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An integrated device of electrodialytic membrane suppressor and charge detector for ion chromatography

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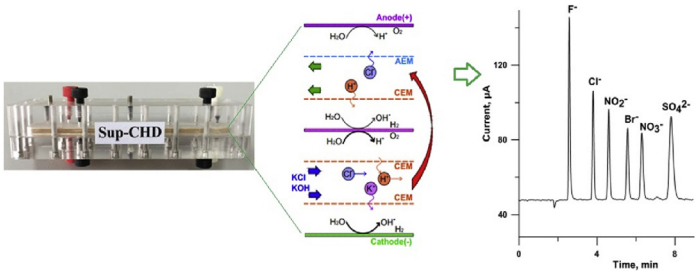
HIGHLIGHTS

- An integrated device combining charge detector and electrodialytic suppressor together.
- The integration device shows comparable performance with separate counterpart.
- The integration device simplifies the structure configuration of IC system.

GRAPHICAL ABSTRACT



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ABSTRACT

An integrated device of electrodialytic membrane suppressor and charge detector (CHD) for ion chromatography (IC) is described, aiming to simplify system complexity and reduce possible extra-column dispersion as well. The device is a flow-through design consisting of five chambers isolated by ion exchange membranes and ionic screens. Two independent electric sources are used to respectively supply CHD and suppressor sections of the device, and a common electrode serves both the cathode of CHD and the anode of suppressor simultaneously. The integrated device has similar performance as a separate suppressor or a CHD while its dead volume and dispersion are reduced ~18% and ~37% compared with the combination of a CHD and a suppressor. To our knowledge, this is the first description of such an integrated device with dual functionalities of suppression and CHD.

1. Introduction

Since introduced in 1975, ion chromatography (IC) in suppressed format has been a well-established technique for the determination of ionic analytes [1]. In modern IC system, electrodialytic devices are important components and the related research is very active [2–5]. Among them, electrodialytic membrane suppressor, a key component in suppressed IC system, can reduce the background conductance of the eluent and enhance the signal of target analytes as well [6]. Although conductivity detector (CD) covers the majority of the IC applications, some new detection modes have been proposed recently [7,8]. E.g., in the previous work of the senior author of the present report, a charge detector (CHD) was reported for the measurement of ionic solutes, in which the response signal is correlated with the total charge of the injected amount (the product of sample concentration and their ionic valence) [7]. This is different from the response behavior of a CD, in which the response signal is correlated with the product of sample concentration and their mobility. Relative to CD, CHD provides

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enhanced detection ability to weakly dissociated species and comparable detection limit for fully dissociated ions [9]. Due to its unique response characteristic, CHD can also be extended as electrodialytic desalter to remove salt in biological samples [10]. In typical configuration of IC system, CHD (or CD) and suppressor are separate components of IC system and they are connected in series via a segment of tubing. Obviously, this adds to the complexity of IC system and brings some extra-column dispersion of analyte to a degree. One solution is to combine two or more IC components into an integrated device. Huang et al. proposed an integrated device of a suppressor and a resistance detector [11], which demonstrated dual functions of effective suppression and conductance detection. Herein, we describe an integrated device by combining a suppressor with a CHD together (abbreviated as Sup-CHD). Sup-CHD has comparable performance relative to a separate CHD and a separate suppressor and can function as both suppressor and CHD simultaneously.

2. Experimental

2.1. Regents

Analyte solutions were prepared in the form of either sodium or potassium salts. Typically, these were analytical grade chemicals, used as received from the vendors. Milli-Q ultra-pure water was used throughout with a specific resistance of about 18.3 MΩ cm.

2.2. Fabrication of Sup-CHD

The planar cascading structure of Sup-CHD is similar to presently commercial electrodialytic suppressor [2] (www.dionex.com) or a membrane-based CHD [7], except for a greater number of layers and addressable flow channels. Its schematic diagram and photograph was illustrated in Fig. 1 and in support information (SI)-Fig. 1. Take suppression of KOH eluent as example, the device consists of five chambers isolated by three pieces of cation exchange membrane (CEM) and one piece of anion exchange membrane (AEM), which is divided into two sections of CHD and suppressor. CHD section uses one AEM and one CEM, with the adjacent screen with anion exchange group functionalized same as the membrane, the central screen being neutral. The suppressor section consists of three channels isolated by two CEMs, namely one eluent and two regenerant channels. Chemically functionalized cation exchange screens are gasketed and placed in the three channels, thus defining the liquid flow pathways. Three screen-shaped platinized electrodes are placed on each channel along the length of the regenerant chamber and are isolated from membrane by the gasket screen mentioned above, one is the anode of the CHD placed at the side of AEM, the second is the cathode of the suppressor placed at the side of CEM of suppressor, and the middle one serves the common electrode of the cathode of CHD and the anode of suppressor (details see Fig. 1). Two independent electric sources are supplied for CHD and suppressor, respectively. The active membrane area of CHD and suppressor is 88 mm length × 8 mm width and 88 mm length × 11 mm width, respectively.

2.3. Chromatographic system

An IC equipment (CIC-160, Shenhan Corp., Qingdao, China) was used to evaluate the performance of Sup-CHD. A PEEK chromatographic pump is used to deliver pure water at the flow rate of 1.0 mL/min, and KOH eluent is online generated via a home-made electrodialytic generator described previously [12]. An anion column (AS20, Thermofisher Corp., USA) was used for anion separation. The effluent of separation column enters the central channel of suppressor section, where effective suppression can be achieved. After that the suppressed effluent flows into the central channel of

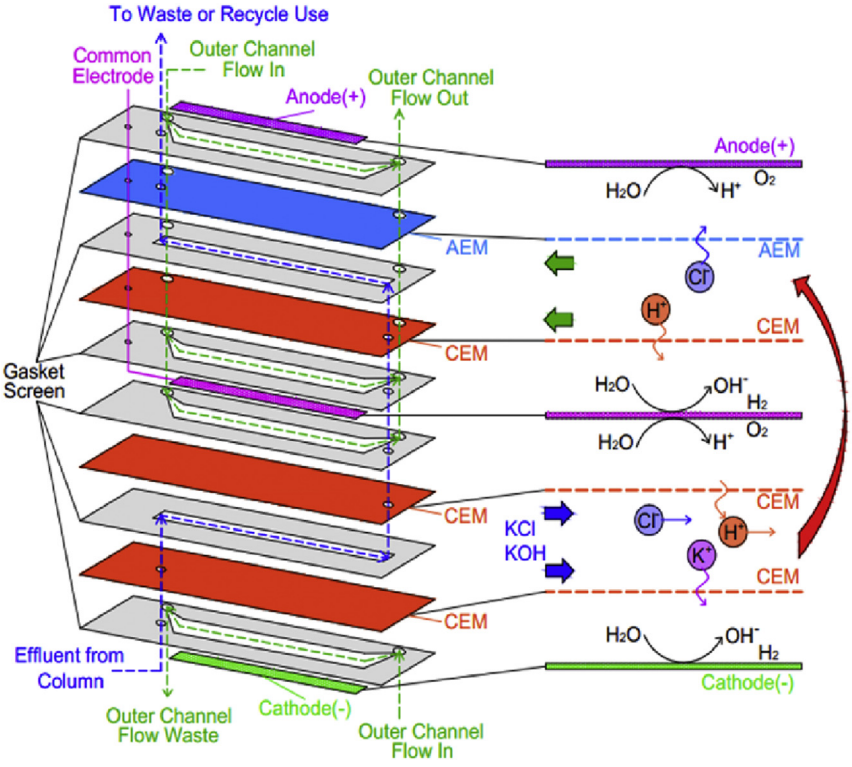

Fig. 1. Schematic diagram of Sup-CHD.