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Review: Fabrication of Coupling Approach Between Flow Injection System – Ion Selective Electrode.

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Abstract

In real-time monitoring applications where batch calibration approaches cannot be easily performed, the strategy of coupling between FIA and ISEs in FIA-ISEs is ideal for usage. On the other hand, manual manipulation of the solutions continues to be the foundation of current analytical equipment. The automated technique Flow Injection Analysis (FIA), combined with the urgent requirement for automated approaches, a significant influence of contemporary characterization methods are carried out. The flow injection analysis is a method involving clear operating fundamentals that shows promise. And although the electrodes are very selective, they are not free, therefore they link with ion selective (IS) as a detector on Selective Electrodes (ISEs) that are used to monitor some of the most important analyses on clinical laboratory and point of care analyzers.

1. Flow Injection System(FIA):

1.1 Introduction FIA:

The chemical industry, which is required to uphold strict international criteria, has gained a new dimension thanks to continuous flow analysis (CFA). One of the key moments in the development of analytical equipment was the invention and use of continuous flow analysis for the automation of the wet chemical method of analysis, Submerge chemical analysis is the term used to describe chemistry that is typically carried out in the liquid phase and is also known as bench chemistry because many of the experiments are carried out on a lab bench. The sample is put in a moving analytical carrier to react with the sample in this procedure. To get the carrier to react with the reagents, sample.[1]

To enable the automation of wet chemical techniques of analysis, Skeggs' work was required. To the analytical, he added a bubble of air stream to segment the sample and preserve its identity. This technique, called segmented continuous flow analysis (SFA). Ruzicka and Hansen in Denmark and Steward in the USA did ground-breaking work that made it possible to apply CFA to analytical streams that were not air bubble-separated, or without air bubbles. Non-segmented continuous flow analysis was the name given to this method by Steward, and Flow Injection Analysis (FIA) by Ruzicka and Hansen.[2]

A moving analytical stream that is not bubble-separated is subjected to a highly reproducible volume of material injection in the FIA CFA technique. At first look, it could appear that the sole difference between the FIA and SFA is whether or not the stream contains air bubbles. However, the FIA differs significantly from the SFA in three key components.

1.2 Sample introduction:

A continuous fluid flow free of air bubbles is injected with a very repeatable amount of material. employing a CFA strategy called the FIA. Although it would seem at first glance that the primary distinction between FIA and SFA is whether or not pockets of gases are present in a torrent that is moving, there are actually three important areas in which FIA and SFA divide. [3]

In FIA, reproducible planning is essential, but in SFA, timing is less crucial because any variation in the amount of time an item takes to complete is in the analyzer would immediately affect the maximum elevation due to transport live feed dilution. [4]

The foundation of FIA is the exact control of flow-induced analyte zone dispersion, which shifts the analyzer's means. SFA, however, depends on the introduction. of air bubbles to minimize the sample-induced dispersion, and the resulting flow profile is turbulent. Dispersion combining occurs, and Fluid velocity is the flow characteristic. The exact control of sample dispersion in FIA ensures, sample integrity. [5] Ruzicka and Hansen state that the FIA method "involves injecting a sample solution into a running, unbroken stream of the appropriate liquid. The inserted sample creates a zone, which is then moved in the direction of a sensor that continuously records the variations in any measured quantity when the sample impacts through the chamber after impact, such as reflectance, electrode potential, or any additional needed to be applied ". [6]

A dynamic analysis method is the FIA. The most basic FIA system, which carries the object to the detector by injecting it into an inert carrier stream, is not in homeostasis.; the sample's physical dispersion into the nearby carrier is out of balance. mechanism, has an impact on the time dependency and trustworthiness of the detector response function; the rate of a chemical reaction of, the connection also influences, the detector response function if the analyte now combines with the carrier and the reaction product is recognized, the distinctions between the response zone's and, the system's analyte and reagent transport, are dependents on the dispersion of the, sample. Along the whole sample zone, the reagent to analyte ratio fluctuates. [7]

It hasn't even been possible to accurately describe how the detector output function varies depending on system operating characteristics like manifold design and flow rate because of how difficult it is to define. the simultaneous physical and chemical processes, Understanding the theoretical underpinnings of FIA is essential to improving system design performance.[8]

A sample that has been introduced into a transport flow traveling via a brief rectangular channel segment, or both, are present at the beginning; The obstruction disperses and combines with the mobile phase as it moves upstream; a pronounced concentration gradient, forms, In the event where turbulence is to blame for; the sample dispersion, the flow profile exhibits a hyperbolic head and tail. This kind of flow, which is characteristic, of most FIA systems, is known, as laminar flow; a limitless The liquid in a flowing stream can have a variety of velocity profiles, with the highest velocity being observed in the middle of the torrent. There is no speed., just at surface of the tube or duct, there are presently two more mass, transfer techniques in use; transverse, dissemination, which is perpendicular to, the stream wise direction and opposite to the, axis of flow; and transport phenomena, which has a circumferential, orientation. [9]

Dispersion is a function of tube radius in laminar flow conditions and increases when the diameter is doubled. As the dispersion increases, the analyte bolus is diluted and scattered., resulting in reduced sensitivity and sample throughput, in order to obtain the appropriate amount of dispersion for analytical purposes. Therefore, when ,developing an FIA system, dispersion, must be kept to a minimum in ,relation to an analytical application, Coiling the tube can reduce dispersion in the ,FIA system. [10]

Dispersion is, described as "Ratio of the sample concentration, before and after the dispersion ,process has taken place in the component of fluid that produces analytical findings." [11] And from the following relation, the dispersion value can be calculate,

$$D = \frac{C_0}{C_{max}}$$

A sample's starting concentration is C_0 after administration, and its peak concentration is reached after the sample zone has gone through all of the diffraction processes and is passing through the detector (or C_{max}). when the sample zone has completed all diffraction processes and is passing through the detector that as show in Figure 1. [12]

Understanding how much the original solution is diluted as it travels through the detector is crucial when creating an FIA cell., how long it takes for the sample to travel, from the puncture site to the output point. Therefore, to determine

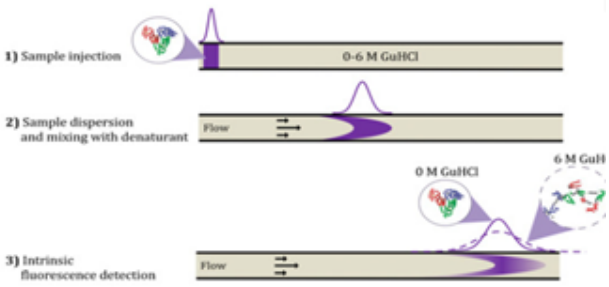

Figure 1. dispersion phenomena.

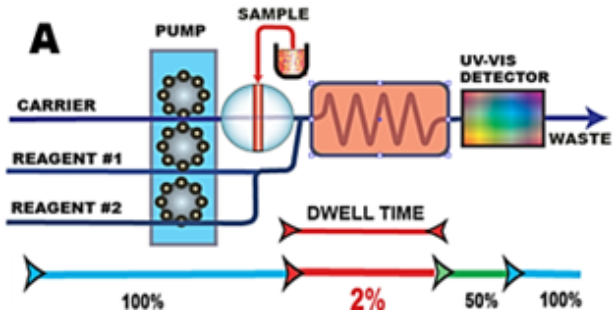

Figure 2. flow rate in FIA.

these dimensions, the dispersion coefficient (D) is employed, D is influenced by sample volume, wall thickness, fluid velocity, and tube diameter of approximately. [13]

There are three main types of dispersion:

1. FIA system with, D values of 1 to 3 for restricted dispersion.

2. FIA device with a medium, dispersion (D = 3 to 10).

3. System with a, large dispersion: FIA with D>10.

width decreases sample efficiency as it rises, perpendicular to the peak position; As the system volume increases, stable; state is reached, and the peak flattens down.[14] Half-volume, S1/2, is a crucial quantity and is determined by the formula S1/2 = 0.693/K.

This quantity of solution is required to get the detector response value to 50% of steady state, where C max for each S1/2 unit is equal to 50% of C0. The sample will only occupy a piece of the tube if the diameter is cut in half. of the tube that is four times longer, producing a smaller sample. Typically, there is less dispersion. [15]. In a narrow tube with a 1 mm internal diameter and laminar flow, the parabolic shape gets more and more apparent as the flow rate is raised. Over the whole area, there is a gradient in the concentration., length of the tube, The parabolic head and concentration polarization increase, in magnitude as flow rate increases, until roughness disturbs the homogeneous fluid motionthat as show in Figure 2. [16]

Centrifugal mixing, begins to cancel out the parabolic velocity, profile produced by the liquid's, forward motion at low rates of flow; If the sample injection is stopped, the dispersion of the sample zone basically comes, to an end with the exception of a little contribution from radial permeation. [17]

Dispersion increases with flow rate, decreasing residence, passing time, and increasing reagent consumption; if a chemical reaction is taking place, its strength reduces. with, rising flow rates as the reaction's time period, gets shorter, Sensitivity declines as sample dilution; from greater dispersion occurs, At low, flow rates, the opposite is true. [18]

Preferably, the carrier stream must flow via a narrow tube with a constant emotional, dimension, including the injection and, detector sections, when the FIA system, is built.

1. To ensure that the carrier stream's motion is unaffected, A exact volume and limited time instantaneous pulse of the sample or fluid is delivered.

2. Side, streams are seamlessly integrated into the ,main stream in a repeatable way.

3. All ,streams run without a heartbeat, and their motions can be initiated and terminated, instantly.

4. Detector, responds to analyte concen- tration promptly and precisely with highest signal ,output .[19]

A recorder, a detector, an analytical manifold, a pump, an injection valve, and the core make up the FIA system. An auto-sampler can also automate devices for sample injection and data processing. [20]

To guarantee a high level of precision, two, parameters must be managed. First, and foremost, accurate timing is necessary, The system flow rate needs to be ,precisely managed because The species is not in balance, and the sample holding time determines how much dispersal there is Second, a highly reproducible ,sample bolus must be injected ,into the carrier stream by carefully, controlling the sample volume and, injection timing. [21]

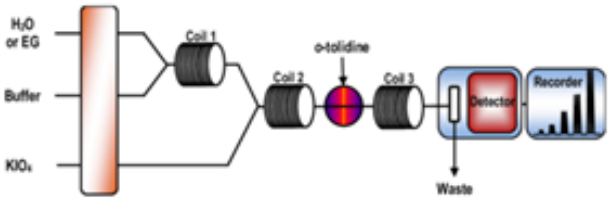

Figure 3. manifold in FIA.

An ideal compressor would provide uninterrupted flow of carriers and reagents. Syringes, pressure bottles, reciprocating pumps, and peristaltic pumps were all used in the development of FIA systems. The use and objective of the system determine the type of pump that is employed; the peristaltic pump is the most common type. Since it is a multiplex pump, the internal diameter of the pump tubes used in each channel can be changed to generate a varied flow rate. Eight to ten rollers, are used in modern pumps, and they are arranged in a circle so that half ,of them are constantly compressing the, tube.[22]

To inject a dependable and repeated wave volley of sample, the injected valve should be constructed so that it has no impact on the stream's flow. into the carrier stream. High performance liquid analysis can use sample volumes ranging from less than 1 L to 200 L, with 10 to 30 L being the most typical range. It is found that two types of injection valves, revolving and gliding gates, are frequently employed. Rotary valves, such as six port HPLC rotary valves, can be used for sample injection.

By turning the valve, the sample is injected into the system, connecting the sample loop to the mobile phase, You can use slider valves, such the ,four-part slider valve. There must be, two valves. After loading the sample loop, the valve state is modified to guide the, payload flow through the determine ,the approximate. [23]

The brain of the FIA is the intricate system. The application dictates the design. It is made of tubes and appropriate for straightforward chemical reactions. For applications like solvent extraction, dialysis, etc., specialized modules are required. that as show in Figure 3 [24]

Manifold coils are often created using Teflon, polypropylene, or polyethylene tubing. Teflon, is regarded as the best material for, tubing. Typical chromatographic ,plastic ferrules and washers are used ,to connect the tubing to one another and ,to other system parts. Dead volume must, be reduced when building a manifold since, it increases dispersion and creates peak, tails.[25]

The detector must meet the following criteria; be fast enough, is swift as well as the detector's capacity is modest. Almost every detector that has been reported to be used with HPLC may be employed with an FIA device. The detector should have a reaction time due to the fact that the majority of FIA's peak widths are only a few hundredths of a second . of less than one second. Maximum potential may alter as system and performance levels rise. [26]

Some, of the detectors used in FIA systems include electromotive force metric, atom absorption, phosphor -rescence, coulometric, fluorometric, pH potentio -metric, ion selective electrode, spectrophotometric, nephlometric, and flame detectors. [27]

FIA systems have been claimed to automate sample dilution and transport as well. for numerous analytical procedures that leverage chemical processes to enhance detection or reduce interference during the monitoring step. FIA systems have also been proposed to reduce reagent usage to as little as microliters.. [28]

It is a tried and true pre concen- tration, approach ,for separation , Injecting, a consistent sample volume into, the a torrent of reagents causes it to change, into an extractable, form.[29]

With the exception of utilizing a solvent, these are effective techniques for eliminating volatile or low molecular weight species from macromolecules. The separator architecture is comparable to a barrier, solvent extractor, whether it be a dialysis membrane, or a gas permeable membrane. After the sample has been processed, by the separator, where the analyte migrates through convection, the contributor; stream is pushed to the detector.[30]

The sample is injected into continuously running, flows of chemicals that saturate the whole, FIA system even when there isn't a, sample present. The concurrent, injection of the sample and reagent into an inert stream and mixing of the these sections in, a manifold with wash buffer or water as the, carrier is one method for minimizing reagent use, This method, known as the, merging zone approach, drastically ,decreases the amount of reagent needed for each, sample to only a few microliters, When using, a costly reagent, this becomes, crucial.[31]

Using titration techniques based on complex metrics, redox, and metal concentrations are frequently assessed in a variety of samples., and neutralization, Titrations are normally carried out in batch mode, which involves filling the titrating ,vessel, performing the measurement, and then emptying, cleaning, and ;reusing the vessel.[32]

Because it is straightforward and does not require the hazardous organic solvents that are used in traditional solvent extraction and solid phase extraction, (SPE) is a sample preparation procedure that is often employed in analytical chemistry ; At a given location on the manifold, the objective is to immobilize, the reagents, which typically flow in a discrete stream or channel during FIA. Despite, the apparent advantages, batch SPE operation is a demanding and drawn-out ,procedure.[33]

In order for these methods to function, the C-P or C-O-P bonds must first be broken, and then the orthophosphate ions produced must be measured using a molybdenum blue method. C-P bonds can be broken online by inducing thermal digestion at 90 °C with per sulphate ions present. C-O-P bonds can be broken by alkaline phosphatase either enzymatically or by the same method. UV lamps can be used to perform the photolysis process, which has the advantages of being simple to perform, not requiring chemicals, and having increased selectivity.[34]

Interactive measurements that are important, which permit the concentration, fluctuations of the reactants, and/or products, are another use for this method. to be tracked over time while the flow is halted with the reaction mixture in the flow cell.[35] With a decrease in flow rate, dispersion in smaller i.d. tubing grows smaller and finally stops nearly totally when the flow is halted .These events are utilized to raise the sensitivity of measurements by allowing reactions to complete without diluting the sample area through dispersion. With this procedure, the pump must be turned off at regular, specified intervals using a timing device.[36]

1.3 Advantages of FIA:

1. The injection valve functions as a micropipette, the tubing lines act as solution containers, and the pump replaces the lab operator when employing all this lab equipment, which is clear when contrasted to manual analyses.

2. Chemical assays have been greatly simplified by the FIA, The advantages of FIA over traditional manual approaches are the primary factors in the success.

3. Sample preparation and detection automation.

4. The FIA configuration's simplicity.

5. Rapid sampling (typically 100-300 samples per hour).

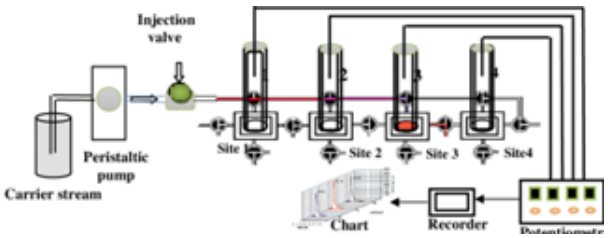

Figure 4. FIA-ISEs.

6. Quick response times with strong reproducibility (typically under a minute).

7. Quick startup and shutdown procedures.[37], [38]

8. Less, sample and reagent usage, which results in less waste production.

9. Easy, adaptable, and inexpensive instrumentation.

10. Lower labor and analysis costs when a large number of samples need to be evaluated.

11. More accuracy in comparison to batch methods.

12. Ease of use for manifolds and continuous separation approaches for flow injection.[39]

The following industries are typical use cases for flow injection analysis:

Medical application , hazard assessment, culinary analysis, epithelial tissue, mineral substance, medical assay, disease - causing micro chemistry, continuous tracking in biotechnology, monitoring waste and its treatments that as show in Table 1.[40]

FIA may be a fantastic conduit between instruments and dissolving equipment (e. g. HPLC). The FIA may be utilized for unstable active component analysis , derivatization, pre- concentration, on-line separation procedure, dilution, selectivity and/or sensitivity augmentation, and near real-time response that as show in Figure 4. [41]

Table 1. Examples of pharmaceutical applications of FIA [42].

S. No.	Sample	Method	Sensitivity	Samples per hour
1	2-chloroquinoxalines and 2- chlorobenzimidazoles.	A novel high-temperature indole formation in flow injection was developed by O'Brien and coworkers using toluene as the solvent between temperatures of 160-220 °C.20 As this reaction involves heating organic azides to elevated temperatures, it is not viewed as a favorable method for synthesizing indoles due to stability issues associated with the starting materials. / 2019	100 ppm	70
2	Small pharmaceutical molecule	optimized EI-LC-MS with SMB system, the solvent enters via a Z-axis capillary tune device to position the solvent delivery capillary in the spray nozzle (Figure 1b). A Z-axis spray probe tune device allows to adjust the position of the spray nozzle with respect to the entrance of the heated vaporization chamber.d spectrophotometric ally./ 2020	$1X10^{-6}$	50
3	Nitrofurazone	Silver nanoparticles were synthesized using Olive oil (O-AgNPs) as reducing as well as capping agent and extensively characterized by Flow injection UV–vis spectroscopy, fourier transform infrared, energy disperse spectroscopy, dynamic light scattering and atomic force microscopy. The chrome yellow color solution of O-AgNPs show the typical absorption maximum at 430 nm. /2018	0.2 mg/ml	100
4	Corticosteroids	Blue tetrazolium is reduced; by steroids in alkaline medium, forming a highly coloured; formazon which is measured spectrophotometric ally at 525 nm. (The method has been, especially studied for a typical corticosteroid, methyl Prednisolone acetate, but has been, extended to additional twelve steroidal drugs.)	0.1 mg/ml	100
5	L-Dopa	Aqueous samples are injected, into an aqueous supporting electrolyte solution, and the flow of open circulatory glassy carbon via the detector, is used to quantify amperiometric ally (A similar technique, with comparable sensitivity and sample frequency, has been, utilized for ferricyanide, ascorbic, and epinephrine.)	0.3 ng	264
6	Glycine	Glycine, forms a strong fluorescent species with o-phthalalde, hyde which ,can be measured at excitation and emission wavelengths of 337 nm and 455 nm respectively.	2 pg/ml	180
7	Glucose	Glucose is degraded, enzymatically by glucose dehydrogenase in the presence of a co- enzyme, nicotinamide adenine dinucleotide, which serves as a chromogen, colour of which is, measured spectrophotometric ally at 340 nm.	1 mM	120
8	Hydrazine	Hydrazine, reacts with 4-dimethyl, aminobenzaldehyde in acidic medium, yielding a, yellow p- quinone like compound which is measured, spectrophotometric ally at 460 nm.	0.02 ppm	350
9	Glycerol	Solution of glycerol in water, is injected into the aqueous stream of a buffer containing a, colour indicator, and the dispersion of the sample zone is measured spectrophotometric ally. The decrease in, absorbance is then, a linear function of the log of viscosity of injected sample.		120
10	Meptazinol	A meptazinol, containing the, sample is injected into a carrier stream of, electrolyte and, determined voltammetrically by means of a glassy, carbon electrochemical detector based on wall-jet principle.	0.01 mg/ml	80

2. Ion selective electrode:

A transducer that gauges the activity of a particular ion in a solution is an ion-selective electrode (ISE), sometimes referred to as a specific ion electrode (SIE). It produces potential electricity. According to the Nernst equation, the voltage is logically dependent on the ionic activity's logarithm. Ion-selective electrodes are used in analytical chemistry, biological, and physical research that requires measurements of the concentration of ions in an aqueous solution.[43]

electrodes made of glass, solid states, liquids, or compounds,are the four main types of ion-selective ,membrane used by ion-selective electrodes, (ISEs). [44] several membranes, and the first paragraph, the crystal, and the electrode The production of glass membranes (chalcogenide or silicate) uses ion-exchange glass. High selectivity is present in this type of ISE, but only for a few number of single-charged cations, primarily H+, Na+, and Ag+. Additionally, chalcogenide glass exhibits selectivity for double-charged metal ions such as Pb2+ and Cd2+. The pH glass electrode is a common example of this type of electrode, as it has good chemical resistance and can function in very abrasive conditions. [45]

Crystalline barriers: Crystalline membranes are created from mono- or polycrystallin; forms of a single substance. They have high, selectivity, since only ions that can enter, the crystal structure can interfere with the, electrode response. This is where these, electrodes and, glass membrane electrodes differ, most from; one another. The possible connections, are fewer since Chooser, there is no internal remedy for Both the cation and anion of the material producing the membrane can create crystalline barriers. One example is the fluoride selective electrode constructed of LaF3 crystals.

In order to, make screens, for willow Electron resins, various organic polymer membranes, that contain a particular, ion-exchange material (resin) are used, The most common, type of ion-specific electrode is one like this. The construction of selective electrodes for tens of distinct ions, both single-atom, and multi-atom, is made possible by, the employment of certain resins. Moreover, anionic selectivity employs these electrodes the most. The potassium, selective electrode, for example, uses valinomycin as an ion-exchange material but has a short "life time" and low chemical and physical durability.[46]

Although not really being ion-selective electrodes, enzyme electrodes fall under the umbrella of ion-specific electrodes. Such an electrode allows an enzyme to interact with a particular chemical, and the end result of this interaction (typically H+ or OH) is detected by a true ion-selective electrode, such as a pH-selective electrode. Because all of these processes take place inside a particular membrane that covers the actual ion-selective electrode, enzyme electrodes are occasionally thought of as ion-selective. Glucose-specific electrodes are one example. [47]

Alkali metal ions Li+, Na+, K+, Rb+, and Cs+ now have electrodes designed particularly for them. These electrodes work on the principle that an alkali metal ion is confined inside a molecular cavity that is the right size for the ion. For instance, a valinomycin-based electrode can be used to measure the concentration of potassium ions. [48]

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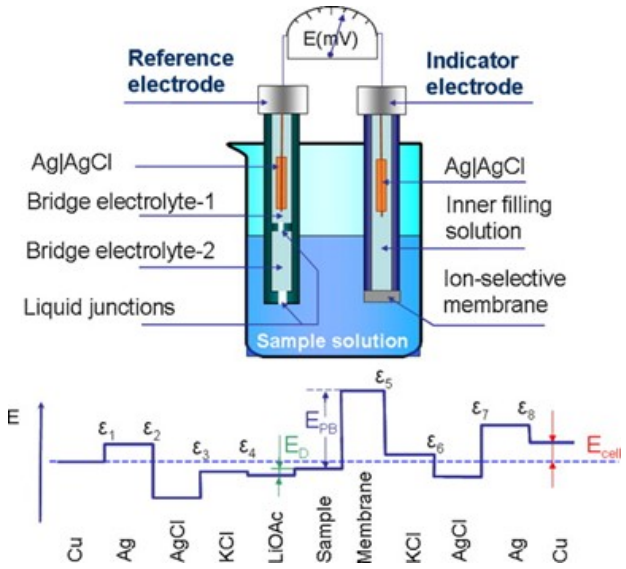

Figure 5. ISEs and process of operation.

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4. Approach of coupling FIA – ISE:

The approach allows for the employment of a small number of samples obtained by analysis, blind source separation, ion-selective electrodes, and digital signal.[49], [50], [51]

An ion-selective electrode (ISE) is a straightforward; method for monitoring ionic activity, but it frequently lacks selectivity, meaning that ions other than the target, one may affect its response, An array made, up of various ISEs might be built up, as a potential solution to this issue. This enables signal processing techniques to retrieve, the needed information by utilizing the array's variety (diversity here means that, each sensor responds differently),

Unsupervised signal processing techniques can be very helpful in this situation since they don't require calibration or just require a small number of training data. Such a characteristic can be intriguing for ionic analysis since it eliminates the requirement for periodic calibration.

In the light of ISE arrays, an unsupervised approach for quantitative analysis leads to a blind source separation (BSS) problem, whose goal is to estimate a set of source signals by only considering mixtures of these sources.

In ISE arrays, the sources and the mixtures are the activities of each ion within the solution and the responses provided by the ISE array, respectively. Among the difficulties in the application of BSS methods to ISE arrays is the fact that the mixing process is nonlinear. [52], [53]

4.1 Methodology:

Use of a flow injection analysis system (FIAs) was contemplated. Pumping the solution through a tube system allows an FIA to continually expose the solution under examination to the sensors. The same remedy might, be injected many times in succession, Considering an FIAs has a number of benefits, In comparison to classic beaker analysis, it offers a low-cost, method that only requires a tiny amount of reagent, and gives a more repeatable and quick result, In the experiments that, were conducted.[54], [55]

The usual solutions were looked at. Figure **??** shows the activities for each of these solutions, including Na+ and K+. Each reference solution received three successive injections for the FIAs. Each standard solution consequently has three peaks connected to it. The ISE array response for a given standard solution was calculated by averaging the three peaks associated with that solution. The signals that were generated and correspond to the mixtures in our circumstance are shown in the following Figure 6. [56], [57]

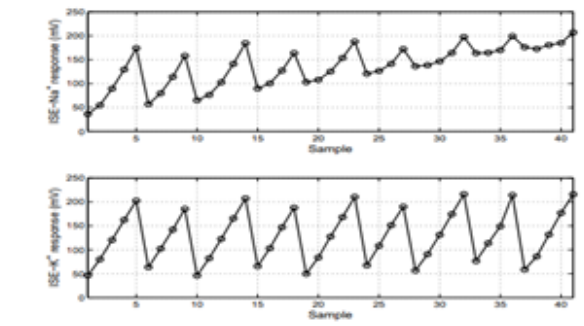

Figure 6. represent of ions response.

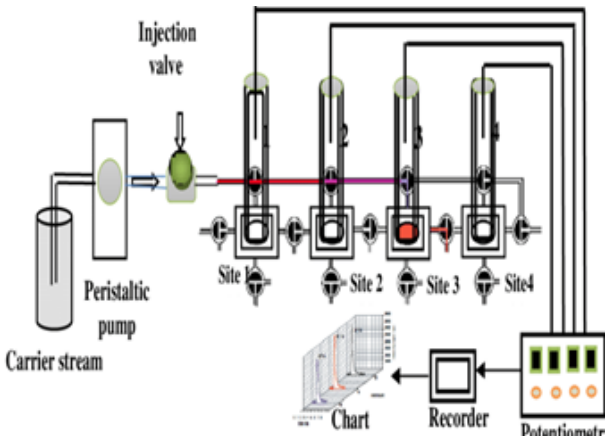

Figure 7. system coupling approach for FIA-ISEs.

The ionic, activity depicted, in mixes were, determined from analyses of separate components, ICA-based algorithm and Bayesian algorithm. The essential, assumption of ICA is that the sources may, be considered as statistically independent random variables. [52]

View the details of the ICA strategy used here. Blind source separation (BSS) is a problem for which the Bayes' rule is utilized in order to find a suitable data representation, according to the Bayesian method. We used the suggested Bayesian BSS method in this letter, which is specific to PNL models and is based on a Markov Chain Monte Carlo (MCMC) simulation. When there is limited readily available data, a Bayesian approach is quite helpful. [58], [59], [60].

You may find the specifics of the ICA approach used here. The Bayesian method views blind source separation (BSS) as an inverse issue for which the Bayes' rule is used to find an appropriate representation of the data. We used the suggested Bayesian BSS technique in this letter, which is likewise specific to PNL models and is based on a Markov Chain Monte Carlo (MCMC) simulation. When only a tiny amount of data is available, a Bayesian approach can be quite helpful. number of samples is available and when the sources are correlated that as show in Figure 7. [61], [62].

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مراجعة في تصنيع نهج الاقتران بين نظام حقن التدفق ـ القطب الكهربي الانتقائي للأيونات

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الخلاصة

ان اهمية نظام الاتمتة اصبح ضروري حيث تبين ان تطبيقات الفحص والمراقبة للنماذج في الوقت الفعلي لا يمكن تنفيذها من خلال أساليب المعايرة للدفعات بسهولة بالطريقة اليدوية، لذا تعد استراتيجية الاقتران بين *FIA* و *ISEs* في شكل *FIA – ISEs* مثالية للاستخدام. ومن ناحية أخرى، لا تزال نسبة الاخطاء اليدوية باجراء الفحوصات هي أساس سبل الطرق التحليلية الحالية. لذا ان التقنية الآلية لتحليل حقن التدفق (*FIA*) جنبا إلى جنب مع المتطلبات الخاصة بالنهج الآلي و الاتمتي اصبحت ضرورية، حيث يتم تنفيذ الاقترانات كثيرة و كبير لطرق الفحص و المعايرة و التحليل.

الكلمات الدالة: التقنية الالية؛ منظومة حقن الجريان؛ نهج الاقتران منظومة الحقن مع الايون الانتقائي للأيونات؛ القطب الانتقائي للأيونات .

التمويل: لايوجد.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات:

تضارب المصالح: يقر المؤلفون أنه ليس لديهم تضارب في المصالح.

الموافقة الأخلاقية: لم يتم نشر المخطوطة أو تقديمها لمجلة أخرى، كما أنها ليست قيد المراجعة.