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Plasma, the new antiseptic soap.

The so called 4th state of matter finds use in disinfecting hands, says S.Ananthanarayanan.

Many of us may know that the atmosphere of the sun is so hot and the atoms move so rapidly that their negative (electrons) and positive (the remaining ion) parts have been torn apart and the gas consists of charged particles that repel and attract, apart from speeding, colliding and ricocheting. Creating a gas like this at ordinary temperatures is found to be a good way to kill bacteria that have become resistant to antibiotics!

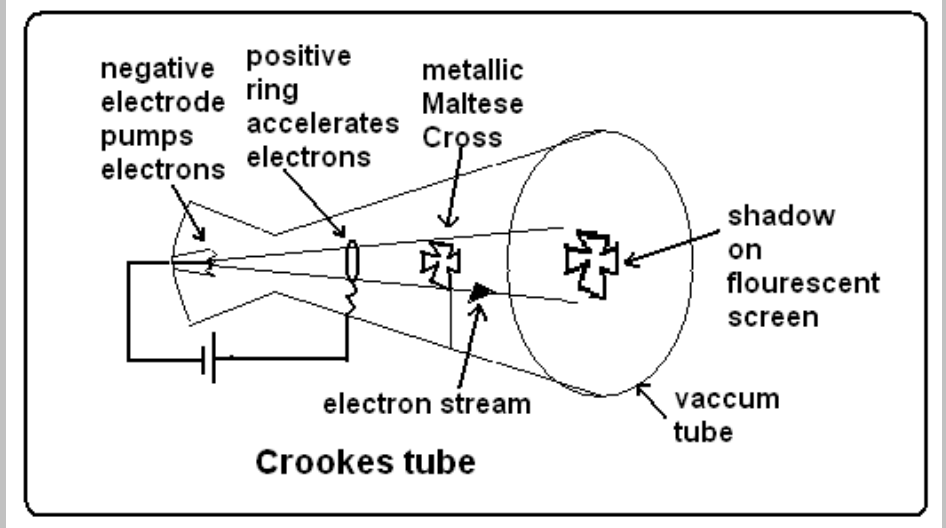
Plasma

The gas we have on the sun, where a good proportion of the components are charged, is called plasma and it behaves quite differently from ordinary gas. In fact, in most of the universe, which consists of gases, the gas is ionized, or the atoms have separated into oppositely charged pairs and the gas, in fact, is plasma. Again, most of the universe is not hot and dense, like the sun, but is cool, but at low pressure, where the plasma can exist without great heat.

The state of matter on the earth is an exception, where things are too cool and too dense to exist as plasma. But still, we have this kind of matter in the ionosphere, in Aurora Borealis, or the Northern Lights, seen at the Poles, in fluorescent lamps, neon lights and in thunderstorms. And because of the magnetic and electrical interaction of particles in plasma, the particles form ‘filaments, beams and double layers’ – colourful displays and uneven distribution of charge and ions, they have effects on atoms and molecules of other materials, etc

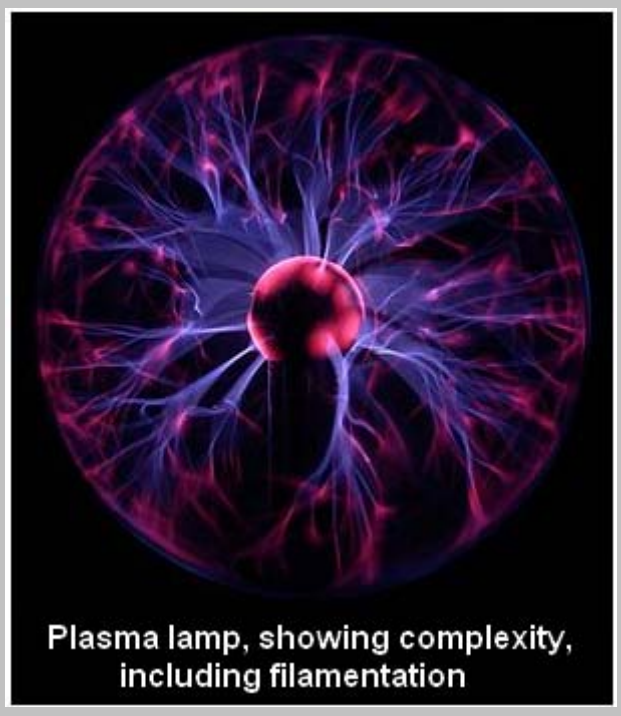
Plasmas were first encountered in the late 1800s, when electrical discharges inside tubes that containedwith low pressure gases were studied. In a classic experiment in 1878, Sir

William Crookes showed that something inside a gas discharge tube moved in straight lines and could cast a shadow. The nature of the discharge was shown to be electrons



and the discoveries were the start of revolution in physics that has continued without let to this day

But the gas inside such tubes was also seen to have got ionized, showing greatly altered behaviour, to respond to magnetic or electric fields, to emit radiation at colours characteristic of the nature of the gas, etc. The name, ‘plasma’ was coined by Irving Langmuir in 1928, perhaps because the ‘filaments and strings’ looked like blood plasma.

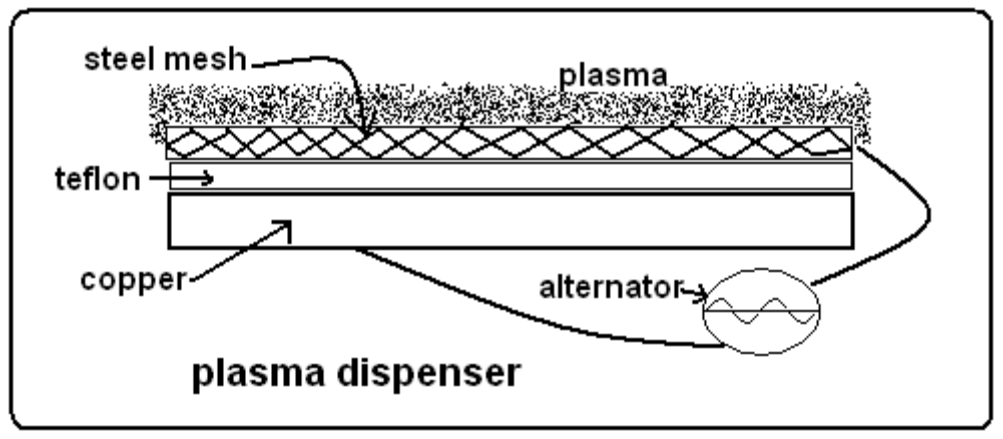


Plasma lamp, showing complexity, including filamentation

Low temperature plasma

For a plasma to exist at ordinary pressure, it needs to be at very high temperature. But if only a small proportion of the atoms of a gas are ionized at any time, then the plasma can be at ordinary temperature. It is like a drop of boiling water in bucket of cool water, the scalding effect is local and very short-lived. In practical low temperature plasma devices, the low percentage plasma is created by electrical ionization of the gas by electricity or radiation, so that there is a proportion of ionized content. The low density, transient plasma has been found effective in containing bacteria and has found application in disinfection of clinical surfaces where other methods have limitations.

The New Journal of Physics (publication of the Institute of Physics and the German Physical Society) reports that a group in the Max Plank Institute of Extraterrestrial Physics, near Munich has developed a convenient device that ‘dispenses’ plasma at low temperature and in good quantity. The design is simplicity itself – just a copper plate and a stainless steel mesh, separated by a 1 mm sheet of Teflon. High frequency voltage is applied to the copper plate and the SS mesh is grounded.



Plasma is created within the mesh, it barely warms up more than 5 degrees C, can cover comfortably the area of a pair of hands and clears bacteria down to nearly a millionth of its population in less than 10 seconds. The device generates UV radiation or toxic gases within permitted limits and is within safe limits of electrical current and voltage.

How it works

An important design consideration in developing a bactericide is that it should not harm human tissue. The first effect of plasma is electrostatic. When things come in contact with plasma they get electrically charged and the charge that is induced reduces when the things bet bigger. As bacteria are about 1 micron in size, which is much less than human tissue, the electrical forces on bacteria are much more disruptive.

The other, more important effect of plasma is that reactive ions of nitrogen and oxygen, that is, the hydroxyl ion and hydrogen peroxide are created. These produce stress on proteins, on the lipid, or oil-based components of cells and on membranes. An important special effect only on bacteria is that the DNA themselves are affected – as bacterial DNA are not protected in the cell nucleus, unlike the DNA of animal cells.

The third effect is of hard UV light. The skin is protected by its outer layer, the ‘stratum corneum’, but bacteria have no such shield. This UV emission does pose a risk to human cell DNA, but this can be controlled by keeping the UV radiation level within permitted limits.

The results of tests carried out are impressive – the bacterial population remaining 18 hours after exposure to plasma for 2 seconds was found depleted by a factor of 100,000. This level of ‘disinfection’ was found to remain even after 48 hours!

The context

The recent Swine Flu scare brought home the importance of hygiene and of washing hands often. This requirement is routine with hospital staff and surgeons. But the precaution has become suspect with the increase in ‘nosocomial’ ie, hospital or community induced infection, coupled with the resistance that bacteria have developed to many antibiotics.

It is reported that in the US alone, over 200,000 patients are affected each year by infection induced by catheter insertion. It is reported that there are over 100,000 cases of 'Multi-drug Resistant Staphylococcus Aureus' infections, leading to 18,000 deaths each year. And then there are the results of infection of animals and transmission to humans. The standard measure of 'scrubbing' by surgeons and other medical persons, takes 3 to 5 minutes and has its own side effects – mechanical stress, chemical allergies, etc. With 60-100 disinfections needed each day, a doctor may have to spend over 3 hours only scrubbing her hands to be adequately safe for patients!

In this context, plasma sterilization, which is fast, harmless to humans, very thorough, being at the molecular level, able to reach deep crevices and cavities, and proven to be deadly to bacteria, would prove to be the real advance after the discovery of antiseptics, and their use in medicine, in the 19th century.

[The team at the Max Plank Institute has also developed an arrangement to use argon plasma for disinfecting wounds, with great efficacy and minimal damage to healthy tissue.]
