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General rules for high performance liquid chromatography-quadrupole inductively coupled plasma-mass spectrometry

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3 Terms and definitions

The terms defined in GB/T 6041, GB/T 13966, GB/T 16631, GB/T 37837, JJF 1159, JJF 1267 and JY/T 0568 apply, together with two terms defined here.

3.1 high performance liquid chromatography-quadrupole inductively coupled plasma-mass spectrometer: an instrument that separates the components to be measured on the principle of high performance liquid chromatography, connects through a coupling interface to a quadrupole inductively coupled plasma mass spectrometer, and detects ions by their different mass-to-charge ratios, for multi-element concentration analysis and isotope ratio measurement.

3.2 matrix effect: the influence that components of the sample solution other than the component to be measured have on the response signal of that component during measurement.

4 Principle of the method

The components to be measured in the sample are separated by the high performance liquid chromatograph.

In the order of their retention times they pass through the coupling interface into the quadrupole inductively coupled plasma mass spectrometer, where they are fully ionised and are then separated and detected according to the mass-to-charge ratio of the ions.

Identification is made on the mass-to-charge ratio together with the retention time, and measurement is made on the response signal corresponding to that mass-to-charge ratio.

5 Reagents and materials

5.1 Gases. Argon shall comply with GB/T 4842, with a volume fraction of not less than 99.99 per cent. Oxygen shall comply with GB/T 14599, with a volume fraction of not less than 99.999 per cent. Helium shall comply with GB/T 4844, with a volume fraction of not less than 99.999 per cent.

5.2 Water shall meet the grade one requirement of GB/T 6682.

5.3 Reagents shall be of guaranteed grade or better, shall not interfere with the analysis, and a reagent blank shall be run before use.

5.4 Reference materials and reference samples shall be certified reference materials or certified reference samples.

5.5 Preparation of calibration solutions. A series of calibration solutions of different concentrations is prepared in order. The eluting strength of the solvent used to prepare them shall be equal to or lower than that of the initial mobile phase, and the concentration range of the series shall cover the content range of the component to be measured in the sample solution.

6 Instruments and equipment

6.1 Composition. The main parts shall include at least the high performance liquid chromatograph, the coupling interface and the quadrupole inductively coupled plasma mass spectrometer.

6.2 Performance. The performance of the pumping system and the column oven of the liquid chromatograph shall comply with JJG 705, and the performance of the quadrupole inductively coupled plasma mass spectrometer shall comply with JJF 1159, the guiding rule being that the instrument suits the analysis actually to be carried out.

The coupling interface should be as short as possible and the fitting between the tubing and the nebuliser should be as tight as possible, so that the dead volume of the transfer line is reduced.

7 Treatment of the test sample

Before the sample enters the instrument, a suitable preparation method shall be chosen according to the aim of the analysis, the nature of the sample and the item to be measured.

The general principles are: to keep the component to be measured stable; to remove substances that interfere with the measurement; to keep the mobile phase compatible with

the coupled instrument; to protect the sample from contamination; to raise the extraction efficiency of the component to be measured as far as possible; and to run a blank test alongside the sample preparation.

8 Analytical steps and methods

8.1.1 Start-up. The instrument is started and warmed up according to its operating procedure until it is in the standby state.

8.1.2 Choice of analytical conditions. The parameters chosen according to the analysis include the type and flow rate of the mobile phase and the elution mode; the type and temperature of the column; the injection volume; the power of the ion source of the quadrupole inductively coupled plasma, the cooling gas flow, the auxiliary gas flow, the carrier gas flow, the sampling position, the ion lens parameters and the mass spectrometric measurement mode; and, where necessary, the oxygen and helium flow rates, so that the analytical performance of the instrument is at its best. The general rules are that the chromatographic resolution shall be not less than 1.0, the total dissolved solids in the mobile phase not more than 2000 milligrams per litre, and the concentration of organic matter in the mobile phase not more than 5 per cent.

8.2.1 Chromatographic resolution interference. Resolution is the key indicator of the separating power of the chromatographic system; where it falls below 1.0, the accuracy of identification and measurement is affected. To raise resolution, one or more of the following may be chosen: changing the proportions of the components of the mobile phase; using gradient elution; reducing the injection volume; lowering the mobile phase flow rate; changing the column temperature; increasing the column length; and changing the type of column.

8.2.2 to 8.2.5 Other interferences. Matrix effect interference may be suppressed or reduced by diluting the sample solution, by the standard addition method, by the internal standard method, by removing the matrix, or by using an organic sample introduction system. Isobaric interference may be reduced or removed by measuring an isotope that is free of interference or by using an interference correction equation, the equation being validated before use. Polyatomic ion interference may be reduced or removed by optimising the operating conditions so that the yield of polyatomic ions falls, by collision or reaction cell techniques, by an interference correction equation, or by a suitable sample separation method that removes the interfering matrix. Doubly charged ion interference may be reduced or removed by optimising the operating conditions so that the yield of doubly charged ions falls, or by an interference correction equation validated before use.

8.3 Qualitative method. The sample solution and the calibration solution are analysed under the same conditions and their chromatograms compared, identification being made on the retention time and the mass-to-charge ratio.

8.4.1 Quantitative methods, general. Peak area or peak height is measured for quantification, and the calibration curve method, the standard addition method, the internal standard method or the isotope dilution method is used. Where a workstation processes the data, sensible integration parameters shall be chosen according to the shape of the peak so that an accurate peak area or peak height is obtained.

8.4.2 Calibration curve method. Not fewer than six calibration solutions of different mass concentrations are prepared, including a solvent blank and prepared fresh for use. They are measured in order of rising concentration for the peak area or peak height of each separated component, and the calibration curve is drawn with the mass concentration of the component on the horizontal axis and the peak area or peak height on the vertical axis; the regression equation is calculated and its correlation coefficient shall be not less than 0.99. The sample solution is then separated under the same conditions, the peak area or peak height of each component measured, and the mass concentration in the sample solution calculated from it. In use, the method should as far as possible be applied where there is no matrix effect or where it can be neglected; matrix effect in the sample solution should be removed as far as possible; the matrix of the calibration solutions and the sample solution should be kept as alike as possible; and the mass concentration of the component in the sample solution should fall within the linear range of the curve. Figure 1 shows the calibration curve of this method.

8.4.3 Standard addition method. Where matrix effect cannot be avoided by diluting the sample solution, the standard addition method may be used. Equal volumes of the sample solution are taken as n portions; one receives no calibration solution and the others receive different volumes of calibration solution in proportion, and all are then diluted to the same volume, so that the mass concentrations run from the sample concentration alone up to the sample concentration plus n minus one times the added concentration, the calibration solution being prepared fresh for use. The n solutions are measured in turn under the prescribed instrument conditions for the peak area or peak height of each component, and the curve is drawn with the added mass concentration on the horizontal axis and the peak area or peak height on the vertical axis; its correlation coefficient shall be not less than 0.99. The absolute value of the point at which the curve extended backwards meets the concentration axis extended backwards is the mass concentration of the component in the solution, as shown in Figure 2, and the concentration in the sample solution is calculated from it. In use, at least five points including the sample solution itself shall be used to draw the curve; the method applies only in the region where mass concentration and response signal are linear; and the smallest added mass concentration should be about the same as the mass concentration of the component in the sample solution.

8.4.4 Internal standard method. Not fewer than six calibration solutions of different mass concentrations are prepared, including a solvent blank and prepared fresh for use, and a set amount of each is injected. The internal standard may be added in either of two ways. In on-line real-time correction, an internal standard of a single mass concentration is added to