Quantum Mechanics_triboelectric effect

The **triboelectric effect** (also known as *triboelectric charging*) is a type of contact electrification in which certain materials becomeelectrically charged after they come into contact with another different material through friction. Rubbing glass with fur, or a comb through the hair, can build up triboelectricity. Most everyday Static electricity is triboelectric. The polarity and strength of the charges produced differ according to the materials, surface roughness, temperature, strain, and other properties.

The triboelectric effect is not very predictable, and only broad generalizations can be made. Amber, for example, can acquire an electric charge by contact and separation (or friction) with a material like wool. This property, first recorded by Thales of Miletus, suggested the word "Electricity" (from William Gilbert's initial coinage, "electra"), from the Greekword for amber, *ēlektron*. The prefix *tribo-* (Greek for 'rub') refers to 'friction', as in tribology. Other examples of materials that can acquire a significant charge when rubbed together include glass rubbed with silk, and hard rubber rubbed with fur.

Triboelectric series

Triboelectric series:

Most positively charged

+

Polyurethane foam

Hair, oily skin

Nylon, dry skin

glass

Acrylic, Lucite

Leather

Rabbit's fur

Quartz

Mica

Lead

Cat's fur

silk

Aluminium

Paper (*Small positive charge*)

Cotton

wool (*No charge*)

0

Steel (*No charge*)

Wood (*Small negative charge*)

Amber

Sealing wax

Polystyrene

Rubber balloon

Resins

Hard rubber

Nickel, Copper

Sulfur

Brass, Silver

Gold, Platinum

Acetate, Rayon

Synthetic rubber

Polyester

Styrene and Polystyrene

Orlon

Plastic wrap

Polyethylene (like Scotch tape)

Polypropylene

Vinyl (PVC)

Silicon

Teflon

Silicone rubber

Ebonite

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Most negatively charged

John Carl Wilcke published the first triboelectric series in a 1757 paper on static charges.[1][2] Materials are often listed in order of the polarity of charge separation when they are touched with another object. A material towards the bottom of the series, when touched to a material near the top of the series, will acquire a more negative charge. The farther away two materials are from each other on the series, the greater the charge transferred. Materials near to each other on the series may not exchange any charge, or may even exchange the opposite of what is implied by the list. This can be caused by rubbing, by contaminants or oxides, or other variables. Lists vary somewhat as to the exact order of some materials, since the relative charge varies for nearby materials. From actual tests, there is little or no measurable difference in charge affinity between metals, probably because the rapid motion of conduction electrons cancels such differences.[3]

Cause

Although the word comes from the Greek for "rubbing", *τρίβω* (τριβή: friction), the two materials only need to come into contact and then separate for electrons to be exchanged. After coming into contact, a chemical bond is formed between parts of the two surfaces, called adhesion, and charges move from one material to the other to equalize their electrochemical potential. This is what creates the net charge imbalance between the objects. When separated, some of the bonded atoms have a tendency to keep extra electrons, and some a tendency to give them away, though the imbalance will be partially destroyed by tunneling or electrical breakdown (usually corona discharge). In addition, some materials may exchange ions of differing mobility, or exchange charged fragments of larger molecules.

The triboelectric effect is related to friction only because they both involveadhesion. However, the effect is greatly enhanced by rubbing the materials together, as they touch and separate many times. For surfaces with differing geometry, rubbing may also lead to heating of protrusions, causing pyroelectriccharge separation which may add to the existing contact electrification, or which may oppose the existing polarity.

Surface nano-effects are not well understood, and the atomic force microscope has enabled rapid progress in this field of physics.

Because the surface of the material is now electrically charged, either negatively or positively, any contact with an uncharged conductive object or with an object having substantially different charge may cause an electrical discharge of the built-up Static electricity: a spark. A person simply walking across a carpet may build up a charge of many thousands of volts, enough to cause a spark one centimeter long or more. Low relative humidity in the ambient air increases the voltage at which electrical discharge occurs by increasing the ability of the insulating material to hold charge[*why?*] and by decreasing the conductivity of the air, making it difficult for the charge build-up to dissipate gradually. Simply removing a nylon shirt or corset can also create sparks. Car travel can lead to a build-up of charge on the driver and passengers due to friction between the drivers clothes and the leather or plastic furnishings inside the vehicle. This charge can then be relaxed as a spark to the metal car body, fuel dispensers, or nearby door handles, etc. When the vehicle's body itself builds up a static charge (acting as a Faraday cage) it can relax through the carbon in the tires. If it remains charged when parked, sparks may jump from the door frame to occupants as they make contact with the ground.
This type of discharge is often harmless because the energy ($(V^2 * C)/2$) of the spark is very small, being typically several tens of micro joules in cold dry weather, and much less than that in humid conditions. However, such sparks can ignite flammable vapours, see risks and counter-measures.

In aircraft and spacecraft

Aircraft flying in weather will develop a static charge from air friction on the airframe. The static can be discharged with static dischargers or static wicks.
NASA follows what they call the **Triboelectrification Rule** whereby they will cancel a launch if the launch vehicle is predicted to pass through certain types of clouds. Flying through high-level clouds can generate “P-static” (P for precipitation), which can create static around the launch vehicle that will interfere with radio signals sent by or to the vehicle. This may prevent transmitting of telemetry to the ground or, if the need arises, sending a signal to the vehicle, particularly critical signals for the flight termination

system. When a hold is put in place due to the triboelectrification rule, it remains until Space Wing and observer personnel such as those in reconnaissance aircraft indicate that the skies are clear.[4]

Risks and counter-measures

Ignition

The effect is of considerable industrial importance in terms of both safety and potential damage to manufactured goods. Static discharge is a particular hazard in grain elevators owing to the danger of a dust explosion. The spark produced is fully able to ignite flammable vapours, for example, petrol, ether fumes as well asmethane gas. For bulk fuel deliveries and aircraft fueling a grounding connection is made between the vehicle and the receiving tank prior to opening the tanks. When fueling vehicles at a retail station it is proper to touch metal on the car before opening the gas tank or touching the nozzle

In the workplace

Means have to be provided to discharge carts which may carry such volatile liquids, flammable gasses, or oxygen in hospitals. Even where only a small charge is produced, it can result in dust particles being attracted to the rubbed surface. In the case of textile manufacture this can lead to a permanent grimy mark where the cloth comes in contact with dust accumulations held by a static charge. Dust attraction may be reduced by treating insulating surfaces with an antistaticcleaning agent.

Damage to electronics

Some electronic devices, most notably CMOS integrated circuits and MOSFETtransistors, can be accidentally destroyed by high-voltage static discharge. Such components are usually stored in a conductive foam for protection. Grounding oneself by touching the workbench, others, or using a special bracelet or anklet is standard practice while handling unconnected integrated circuits. Another way of dissipating charge is by using conducting materials such as carbon black loadedrubber mats in operating theatres, for example.

Devices containing sensitive components must be protected during normal use, installation, and disconnection, accomplished by designed-in protection at external connections where needed. Protection may be through the use of more robust devices

or protective countermeasures at the device's external interfaces. These may be opto-isolators, less sensitive types of transistors, and static bypass devices such as metal oxide varistors.

See also

- Antistatic agent
- contact electrification
- Electrical phenomena
- Electronegativity
- Electrophorus
- ESD materials
- Static electricity
- Triboluminescence
- Wimshurst machine
- Xerography

References

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2. ^ Disputatio physica experimentalis, de electricitatibus contrariis... Typis Ioannis Iacobi Adleri, 1757.
3. ^ The TriboElectric Series
4. ^ Flight Rules and Triboelectrification (What the Heck is That?) at NASA.GOV