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Note

Determination of ortho- and pyrophosphates in liquid artificial fertilizers by high-speed isotachophoresis

P. BOČEK, B. KAPLANOVÁ, M. DEML and J. JANÁK
Institute of Analytical Chemistry, Czechoslovak Academy of Sciences, 662 28 Brno (Czechoslovakia)
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Ortho- and pyrophosphates are important components of modern artificial fertilizers. Orthophosphate is activated instantaneously while pyrophosphate provides a reservoir of phosphorus in the soil. Simultaneous determination of ortho- and pyrophosphates is still laborious and time consuming[1,2]. Neither chromatographic techniques[3,4] nor paper electrophoresis[5–7] produce shorter separation times than 1 h, and quantitation levels are no better than ±15%. This paper illustrates that capillary isotachophoresis can provide a precise solution to the quantitation problem, as well as shortening the analysis time.

EXPERIMENTAL

The system of 0.005 *M* HCl and 0.01 *M* histidine (Loba Chemie, Vienna, Austria) at pH 6 without any further admixtures was used as a leading electrolyte. 0.01 *M* glutamic acid served as terminator. All chemicals used were of analytical grade (Lachema, Brno, Czechoslovakia). Standard substances $Na_4P_2O_7$, $Na_5P_3O_{10}$, $Na_3P_3O_{10}$, and $Na_4P_4O_{12}$ were obtained from the Institute of Inorganic Chemistry, Faculty of Natural Sciences, University of Brno, Czechoslovakia. The liquid fertilizer under analysis was of N–P type (North Bohemian Chemical Works, Lovosice, Czechoslovakia). The isotachophoretic separations were carried out on an isotachopherograph of the authors' own design[8,9], at a constant current of 140 μA and at a temperature of 22°.

RESULTS AND DISCUSSION

An example analysis of the standard mixture of liquid fertilizer is recorded in Fig. 1. In Fig. 1 (a) an analysis of 2.60 μl samples of model mixture, being 4.0, 4.5, and 9.1×10^{-4} *M* Na_3PO_4, $Na_4P_2O_7$, and $Na_5P_3O_{10}$ respectively, is shown. In Fig. 1 (b) samples of 2.60 μl of 1000-fold diluted liquid fertilizer were injected. It can be seen that the complete separation is very fast, taking less than 4 min. The concentrations of ortho- and pyrophosphate in the fertilizer were determined by a direct comparison of step lengths in the analysis records of the fertilizer and standard solution.

Table I shows quantitative results of the analysis of the liquid fertilizer obtained by isotachophoresis and analysis performed gravimetrically by the classical

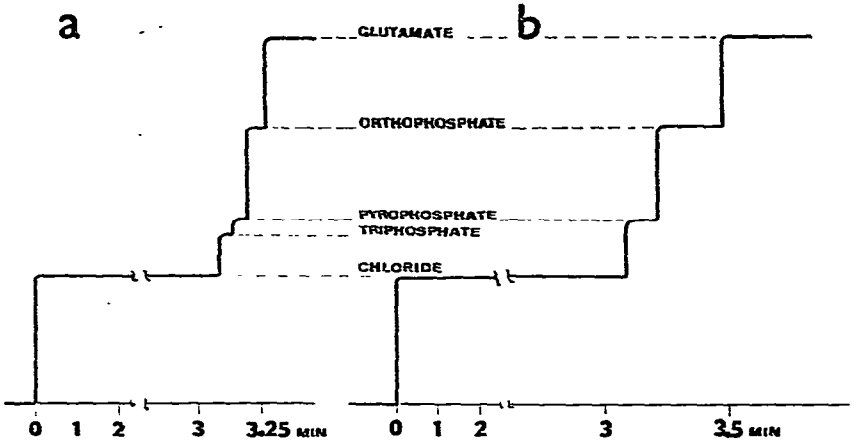

Fig. 1. (a) Isotachopherogram of 2.60 μl of the model mixture 4.0, 4.5, and 9.1 $\times 10^{-4}$ M Na_3PO_4, $Na_4P_2O_7$, and $Na_5P_3O_{10}$, respectively. (b) Isotachopherogram of 2.60 μl of 1000-fold diluted liquid fertilizer.

TABLE I

QUANTITATIVE RESULTS OF LIQUID FERTILIZER ANALYSIS

Species	*Isotachophoresis*			*Gravimetry*	*Difference*	
	P_2O_5 (g/l)	*S.D.**	*rel.%*	*P_2O_5 (g/l)*	*P_2O_5 (g/l)*	*rel.%*
Orthophosphate	312.4	6.0	1.9	310.2	+2.40	+0.8
Pyrophosphate	163.3	5.3	3.2	168.9	−5.6	−3.3

* Average from 3 determinations.

procedure[10]. It can be seen that both the accuracy and the precision of the isotachophoretic results are very good. Moreover, the separate injections of standard solution of $Na_3P_3O_9$ and $Na_4P_4O_{12}$ gave mixed zones of higher mobilities than that of triphosphate under the working conditions *i.e.* neither P_3O_9 nor P_4O_{12} ionic species interfered with the determination of pyro- and orthophosphate. All the above results confirm the possibility of using high-speed analytical isotachophoresis for the determination of ortho- and pyrophosphates in liquid N–P fertilizers and illustrate the prospects of isotachophoresis as an analytical aid in such cases.

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