Piezoelectric effect in liquids

Published On: 29-03-2023

Why is in news? For the first time, scientists have reported evidence of the piezoelectric effect in liquids.

What is the piezoelectric effect?

In the piezoelectric effect, a body develops an electric current when it is squeezed. Quartz is the most famous piezoelectric crystal: it is used in this capacity in analog wristwatches and clocks.

Such crystals are also used in cigarette lighters, electric guitars, TV remote controls, audio transducers, and other instruments where converting mechanical stress to a current is useful.

The effect has been known for 143 years and in this time has been observed only in solids.

Quartz is silicon dioxide (SiO_2). The quartz crystal consists of silicon and oxygen atoms at the four vertices of a three-sided pyramid; each oxygen atom is shared by two pyramids. These pyramids repeat themselves to form the crystal.

The effective charge of each pyramid is located slightly away from the centre. When a mechanical stress is applied – i.e. when the crystal is squeezed – the position of the charge is pushed further from the centre, giving rise to a small voltage. This is the source of the effect.

Piezoelectric effect in liquids

The reason the piezoelectric effect has only been expected in solids thus far is that the body being squeezed needs to have an organised structure, like the pyramids of quartz. Liquids don't have such structure; instead, they take the shape of their container.

Normal liquids and gases have not been shown to exhibit order that persists long enough to be observed and characterised

The effect was found in pure 1-butyl-3-methyl imidazolium bis(trifluoromethyl-sulfonyl)imide and 1-hexyl-3-methyl imidazolium bis(trifluoromethylsulfonyl)imide – both ionic liquids (i.e. liquids made of ions instead of molecules) at room temperature.

Physicists explain the effect using a combination of Hooke's law – that the force required to squeeze an object is linearly (i.e. non-exponentially) proportional to the amount of squeezing – and the properties of dielectric materials. These are materials that don't conduct electricity but whose electrons are still mildly affected by an electric field.

Indeed, their discovery will have to be modelled in ionic liquids specifically. This is because, according to the paper, 'normal' and ionic liquids of the kind tested in the study respond very differently, at the molecular level, when an electric charge is "imposed" on them.

Significance of the Findings

The discovery … opens the door to applications that have previously not been accessible with solid-state materials, and [room-temperature ionic liquids] are more readily recyclable and in many instances pose fewer environmental issues than many currently used piezoelectric materials

The liquids also displayed the inverse piezoelectric effect: they became distorted when an electric charge was applied. This fact could be used to control how the liquids bent light passing through them by passing different currents through them. That is, using this simple control mechanism, vials of these liquids could be lenses with dynamic focusing abilities.

Having a theory to explain the liquids' behaviour could reveal why these liquids behave the way they do, which could in turn reveal better ways to manipulate them, and develop newer applications.