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Optimization of Micellar Electrokinetic Capillary Chromatography as a Nano Separation Technique Using Three Dimensional and Two Dimensional Plottings of Characteristic Equations

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The micellar electrokinetic capillary chromatography (MECC) strength of separation is due to nano scaled pseudo stationary phase. This is the reason that this technique could be called nano separation technique. There are four characteristic equations obtained from the resolution equation of Terabe and Ghowsi and resolution equation per unit time R_s/t_R. These characteristic equations are plotted three dimensionally and two dimensionally. Optimum conditions for these characteristic equations are extracted from three and two dimensional plots.

Key Words: Micellar electrokinetic capillary chromatography, Nano separation technique, Characteristic equation and Optimization.

INTRODUCTION

Feyman considered the possibility of direct manipulation of individual atoms as a more powerful forms of synthetic chemistry than those used at the time. In conventional chromatography there are two phases involved one is the stationary phase and one is the mobile phase[1]. Terabe *et al.*[2] proposed micellar elecktrokinetic capillary chromatography (MECC), which has the smallest pseudo stationary phase within nano range called micelle. The high strength of separation comes from these nano sized materials. Due to this reason, we call this technique MECC nano separation technique.

There are several work which have been done to find the optimum conditions of this nano separation technique[1-5].

In all optimization characteristic equation is the focus.

In column chromatography the resolution equation is given as[1]

$$R_s = \frac{N^{1/2}}{4}.\frac{(\alpha-1)}{\alpha}.\frac{k'}{(1+k')} \qquad (1)$$

where k' is the capacity factor, α is the selectivity and N is the number of theoretical plates. Terabe *et al.*[2] proposed the micellar electrokinetic capillary chromatography (MECC) for the first time and they proposed the resolution equation for MECC:

$$R_s = \frac{N^{1/2}}{4}.\frac{(\alpha-1)}{\alpha}.\frac{k'}{(k'+1)}.\frac{(1-t_0)/t_{mc}}{1+(t_0/t_{mc})k'} \qquad (2)$$

where N, α and k' were already were defined a new term is appearing in equation (2) for resolution is $\frac{(1-t_0)/t_{mc}}{1+(t_0/t_{mc})k'}$. In this term k' is the capacity factor and t_0 and t_{mc} are retention times of the aqueous and micellar phases respectively. The characteristic equation for MECC to optimize is from equation (2):

$$f(k', t_0/t_{mc}) = \frac{k'}{(k'+1)}.\frac{(1-t_0)/t_{mc}}{1+(t_0/t_{mc})k'} \qquad (3)$$

This characteristic equation has two variables k' and the ratio t_0/t_{mc}.

In a recent work a new model for the MECC using a model based on effective length solute migrated as a similar to tread mill case were proposed[6]. Based on this model

$$R_s = \frac{1}{4}[(D_{ep})_B RT/4]^{\frac{1}{2}}(N_{pseudo}{}^{\frac{1}{2}})[\frac{\alpha-1}{\alpha}][\frac{k'}{k'+1}]^{\frac{3}{2}}\frac{1-(t_0/t_{mc})}{1+(t_0/t_{mc})k'} \qquad (4)$$

Variables of this equations were defined in the previous work[6]. The characteristic equation of R_s for equation (4) is the last two terms

$$f(k', t_0/t_{mc}) = (\frac{k'}{k'+1})^{3/2}.(\frac{1-t_0/t_{mc}}{1+(t_0/t_{mc})k'}) \qquad (5)$$

In a comparison between the characteristic equation of the resolution equation (3) obtained by Terabe[2] and the characteristic equation obtained based on the new model[7], equation (5), the difference is the power of $[k'/(k'+1)]$ term where in equation (3) the power of this term is 1 and in equation (5) the power of this term is 3/2.The rest of these two equations (3), (5) are the same.

There are two other characteristic equations need to be obtained. For the first time Foley[3] obtained an equation for a compromise between resolution and the migration time. He introduced R_s/t_R. t_R is given in Terabe *et al.*[2] as:

$$t_R = \left[\frac{1+k'}{1+\left(\frac{t_0}{t_{mc}}\right)k'}\right]t_0 \qquad (6)$$

Two characteristic equations for R_s/t_R are obtained one is for Terabe R_s equation (2) and the other one is for R_s in equation (4). The two characteristic equations for R_s/t_R are given as below correspondingly.

$$f(k',t_0/t_{mc}) = \frac{k'}{(k'+1)^2}.(1-t_0/t_{mc}) \qquad (7)$$

$$f(k',t_0/t_{mc}) = \frac{k'}{(k'+1)^{5/2}}.(1-t_0/t_{mc}) \qquad (8)$$

Optimization of characteristic equations by two dimensional plots, level curves and three dimensional plots

For Terabe's R_s resolution characteristic equation (3). The three dimensional surface was obtained in previous work[7]. Maximum $f(k',t_0/t_{mc}) = 0.51$ occurs at $t_0/t_{mc} = 0.1$, $k' = 3$ and minimum $f(k',t_0/t_{mc}) = 0$ occurs at $t_0/t_{mc} = 1$, $k' = 0$. Similar information could be obtained from level curves plotted by Dplot software presented at this work Fig. 1. This two dimensional plot is the image of three dimensional plot on the surface of the plane $t_0/t_{mc} = 0.1$, $k' = 1$.

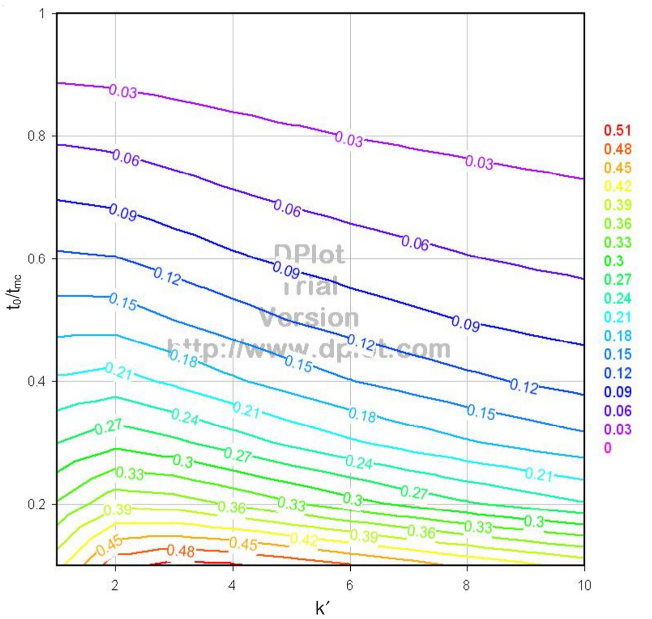

Fig. 1. Two dimensional plot, level curves, of Terabe's characteristic equation (3)

Ghowsi's R_s resolution characteristic equation (5) the three dimensional surface was obtained in previous work[7]. Maximum $f(k',t_0/t_{mc}) = 2.3$ occurs at $t_0/t_{mc} = 0.1$, $k' = 1$ and minimum $f(k',t_0/t_{mc}) = 0$ occurs at $t_0/t_{mc} = 1$, $k' = 1$.Similar information could be obtained from level curves plotted by Dplot software presented at this work Fig. 2. This plot is the image of three dimensional plot on the surface of the plane $t_0/t_{mc} = 0.1$, $k' = 1$.

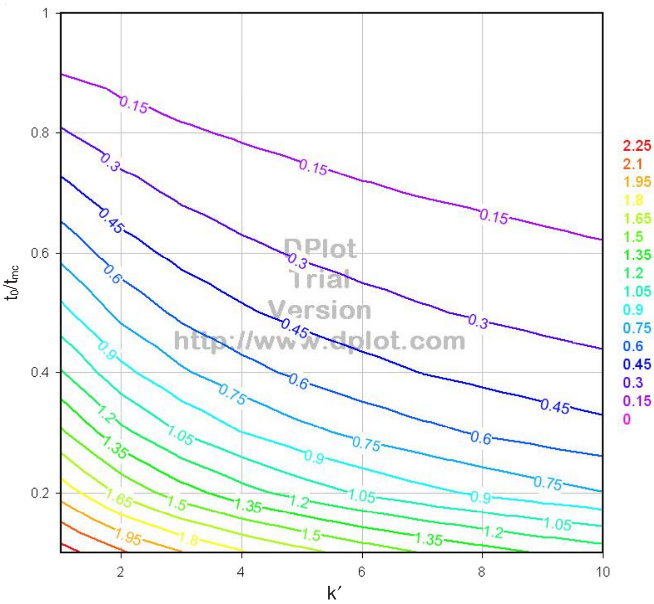

Fig. 2. Two dimensional plot level curves ,of Ghowsi's characteristic equation (5)

Foley's characteristic equation (7) has also been plotted three dimensionally Fig. 3 and two dimensionally level curves Fig. 4. The information obtained from either these two plots is as following[7]: Maximum $f(k',t_0/t_{mc}) = 0.225$ occurs at = 0.1, $k' = 1$ and minimum $f(k',t_0/t_{mc}) = 0$ occurs at $t_0/t_{mc} = 1$, $k' = 1$.

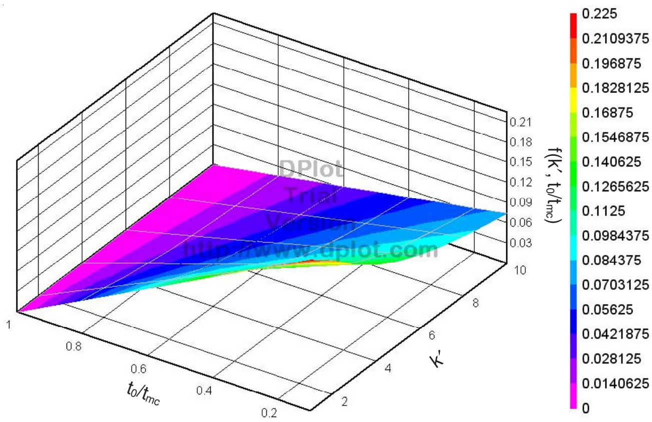

Fig. 3. Three dimensional plot Foley's characteristic equation (7) resolution per unit time R_s/t_R

Ghowsi's characteristic equation (8) has also been plotted three dimensionally (Fig. 5) and two dimensional level curves (Fig. 6). The information obtained from either these two plots is the following: Maximum $f(k',t_0/t_{mc}) = 0.16$ occurs at $t_0/t_{mc} = 0.1$, $k' = 2$ and minimum $f(k',t_0/t_{mc}) = 0$ occurs at $t_0/t_{mc} = 1$, $k' = 1$.

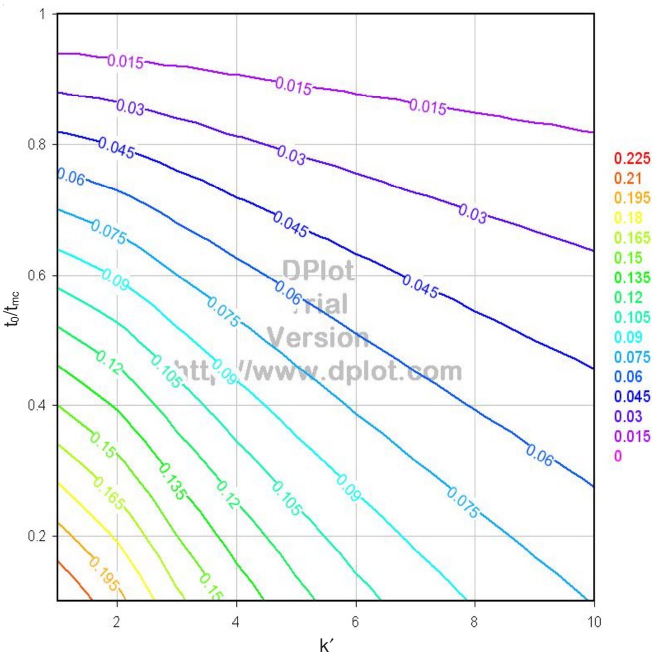

Fig. 4. Two dimensional plot, level curves, of Foley's characteristic equation (7) resolution per unit time R_s/t_R

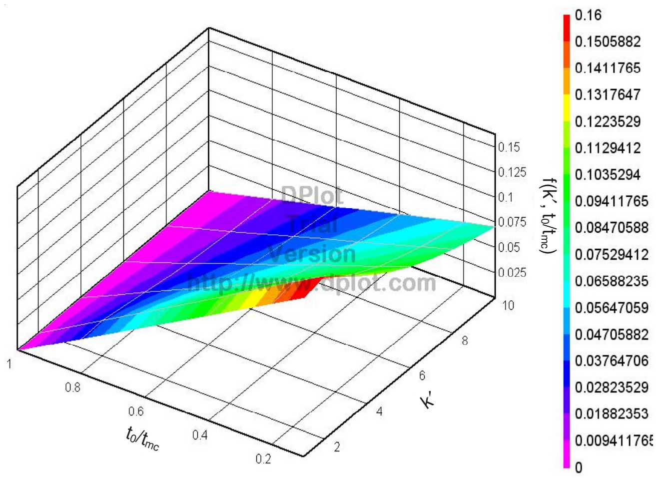

Fig. 5. Three dimensional plot of Ghowsi's characteristic equation (8) resolution per unit time R_s/t_R

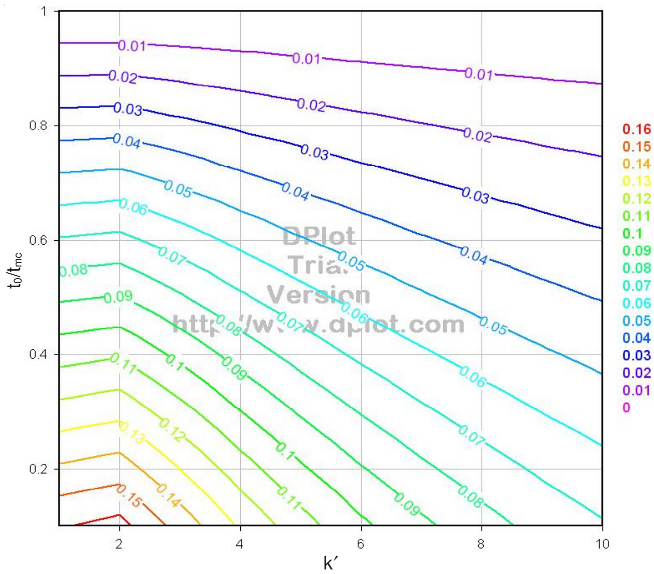

Fig. 6. Two dimensional plot level curves of Ghowsi's characteristic equation (8) resolution per unit time R_s/t_R

Conclusion

In present work the three dimensional plots of the four characteristic equations are obtained. The maximum and minimum values for the $f(k', t_0/t_{mc})$, t_0/t_{mc}, k' were extracted from the plots. Two characteristic equations are relating to R_s and the other two characteristic equations are relating to R_s/t_R correspondingly. The characteristic equations are a comparison between Terab *et al.*[2] model and Ghowsi's thread mill model[6]. The maximum and minimum values for the $f(k', t_0/t_{mc})$, t_0/t_{mc}, k' are the optimum conditions obtained for separation.

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