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Development in High Pressure Liquid Chromatography: Modern Instrumentation and Training Strategy

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1 Development of HPLC

High pressure liquid chromatography (HPLC) was developed in mid 1970's as a result of interaction between modern instrumentation and the principle of chromatographic separation. Since this time HPLC has been further developed. Survey of the development of the technique provides that development of HPLC could be described in terms of development of its components. For example pumps that are able to deliver mobile phase at small flow rate (micro-pumps) with columns of very small internal diameters (micro-columns) leads to micro-HPLC, a technique that provide high sensitivity. Injection system has been developed to provide sequential injection chromatography (SIC). SIC is a modification of the flow injection technique in which sample and reagent are injected sequentially enabling analytical reaction before detector. SIC is based on reproducibility rather than equilibrium. Low pressure columns are very important for SIC such as monolithic columns. Another modification in particle-based columns depends on the modification of the particle. Small particles (internal diameter is lass than 3μm) provide high efficiency, small run time and high pressure resulting in fast-HPLC or ultra pressure liquid chromatography (UPLC). Development based on detector provides more dimensionality as in diode array detector (3 dimensional chromatogram in terms of absorbance, time, and wavelength axis) plus many important hyphenated techniques such as HPLC-MASS (HPLC-MS). The idea of interfacing HPLC with other detector as mass spectrometer provides many creative interfaces such as electro-spray ionisation interface (EIS) (HPLC-EIS-MS). A map of the development of HPLC is illustrated in figure 1.

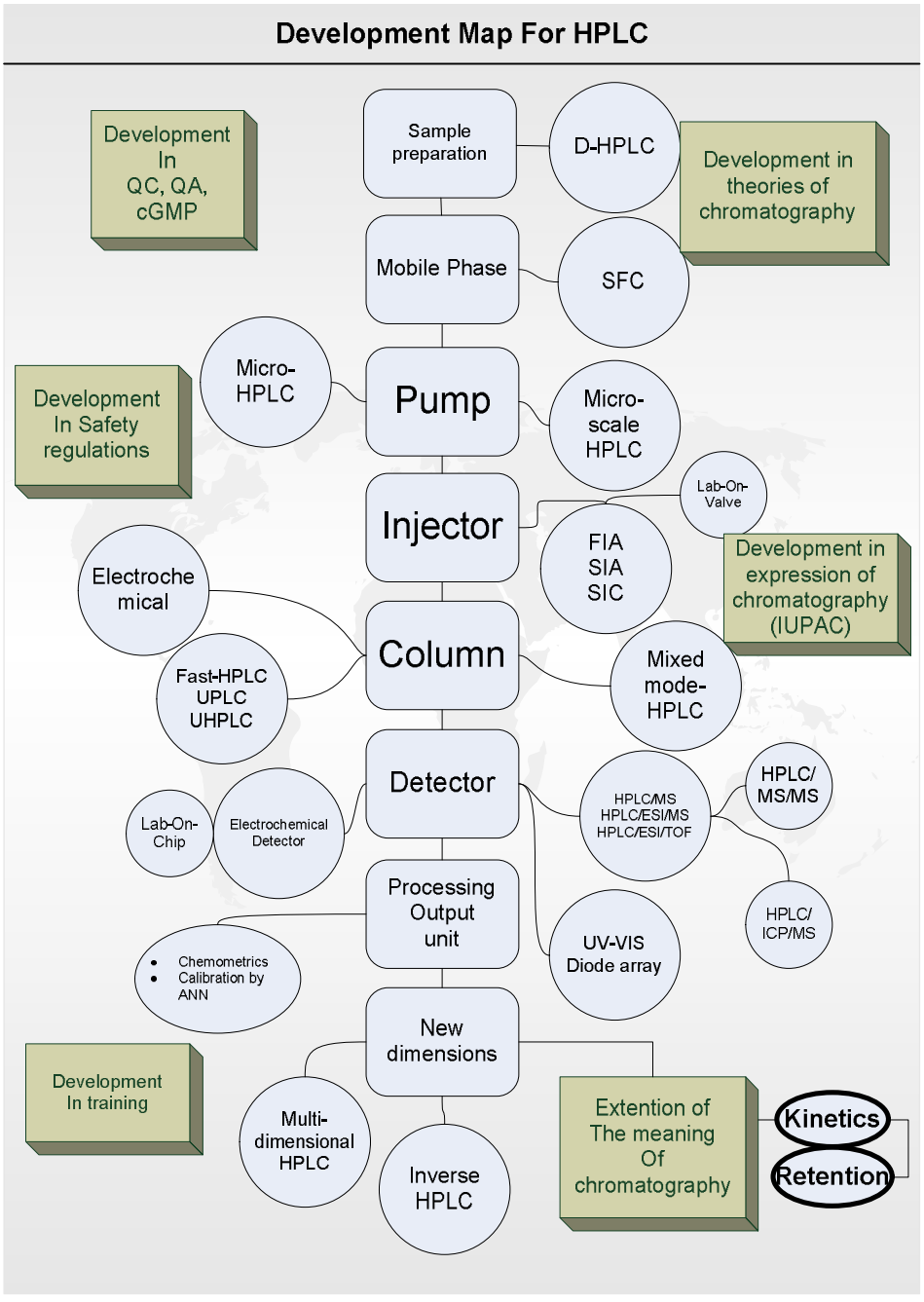

Figure 1 Development map of HPLC

2 Development patterns

From the above survey development go through several steps the most important is the creative idea which come from integration between scientific logic and scientific imagination, then the scientist try to overcome mental and physical barriers for example the

mental barrier in FIA is to depend on reproducibility of the analytical reaction rather than equilibrium. Physical barrier is related to the hardware as in the micro-pump. After development the scientist tries to find new dimensions, for example multidimensional HPLC and HPLC/MS/MS.

A result comes from the above idea, is the idea of development patterns. Many creative ideas were discussed but there are simple ideas or **material level pattern** such as using of autosamplers rather than manual injectors. Another pattern **is removing barriers between disciplines** such as integration between software and HPLC, integration between HPLC and electrochemistry. An important pattern is the **creative ideas inspired by logic and imagination** such as electrospray ionization. Finally **finding new dimension** pattern is observed in HPLC/MS/MS, HPLC/diode array and analysis of HPLC results by artificial intelligence techniques such as artificial neural networks (ANN)

The idea of development patterns does not means fixed rule for development but it implies employment of these patterns in the next creative ideas.

3 Training

3.1 Philosophy of Training

The philosophy of training may be derived from the development of systems, modern definition of analytical chemistry and from the nature of training process.

Training may be defined as “a think experiment in which an interaction takes place between ideas and minds resulting in improved or new activities and applications affecting the whole environment. Ideas are sequenced from interpretation of the analytical technique to the interpretation of analytical ideology. The trainer job is practicing the art of introducing modern multidiscipline ideas and providing a suitable environment in which the trainee is part of the team work rather than a consumer of the service"

3.2 Training model

A training model (figure 2) is designed for HPLC and is also applicable to other techniques covering the following items:

3.2.1 Concepts and language. The trainer introduces the main principles and concepts behind HPLC as well as different meanings within chromatographic environment including

the specific nature of chromatographic experiment (specific sequenced physico-chemical interactions leading to separation, qualitative and quantitative analytical applications).

3.2.2 Ideas. The theoretical background, the important laws and the logic behind the processes are illustrated. The sequence of processes (mental or physical) carried out by the chromatographer is explained. The sequence is configured according to the application such as problem solving, developing new method and driving HPLC system for routine analysis. The simple details of the process must be emphasized.

3.2.3 Tools. Providing productive tools (rather than illustrative tool) to the trainee enhances the learning process. The trainer provides tools such as customization techniques including design of spread sheets, using simple programming such as macros-based spread sheets and design of simple database to fulfill specific tasks. Understanding and comparisons allows efficient employment of tools such as comparisons between particles- packed and monolithic columns.for. Another example is employment of the information in internet in HPLC method development

An important tool is to learn strategies for expressing ideas and information. A modern strategy is mind mapping, in which, ideas are presented as a central idea that branches to related sub-ideas. Mind mapping may not provide the required flexibility for analytical method presentation. This article suggests that ideas could be presented visually in a manner closer to the interaction of chemical molecules. The interaction of many ideas forms a new one. During the analytical procedures each process could be presented as a neural cell the body of which leads inputs to output, a technique used in artificial intelligence applications such as artificial neural networks.

3.2.4 Evaluation. Training model communicates also with other skills such as evaluation of the points of weakness that needs to be developed and the ability to develop strategies for problem solving and ability to write reports describing effectively the current situations and the development solutions.

3.3 Trainer Tools

Trainer tools may exhibit simplicity in order to deliver complicated ideas effectively. Communication skills are very important. Trainer may use variety of illustration tools such

as power point slides, simulations and 3D models. An important tool is catalyzing the self-learning process to the trainee by introducing subjects and self-learning materials such as interactive books.

3.4 Points of Effect

Training target is the interaction between trainee, system, and environment to enhance understanding and performance and add values to the environment.

3.5 Training Horizons

Training should fulfill the requirements of modern analysis such as precise micro-analytical applications. The effect of HPLC-training may be transferred to other techniques; i.e. enhanced performance and problem solving skills. In the light of that there is no isolated development, training as a tool for people development leads to the development of the whole work environment; i.e. training is an economic source.

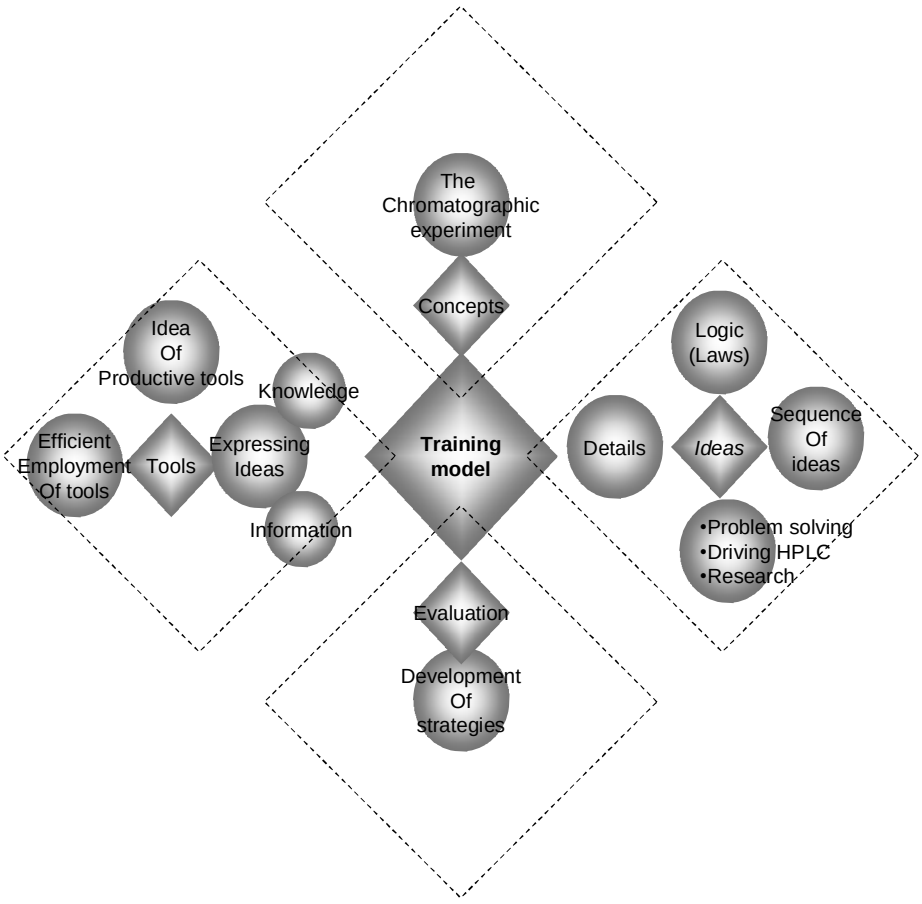

Figure 2 Training model