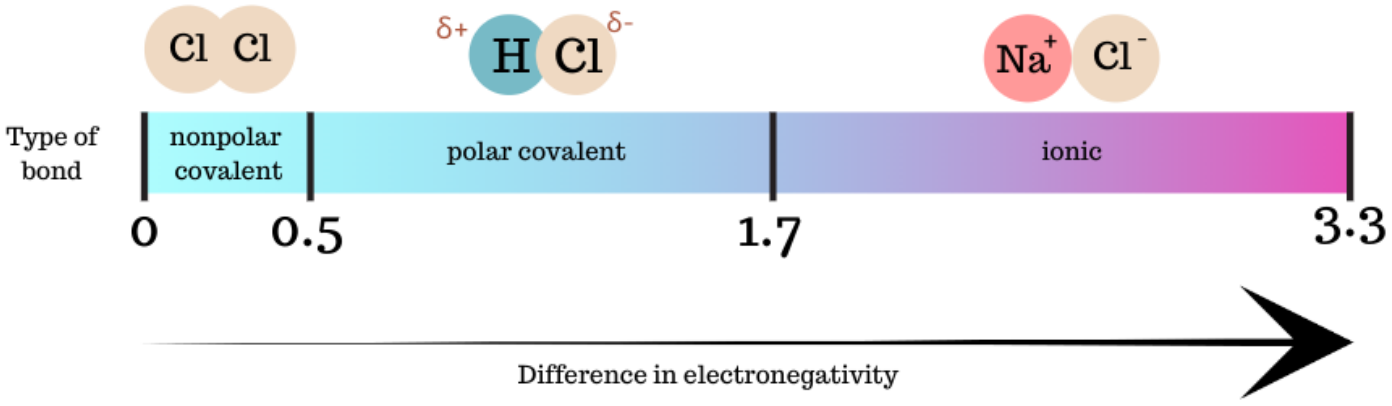
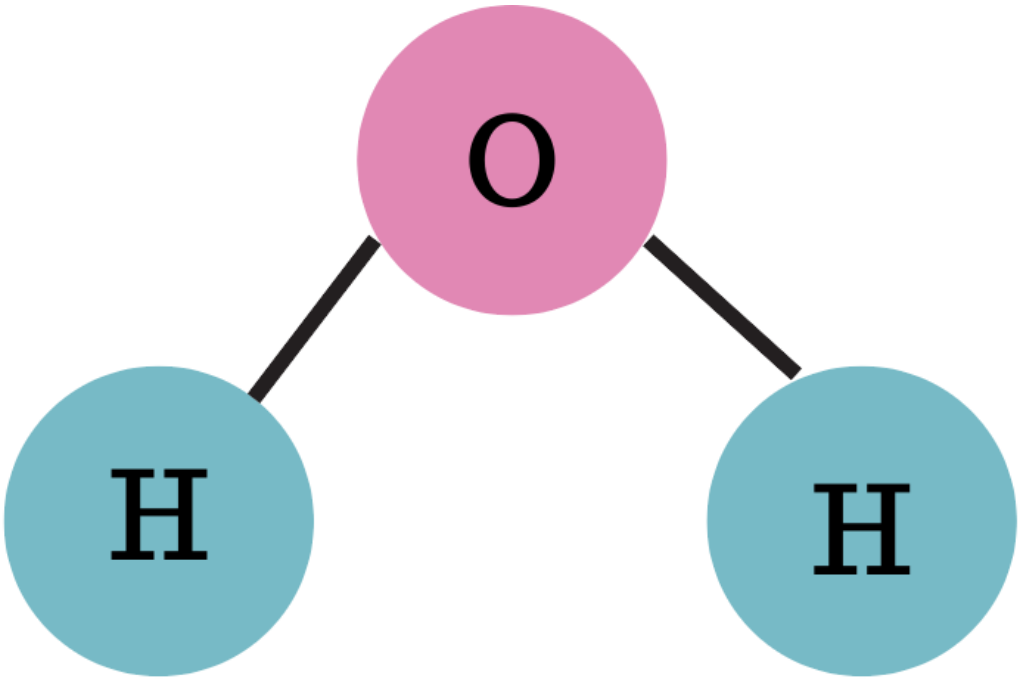


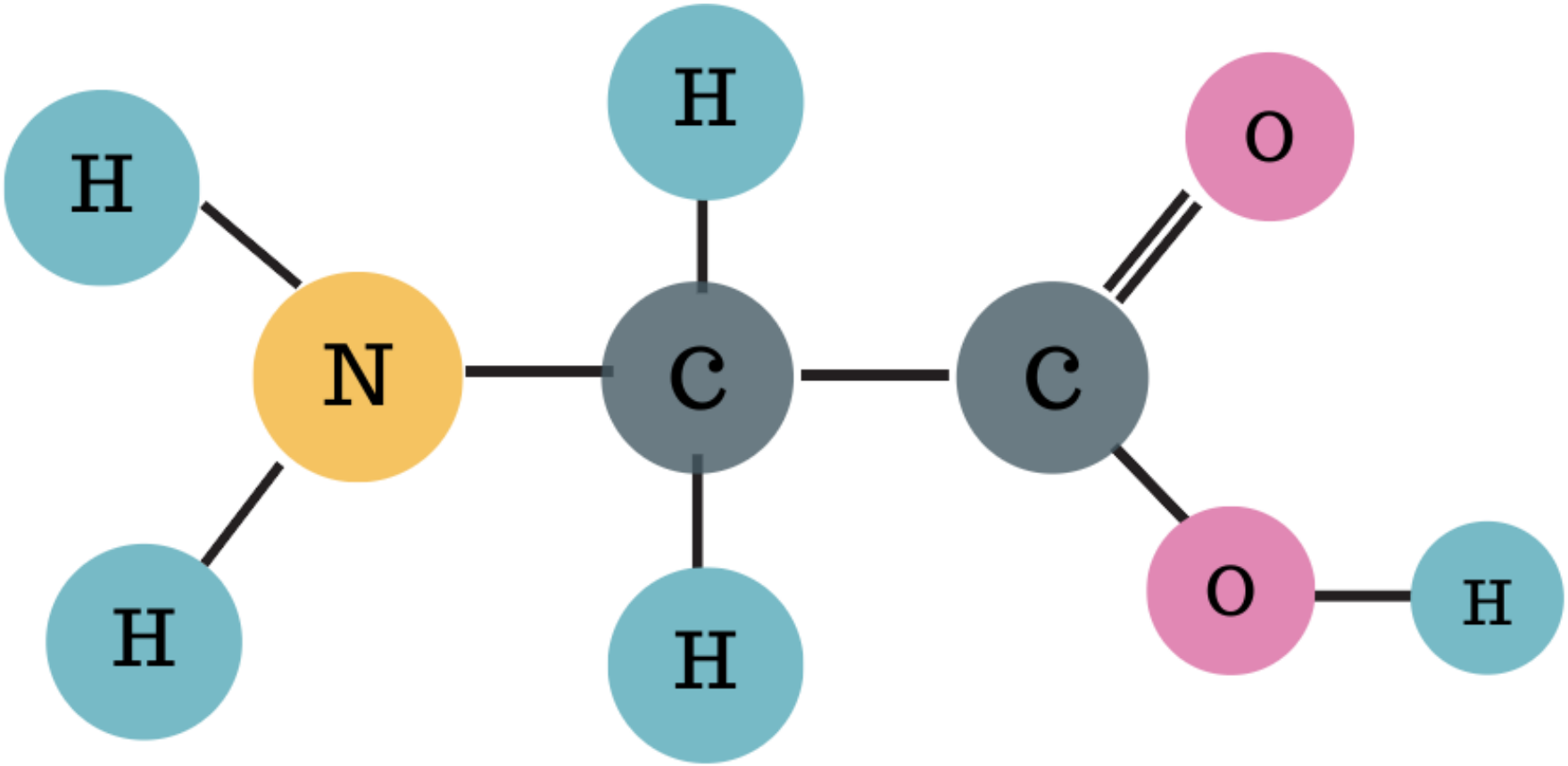
Figure 4

Activity using the molecules below..

1. Identify the electronegativity of each atom. (use Figure 3 above) Label each with its electronegativity value.
2. For each bond within two atoms, calculate the difference in electronegativity. Write the difference between the two atoms, and CIRCLE it.
3. Using the differences in electronegativity, identify any polar covalent bonds (use Figure 4 above). In these polar covalent bonds, add partial charges to each atom. The atom with the higher electronegativity will draw more electrons towards it, and will be partially negative. The atom with the lower electronegativity will be partially positive.

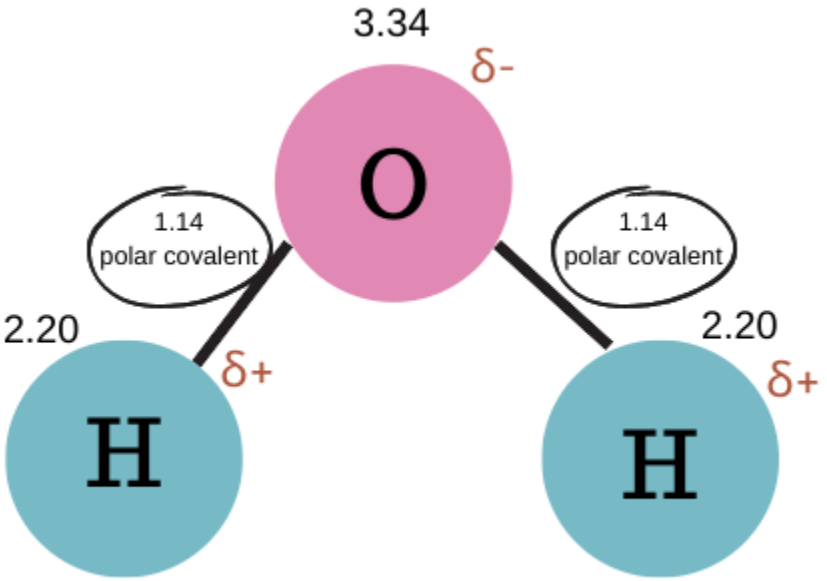


Water

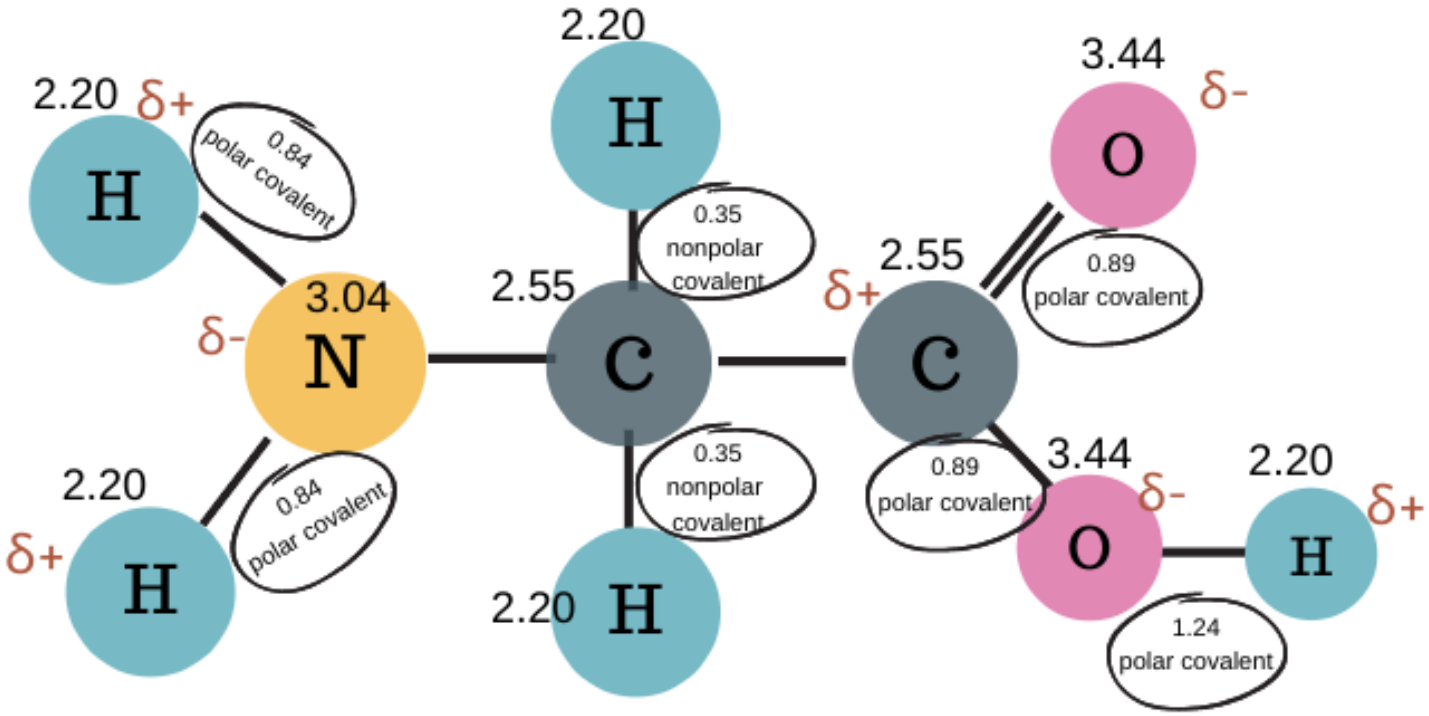


Glycerin

Activity Answer Key:



Water



Glycerin