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ISOTHERMAL IONIC MIGRATION IN MELTS

by

S. FORCHERI and A. BERLIN

1966



Joint Nuclear Research Center
Petten Establishment - Netherlands

Materials Department
Electrochemistry

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This technique utilizes two different types of support layer for the electrolyte: powder deposited on fritted impermeable ceramic strips (Al_2O_3 or ZrO_2) or fritted porous ceramic material fixed on similar impermeable strips.

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The ionic mobilities and transport numbers are calculated by determining the displacement of the labelled zone and the weight of the salt system on the strip, and coulometrically the quantity of electricity.

The self-diffusion coefficients (tracer-diffusion) are measured from the widening of the labelled zone and from the conductivity of the molten salt system on the strip.

The measurement of the ionic mobilities and transport numbers requires also the knowledge of specific conductivities and densities of the electrolyte.

Some applications of this method to the investigation of molten nitrates are presented. The characteristics of methods of this kind as applied to the study of the molten systems are critically discussed.

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SUMMARY

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INTRODUCTION

The investigation of isothermal transport processes in molten salts has been the object of much research in recent years (x).

The porous plug methods (3,4,5,6,7,8,9,10) used in the determination of transport numbers in fused salt mixtures present the disadvantage that the precision of the measurement for a given species is a function of its concentration in the melt. Thus the determination of the mobility of an extraneous ion in a molten salt in which its concentration is vanishingly small is impossible.

The electrophoretic method coupled with the use of radioactive isotopes overcomes this difficulty, the precision of the measurement being principally a function of the precision with which the displacement of the labelled zone is measured.

Ionophoretic techniques have been used by several authors for these determinations. As supporting media for the molten salt in the electromigration experiments, use has been made of asbestos (11) and of borosilicate glass fiber (12,13,14,15,16).

We have used thin layers of fired ceramic oxides powders or of fritted porous ceramic oxides (Al_2O_3 , MgO , ZrO_2) fixed on impermeable (zero opened porosity) fritted ceramic oxide strips (Al_2O_3 , ZrO_2).

(x) For a review relative to the techniques utilized for the determination of transport quantities, and for the significance of these transport quantities see references (1) and (2).

These supporting media for ionophoretic experiments have the following characteristics:

- Possibility to vary the thickness of the oxide layer. The quantity of salt per unit of area can thus be varied and the optimum working conditions for the system under investigation chosen.
- The refractory characteristics and chemical inertness of these strips permit their use with corrosive salts and at high temperature.
- The high temperature of the preparation procedure leads to a small specific area and to an inactive state of the support surface. Exchange reactions or chemisorption with the molten system cannot take place.

The present work deals with the application of this ionophoretic technique to the determination of ionic mobilities and transport numbers in molten salts. The determination of self-diffusion (tracer-diffusion) coefficients with the zone diffusion method is also described.

Besides the characteristics of electrophoretic methods as applied to the investigation of molten salts are critically discussed.

EXPERIMENTAL

Preparation of the support

Ceramic oxide (Al_2O_3 , ZrO_2) sintered strips (10 to 30 cm long, 0.5 to 2.0 cm wide and 0.2 cm thick) especially prepared by Degussa A.G. (*), are used. These sintered

(* Frankfurt/Main - Germany.

strips have a zero opened porosity as determined with a mercury porosimeter.

Two different types of porous ceramic oxide layers are used: powdered and sintered.

a) Powdered thin layers

A water suspension made of calcinated ceramic oxides (Al_2O_3 , ZrO_2 , MgO ; size of some tenths of microns) is sprayed on the strips by means of a spray gun. Homogeneous layers of 5 to 20 mg/cm^2 are obtained when the spray gun is placed at 1-2 m from the strip. The prepared strips are dried for several hours at 500°C.

b) Sintered thin layers

The fritted layers are obtained by means of a flame spraying technique. The strips are sanded on one side and then exposed to a flux of molten ceramic particles. In the case of alumina a Metco Flame Spray apparatus is used, while with zirconia and magnesia a Metco Plasma Jet is employed for spraying the molten particles on zirconia strips.

The flame spray gun is driven automatically to obtain a homogeneous distribution of the sintered ceramic material. The characteristics of the thin layer can be varied greatly depending on the procedure. The porosity depends particularly on the spraying distance, while the thickness of the layer on the number of passages (*).

With both methods it is possible to obtain layers from few milligrams per square centimeter to several tenths.

(*) For example, if a scanning speed of 1.3±1.4 cm/sec is used, with a spray distance of 16 cm, alumina porous layer of 6-9 mg/cm^2 , with an average channel diameter of the order of ten microns, can be obtained with one passage.

Apparatus

The strip is connected via quartz fiber, "alumina paper" (*) or small ceramic strip bridges to two reservoirs (3-10 cc in volume) containing the ionic melt.

Working electrodes (Pt, W, etc) are fixed in the reservoirs. In some cases (for homogeneity control) auxiliary Pt wire electrodes are fixed on the strip.

The assembly is introduced into a tubular furnace (100 cm long) whose temperature is maintained constant over 30 cm ($\pm 2^\circ\text{C}$ below 500°C). The temperature of the strip under working conditions is measured by means of a thermocouple placed near the strip. The furnace has been equipped for controlled atmosphere operation, as many molten salts are sensitive to water vapour and oxygen (**).

Impregnation of the strip

The impregnation is done by capillary action: it proceeds at a variable rate (normally 2-5 cm per hour) depending on the salt, the temperature and the characteristics of the strip. Usually, in order to reach equilibrium conditions, the strip is left for conditioning overnight.

(*) The "alumina paper" is prepared by fritting a poorly sanded alumina strip. The porous layer formed on the strip does not adhere .

(**) Contact angle measurements of molten salt drops on sintered alumina have shown that the presence of water vapour in particular or of oxygen decreases the contact angle between the melt and the solid appreciably (17).

This method of impregnation is used both for pure salts and for mixtures. The specific surface of the ceramic materials used on the strip was measured with a BET-ograph (Atlas Werke). It was found to be below the limits of sensitivity of the instrument and therefore certainly smaller than the values of surface active areas ($>6 \text{ m}^2/\text{gr}$) necessary to achieve chromatographic separations (18). Selective chromatographic effects when the impregnation is done with molten mixtures, or during a transport experiment are not expected: nevertheless the absence of such effects can be tested by classical adsorption-chromatography experiment (19).

When the rate of impregnation is fast, it can lead to hydrodynamic flow during the electromigration experiment and consequently to an erroneous displacement of the labeled zone. This hydrodynamic flow during the transport experiment, which depends on the viscosity of the melt and on the interfacial surface tension of the system, can in some cases influence appreciably the measurement (20). These effects can be minimized if care is taken to equalize the salt levels in the reservoir or if the electromigration is performed after the equilibrium conditions have been achieved.

The equilibrium quantity of salt on the strip is usually between 5 and 30 mg/cm^2 . This corresponds to a weight ratio of the salt to the thin ceramic layer of 1-3 in the case of ceramic powders and 0.3 - 2 in the case of fritted ceramics.

Homogeneity control

The homogeneity of the layer is checked by measuring the resistance (\times) between auxiliary electrodes (platinum wires, ϕ - 0.2 mm) placed on the impregnated strip: the linearity of the plot resistance vs. strip length can be verified. The fritted thin layers as prepared by the method described above are very homogeneous if the sanding of the strip has been done properly.

Maximum permissible power during electrophoresis

The maximum power under which electrophoretic experiment can be performed, without an appreciable heating of the strip by Joule effect, depends on the characteristics of the molten salt system under study: electric and thermal conductivity as well as vapour pressure of the salt, temperature of the experiment and thermal characteristics of the apparatus.

The heating of the strip is non-homogeneous: it is apparent that the central region of the strip is hotter than the other parts as it is more distant from the liquid of the reservoirs which acts as cooling media. If this non-homogeneous heating causes an appreciable differential vaporization of the liquid on the strip more serious limitations are involved (21).

(\times) These determinations were carried out by applying a potential difference of about 30V between the working electrodes in the reservoirs, measuring the potential drop between the auxiliary electrodes with an electrometer (Keithley 610 A), and recording the current intensity (Sargent recorder mod. MR). In some cases an LKB a.c. (1 or 2 kc/sec) Bridge was used.

The determination of the maximum power allowable can be done, either by placing a thermocouple directly in contact with the strip, or by checking the linearity of the current tension curve.

In Fig. 1 a series of V-I curves for NaNO_3 on layer of different thickness is shown: one can observe that at the same temperature the maximum power that can be dissipated is almost independent from the quantity of salt on the strip.

Thus it is possible to give some guide limits of power dissipated for several salts without increasing the temperature more than 2°C (Table 1).

T A B L E 1

Salt	Temperature ($^\circ\text{C}$)	Dissipation W/cm^2
NaNO_3	350	0.1
KNO_3	350	0.3
CsNO_3	450	0.3
TlNO_3	300	0.05
AgNO_3	250	0.05

Above these limits it was verified that the temperature of the central zone becomes higher than the ends of the strip. These limits are in general much smaller than the power usually dissipated in experiments of this kind in molten salts (Table 2).

An electromigration and a diffusion experiments

The electrophoretic cell, equilibrated overnight at the temperature of the experiment, is cooled rapidly and then the radioactive tracer (a quantity usually smaller than one mg) placed on the strip. The temperature is brought again to the initial value.

For a migration experiment the strip is left at this temperature only for a few minutes and then scanned radiometrically to determine precisely the position of the starting point.

The strip is now ready for the experiment. For the migration a stable potential difference of up to 10 V/cm is applied to the working electrodes for 0.5 to 4 hours. This produces a displacement of the marked zone of several cm.

For the diffusion after placing the tracer the strip is disconnected from the reservoirs and left at the temperature of the experiment up to 10 hours (*). The diffusion zone is of several cm. After the experiment the strip is again scanned. In Table 2 usual experimental conditions are compared with those relative to other molten salts ionophoretic techniques.

(*) The best procedure for diffusion experiments with strips wider than 0.5 cm requires that the tracer is deposited as a filiform trace perpendicular to the strip axis.

T A B L E II

Support	Authors	Max.work temp.	mg of salt cm ² of sup.	wt.ratio of salt to sup.	Max.tension applied (V cm ⁻¹)	Electrolysis current (mA)	Remarks	Ref.
Asbestos	Arnikar and Chemla	400°C	30		10	400	Salt sprinkled on support not saturated	(2)
Borosilicate glass fiber	Alberti et al		120		2			(12)
	Ketelaar and Honig	500°C	60	10	2-8	40-160	Salt sprinkled on support dipped in molten salt	(16) (20)
	Bailey and Steger					10	Support dipped in aq. solution	(13)
Silica Fiber	Ketelaar and Kwak							(16)
Ceramic Powders	Forcheri and Berlin	800	10-30	1-3	10	10-30	Impregnation by capillary action	this work
Sintered Supports			5-30	0.3-2		5-30		

Determination of the labelled zone of the electromigration and diffusion experiments

The position of the maximum of the activity curve after an electromigration experiment is determined by scanning the strip placed under a G.M. counter with a narrow window. The determination of the diffusion coefficients requires not only the knowledge of the position of the maximum but also that of the form of activity distribution curve. After a diffusion experiment a more precise method⁽²⁹⁾ is used: the strip is scanned with a G.M. counter adapted with a high density material collimator in direct contact with the strip having a window from 0.5 to 1 mm. The collimator having a thickness of only 1 mm has generally a partial transparency and this is corrected for by scanning the strip with a windowless collimator (*).

Calculation of the transport parameters from the experiment

a) Mobility and transport number

In an electrophoretic experiment the displacement of a labelled zone, l_i , is related to the absolute mobility of the ion i (u_i) by the relation:

$$u_i = K \frac{l_i}{t} \frac{1}{\nabla\phi} \quad (1)$$

in which $\nabla\phi$ is the applied potential gradient and t the

(*) A new technique is developed at present by B.Langevin and A. Berlin. It consists essentially in a continuous scanning method using a sensitive scintillator. Both these methods will be described in details elsewhere.

duration of the experiment. K is a factor defined operationally as R_p/R , the inverse of the obstructive factor as defined by Crawford and Edward (22) for paper electrophoresis (R_p is the electrical resistance of the strip and R the calculated resistance from the dimensions of the strip and the quantity of the molten system, and the specific resistance of the salt)

$$K = \frac{R_p}{R} = \frac{\nabla\phi \cdot X \cdot p}{i \cdot d} \quad (2)$$

where:

X is the specific conductance of the electrolyte;

d the density of the electrolyte;

p the weight of ionic melt per unit of length of support;

i the intensity of the current.

From equation (1) and (2) it follows that the expression for the ionic mobility of species i in a molten ionic mixture of m salts is:

$$u_i = \frac{X}{d} \cdot \frac{p \cdot l_i}{q} \quad (3)$$

where q is the quantity of electricity passed through the cell. Combining equation (3) with the following relations:

$$t_i = \frac{f_i \cdot F \cdot N_i}{\Lambda} \quad (4)$$

and

$$\Lambda = \frac{X}{d} M_{e_a} \quad (5)$$

where t_i is the transport number of the species i, f_i the equivalent ionic fraction of the ion i and M_{e_a} the average equivalent weight of the system, one obtains:

$$t_i = \frac{p \cdot l_i \cdot F}{q} \cdot \frac{f_i}{M_{e_a}} \quad (6)$$

By expliciting f_i and M_{e_a} this expression becomes:

$$t_i = \frac{p l_i}{z} \frac{v_i \cdot r_i}{\sum_{j=1}^m n_j \cdot M_j} \quad (7)$$

where:

- v_i - the valence of ion i
- r_i - number of gram ions of the specie i
- n_j - number of moles of the salt j
- M_j - the molecular weight of the salt j
- z - the number of Faraday passed through the cell.

The radiometric determination of the displacement of the labelled zone and the coulometric determination of the quantity of electricity passed in the cell enables the evaluation of the ionic mobility of the labelled species, provided that the conductivity and density of the system are known.

For determining the transport number the knowledge of the latter parameters is not necessary.

b) Diffusion

The solution of the diffusion equation corresponding to our experimental conditions of a line source at the time $t = 0$, is the solution of the equation corresponding to the one-dimensional infinite diffusion case (23).

Experimentally, the slop of log activity from the radiometric scanning versus the square of the linear distance from the centre of the Gaussian curve $[(x - x_0)^2, \text{Fig. 3}]$, is equal to $-\frac{1}{4 D_1' t}$ (see Fig. 4), where D_1' is an apparent diffusion coefficient, t the duration of the experiment (*)

(*) This method for evaluating the diffusion coefficients is essentially similar to that of Arnikaar and Chemla (11).

If the Edward' (24) relation between the K factor defined in equation (2) and the ratio of the real ionic path, l in the porous support to the linear one, l' , is used:

$$K = \frac{R}{R'} = \left(\frac{l}{l'}\right)^2$$

then:

$$D_i = K D_i'$$

where D_i is the self-diffusion coefficient of the i species.

Thus the ionic mobilities and the transport numbers can be determined without the explicit knowledge of K (the measurement of ϕ during the experiment using auxiliary electrodes is not necessary), while for the determination of the diffusion coefficient K must be measured.

Some applications (*)

Some typical experiments relative to the determination of an ionic mobility, of a diffusion coefficient in molten nitrates and some results relative to the investigation of the mobility of transition metals in molten nitrate chloride systems are presented.

Fig. 2 represents an electropherogram of $\text{Cs}^{137} \text{NO}_3$ in sodium nitrate at 350°C . The two curves are the result of the readings before and after the electromigration.

The distribution of the activity after the experiment (curve B) does not present tailings or asymmetries: this

(*) Some results using this electromigration technique as applied to the study of some molten systems were previously reported (25,26,27). Recently the binary systems $(\text{Cs-Ag})\text{NO}_3$ and $(\text{Na-Tl})\text{NO}_3$ have been investigated (19).

permits to exclude the existence of chemical phenomena between the porous support and the migrating species (chemical reaction, chemisorption, or decomposition of CsNO_3 with formation of Cs_2O). The mobility value calculated from the formula (3), is $2,72 \cdot 10^{-4} \text{ cm}^2 \text{ V}^{-1} \text{ sec}^{-1}$ (*).

In Fig. 3 are reported the readings of the activity after a diffusion experiment: $\text{Na}^{22} \text{NO}_3$ in sodium nitrate at $T=325^\circ\text{C}$. The curve A is obtained with a collimator of Pb thick 1 mm. with a window of 0.5 mm. The B curve is obtained through a Pb sheet with the same dimensions but without window. The correct diffusion profile is given by curve C (**). In Fig. 4 the function \log activity vs. the square of the linear distance from the Gaussian centre is plotted.

From the slope a value of $D_{\text{Na}} = 2.2 \cdot 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$ is obtained (with a measured K value of 1,9). It can be compared with the value of $1.94 \cdot 10^{-5} \text{ cm}^2 \text{ sec}^{-1}$ of Dworkin et al. (30)) at $T = 320^\circ\text{C}$.

The results relative to the investigation of the mobility of traces of transition metals in nitrate-chloride environment indicate that ionic mobilities can vary appreciably with melt composition. The formation of a metal halogenide association is often pointed out by a change in the sign of the mobility of the metal (starting from pure nitrate melt).

(*) Specific conductivity and density interpolated from data of reference (28).

(**) For a detailed description of the counting apparatus see reference (29).

In Fig. 5 is presented an electropherogram of a solution of $\text{Cd}(\text{NO}_3)_2$ in LiKNO_3 eutectic; in the same figure is reported an electropherogram of a solution of $\text{Cd}(\text{NO}_3)_2$ in the same eutectic in which a quantity of KCl was dissolved, (ratio $\text{Cl}/\text{Cd} = 5$). The asymmetry of the cadmium zone is due to the slight decomposition of the cadmium species with formation of CdO during the electromigration. This phenomenon is unavoidable also by working in atmosphere of inert gas and it increases with an increase in temperature. The cadmium zone after migration in the solution $\text{LiKNO}_3 + \text{KCl}$ is symmetric: the cadmium chloride association is more stable than cadmium.

The behaviour of zinc in such melts has been found to be rather similar to that of cadmium.

It seems that most transition metals have a tendency toward the formation of halogenides associations in molten systems. It is worth to note that these electrophoretic observations are in accord to the spectroscopic studies on the formation of this kind of association in melts (31, 32).

DISCUSSION

In the ionophoretic experiments just described, while the contact surface between the molten system and the porous wall is normally smaller than in the case of porous plug experiments, the atmosphere to molten salt contact surface is much larger.

This large ratio of gas to molten salt contact surface presents a major drawback. Work at temperatures at which the vapour pressure is higher than 1-2 mm of Hg is very difficult.

The loss of salt by evaporation leads to a continuous pumping of the salt from the reservoirs to maintain steady conditions on the strip: this can affect the measurement of the displacement of the labelled zone. The presence of an appreciable vapour phase above the strip can produce also a non-negligible isotopic exchange between the gas phase and the liquid; in favorable cases one observes a widening of marked zone (and in less favorable cases the whole strip can become active).

The slight decomposition or hydrolysis of the melt which occurs often at the surface is also to be avoided. It is often necessary to maintain an inert and dry atmosphere at all times while the salt is in the molten state.

For example the determination of the transport parameters of AgNO_3 while realizable with porous plug techniques (4) presents some difficulties when using ionophoretic methods. A dry inert atmosphere is necessary to prevent the decomposition of the AgNO_3 with formation of silver oxide (also at temperature below 250°C) (*).

The investigation of mobilities of transition metals in molten systems can be performed only in inert dry atmospheres.

(*) Ceramic oxides supports do not show reaction with this salt. Chemisorption occurs with glass fibers support (20). It is also probable that asbestos, due to its ion exchange properties, is not inert to the silver nitrate.

The K values, in absence of specific interactions of the support with the melt, are a measure of the geometry of the salt on the support. These values for molten nitrates are usually 1,3÷1,5 (powder) and 1,5÷1,9 (fritted) depending on the quantity of the molten system with respect to the porous thin layers. These values are slightly smaller than the corresponding value of aqueous electrolyte solutions absorbed on paper (22).

The applicability of the equation (3) and (7) to the electromigration experiments for the calculation of the ionic mobilities and transport numbers of the species of the salt system absorbed on the porous support is limited to the cases in which selective interactions between the porous support and the ionic species do not exist, and when the geometry of the salt on the porous support is such that all the system fully participates in the ionic transport.

In the first case the K factor can no longer be expressed as R_p/R for all the ionic species: the quantities calculated with the equation (3) and (7) will be also a measure of an electroosmotic effect due to selective wall interactions (27,33).

A chemical reaction of the support with an ionic component of the salt or chemisorption can cause such an effect. Fired or fritted ceramic oxides do not show chemical interaction with molten nitrates. Exchange properties of the pyrex glass, can render in some cases this material poorly suitable for electromi-

gration experiments (*) (16).

In the second case the non applicability of the formulas (3) and (7) arises from the lack of knowledge of the factor p (weight of the salt which effectively participates on the electrical transport per unit length of the strip). If p is taken as the total salt weight for unit length of the strip, the quantities measured are too large (**). This point should be verified, for instance, when in the support some pore diameters are very small: part of the salt can be placed in cavities with small openings so that the ion exchange between the bulk might be slower than the electrical transport .

In general, it is likely to suppose that the transport processes of molten salts absorbed on a porous support are influenced by the pores size (or by the extension of the surface) of the support below a critical size value. The critical value lies probably in the range $1-10^{-2} \mu$.

(*) In some electromigration experiments in molten sodium nitrate carried out on alumina powder deposited on pyrex strips an unusual variation of the cationic transport number with temperature was observed (from 0,7 to 0,5 passing from 370°C to 420°C). After the experiments radioactive sodium was observed in the pyrex strip without any change in weight of this latter.

(**) Experimentally this point has been verified with ceramic sintered support (Al_2O_3 and ZrO_2) presenting a large spectrum of pore diameters (from 1 micron to 100 Å). These supports were prepared by a prolonged but not complete sintering. In a series of determinations of the cationic transport numbers of molten sodium nitrate, values larger than one were obtained. The K values were unusually large (~ 4). A difference between a.c. (2 Kc/sec) and d.c. conductivity (a.c. larger than d.c. conductivity)

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The ceramic support presented (either powdered, either fritted) have an average pores size of the order of ten microns or more. This fact and the absence of chemical interactions with molten nitrates give a positive indication on the validity of the method as a tool for determining the isothermal transport quantities of these systems.

was observed. (such a situation appears to be similar to that of some heterogeneous systems as, e.g., to that homogeneous glasses (34)). After the experiments it was very difficult to remove the salt from these supports by water washing.

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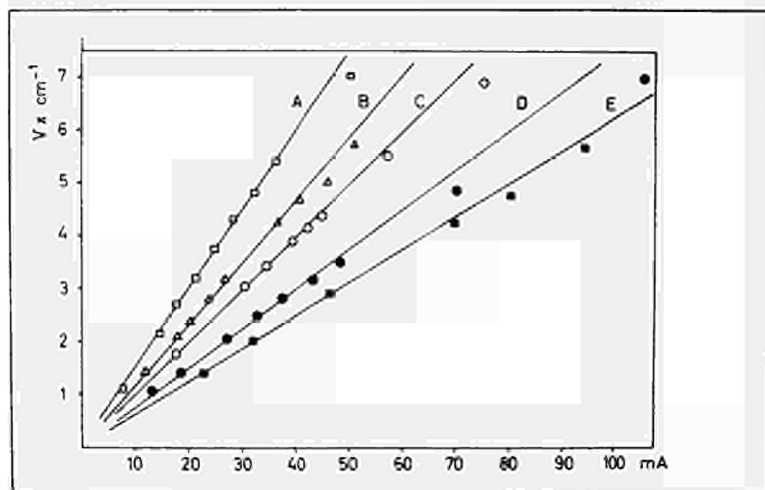


FIG. 1

Potential-current curves for different thicknesses of alumina layer impregnated with molten sodium nitrate at $T = 350^{\circ}\text{C}$
Thickness of the porous layer:

A - 5 mg cm^{-2}	C - 14 " "
B - 9 " "	D - 17 " "
	E - 19 " "

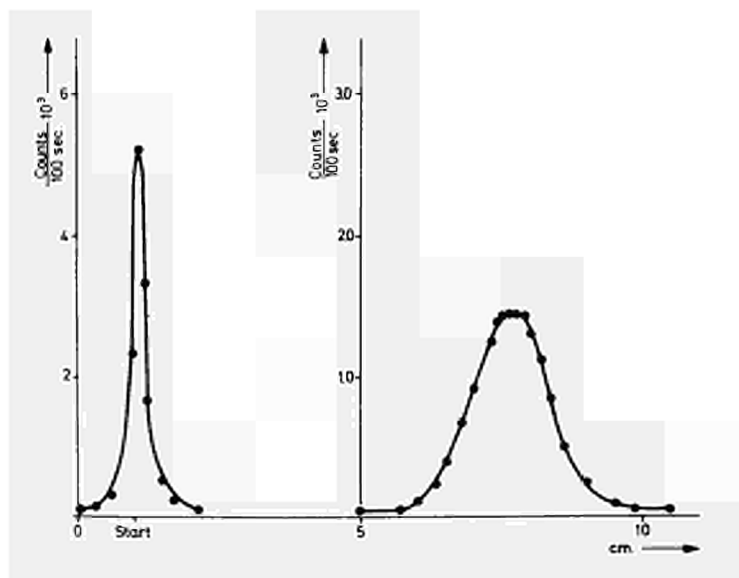


FIG. 2

Electropherogram of $\text{Cs}^{137}\text{NO}_3$ in molten NaNO_3 on thin layer of porous fritted alumina (thickness $\sim 7 \text{ mg cm}^{-2}$) at $T=330^\circ\text{C}$.

Conditions: applied electrical field $\sim 6 \text{ V cm}^{-1}$; current intensity $\sim 11 \text{ mA}$; time - 2 hours; quantity of salt per centimeter length of the strip, $p = 5.35 \text{ mg cm}^{-1}$; quantity of electricity flowed through the cell, $q = 80.1 \text{ coulomb}$.

The activity distribution curves have been obtained by radiochemical reading of the strip (β counting), before and after the electromigration, through a lead sheet 1 mm thick with a window 0.7 mm wide, placed at 0.5 mm from the strip.

The l_{CS} value is given by the difference of the abscissa of the two maxima.

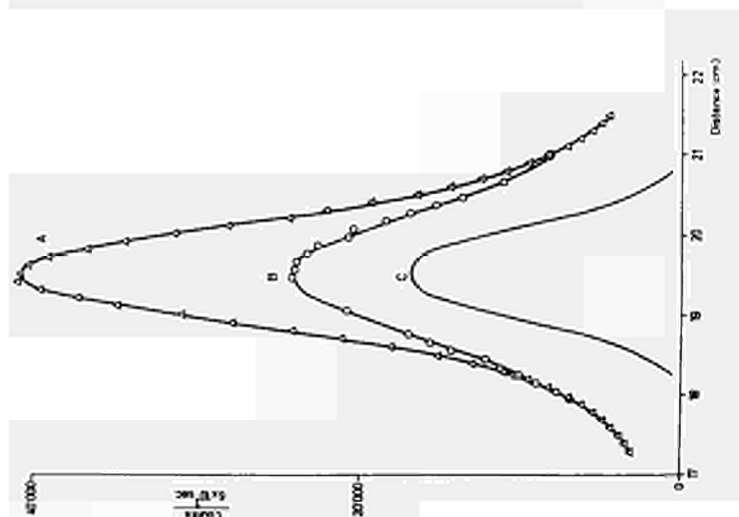


FIG. 3

Diffusion of $\text{Na}^{22}\text{NO}_3$ in molten NaNO_3 on thin layer of porous fritted alumina (thickness $\sim 11 \text{ mg cm}^{-2}$) at $T = 325^\circ\text{C}$; time of diffusion - 188'.

- △ Activity measurements obtained by radiochemical readings of the strip (β counting) with a lead collimator 1 mm thick with a window 0.9 mm wide (A curve)
 - Activity measurements obtained with a lead sheet of the same dimensions without window (B curve)
- The C curve (A-B) is the correct diffusion profile.

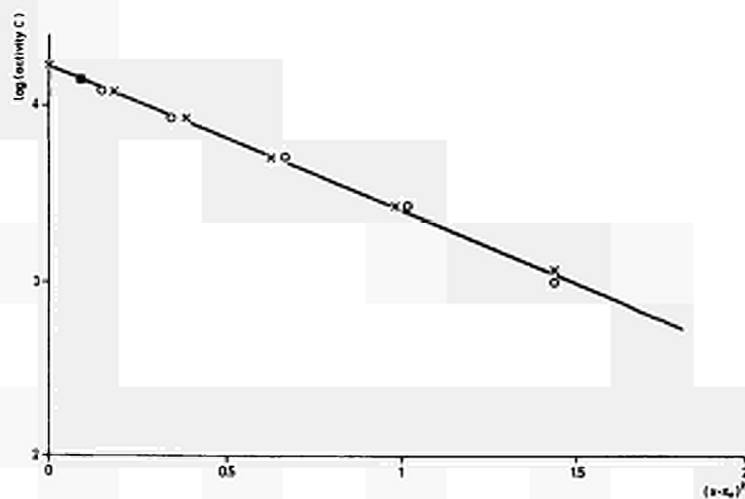


FIG. 4

Logarithm of activity of the correct diffusion profile (curve C, fig. 3) as a function of the linear distance square from the Gaussian centre.

- right side of the curve
- × left side of the curve

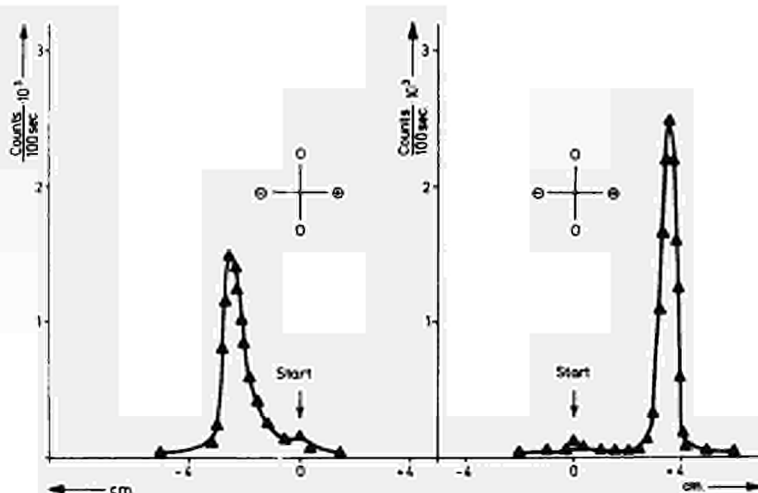


FIG. 5

Electropherograms of solutions of $\text{Cd}^{115}\text{NO}_3$ in molten LiKNO_3 at $T=190^\circ\text{C}$ (left side) and in molten $\text{LiKNO}_3+\text{KCl}$ 0.6 M (right side); electrolyte composition: respectively LiKNO_3 and $\text{LiKNO}_3+\text{KCl}$ 0.6 M; porous support: thin layer of α -alumina powder (thickness $\sim 7 \text{ mg cm}^{-2}$).

Conditions: electrical field applied $\sim 8 \text{ V cm}^{-1}$; current intensity - mA 15+20; time - 3 hours.

The activity distribution curves have been obtained by a radiochemical reading of the strip (β counting) after the electromigration, through a lead sheet 1 mm thick with a window 1 mm wide, placed at 0.5 mm from the strip.

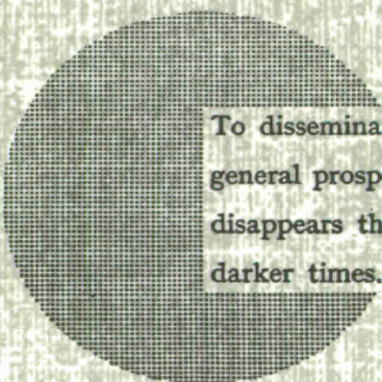
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Alfred Nobel

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