appeared on 13th July 2005

Behind fluorescence lines

The mineral fluorite (calcium fluoride) is nature's own short-changer, says S.Ananthanarayanan.

Fluorite has lent its name to fluorescence, a light emitting property exhibited by many materials, including the coating of the domestic tube light, or the fluorescent lamp.

Fluorescence

In fluorescence, an ordinary, cold body emits light, usually in the visible range, not by being heated, but just by being bathed in a different kind of light. Unlike reflection, where the light falling on a body bounces off unchanged, in fluorescence, the light falling on the body is absorbed and then re-emitted, with a little of the energy being 'pocketed' by the fluorescent body.

A ready application is in the fluorescent lamp, where the coating on the inside of the lamp is the fluorescent material. An electric discharge inside the lamp generates ultra violet light and induces the coating in the lamp to emit light of a brace of colours that add up to nearly white light. Other applications are fluorescent paints, which changes dim light into a colour that the eye is more sensitive to.

So what's going on?

The molecules of materials consist of different atoms in combination and kept stable by the forces between the nuclei of the atoms and the charges of the electrons in orbit around the nuclei. In free atoms, the electron cloud is equal to the nucleus and the atoms are neutral. But when combined in a molecule, the atoms are no more 'free', for they have 'given up' or 'borrowed' electrons from one another, leading to net charges, which create the forces to keep the molecule together.

When a particle of light strikes a molecule of a fluorescent material, the energy of the light particle gets absorbed by one of the electrons, which gets promoted to a higher energy orbit. The energy of the whole molecule also increases, as a consequence. In the normal course, this 'promoted' electron can come back to its initial state, with a photon of the same energy as the first one being emitted and the molecule is where it started.

Los of energy

But in fluorescent materials, before the electron in the higher state actually 'decays', the rest of the molecule readjusts itself to be in the most stable condition that is consistent with the higher energy of the whole molecule. This 'optimal' condition is soon found, an instant slower than the electron, which is much lighter, jumping to the higher state. But this condition is with just a little of the total energy having to be discarded, and this extra energy shows up as a rise in the vibration or thermal energy of the molecule. The result is

that the higher state, in which the ‘promoted’ electron continues to be, is actually a slightly lower energy level than it was when the electron first occupied it.

And, when the electron descends to its original energy level, it gives off a particle of light with a little less energy than the energy it absorbed to get to the higher energy level. This shows as the emission of light of a lower wavelength.

Usually the molecule will have to readjust to the lower energy state being restored and this could be by absorbing some thermal energy from the rest of the material, which would compensate the slight increase during the first readjustment.

New use of fluorescence

A novel use for fluorescent materials is to track migration of rare bird varieties. The grain the birds feed on is sprinkled with fluorescent material. This leads to the bird droppings being fluorescent and the path the birds take when the fly from place to place becomes easily visible!