TAP 125- 1: Super-capacitor

All the essential ideas of a capacitor can be illustrated thorough a dramatic demonstration, with a large-scale capacitor connected to a high-voltage supply. Some of the effects are best seen in subdued lighting.

You will need

- ✓ two sheets of aluminium foil, approximately 50 cm × 150 cm
- ✓ a slightly larger sheet of heavy-gauge polythene (damp-course material works well or even a good bin liner)
- ✓ educational use EHT power supply, 0–5 kV, dc used with internal 50 MΩ resistor
- ✓ four leads, with no side screws.
- ✓ two crocodile clips, insulated ones are best

Safety

High voltage warning, capable of giving an unpleasant shock. To protect the teacher from accidental contact with the high voltage foil, support a glass or Perspex plate (a glass cupboard door is good) about 100 mm above the capacitor.

What to do

1. Make a crude capacitor by laying the polythene between the two sheets of aluminium on a bench. Ensure the top and bottom sheets of aluminium are not in contact anywhere.
2. Using crocodile clips, connect each aluminium sheet to a terminal of the power supply, set initially at 0 V. Make sure the negative terminal of the power supply is earthed and is connected to the sheet of aluminium on the bench.
3. Listen carefully and watch the foil as you gradually increase the potential difference. You should hear a crinkling sound and notice the foil is being pulled down flatter.
4. Why is this happening? The power supply removes electrons from one foil sheet and at the same time adds electrons to the other. They cannot move round the complete circuit because polythene is an electrical insulator. Charge is stored on the foil sheets in amounts + Q and – Q. Having opposite charges, the foil sheets attract.
5. You should notice that the force of attraction gets larger for larger potential difference, V. This suggests Q increases with V.
6. If you go on increasing the potential difference, there may be a sudden discharge (or discharges), almost explosive sparking. A channel through the polythene has been made conducting because of the high potential difference. This is just like lightning discharges through the (insulating) air.
7. If you look closely at where this happens, you will see it is where the foil sheets are closest together.
8. Turn the power supply off. Discharge the capacitor then examine the polythene. You will find it has holes in it! The polythene has been melted by the heating effect of each discharge. The capacitor clearly has stored energy as well as charge. (It could however be argued that this is resistive heating once breakdown has occurred, with energy transferred from the power supply directly, rather than from the capacitor.)
9. At this point, look at a large-value commercial capacitor, say 100 mF. You will notice it is shaped like a cylinder. It has a similar structure to the ‘super-capacitor’, but has been rolled up to save space. The labelling on this capacitor includes a voltage: this

is the maximum potential difference which can be applied in normal use, that is, without the insulator breaking down.

Steps 4 and 5 help to develop students' understanding of how capacitors work. You may wish to omit them at this stage.

External references

This activity is taken from Advancing Physics Chapter 10, 90D