Exp. 2: Producing and Measuring Electrostatic Charge

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Abstract

A study was done to calculate charge density on various items after charging them with static electricity. By using a charge sensor to measure the amount of charge on a nylon and PVC rod after being rubbed with a piece of vinyl or wool, the nylon and PVC disks’ charge densities could be calculated by dividing the disks’ surface area by their total charge. The nylon disk and the PVC disk had charge densities of 1742 and -40 nC/cm2, respectively.

Introduction

Different materials have varying properties when being charged. Some materials attract electrons much more easily than others. These materials are said to have a high electron affinity. This experiment tested the electron affinities of various materials. By measuring the amount of charge on a rod after being charged with a piece of wool or vinyl, we can determine the relative affinity of the rod’s material.

Also, by measuring a charge on an object, the number of electrons transferred can be calculated by multiplying the charge on the disk by and dividing the result by , which represents the charge of a single electron. To determine the charge density over the surface of the object, the object’s charge is then divided by its surface area. This gives us the amount of charge per amount of material on the object’s surface.

Procedure

In this experiment, four rods were used. The first two were made of purely nylon or PVC, while one had a nylon disk at the end and the other had a PVC disk at the end. To measure the electron affinity of the first two rods, the rods were statically charged by rubbing either a vinyl or wool sheet along the rod until it was sufficiently charged. It was then held in the center of a Faraday Cup where a charge sensor measured the charge on the rod.

Next, the charge on the nylon and PVC disks were measured by rubbing them together and holding them in the center of the Faraday Cup, discharging the disks on a wet paper towel between trials. Both the number of electrons transferred in the process and the relative charge densities of the disks were then calculated. By measuring the inner and outer diameter of the disks, the surface area of the circular face of the disks was calculated. The charge density of each disk was then calculated by dividing the charge of the disk by the surface area of its face.

Then, by rubbing the disks on the outside of a Faraday Cup, a charge was transferred to the Faraday Cup. After measuring this charge and the diameter and height of the Faraday Cup, the same process as above was used to calculate the surface charge density over the Faraday Cup’s outer surface.

Finally, the Faraday Cup was charged by induction. This was done by attaching a wire to a grounding plate and placing the charged nylon disk into the center of the Faraday Cup. The Faraday Cup was then touched by the grounded wire briefly, after which the wire and disk were removed.

Results

The electron affinities in nC/J from Part 1 are as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| PVC Rod & Vinyl Sheet | PVC Rod & Wool Cloth | Nylon Rod & Vinyl Sheet | Nylon Rod & Wool Cloth |
| -8.74 | -40.00 | 1.09 | -0.26 |

Question 1: Vinyl has a greater electron affinity compared to PVC.

Question 2: Wool has a greater electron affinity compared to PVC.

Question 3: Nylon has a greater electron affinity compared to Vinyl.

Question 4: Nylon has a greater electron affinity compared to Wool. (Although this is very slight and differs from what was found on the triboelectric table.)

The charge density for the face of the nylon disk was measured at 1742 nC/cm2 with the PVC disk’s charge density being measured at -40 nC/cm2.

Question 5: One disk had a negative charge while the other had a positive charge. The charges of the disks differ by about 1 nC, but both are very close to zero. (This may be because of an error in reading the measurements.)

Question 6: The nylon disk obtained a portion of the PVC disk’s electrons because it had a higher electron affinity, gaining a charge.

Question 7: The number of electrons in a closed system will remain constant along with the charge. This follows because one disk took a number of electrons from the other, increasing its charge while decreasing the other disk’s charge.

The surface charge densities for the Faraday Cup using the Nylon and PVC disks’ charges were 558 and -281 nC/cm2, respectively.

Questions to Answer

1. A diagram of a diagram of a step

   Description automatically generated
2. A diagram of arrows pointing to a circle

   Description automatically generated
3. The walls of the pint became charged and would not allow any charges inside. This kept the cork from becoming electrically charged.