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IE Series

Liquid Ion Exchangers

INSTRUCTION MANUAL

CAUTION

The toxicological properties of this LIX have not been fully determined. Ingestion or contact with the human body may be harmful. Exercise due care!

LIXes should be stored in a cool place out of direct sunlight.

For laboratory use only. Not for food, drug, household or other uses.

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World Precision Instruments

Warranty

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

• Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. In some instances, photographic documentation may be required. Some items are time sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

• WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.

• Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.

• Goods returned for repair must be reasonably clean and free of hazardous materials.

• A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.

• Equipment which was built as a special order cannot be returned.

• Always refer to the RMA# when contacting WPI to obtain a status of your returned item.

• For any other issues regarding a claim or return, please contact the RMA department.

Warning: This equipment is not designed or intended for use on humans.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

References

1. Ion and Enzyme Electrodes in Biology and Medicine, M. Kessler, L.C. Clark, Jr., D.W. Lubbers, I.A. Silver, W. Simon (eds.), University Park Press, Baltimore (1976)

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4. "Ionic Activities in Cells", A.A. Lev, W. McD. Armstrong, *Current Topics in Membranes and Transport*, **6** 59-123 (1975), Academic Press, New York

5. "Distribution of Na+, K+, and Cl- Between Nucleus and Cytoplasm in Chironomus Salivary Gland Cells", L.G. Palmer, M.M. Civan, *J. Memb. Biol.,* **33** 41-61 (1977)

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8. "Ion-Selective Liquid Ion Exchanger Microelectrodes", J.L. Walker, *Ion and Enzymes Electrodes in Biology and Medicine*, p. 116-118, M. Kessler, L.C. Clark, D.W. Lubbers, I.A. Silver and W. Simon (eds.), University Park Press, Baltimore (1976)

9. "Intracellular Ionic Activity Measurements in Nerve and Muscle", J.L. Walker and H.M. Brown, *Physiol. Rev.* **57** 729-778 (1977)

10. "Submicron Tip Breakage and Silanization Control Improve Ion-Selective Microelectrodes", S. Tripathi, N. Morgunov and E.L. Boulpaep, *Am. J. Physiol.* **249** (Cell Physiol. 18) C514-C521 (1985)

11. "Silanization of Glass in the Making of Ion-Sensitive Microelectrodes", J.L. Munoz, F. Deyhimi and J.A. Coles, *J. Neuroscience Methods* **8** 231-247 (1983)

12. "A Simple Method for Making Ion-Selective Microelectrodes Suitable for Intracellular Recording in Vertebrate Cells", M.J. Borrelli, W.G. Carlini, W.C. Dewey, B.R. Ransom, *J. Neuroscience Methods* **15** 141-154 (1985)

WPI's Liquid Ion Exchangers (**LIX**), for use with the **FD223** Electrometer, allow intracellular measurements to be made for cations (hydrogen, potassium and calcium) using the procedures described in this manual.

CATIONS

ION	H+	K+	Ca++
ORDER NO.	**IE010**	**IE190**	**IE200**
SELECTIVITY COEFFICIENTS*			
Na+	12.7	1.97	5.5
Mg++	-	2.95	4.9
K+	-	-	5.4
Ca++	-	2.7	-
USEFUL pH RANGE	2-10	4-10	4-10
SLOPE	56 mV	58 mV	28 mV
LINEAR RANGE	pH 4-12	pK 0-3	pCa 1-7
REFERENCES	12	3, 4	16

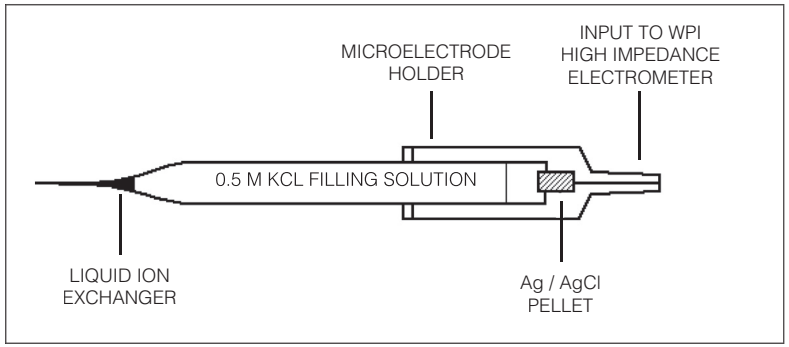
**Selectivity Coefficients are expressed here as -log Kij or pKij.*

Fabrication of Ion-Selective Microelectrodes

Ion selective microelectrodes have gained wide use in biology as a means for examining intracellular ion activities (**1**, **3**, **4**, **9**). The construction of electrodes with tip diameters of one micron or less using liquid ion exchanger resins is, in principle, straightforward and follows a few simple steps (**2**, **5**, **6**, **7**). The general procedure is to:

1. Pull the microelectrode from a suitable glass capillary.
2. Apply a hydrophobic coating to the interior of the electrode tip.
3. Fill the tip with the ion exchanger.

In practice, the specific method employed will depend upon the individual requirements and laboratory conditions (*e.g.*, the resin used, glass type, electrode shape and tip size, and ambient humidity). Variations in this procedure most often involve the method for producing the hydrophobic coating. The following note presents a general method for constructing ion selective microelectrodes using liquid ion exchangers and also illustrates variations in the method which may be relevant to specific applications.



Pulling the Microelectrode

Conventional methods are used to pull the micro- electrode. The method chosen is more dependent upon the use of the electrode than the fact that it is to be used to construct an ion selective electrode. Tip diameters can be one micron or less.

Electrodes can be pulled from a variety of capillary glasses. Pyrex glass with or without an internal fiber has been most often used. Multi-barrel glass can also be used, but caution must be taken to avoid coupling between barrels at the tip of the resulting microelectrode.

The most important consideration in this initial step is that the glass must be thoroughly cleaned before use. A recommended procedure is to soak the capillaries in a commercial glass cleaning solution (sulfuric and chromic acids) for several hours followed by thorough rinsing – first in distilled water, then in acetone, and finally drying in an oven.

Silanizing the Tip

Ion exchanger resin will not stick well to a hydrophilic clean glass surface. It is necessary, therefore, to make the inner surface of the electrode hydrophobic in order to stabilize the resin in the tip and to form a good seal with glass surface. This is a critical step and can significantly influence both the sensitivity and selectivity of the resulting electrode (**8**). The general procedure is to coat the electrode with a chloro- or alkoxysilane dissolved in an organic solvent, and to then heat the electrode to fix the hydrophobic layer to the glass surface. Too much silane will plug the tip, while too little will not hold the resin.

A recommended procedure uses dimethyldi-chlorosilane dissolved as a 5% solution in xylene (**5**). Immediately after pulling, the shaft of the electrode is exposed to this solution vapor for 1-2 minutes. The electrodes are then baked for one hour at 100 °C.

Because of the critical nature of this step no single method has proven best in all cases. Several other silanizing solutions and curing methods have been reported. A sampling includes: exposure to non-diluted dimethyldi-chlorosilane vapor (**6**); a 1% solution of Siliclad in 1-chloronapthalene (**7**, **8**); or a 1.25% solution of Dow Corning 1107 fluid in trichloroethylene (**2**). Baking times and temperatures are also variable, but do not seem to be critical for a successful electrode. While this list is not complete, it illustrates possible variations which may be used in an attempt for an improved electrode.

Filling the Tip

Following silanization, the ion selective membrane is formed by filling the tip of the electrode with a 200-500 micron length of ion exchanger. Several methods are again possible. A recommended method is to construct electrodes using glass capillaries containing an internal glass fiber (**6**). When a small drop of resin is placed in the electrode shank, it will rapidly migrate and fill the tip. A distinct advantage in this method is that it is rapid and requires only a small amount of the ion exchanger.

If capillaries without an internal fiber are used, the electrodes may also be filled from the inside by working the resin to the tip with a thin glass fiber inserted into the back of the electrode. Positive pressure applied to the electrode can also be used. Alternatively, electrodes may be filled from the front by dipping the tip in the ion exchanger until the required column is formed. The time required for filling will depend on the tip diameter. This method has the advantage that failure to fill indicates a plugged tip most often resulting from particles in the resin or from the silanizing procedure.

Whichever method is chosen for forming the ion selective membrane, the tip should be visually checked under the microscope to verify the completeness of filling and to confirm the absence of air bubbles in the exchanger column. The electrode can then be filled with a reference electrolyte (0.5 M KCl or NaCl are recommended for potassium and sodium exchangers) and stored with tip immersed in the identical solution. Although electrodes may be stored for extended periods, a loss of both selectivity and sensitivity usually occurs with time. It is recommended that fresh electrodes be made on the same day as usage if possible.