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Department of Physics

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DIELECTRICS (రోధకములు)

Based on electrical conducting properties, materials are categorized as conductors, insulators and semiconductors. Every material is made up of molecules which are in turn made up of atoms. When subjected to electric field these atoms in the material undergoes certain displacements and changes in properties.

Every material is made up of atoms. Atoms contain both negatively and positively charged particles. The central nucleus of the atom is positively charged. In any material, the atoms are arranged as dipoles represented with a positive and negative charge on its end. When these materials are subjected to electric field, dipole moment takes place.

The term "Dielectric" is the combination of two words- 'Dia' and 'electric'. The electrical conductivity of a perfect dielectric is zero. A dielectric stores and dissipate the electrical energy similar to an ideal capacitor. Some of the main properties of a Dielectric material are Electric Susceptibility, Dielectric polarization, Dielectric dispersion, Dielectric relaxation, Tunability, etc…

Types of Dielectric Material (రోధకముల రకములు)

Dielectrics are categorized based on the type of molecule present in the material. There are two types of dielectrics – Polar dielectrics and Non-polar dielectrics.

Polar Dielectrics (ధ్రువ రోధకములు)

In polar dielectrics, the center of mass of positive particles does not coincide with the center of mass of negative particles. Here the dipole moment exists. The molecules are asymmetrical in shape. When the electric field is applied the molecules align themselves with the

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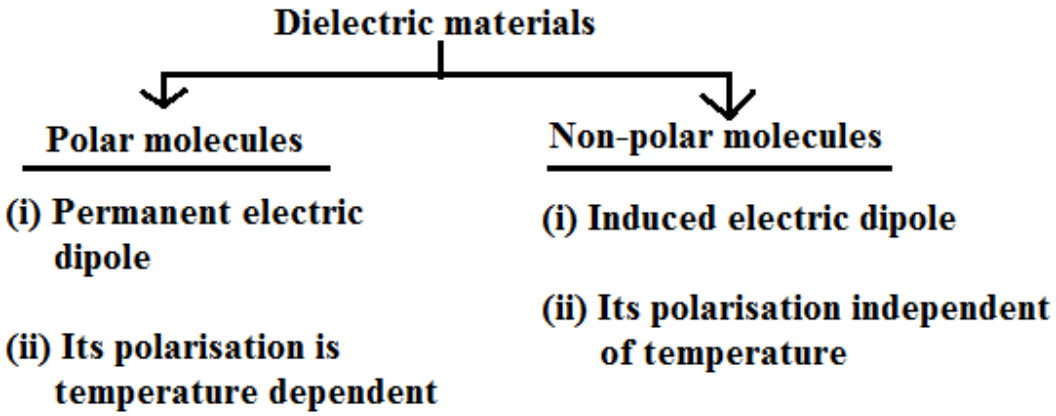
electric field. When the electric field is removed random dipole moment is observed and the net dipole moment in the molecules becomes zero. Examples are H2O, CO2, etc…

Non-Polar Dielectrics(అధ్రువ రోధకములు)

In the non-polar dielectrics, the center of mass of positive particles and negative particles coincide. There is no dipole moment in these molecules. These molecules are symmetrical in shape. Examples of non-polar dielectrics are H2, N2, O2, etc…



Some important applications of Dielectric Materials

1. These are used for energy storage and enhancement of capacitance in capacitors.
2. To enhance the performance of a semiconductor device, high permittivity dielectric materials are used.
3. Dielectrics are used in LCDs.
4. Dielectrics are used in enhancement of dielectric constant and dielectric strength.
5. Dielectrics are used High insulation applications..

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Non polar dielectric in Electric field:

A nonpolar molecule is molecule without a dipole in which the charges are equally distributed. Non polar dielectrics will be effected by an electric field. In an electric field, the positive and the negative charges in a nonpolar molecule experience forces in opposite directions as a result of their opposite polarities. Due to this force, the electron cloud of a nonpolar molecule will be displaced in the direction of the attraction. Thus, in the presence of an electric field, nonpolar molecule experiences induced dipole moment. This dipole moment induced is in the direction of the field and is directly proportional to the strength of the electric field. Due to the induced nature of polarity, the polarity of this material will be lost when the field is removed.

Polar dielectrics in Electric field:

polar molecule has electric dipoles due to which it has dipole moment. Due to thermal agitation, the dipoles in a polar material are oriented randomly. Here, the net dipole moment of the material is zero.

When an electric field is applied, the individual dipoles align themselves in the direction of the electric field. This means that the bonds, their nature and their orientation remain constant and the polar molecule only rotates about its axis minutely to align itself. The sum of dipole moments of all the molecules leads to a net dipole moment in the direction of the electric field. The extent to which the polar molecules get polarizes and align themselves depends upon the strength of the external field and the thermal energy that breaks this alignment.

Dielectric polarization (రోధక ధ్రువణం:

A dielectric may be made up of polar or non-polar molecules. When external electric field is applied to polar on non polar molecules, they orient towards the external field direction. The orientation depends upon the strength of the field applied.

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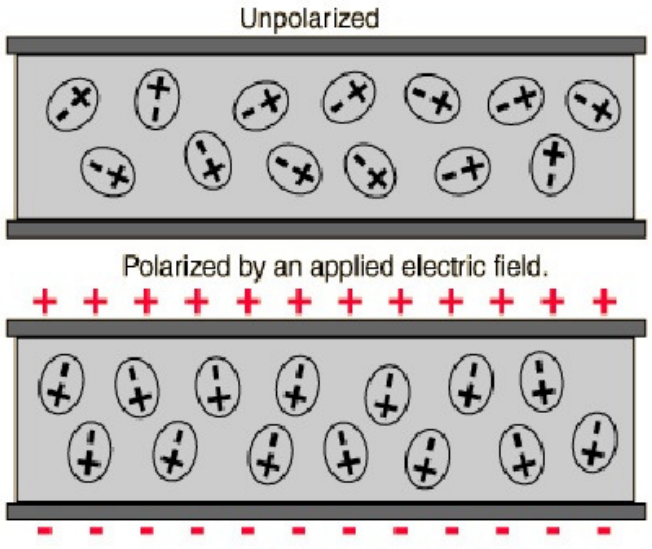
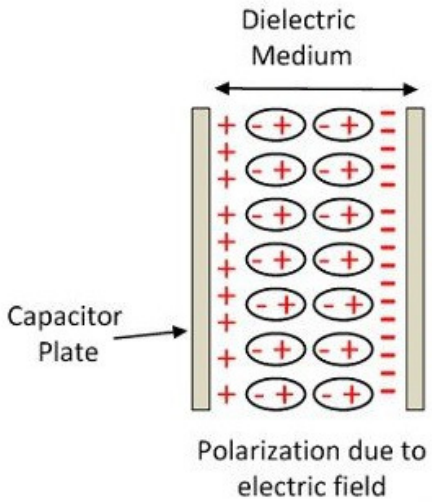
Let us consider a dielectric slab in an electric field which is acting in the direction shown in the figure. The arrangement of charges within the molecules of the dielectric in the electric field is as shown in the figure. The positive charges move in the direction of the field and the negative charges in the opposite direction. In other words, the electric dipoles align themselves with the direction of the field. In this state, the entire dielectric and its molecules are said to be polarised.





The alignment of the dipole moments of the permanent or induced dipoles with the direction of the applied electric field is called as polarisation.

Polarisation is a phenomenon in which an alignment of positive and negative charges takes place within the dielectric resulting in no net increase in the charge of the dielectric.

The extent to which a dielectric is polarized is described by a vector quantity 'P' called the polarisation.

Mathematically, polarisation is defined as the electric dipole moment per unit volume.

When this definition is applied to a dielectric slab of area of cross section 'A' and length 'l', the dielectric polarization is given by

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$P = \frac{q'l}{Al} = \frac{q'}{A}$ (where, q' is induced surface charge, $q'l$ is dipole moment and Al is volume of the dielectric slab.

In other words, the dielectric polarization 'P' is numerically equal to the induced surface charge density.

Model Questions (మాదిరి ప్రశ్నలు)

1. What are the types of dielectrics
2. Distinguish polar and non polar dielectrics
3. Explain the behavior of dielectrics in the presence of external electric field.
4. Define dielectric polarization
5. What is dielectric polarization? Explain.
6. Mention some applications of dielectrics.

References

1. Unified Physics, Volume III, JAI PRAKASH NATH PUBLICATIONS, MEERUT

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