Kinetic parameters of oscillating reaction of amino acid-BrO$_3^-$-Mn$^{2+}$-H$_2$SO$_4$-acetone system

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Abstract The oscillating behavior of thirteen amino acids [leucine (Leu), threonine (Thr), arginine (Arg), lysine (Lys), histidine (His), alanine (Ala), glutamine (Glu), glycine (Gly), methionine (Met), cystine (Cys), tryptophan (Trp), serine (Ser) and tyrosine (Tyr)] in amino acid-BrO$_3^-$-Mn$^{2+}$-H$_2$SO$_4$-acetone system is studied by using a potentiometric determination. With the help of the oscillatory induction period and oscillation period obtained by the oscillating wave, and Arrhenius equation, the kinetic parameters [the apparent activation energy ($E_a$) and pre-exponential constant ($A$)] and rate constant ($k$) of the above-mentioned oscillating reaction are estimated.

Keywords: amino acids, chemical oscillation, closed system, kinetic parameters, rate constant.

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In the previous papers$^{[1-3]}$, the oscillating reaction using amino acids as organic substrates was studied. In order to obtain information about the kinetic parameters of oscillating reaction of amino acids in amino acid-BrO$_3^-$-Mn$^{2+}$-H$_2$SO$_4$-acetone system, the kinetic equation describing the oscillatory induction period, oscillation period with temperature is studied. This is quite useful for understanding the oscillating reaction that amino acids participate in the point of view of kinetic behavior.

1 Experimental

(i) Chemical reagents. Amino acids (biochemical reagent); KBrO$_3$ (analytical grade); MnSO$_4$ (analytical grade); H$_2$SO$_4$ (analytical grade); acetone (analytical grade). The solutions used in this work were prepared with deionized water.

(ii) Instruments. PXS-215 ion activography; 213-platinum electrode; 217-SCE type calomel electrode; XWC autobalance recorder.

(iii) Experimental methods. The experiments were conducted at 30±0.2°C. The solution volume was 50 mL. Add H$_2$O, H$_2$SO$_4$, amino acids, MnSO$_4$, acetone (denoted as Act) in glassware in proper order. At last, add KBrO$_3$ being at constant temperature under even stirring. It is timed when half KBrO$_3$ solution has been added. The concentration of reactant in solution obtained by this method is shown in Table 1. PXS-215 ion activography was used to determine the redox potential (in [Ox]/[Red]) of system. 213-platinum electrode was used as the indicator electrode. 217-SCE type calomel electrode was used as the reference electrode. $E$-t curve of oscillating reaction was obtained by using an autobalance recorder. The experimental repeatability was very good.

2 Results and discussion

The oscillating waves of Leu, Thr, Arg, Lys, His, Ala, Glu, Gly, Met, Cys, Trp, Ser and Tyr in amino acid-BrO$_3^-$-Mn$^{2+}$-H$_2$SO$_4$-acetone system are shown in Figs. 1—13, respectively. The initial data [the oscillatory induction period ($t_i$) and oscillation period ($t_p$)] obtained from Figs. 1—13, the kinetic parameters [the apparent kinetic parameters, rate constant].
In general, the oscillating reaction can be divided into four periods (Fig. 1)\(^{(5-8)}\): (i) line \(AB\), fast increase of \(\text{Br}_2\) or the induction period of oscillation; (ii) line \(BC\), fast wastage period of \(\text{Br}_2\) or the period of accumulating energy; (iii) line \(CD\), the balanced period; (iv) line \(DE\), wastage period of energy and \(\text{Br}^-\). Through the above four periods, the system will begin oscillation. This was a common feature of the oscillating reaction using amino acids as oscillating substrates.

From Figs. 1—13, the following observations may