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Report by the Analytical Methods Committee
Evaluation of analytical instrumentation.
Part XII. Instrumentation for capillary electrophoresis

Analytical Methods Committee†

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†The Analytical Methods Committee has received and approved the following report from the Instrumental Criteria Sub-Committee.

Introduction

The following report was compiled by the above Sub-Committee of the AMC, which consisted of Professor S. Greenfield (Chairman), Professor L. N. Miller, Dr P. J. Potts, Mr D. C. M. Squirrell, Dr C. Burgess, Dr K. E. Jarvis, Dr S. J. Hill and Dr K. D. Altria, with Mr C. A. Watson as Honorary Secretary. The initial input of the features for consideration was undertaken by a working party chaired by Dr K. D. Altria with Mr G. S. Clarke and Professor D. Perrett, to whom the committee expresses its thanks.

The purchase of analytical instrumentation is an important function of many laboratory managers, who may be called upon to choose between a wide range of competing systems which are not always easily comparable. The objectives of the Instrumental Criteria Sub-Committee are to tabulate a number of features of analytical instruments which should be considered when making a comparison between various systems. As is explained below, it is then possible to score these features in a rational manner, which allows a scientific comparison to be made between instruments.

The overall object is to assist purchasers in obtaining the best instrument for their analytical requirements. It is also hoped that this evaluation will, to some extent, also help manufacturers to supply the instrument best suited to their customers' needs. It is perhaps pertinent to note that a number of teachers have found the reports to be of use as teaching aids.

No attempt has been made to lay down a specification. In fact, the Committee considers that it would be invidious to do so: rather it has tried to encourage the purchasers to make up their own minds as to the importance of the features that are on offer by the manufacturers.

The XIIth report of the Sub-Committee deals with capillary electrophoresis.

Notes on the use of this document

Column 1. The features of interest.

Column 2. What the feature is and how it can be evaluated.

Column 3. The Sub-Committee has indicated the relative importance of each feature and expects users to decide on a weighting factor according to their own application.

Column 4. Here the Sub-Committee has given reasons for its opinion as to the importance of each feature.

Column 5 onwards. It is suggested that scores are given for each feature of each instrument and that these scores are modified by a weighting factor and sub-totals obtained. The addition of the sub-totals will give the final score for each instrument.

Notes on scoring

1. (PS) Proportional scoring. It will be assumed, unless otherwise stated, that the scoring features will be by proportion, *e.g.*, from worst/0 to best/100.
2. (WF) Weighting factor. This will depend on individual requirements. An indication of the Sub-Committee's opinion of the relative importance of each feature is indicated as follows: VI (very important), I (important), NVI (not very important). A scale is chosen for the weighting factor which allows the user to discriminate according to needs, *e.g.*, $\times 1$ to $\times 3$, or $\times 1$ to $\times 10$. The factor could amount to total exclusion of an instrument.
3. (ST) Sub-total. This is obtained by multiplying PS by WF.

Capillary electrophoresis (CE) is a well established analytical technique with applications in many areas. A range of instrumentation is available from a number of different manufacturers. Systems range from simple instruments, with a single capillary and detector, to complex systems with autosamplers and microcomputer-based controllers for continuous operation and sophisticated mass spectrometric or diode array spectroscopic detectors. Selection of a suitable instrument for purchase is, therefore, not an easy task and the purpose of these notes is to provide some guidance to areas which should be considered, so that the choice is based on a full consideration of the available options. However, the performance of any CE method depends primarily on the separation conditions and thus on the nature of the capillary and electrolyte employed. The nature of the analyte and the requirements for sensitivity and selectivity will influence the choice of detector.

The first task in the selection of an instrument is to examine the range of analyses that it will be expected to perform. Care should be taken not to specify these requirements too closely as uses change with time. The analytical scientist should also not try to envisage every potential application or the selection criteria may become too detailed. The choice of the capillary type and electrolyte are outside the scope of these guidance notes but any specific requirements should be noted, such as special detectors, injectors or accessories.

With these requirements in mind, the user should then evaluate the instruments available on the market while bearing in mind the guidelines and any financial limitations. In many instances it will quickly become clear that a number of different instruments could be satisfactory and non-instrumental criteria may then be important. However, in some specialised cases only one or two instruments will have the necessary features to carry out the assay.

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The guidelines are intended to be used as a check list of features to be considered, mostly of the instrument itself, but some also of its service requirements and of the relationship of the user with the manufacturer. Their relative importance will depend on the installation requirements of the instrument as well as the uses to which it will be put. Therefore, to some extent, the selection process will inevitably be subjective, but if all the points have been considered, it should be an informed choice.

In addition, because a separation depends so much on the capillary, electrolyte and operating conditions, it may sometimes be difficult to assess the actual operating performance of a particular feature from the manufacturer's specificatons. For some applications it may be necessary to evaluate the performance of the instrument under consideration using the system suitability test mixture chosen for a particular application. The purpose of this is to demonstrate the systems ability to perform a critical separation. CE instruments are often sold as complete systems, so that compromises between features may have to be accepted, but it will still be important to distinguish between critical features and those which are optional.

The Committee consider that, in general, CE equipment is safe in normal use, but suitable precautions should be taken when handling flammable solvents. In addition, eye protection should be worn when aligning or changing UV lamps or capillaries.

Finally, as many laboratories are now working to quality standards such as GMP/GLP/NAMAS/ISO Guide 25, some consideration should be given to third party recognition of the manufacturer to standards such as ISO 9001. Such accreditation should extend to the service organisation, which is particularly important when working to NAMAS or GLP criteria.

Previous reports in this series from the Analytical Methods Committee

Evaluation of analytical instrumentation

Part I Atomic-absorption Spectrophotometers, Primarily for use with Flames, *Anal. Proc.*, 1984, **21**, 45. Revised 1997. *Analyst*, 1998, **123**, 1406.

Part II Atomic-absorption Spectrophotometers, Primarily for use with Electrothermal Atomisers, *Anal. Proc.*, 1988, **22**, 128. Revised 1997. *Analyst*, 1998, **123**, 1415.

Part III Polychromators for use in Emission Spectrometry with ICP Sources, *Anal. Proc.*, 1986, **23**, 109.

Part IV Monochromators for use in Emission Spectrometry with ICP Sources, *Anal. Proc.*, 1987, **24**, 3.

Part V Inductively Coupled Plasma Sources for use in Emission Spectrometry. *Anal. Proc.*, 1987, **24**, 266.

Part VI Wavelength Dispersive X-ray Spectrometers, *Anal. Proc.*, 1990, **27**, 324.

Part VII Energy Dispersive X-ray Spectrometers, *Anal. Proc.*, 1991, **28**, 312.

Part VIII Instrumentation for Gas–Liquid Chromatography, *Anal. Proc.*, 1993, **30**, 296.

Part IX Instrumentation for High Performance Liquid Chromatography, *Analyst*, 1997, **122**, 397.

Part X Inductively Coupled Plasma-Mass Spectrometers, *Analyst*, 1997, **122**, 393.

Part XI Instrumentation for Molecular Fluorescence Spectrometry, *Analyst*, 1998, **124**, 1649.

Instrumental criteria sub-committee evaluation form

Type of instrument: Capillary electrophoresis

Manufacturer:

Model No.:

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score		
Non-instrumental criteria						
Selection of manufacturer	Laboratories in possession of other CE systems should score highest for the manufacturer with the best past record based on the following sub-features:					
(*a*) Previous instruments						
(*i*) Innovation	Company's record for developing instruments with innovative features.	I	The manufacturer should be alert to developments in technology and electrophoresis.	PS WF ST		
(*ii*) Reliability record	Company's record for instrument reliability.	I	Indicates history of sound design/manufacturing concepts.	PS WF ST		
(*iii*) Similarity of operation, layout and design to existing instruments in the laboratory	For routine purposes this may be important. However, this may be less important for research applications.	I	Similarity of layout means that operators can draw on in-house expertise, resulting in reduced training costs and time. It may also maximise the use of spares and fittings.	PS WF ST		
(*iv*) Confidence in the supplier	Confidence gained from past experience.	I	Good working relationship already in place.	PS WF ST		
(*b*) Servicing	Score according to manufacturers' claims and past record, judged by the sub-features (*i*)–(*v*) below:					
(*i*) Service contract	Availability of suitable service contracts from the supplier, agent or third party contractor.	VI	Suggests long term commitment to user. Often ensures preferential service and guarantees a specific response time to call-outs.	PS WF ST		

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score		
(*ii*) Availability and delivery of spares	Range of stock carried by, or quickly available to, the manufacturer/agent/ contractor.	I	Rapid delivery of spares reduces downtime.	PS WF ST		
(*iii*) Call-out time	Availability of adequate service such as the time for the engineer to reach the laboratory following a call.	VI	Keeps laboratory in operation by reducing down time [see also (*i*)].	PS WF ST		
(*iv*) Effectiveness of service engineers	The ability of the service engineers as judged from previous experience and reports of others, including the carrying of adequate spares.	I	Ability to repair on-site avoids return visit or removal of equipment for off-site repair so reduces down time and may reduce service cost.	PS WF ST		
(*v*) Cost of call-out and spares	It *may* be inappropriate to score this feature if in-house servicing is contemplated.	I	The proximity of the service centre may be a factor in travel costs.	PS WF ST		
(*c*) Technical support	As in (*b*) score in consideration of sub-features (*i*)–(*iii*) below.	VI for new user				
(*i*) Advice from applications department	The advice and training available from the manufacturer's applications department.	I	This helps in-house staff with new applications problems.	PS WF ST		
(*ii*) Technical literature	The range and quality of technical literature including the operating manual.	I	Guidance on optimum use of instrument suggests manufacturers awareness of applications.	PS WF ST		
(*iii*) Telephone assistance	Willingness of the manufacturer/supplier/ contractor to give effective advice over the telephone. This can normally only be evaluated by reference to existing users.	I	Rapidly available technical help reduces the number of call outs and enhances productivity.	PS WF ST		
Instrumental criteria						
1. General features						
(*a*) Facilities required for:						
(*i*) Access and location of connections and controls on instrument	Score according to convenient access taking into account the proposed location of the instrument.	I	Depending on bench position and layout, connections and controls may limit accessibility for servicing and installation particularly at the rear of the instrument.	PS WF ST		
(*ii*) Power requirements	Many systems require multiple power inputs. Score maximum for instruments with the minimum of separte power leads.		Excessive numbers of power cables when combined with other services create hazards and make servicing more difficult.	PS WF ST		
(*iii*) Power failure effects	Score highest for systems that allow recovery from power failure with minimal data control loss.	I(VI)	Down time is increased if power failure necessitates resetting of instrument control parameters. This is critical for unattended operation with long runs.	PS WF ST		
(*iv*) Size of equipment	Score according to convenience of installation, taking into account the proposed location of the instrument.	I(VI)	Dimensions may be critical if space is limited.	PS WF ST		
(*iv*) Gas supplies	Many instruments require compressed gas supplies for operations. Score highest for systems that have internal compressors.	I	Internal compressors reduce operating costs.	PS WF ST		
2. Power supplies						
(*a*) Functions	Score highest for instruments which offer constant voltage, current and power modes.	I	Specific analytical methods may require a particular mode.	PS WF ST		
(*b*) Stability	Score highest for systems with greatest stability.	VI	Changes in supply leads to fluctuating migration times.	PS WF ST		
(*c*) Voltage polarity	Score highest for instruments where polarity can be automatically switched through software.	I	Minimises safety hazards and eliminates possibility for errors.	PS WF ST		
(*d*) Spillage containment	Score highest for systems which have features to prevent ingress of solvents into the instrument.	I	Minimises potential damage to the instrument.	PS WF ST		
(*e*) Safety	Score highest for systems which have adequate and sufficient safety interlocks.	VI	Minimises hazards in interest of safety.			

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score		
3. Liquid handling systems						
(*a*) Instrument control	Score highest for instruments which allow adequate software control of all key operaional functions.	VI	Software control facilitates method compliance.	PS WF ST		
(*b*) Flow control	Score highest for wide range of rinse pressure settings, rinse times and directions.	I	Extended range improves flexibility of instument control.	PS WF ST		
(*c*) Buffer replenishment	Score highest for systems with built-in facility for buffer replenishment.	I	Useful for reducing buffer depletion effects in long injection sequences.	PS WF ST		
(*d*) Materials of construction	Score highest for durability as judged from the obseved quality of constuction and manufacturers information.	I	Poor quality or inappropriate materials can lead to contamination of electrolyte and corrosion of casings and connectors.	PS WF ST		
4. Autosampler						
(*a*) Autosampler options	For more complex systems, score highest for systems which have the greatest number of these additional features as appropriate to the application:	I		PS WF ST		
	thermostatting of the sample tray		Important for stability of certain sample solutions.			
	full software control of injection numbers and sequences		Useful for routine operation and method development.			
	ability to perform liquid transfers or dilutions		Useful for pre-separation derivatisation or dilution.			
	minimisation of sample solution evaporation		Reduces systematic errors.			
	usage of microvials for small sample solution volume		Important when only sub-ml sample volumes are available.			
	ability to protect samples from light		Important for light sensitive samples.			
(*b*) Pressure based injection	Score highest for systems which can best control the time and pressure setting.	I	Allows additional flexibility for the instrument and the applications that it can be used for.	PS WF ST		
(*c*) Electrokinetic injection	Score highest for systems which can best control the time, voltage setting and polarity.	I	Allows additional flexibility to the instrument.	PS WF ST		
(*d*) Injection repeatability	Score highest for systems which deliver the best injection precision.	VI	Consistent sample introduction onto the capillary is a critical factor in obtaining reproducible peak areas.	PS WF ST		
5. Capillaries and fittings	[**N.B.** Capillary materials and coatings are outside the scope of this evaluation.]					
(*a*) Capillary housing	Score highest for systems which use a capillary housing cartridge.	I	Cartridge columns can make column changing easier and quicker and protect the capillary from breakage.	PS WF ST		
	If capillaries are held in a cartridge, score highest for systems which: are easy to fit have low dead volume are robust are low cost allow easy accurate alignment of capillary	I	Improves the ease of use for the instrument.	PS WF ST		
(*b*) Capillary switching	Score highest for systems which allow the quickest installation of the capillary into the cartridge.	I	Increases productivity.	PS WF ST		
6. Temperature control						
(*a*) Temperature controller design; size shape and special features	Temperature controller design must allow easy accommodation of user selected capillaries and have an adequate thermal capacity.	I	Increased range of applications.	PS WF ST		
(*b*) Temperature range	Score highest for temperture control device with widest range of operating temperatures.	VI	Accuracy and precision of temperature control are important to obtain reproducible separations.	PS WF ST		
(*c*) Heat dissipation ability	Score highest for control device which dissipates the heat inside the capillary most effectively. This system will produce the lowest operating currents.	I	Often improves separations and allows use of higher buffer concentration if required.	PS WF ST		

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score		
7. Detectors (general)						
(*c*) Availability	If appropriate to the applications, score maximum for the widest range of detectors which can be fitted to the standard instrument.	VI	Increases versatility of the instrument.	PS WF ST		
(*b*) General features						
(*i*) Linear dynamic range	Score maximum for widest linear dynamic range in the spectral region of interest for the type of detector employed.	I	Facilitates quantitation over a wide concentration range.	PS WF ST		
(*ii*) High signal to noise ratio	Score highest for highest signal to noise ratio.	VI	A high signal to noise ratio facilitates the achievement of lower detection limits.	PS WF ST		
(*iii*) Flow cells and geometry modified capillaries	Score highest for systems that have: flow cells which are easy to remove and clean low dead volume capillaries which have a modified detection area such as bubble or z-cell	I	This provides extension of the analytical range. Flow cells may become blocked and require cleaning. Low dead volumes should be minimised to prevent band broadening.	PS WF ST		
8. UV–visible detectors			UV–visible detection is the most widely employed as many solutes of interest contain chromophores. The complexity of the detector required depends upon the application.			
(*a*) Filter detectors	Score highest for detectors which have: a wide range of filters narrowest bandpass ease of lamp changing deuterium lamp rather than fixed wavelength lamp	VI	Such detectors have wide applicability and high sensitivity as well as ease of maintenance but are limited by the wavelengths selectable.	PS WF ST		
(*b*) Continuously variable wavelength	Score highest for detectors which have: wide wavelength range narrowest bandpass best accuracy and precision of wavelength selection	VI	Such detectors have wide applicability and high sensitivity where wavelength selection is critical	PS WF ST		
(*c*) Diode array/ scanning detectors	Score highest for detectors which have: a wide wavelength range the best resolution the highest sensitivity a flexible readout capability	VI	Such detectors have wide applicability and high sensitivity where complete spectral information is required. These detectors need good software and powerful multi-tasking computer systems.			
(*d*) Indirect UV detection	Score highest for systems that have the ability to revese the detector output polarity automatically.	NVI	Production of positive peaks makes automatic peak integration easier.	PS WF ST		
9. Fluorescence detectors			Some chromophores will emit light as fluorescence when irradiated with UV–visible radition. For some applications a simple filter based detector will be adequate.			
(*a*) Filter detectors	Score highest for detectors which have: a wide range of filters for excitation and emission the narrowest bandpass high energy lamps or lasers	VI	Such detectors have high sensitivity and selectivity as well as ease of maintenance.	PS WF ST		
(*b*) Continuously variable wavelength	Score highest for detectors which have: a wide wavelength range the narrowest bandpass best accuracy and precision of wavelength selection	VI	Such detectors have very high sensitivity and selectivity when optimised excitation and emission wavelengths are necessary.	PS WF ST		
(*c*) Indirect fluorescence detection	Score highest for systems that have the ability to reverse the detector output polarity automatically.	NVI	Production of positive peaks makes automatic peak integration easier.	PS WF ST		
10. Other detectors	If appropriate, score highest for systems which have available specialist detectors including: conductivity electrochemical MS-interfacing	I(VI)	An application may require a particular detection method since the solute may not contain a chromophore. Additional sensitivity or specificity may also be needed.	PS WF ST		

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score		
11. Data handling			The selection of a data handling system is outside the scope of this study as many software packages are available for data handling which are interchangeable between personal computers. Providing the instrument can output the data to a suitable computer, it should not affect the choice of the instrument, so scoring is inappropriate. However the following features should be taken into consideration.			
(*a*) Integrated systems	Score for facility to carry out instrument control, data capture, collation and integration and extensive reporting capabilities.	VI	The ability to carry out these tasks in a controlled manner is essential for data and information integrity,	PS WF ST		
(*b*) Interfacing requirements for non integrated systems	Score highest for systems employing adequately documented industry standard interfaces and protocols.	VI	Provision of such hadrware and software is essential to secure data communication to other systems.	PS WF ST		
(*i*) Data capture rate	Score highest for systems which have the fastest data capture rates.	I	The peaks in a highly efficient CE system have widths which require use of a fast data capture rate.	PS WF ST		
(*ii*) Data transfer	Score highest for systems which generate data in a format that can be readily transferred to other programmes.	I	Ease of data transfer reduces time and prevents possibility for transcription error.	PS WF ST		
				Sum of sub-totals		
12. Value for money (Points per £)	Sum of the previous sub-totals divided by the purchase price of the instrument. Subject to proportional scoring and weighting factors, including ST in grand total.	I	'Simple' instruments are often good value for money, whereas those with unnecessary refinements are often more costly.	PS WF ST		
				Grand total		

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