INVESTIGATION OF DAMPING CAPILLARY WAVES IN FLUIDS OF DIFFERENT CHEMICAL COMPOSITION

By L. MÉSZÁROS

Institute of Organic Chemistry, The University, Szeged

(Received October 3, 1958)

A new method was evolved for the photographic registration of time/amplitude diagrams of capillary waves which form when a needle is brought into contact with the surface of a fluid. The diagrams were found to be reproducible and characteristic of the composition of the fluid examined.

A great number of methods are known for the determination of surface tension by statical or dynamical way. In the case of one of the dynamical methods, capillary waves are produced on the surface of the fluid, with the use of vibrations of constant frequency and amplitude. By the known methods, conclusions can be drawn with respect to *e. g.* the concentration of solutions [1], the degree of contamination in glass [2], the effect of temperature, viscosity and specific gravity of various homologues [3] and other physical and chemical parameters of importance.

In the present paper a dynamical method of investigation is described which makes possible the quick and well reproducible photographic registration of capillary waves. The method appears to be suitable for the examination of certain physical and chemical properties of fluids.

Light emitted by a light source (16) located on a stand (9) is converted into parallel rays by the system of lenses (15) and is directed through two diaphragms (13, 14) vertically upwards as a thin parallel beam. Shield (12) protects the slit (7) against diffuse light. The beam of light passes cuvette (11) filled with fluid, standing on a small adjustable table whith a central hole. The light arrives then into the centre of a slit (7) located in a plane perpendicular to the plane of the figure. A photosensible paper ribbon (6) moves before this slit. Mirror (23) and needle (25) adjustable by a thread are placed in a plane perpendicular to that of the figure, at a distance of 30 and 1 millimeter, respectively, from the beam of light. The ribbon is wound off from a drum (1) through two rollers (2, 3) which secure its close contact with the slit [7]. The paper ribbon passes then a spindle with fixed axis which can be moved at variable speeds (5) and a cylinder (4) which can tightly be pressed to the spindle, reaching finally an empty area (8). An adequately quick start is made possible by a fly-wheel. Another support (17) holds a needle adjustable by a thread (25) fixed to a lamellar

spring the height of which can be varied with the use of a binding ring (24). Light of a light source (18) is converted by the lense system (19) with the use of two diaphragms (20) into a thin horizontal parallel light beam which, on passing a perforated disk (22) rotated by the synchronous motor (21), is reflected by mirror (23) in a vertical direction just into slit (7). In the present experiments photosensitive paper of 50 mm width was used, the inner diameter of the cuvette being 8 cm, the thickness of the fluid in the cuvette ranging 20 mm. The number of holes inserted in the perforated disk rotated by the synchronous motor made possible the registration of time signals of 0,01 sec.

The vertical light beam describes at the start of registration a horizontal line in the centre of the photosensible paper ribbon. When the needle gets into contact with the surface of fluid, by cautiously winding thread (25), damped capillary waves arise around the needle, and the time/amplitude curve of the formed waves can be registered by photographic way.

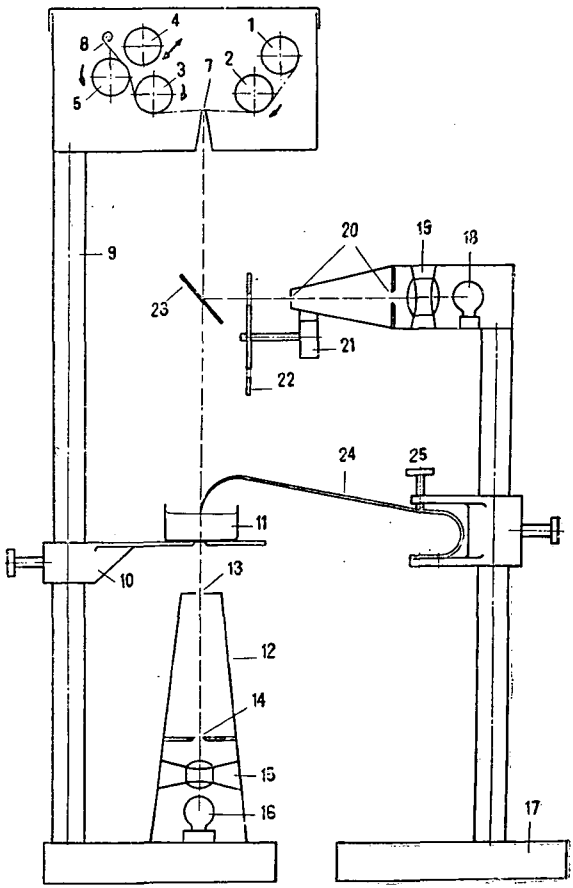

Fig. 1

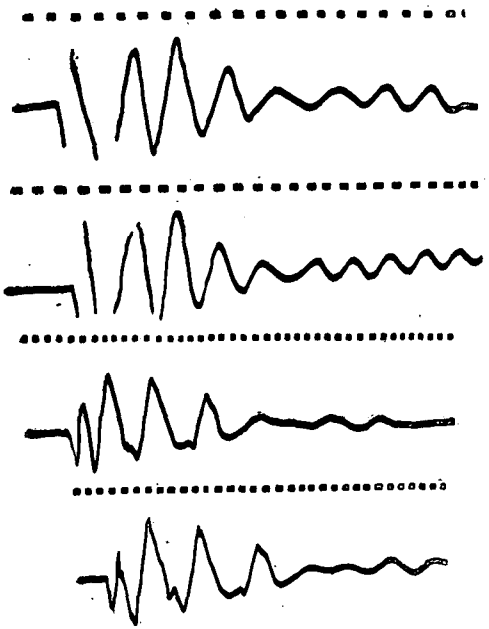

Fig. 2a

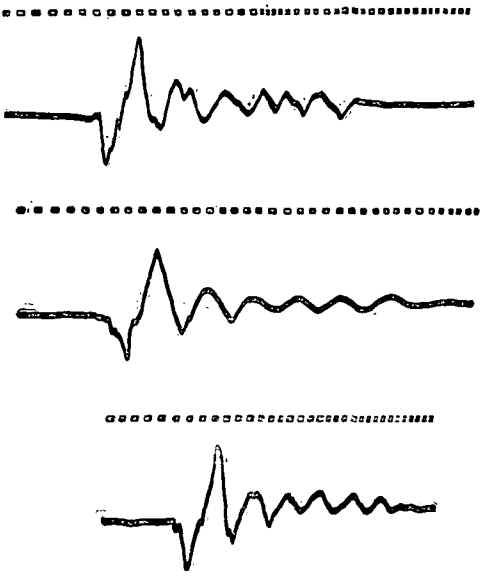

Fig. 2b

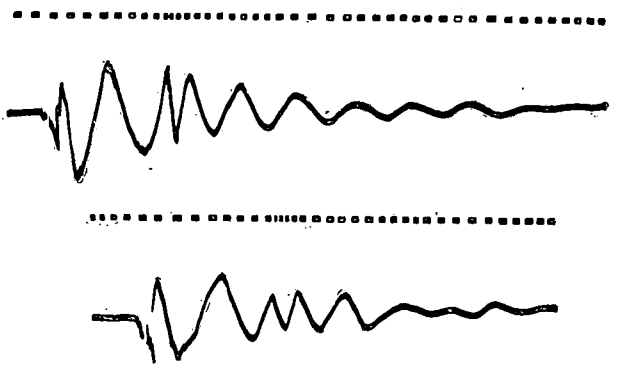

Fig. 2c

The quality of photographs can be improved by adequately increasing the intensity of light, the velocity of the ribbon, the distance between the cuvette and the slit, the number of holes on the perforated disk and the sensitivity of the photosensitive ribbon, further by decreasing the cross section of light beam and the width of slit. Opaque and semi-transparent fluids can also be examined by the same apparatus, with the difference that the light arrives to the slit after being reflected by the surface of fluid. According to our experience, it is practical to apply fluids of a layer thickness of at least

20 mm. The obtained curves proved to be reproducible under identical physical and chemical conditions, and to be characteristic of the fluids examined. Some typical diagrams are shown by Fig. 2. Time signals of 0,01 sec indicate that damping takes place, in general, in 0,2 seconds. Similar diagrams were prepared with mixtures of water-acetone, water-ethanol, water-sulphuric acid, water-glycerol, acetone-ethanol, acetone-glycerol, water-sucrose and water-soap, varying the composition of the mixtures by 10% steps. It was found that the curves are well reproducible and are characteristic of the composition of the substance, provided other parameters are not varied.

It is not advisable to choose cuvettes with diameters below 8 cm, since waves reflected by the vertical walls may interfere with the investigation. The described apparatus lends itself to the examination of the superficial spreading of capillary waves as well. In this case two light beams *e.g.* 20 mm far from each other should be applied. The needle described above is placed beneath one of the light beams, the surface of fluid touched by the needle, and the arrival of the vibration after some hundredth of a second observed by the appearance of waves in the other light beam. The velocity of spreading can be calculated from the lenght of time elapsed until both lines became vibrating, and from the distance of the two light beams.

The reproducibility of the time/amplitude diagrams of the capillary waves produced by touching the surface of the fluid with a needle and the specificity of this phenomenon makes possible to consider this diagram as a characteristic physical feature of the fluid examined.

References

[1] *Adam, N. K., H. L. Shute:* Trans. Faraday Soc. **34**, 758 (1938).
[2] *Smit, W. O., M. D. Crane:* J. Amer. Chem. Soc. **52**, 1345 (1930).
[3] *Hunton, K. W., O. Maass:* J. Amer. Chem. Soc. **51**, 153 (1929).