

## A New Capillary Electrophoresis Apparatus with Piezoelectric Ceramics High Voltage Source and Amperometric Detector

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**Abstract:** A new capillary electrophoresis apparatus was designed. Piezoelectric ceramics transformer technology was first applied in capillary electrophoresis, a high voltage and stable source was made. Amperometric detector was used in which the working electrode was closely opposite to the end of capillary. The apparatus was characterized in good reproducibility, safety and very low cost.

**Keywords:** Capillary electrophoresis, piezoelectric ceramics, amperometric detector.

### Introduction

High performance capillary electrophoresis (HPCE) is a new analytical technology rapidly developed in recent years. With the advantages of small sample, high sensitivity, high resolution, rapid analysis and very cheap running, it has been applied in chemistry, life sciences, pharmaceutical analysis, clinic examination and environmental analysis *etc.* But the application is restricted because of expensive commodity instrument. So it is very important to research and design new HPCE set with good characters and low cost.

HPCE apparatus consists of high voltage source, detector, sampling system and data recorder, of which the first two are key parts.

Usually, is used as the high voltage sources in all instruments, electromagnetic transformer. The disadvantages of electromagnetic transformer were obvious, such as complicated manufacture arts, difficulty in insulation between cycles, high cost and easy to be burned off, *etc.* It has been discovered that when the piezoelectric ceramics was polarized by voltage of proper frequency, it would output harmonic high voltage at the end of longitudinal direction<sup>1</sup>. According to this principle, it would be possible to use piezoelectric ceramics to make transformer.

In this paper, the technology of piezoelectric ceramics transformer was first applied to design a new high voltage source. It combined with an amperometric detector to be a new HPCE apparatus. The characters of the apparatus were investigated.

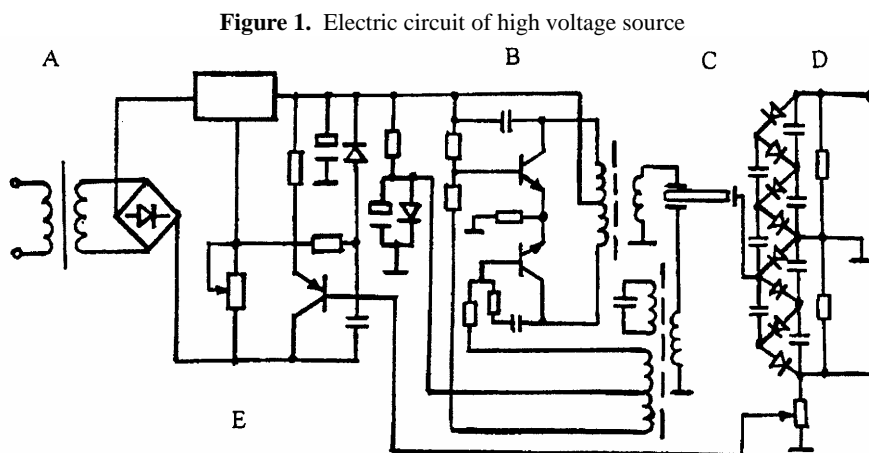
## Experimental

### *Reagents and Instruments*

Tris (hydroxymethyl) aminomethane (tris), boric acid, phenol, formaldehyde were of AR grade. Voltammeter (model AD-2A) was made by Jintan Instrument Factory, Jiangsu. Recorder (model LM14-204) was made by Dahua Instrument Factory, Shanghai. Fused-silica capillary (50  $\mu$ m-id) was made by Yongnian Optical Fiber Factory, Hebei.

### *High Voltage Source*

The basic electric circuit of high voltage source is given in **Figure 1**, in which part A is power supply, part B is oscillating circuit, C is piezoelectric ceramics, part D is multiple rectifier circuit, and part E is controlling and stabilizing circuit.



A: power supply; B: oscillating circuit; C: piezoelectric ceramics;  
D: multiple rectifier circuit; E: controlling and stabilizing circuit.

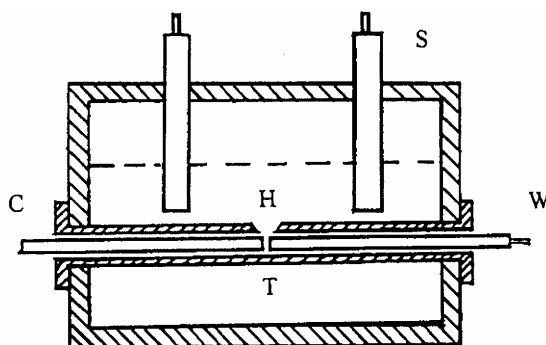
### *Electrochemical Cell*

The structure of electrochemical cell is given in **Figure 2**, which is end-column detection. The ends of capillary and working electrode were fixed closely and oppositely *via* a tube with a hole at the position of the end of column.

### *Capillary Electrophoresis Apparatus*

The HPCE apparatus consisted of high voltage source, recorder and amperometric detector which included electrochemical cell and voltammeter, as shown in **Figure 3**.

Figure 2. Scheme of electrochemical cell

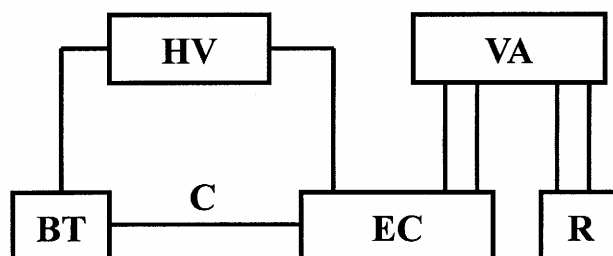


C: capillary, H: hole, S: SCE, T: tube, W: working electrode

#### Analytical Condition

The length of capillary was 60 cm. Buffer was Tris- $\text{H}_3\text{BO}_3$  (20 :20 mol/L). Sample was 0.1 mmol/L of phenol with 0.1 mmol/L of formaldehyde as internal standard. The sample was introduced by gravitation for 10 seconds, separated at 20.0 kV and detected at 1.0 V(vs.SCE). Carbon paste electrode was used as working electrode.

Figure 3. HPCE apparatus



BT: buffer tank, C: capillary, EC: electrochemical cell,  
HV: high voltage source, R: recorder, VA: voltammeter.

#### Result and Discussion

##### Stability

When the power voltage changed from 100 to 250 V, the changes of output of high voltage source and migration time of sample were less than 0.5%. When the resistance in line of load changed in 2%, or the resistance by side of load changed in 60%, the change of migration time were less 0.5%.

### *Reproducibility and Precision*

In same conditions, a sample was injected ten times, the relative standard deviation (RSD) of migration time and the peak area of sample were 0.42% and 1.8% (formaldehyde was used as internal standard) respectively.

### *Linear Range and Detection Limit*

In the range of concentration of phenol from 0.02 to 60.0 mmol/L the correlation coefficient were 0.989. The limit of detection was estimated to be  $1.2 \times 10^{-12}$  mole.

### *Conclusion*

The high voltage source made from piezoelectric ceramics was very stable. Its good stability and reproducibility were the basis for qualitative and quantitative analyses, which would suit for capillary electrophoresis. Besides, it could protect itself in any cases such as short circuit and overload, *etc.* The apparatus would be popularly available to various fields at a rather low price.

### **Acknowledgment**

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### **References**

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