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WEIGHING IN LIQUID CHROMATOGRAPHY*

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ABSTRACT

A method is presented of measuring the force acting on a sample in the inhomogeneous part of the electronic field of a condensor. This paper describes a new method which is based upon the widely diverging values of the dielectric constants of most substances.

INTRODUCTION

During the last ten years much attention has been paid to the automatization of chemical analysis. One of the subjects of these studies has been the dielectric constant, which is also called permittivity. This paper deals with a particular way of measurement of this property with regard to fluids.

If the measurement of dielectric constant or permittivity is mentioned, most people think of a capacitor filled with the liquid to be measured and of an electronic circuit to evaluate the capacity. In the present paper we will consider a different, basically non-electronic way of measuring the permittivity.

Already Thales of Milet, more than 2500 years ago described the attraction of small solid bodies by a piece of amber, electrified by friction. Boltzmann gave a quantitive analysis of the forces in an inhomogeneous field on a dielectric body, which he used to measure the dielectric constant. Pohl incorporated this principle in the demonstrations of his famous physics courses at the university of Göttingen, using a torsion balance for measuring the forces. In 1943, one of the authors demonstrated the possibility to use such an arrangement in an extended frequency range for the analysis of high polymers. His coworker Alpers, now his wife, made, some years later, a thorough investigation on the inherent possibilities, constructing for this purpose an

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automatically compensating balance[1]. In the last two years, the other two authors, starting from a different point of view, aimed at the development of a more practical arrangement, using Newtons third law. Instead of measuring the attracting force on the sample, they measured the reactive force on the capacitor by a commercially available electromagnetic microbalance (Sartorius 4102 after Gast)[2, 3].

The use of such a device implied, that the forces they measured were vertical and could, therefore, not be distinguished from any forces of gravitational origin. The limitations of the accuracy brought about by this fact were the reason that, in the next step, the three authors decided to design an apparatus such as to deal with horizontal forces on the capacitor.

APPARATUS

The apparatus is shown in the Fig. 1. We see a taut band suspension, which carries a horizontal beam to the end of which two triangular condensor plates with a cylindric curvature are fixed. Only one of them is visible in the figure. Each of the plates is part of a condensor, together with a larger electrode, which is also cylindrically shaped.

Between each pair of electrodes, a tube has been mounted, consisting of fused quartz. The liquid to be measured, is sent through the tube in one of the capacitors, while the tube in the other capacitor can be filled with a reference liquid.

The triangular plates are connected to earth, the opposing ones to an AC high-voltage source (some hundred volts). Because of the inhomogeneity caused by the two tubes, tangential forces arise, the moments of which cancel, if the tubes are

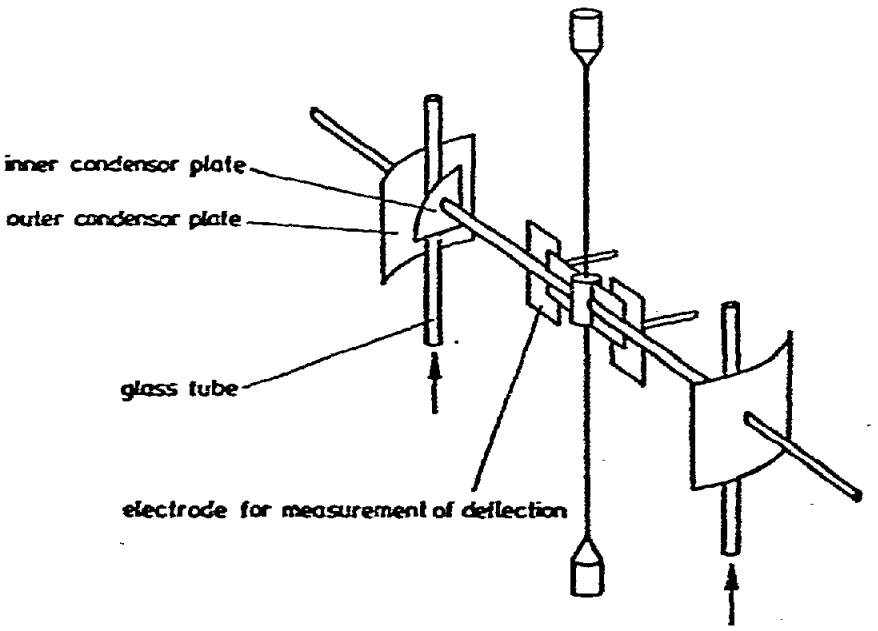

Fig. 1. Measurement of permittivity by forces.

filled with equal liquids. If the dielectric constants of the liquids are different, there will be a resulting torque, causing a rotation of the beam. This rotation is measured by a differential capacitor, consisting of the vane, which is fixed to the center of the beam and two corresponding electrodes, fixed at the casing. A capacitance bridge is used with a lock in amplifier in the signal path. The output of the amplifier is recorded.

MEASUREMENTS AND DISCUSSION

Several different liquids have been sent through the measurement tube. The measurements were repeated several times and proved to be reproducible within a few percent. Though reproducible, the values measured were sensitive to conductivity caused most probably by water content of the liquids. If we remember, that application to analysis was the aim of the study, we should admit, that the measurement of resistivity could also be useful.

By a set of measurements with different frequencies, dielectric constant and conductivity could both be evaluated, which would increase the usefulness of the method. It is also possible, to apply the principle of automatic compensation to the torque measurement, thereby increasing the signal-to-noise ratio and the speed of measurement.

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