

- [54] METHOD AND APPARATUS FOR THE MASS SPECTROMETRIC ANALYSIS OF SOLUTIONS
- [75] Inventors: Michael J. Labowsky, Wayne, N.J.;  
John B. Fenn, Branford, Conn.;  
Masamichi Yamashita, Tokyo, Japan
- [73] Assignee: Yale University, New Haven, Conn.
- [21] Appl. No.: 486,645
- [22] Filed: Apr. 20, 1983
- [51] Int. Cl.<sup>3</sup> ..... B01D 59/44
- [52] U.S. Cl. .... 250/288; 250/281;  
250/282; 250/286
- [58] Field of Search ..... 250/281, 282, 288, 286

2240-2249, Dole, M., Mack, L. L., Hines, R. L., Mobley, R. C., Ferguson, L. D.  
*The Journal of Chemical Physics*, vol. 52, (10), 1970, 4977-4986.

Primary Examiner—Bruce C. Anderson  
Assistant Examiner—Paul A. Guss  
Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch

[56] References Cited

U.S. PATENT DOCUMENTS

- 4,121,099 10/1978 French et al. .... 250/296
- 4,209,696 6/1980 Fite .
- 4,300,044 11/1981 Iribarne et al. .

OTHER PUBLICATIONS

*Analytical Chemistry*, 1979, vol. 51, pp. 682A-701A, Arpino, P. J. and Guichon, G.  
"1st Workshop on LC/MS," Published in *Journal of Chromatography*, 1982, vol. 251, pp. 91-225, (Montreux, Oct. 1981).  
*Journal of Electrostatics*, 1978, vol. 5, p. 411, Stimson, B. A. and Evans, C. A., Jr.  
*Biopolymers*, 1971, vol. 10, pp. 821-826-Clegg, G. A. and Dole, M.  
*Adv. in Chem.*, (1973), vol. 125, p. 73-Dole, M., Cox, H. L., Jr., Gleniec, J.  
*The Journal of Physical Chemistry*, vol. 82, No. 6, (1978), p. 660, Stimpson, B. A. and Evans, C. A., Jr.  
*Journal of Chemical Physics*, (1968), vol. 49, No. 5, pp.

[57] ABSTRACT

An electrospray ion source for a mass spectrometer capable of generating ions from samples dissolved in a solution comprises a capillary tube through which the said solution is pumped into a first chamber maintained substantially at atmospheric pressure and in which an inert gas is flowing in a direction counter to the flow of the solution, and a small orifice in the end wall of the chamber opposite to and aligned with the capillary. A high potential difference is applied between the capillary and the end wall so that the solution is electrosprayed into the chamber and ions characteristic of the sample are formed. These ions are desolvated to a controllable extent by the inert gas, which may also be heated to improve the efficiency of the process and increase the maximum permissible flow rate of solution. The ions so formed pass through the small orifice into a second chamber maintained at a reduced pressure, and into a mass spectrometer. Alternatively an additional pressure reduction stage can be included, so that the ions pass into a third chamber maintained at a still lower pressure in which the mass spectrometer is situated through a conventional nozzle and skimmer arrangement. The ion source is particularly effective for the production of unfragmented and unsolvated ions from thermally unstable or involatile samples, and may be used as a liquid chromatograph-mass spectrometer interface.

37 Claims, 5 Drawing Figures

