Impedance spectroscopy: a tool to characterize materials

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Impedance spectroscopy is a powerful technique to characterize materials. It permits to describe the charge migration and the orientation of permanent dipoles inside them. A large range of frequencies and temperatures must be used, in order to obtain a complete characterization of the dielectric response, and this require using different techniques. The different regimes of the dielectric function can be detected, and the dynamics of the relaxations processes can be found.

Impedance spectroscopy provides the measurement of the complex impedance, $Z^*(\omega)=Z'(\omega)-iZ''(\omega)$. From this value, it is possible to calculate derived quantities related to it, such as the admittance, $Y=Z^{-1}$, that is, $Y^*(\omega)=Y'(\omega)+iY''(\omega)$, the complex permittivity, $\varepsilon^*(\omega)=\varepsilon'(\omega)-i\varepsilon''(\omega)$, and the dielectric modulus, $M=\varepsilon^{-1}$, $M^*(\omega)=M'(\omega)+iM$.

In this talk, different examples of using impedance spectroscopy to characterize materials are presented, showing the ability of this technique. It offers performances that permit to investigate the fundamental aspects of the electrical properties, yielding a wealth of information about the molecular motions and relaxation processes present in the materials. Several relaxation models are discussed, relating the morphological, structural and dielectric properties of different materials, and the electrical circuits modeling is presented.