NOTIZEN

Electrokinetic Determination of Turbulent Transition

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Experimental determinations of critical Reynolds numbers of Hagen-Poiseuille flow have been conducted by examining the electrokinetic phenomena generated by the interaction of the fluid flow and the electric double layer. The minimum critical Reynolds number was found to be 1907 with a standard deviation of 18, indicating the high repeatability of the technique. The technique itself is based on the appearance of the characteristic and singular fluctuations in the streaming potential which are due to hydrodynamic perturbations. The electrolytes used were dilute KCl solutions and borosilicate glass capillary tubing was used for the pipes.

Fluid mechanists have studied fluctuations in the streaming potential observed in turbulent pipe flow. REICHARDT [1] predicted the fluctuations and BOCQUET [2] was able to record them. The fluctuations have also been identified with turbulence by BINDER and CERMAK [3].

The present note describes the successful use of streaming potential fluctuations for the very repeatable determination of critical Reynolds numbers in pipe flows. This method has the advantage of not requiring probes in the flow.

The apparatus used in generating the streaming potential is shown in Figure 1. The electrodes were of the Ag – AgCl type formed on platinum helices and the pipes were borosilicate precision bore glass tubing. The above apparatus was enclosed in a Faraday cage, itself in a room in which the air was held to a fixed temperature ±0.3 °C. The electrodes were connected to a high input impedance electrometer whose input either fed to a chart recorder or an oscilloscope. Dilute KCl solutions, made from conductivity water, served as the fluid.

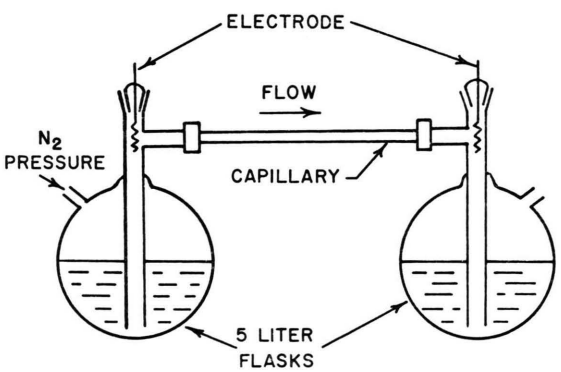

Fig. 1. Schematic diagram of apparatus.

The critical Reynolds numbers, i. e., Reynolds number of the transition from laminar to turbulent flow, were determined for two pipes. Pipe No. 1 was 12.2 cm long and its diameter was 0.06 ± 0.0007 cm. The entrance was roughened in an attempt to measure the minimum critical Reynolds number. The result of 32 measurements was an average of 1907 with a standard deviation of 18. The critical Reynolds number was determined by noting the first appearance of the streaming potential fluctuations. The fluid was 0.001 N KCl. For comparison, the classic experiments of REYNOLDS [4] yielded a value of approximately 2000. Reynolds used mass flow rate measurements which indicate the critical Reynolds number at which the turbulence has increased sufficiently in severity to increase the flow resistance appreciably; the present technique indicates the presence of single eddies of low amplitude. Comparison with another method is afforded by the work of BARNES and COKER [5] in which the wall of the pipe was heated and the onset of turbulence was indicated by a sharp rise in the temperature of the interior of the flow. They found this Reynolds number to be 1900.

Pipe No. 2 dimensions were: diameter: 0.16 ± 0.0007 cm, length: 86.4 cm. The critical Reynolds number for this pipe with its entrance geometry was 2530. The small scatter as well as the growth of the fluctuations is indicated in Fig. 2, which shows the R.M.S. values of the fluctuations measured by a random signal R.M.S. voltmeter following the electrometer. The presence of the characteristic streaming potential fluctuations is in-

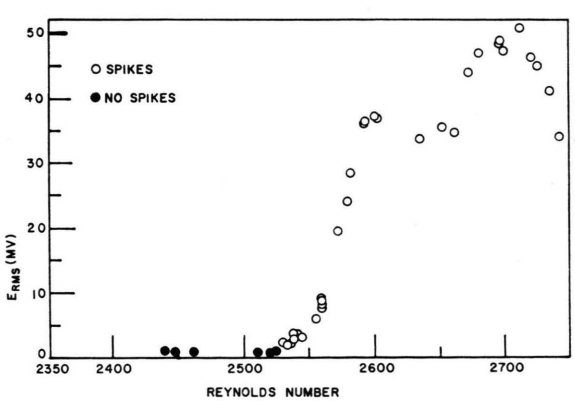

Fig. 2. R.M.S. component of streaming potential vs. Reynolds number, Pipe No. 2.

dicated by the open circles. With this pipe, it was not intended that the minimum critical Reynolds number be attained; still, the pipe entxrance was far from smooth. The solution used was 0.5364×10^{-6} N KCl.

Experimental results show that the streaming potential technique is an extremely sensitive and repeatable method of detecting the onset of (or the presence of) turbulence in the flow of liquids. This sensitivity also makes it possible to study the effect of very small changes in inlet conditions upon the transition Reynolds number.

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Massenspektrometrische Untersuchungen an anellierten Phenothiazinen und Phenothiazinylen

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In der Reihe der nicht-substituierten Phenothiazine ist massenspektrometrisch bisher nur die Stammverbindung I untersucht worden [1]. Wir berichten in der vorliegenden Arbeit über die Massenspektren der anellierten Phenothiazine II—VI sowie der stabilen Phenothiazinyl-Radikale VII und VIII. (Formelübersicht siehe Seite 171).

Sowohl die Phenothiazine wie die Phenothiazinyle sind bei Elektronenbeschuß sehr stabil. Als Beispiel ist in Abb. 1 das Massenspektrum der Verbindung IV stellvertretend für alle anderen Substanzen wiedergegeben [2]. Der Molekülpeak ist in allen Fällen der größte Peak. Im unteren Massenbereich treten im wesentlichen doppeltgeladene Ionen auf. Die im oberen Massenbereich auftretenden Bruchstücke entsprechen der Abspaltung von Schwefel als S, SH, CS und HCS direkt aus dem Molekülion bzw. aus dem Ion M—H und der von Stickstoff als CN, HCN und H_2CN. Die Stickstoffabspaltung erfolgt z. Tl. aus dem Molekülion bzw. aus dem Ion M—H, überwiegend aber nach vorheriger Schwefeleliminierung. Das Zerfallsschema entspricht bei allen untersuchten Substanzen im wesentlichen dem des Phenothiazins, wie es bereits früher vorgeschlagen wurde [1].

Mit größerer Intensität treten im oberen Massenbereich nur Fragmentionen M—H, M—S, M—SH und

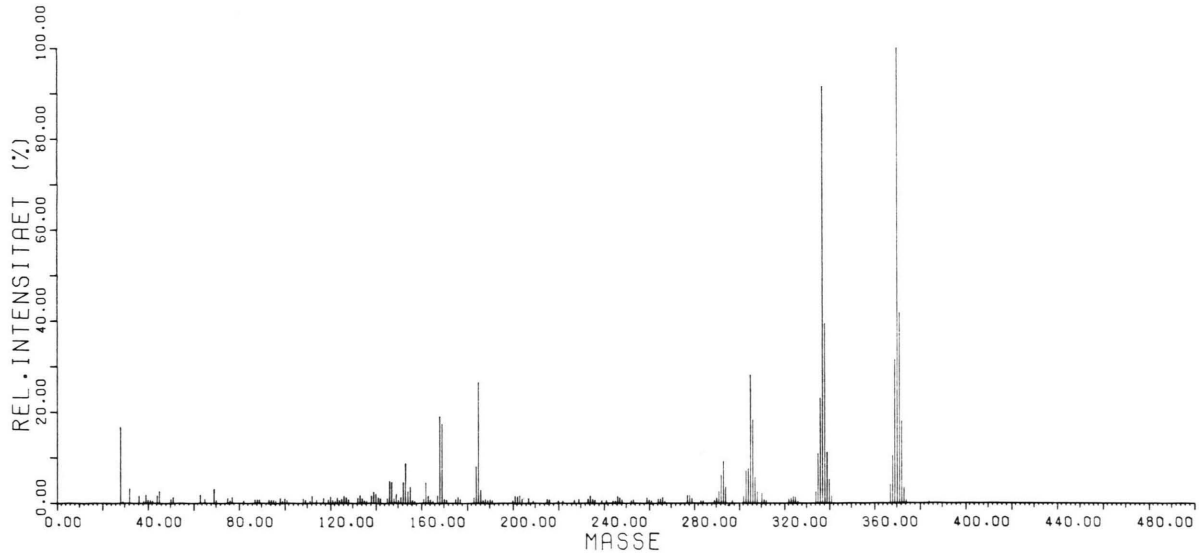

Abb. 1. Massenspektrum von 5,13-Dihydro-phenothiazino[2,1-a]phenothiazin (IV).

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