ELECTRO-ODOCELL
FOR ODOR MEASUREMENT

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It is of interest to observe that the basic research on odor and olfaction and especially on measurement of odor objectively has not been developed enough to study basic facts on odor and scientific and technical problems related to odor.

The aim of odor research work in Robert College Research Center *, has been to develop an objective odor measuring instrument applicable as a supplement to organoleptic evaluation in grading and inspection of edible commodities.

In attempting to set experiments and instruments by which odors might be detected, it is of importance to try to define odor. Immediately this raises several questions, for it appears that many materials which are inodorous to the human nose are easily detected by the nose of the lower animals. It is, of course, quite impossible to state whether this difference lies in sensitivity of detection and range of detection. It should perhaps be borne in mind that just as the human eye is blind to light of certain frequencies, which in some cases other animals can detect, and the human ear is deaf to certain frequences, so the human nose may be entirely insensitive to certain materials which other animals might find odorous.

Knowing that small amounts of material may produce measurable changes in surface tension, a series of studies were made with pendant drop method to see if odorous materials in the air would also produce measurable changes in surface tension.

An instrument is developed and called odocell using the pendant drop method to detect the odor in the air. The experiments with odo-cell indicate that the surface tension of distilled water, meneral oil, and water-stabilized mercury undergo considerable change when the air in contact with the drop is contaminated. The change of surface tension of particular liquid follows a pattern characteristic of the contaminant. The same contaminant produces different surface tension changes in the three different liquids studied. (1, 2, 3, 4).

The time spent to obtain a surface tension change versus time curve for a given odorant has been more than one hour and some odorants do not give a measurable change in surface tension of water or mercury. Our objective was to overcome this difficulty.

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A new method and instrument were necessary to reduce the time of measurement and find new detecting surfaces which are sensitive to almost all kinds of odors. Instrument research has started in two directions, one uses the same principles as odocell but record the results of measurements automatically; the second develops a transducer which will change the surface tension or surface potential changes to electric current and record this changes automatically. Electro-Odocell with which the present paper is concerned is the result of instrument research carried on in connection with the idea of development of an olfactory-electrical transducer.

Electrical Method of Measurements:

The possibility of using surface potential change on sensitive liquid surface due to odorants instead of surface tension changes was suggested by **Eaton** and **Tanyolaç** in 1949. The work carried out by **Chapman, Eaton, Kopplin** and **Christian** using the Kelvin method as modified by **Zisman** for measurement of change in surface potential of liquids or solids surfaces due to contamination of odorous materials have been reviewed. Repeatability and sensitivity problems of other investigators have been carefully investigated. The broad definition of odor has been made by Tanyolaç. "Theoretically all the materials available have odor and odor is due to the molecules given off by the odorants at normal temperature and pressure, and the three dimensional molecular structure of materials plays a major part in olfaction".

By this definition, an odor sensitive device would be one which detects and identifies the presence of sub-microscopic contamination in air regardless of the contaminating material concerned. This definition makes oxygen, nitrogen, water vapor and other materials present in the air, but not detected by the human nose, as odorous material.

A new instrument is developed and named Electro-Odocell for the detection and measurement of odor. Electro-Odocell is made of three parts. (Fig. 1). Part one is a detector-transducer which has a surface, sensitive to the molecules of materials and produces a change in voltage on the detector depending on the type and the amount of molecules absorbed on its surface. The sensitive surface of the detector (a) is open to the odor molecules and is made of dielectric materials like mica, glass, plastics, paper, etc. The conducting

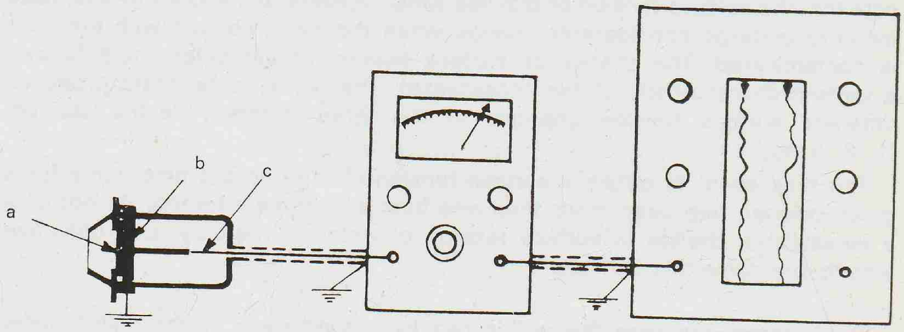

Fig. 1

surfaces of the detector (b) is covered with a copper or silver plate which is connected to a cable (c) well insulated from outside leakage and static changes. Part two is a micro-voltmeter which can record the voltage changes in the detector. Third part is an automatic recorder which records the indication of the micro-voltmeter as a micro-volts versus time curve.

Two different qualities of mica were used as detector surfaces. One is brown mica with an average relative dielectric constant (8.5); the other is the white mica with a relative dielectric constant (4.7). In all experiments the same volume of odorous materials with the same surface area were used. Odorants were placed inside an emery necked vial. The height of the odorant, therefore, distance to the detector surface were the same in all measurements. Chemical materials used were analytical quality.

First the initial voltage and atmospheric condition were recorded, and micro voltmeter was adjusted for zero reading; then the bottle was brought to the mouth of the detector at the same time the automatic recorder was initiated to record the change in voltage or change in current. The micro-voltmeter used was Hewlett-Packard-D.C. Microvolt-anmeter model 425 A. The recorder used was Brush recorder Mark II.

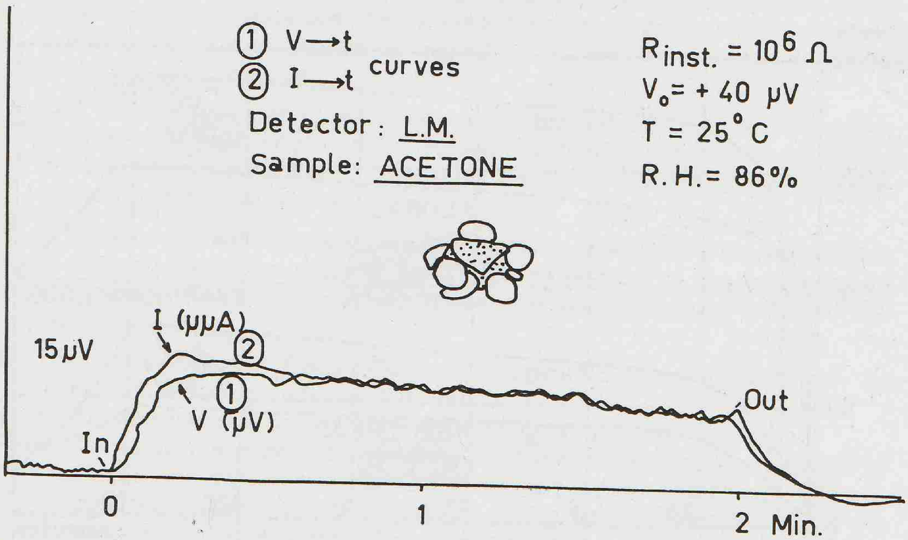

Fig. 2

Figure 2 shows the voltage versus time and current versus time curves for acetone. The input impedance of the microvolt meter being one megaohm, the voltage time versus with the micro volt and current curves with micro-amperes are almost the same.

Figure 3 shows a sample of voltage versus time curves for acetone (a) ammonium hydroxide (b) and hydrogen sulphide molecules (c); these curves are plotted together using the separate records made by electro-odocell for these odorants under the same conditions.

Figure 4 indicates plots of measurements made with (a) trichlorethylene, (b) camphor, (c) oil of roses, (d) formic acid, (e) hydrogen sulphide-odorants of very different characteristics and very different molecular shape as logarith-

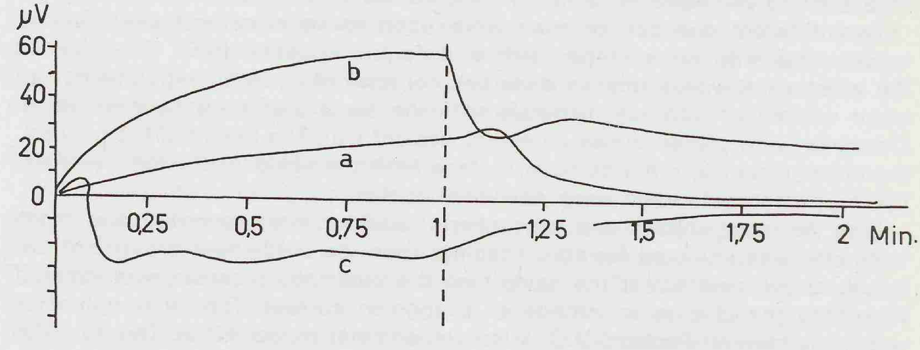

Fig. 3

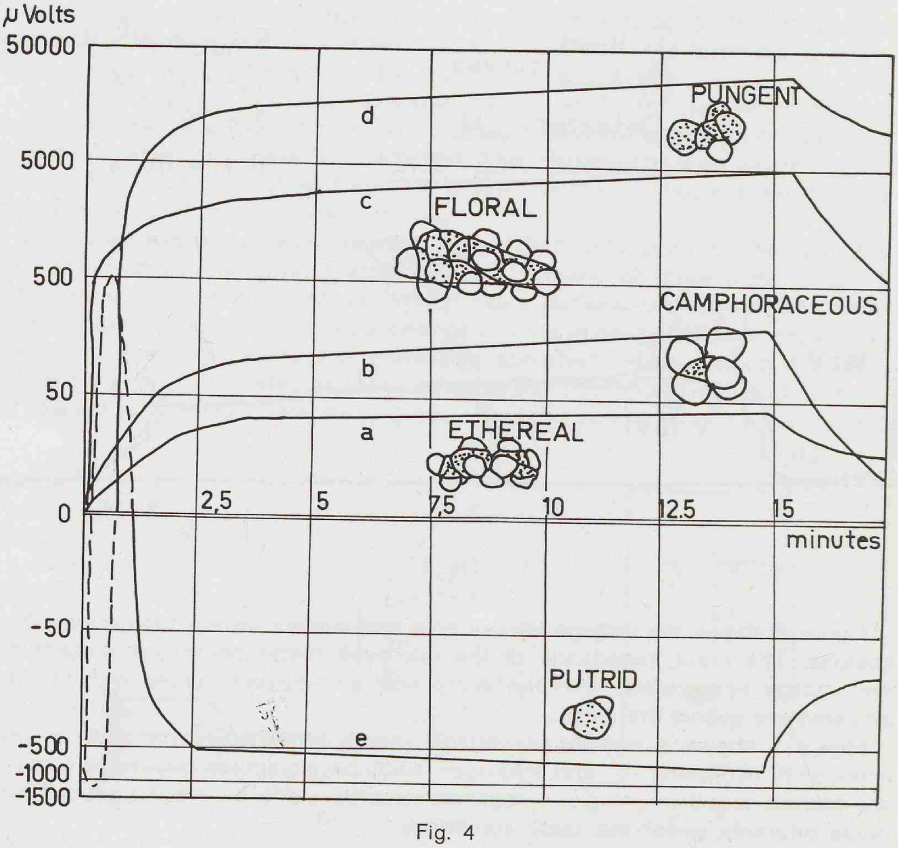

Fig. 4

metic function of voltage change versus time curves. For comparison purposes individual curves recorded by the Electro-Odocell for these odorants of very different scales were replotted on logarithmic scale.

John E. Amoore, James W. Johnston Jr. and Martin Rubin in their article "The Stereochemical Theory of Odor" identified seven primary odors. Five out of these seven primary odors were available for experiments with electro-odocell. It is interesting to observe that the difference of the final values of the surface potentials due to these odorants are very great, in other words the separation between each primary odors permits one to place the others between these primary odors.

Results

1. Experiments carried out with Electro-Odocell at Robert College Research Center indicate that standard voltage — time or current — time characteristic curves for odorants or molecules of materials can be plotted for a given detecting surface and used as a reference curve to detect and measure odor or micro-micro amount of materials in the air.
2. The general shape of the curve plotted and the final value of the voltage measured for a given detector are the main characteristics of given odors or molecules of materials. The transient value of the voltage or current curve or its rate of change is related to the density of a given odor or molecule of a material.
3. The minimum amount of molecules which can be detected is much lower than the threshold value of the nose and this sensitivity for a given detector surface can be controlled by changing the thickness and or the dielectric constant of the transducer.
4. If the time of response is defined as the time at which the transient value of the voltage of the detector will reach ten percent of the final value of the voltage, Electro-Odocell can detect the odor molecules within of few seconds.
5. The possibilities of Electro-Odocell in scientific research work can be classified in two groups, as follows:
   a. To develop our limited knowledge of odor and olfaction.
   b. To study the molecular structure, and the behaviour of molecules of simple and compound materials. This can include the study of forces between molecules and evaluation of the existing theories about the behaviour of molecules. This work may lead to various new concepts of molecular physics and of the physical chemistry of surfaces.
6. Possibilities of Electro-Odocell in applied research work are:
   a. To develop new basic method of odor control.
   b. To detect and analyze the micro-micro quantities which cannot be detected and analyzed by classical methods in the chemistry laboratories.
   c. To establish a new physical method of analysis of materials which may replace some of the classical analysis methods used in chemistry laboratories.

d. To develop new methods of storage, packing and transportation and quality control for agricultural products.

e. To contribute to the development of new processes and quality control methods in the chemical, petroleum, pharmaceutical, perfume and food industries.

f. To contribute to the development of new methods of diagnosis of diseases and other aspects of applied research in medical and biological fields.

g. To develop methods for psychological and social service research work related to odor and its effects.

h. To contribute to the development of a special detector to locate enemy activities for military purposes.

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