[Chem. Pharm. Bull. 19(12)2579—2584(1971)]

UDC 615.31.011.4 : 541.18.055

# Electrodialytic Extraction in Drug Analysis.II.[1] Examination of Ordinary Drugs from the Extractability View Point

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(Received June 15, 1971)

In order to evaluate the electrodialytic extraction method, a large number of drugs were extracted with the proposed apparatus,[1] and the following results were obtained.

1. Organic acids, sulfonamides, amino acids and barbiturates could be extracted by using 0.5M $NH_4OH$ as a basic carrier solution.
2. Amines, sulfonamides and amino acids could be extracted by using 0.5M acetic acid as an acidic carrier solution.
3. Substances which have very low dissociation constant could be made into useful carrier solution by adding a strong electrolyte such as NaCl. The most desireable specific conductivity is about $1.0 \times 10^{-3}$ mho/cm.
4. Some sugars could be extracted in the form of borate complex.

Many kinds of extraction agents have been used in the conventional extraction, such as acids, alkalies, buffers of various concentrations and organic solvents, and these extraction agents have been selected empirically for each case on the basis of the partition coefficient of the specific component. It is possible to perform electrodialytic extraction with a small number of agents because the rate of extraction is controlled by specific conductivity. In this paper, the applicability of electrodialytic extraction was evaluated by investigating many kinds of drugs such as organic acids, barbiturates, sulfonamides, *etc.*,

## Experimental

**1. Samples**——1) Sample $S_1$: 25 g of microcrystalline cellulose and 0.25 m mole of the drug were taken, 25 ml of 2% sodium carboxymethyl cellulose solution was added and these were mixed uniformly in a mortar. The mixture was dried for 1 hour at 60°, pulverized in a mortar and sieved wih a 100 mesh sieve to obtain sample $S_1$.

2) Sample $S_2$: Same as $S_1$, but 25 ml of 2% sodium carboxymethyl cellulose solution was replaced by 25 ml of distilled water.

3) Sample L: The drug was dissolved with a liquid having the same composition as the carrier solution. The concentration of these sample solutions was 1000 $\mu$g/ml in most cases but in the experiments with the drugs of low solubility or high absorbancy, a saturated solution or a more diluted solution was used.

**2. Carrier Solutions**——The compositions and codes of the carrier solutions used in this work are shown in Table I.

Table I. Codes of Carrier Solution

| Code | Composition | Code | Composition |
|---|---|---|---|
| I | 0.5M $NH_4OH$ | IV | 0.05M (tris-hydroxymethyl)-aminomethane+0.01M NaCl |
| II | 0.5M AcOH | | |
| III | 01M AcOH+0.1M AcONa | V | 0.1M sodium borate |
| | | VI | 0.1M NaOH |

1) This report was presented at the Meeting of Kanto Branch, Pharmaceutical Society of Japan, Tokyo, December 1969. Part I: N. Tsunakawa, *Chem. Pharm. Bull.* (Tokyo), **19**, 1164 (1971).
2) Location: *Narihira 5-6-9, Sumida-ku, Tokyo.*

Table II. Electrodialytic Extraction Data of Organic Acids

| Compound | Sample | | Carrier solution | Extraction condition | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | | Current density (mA/cm²) | Flow rate (ml/min) | Extraction time (min) | | |
| Acetylsalicylic acid | $S_1$ | 200 mg | I | 15 | 1.54 | 30 | 298 | 98.2 |
| *p*-Aminobenzoic acid | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 30 | 267 | 98.8 |
| *p*-Aminosalicylic acid sodium salt | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 25 | 267 | 100.0 |
| 2-Phenylquinoline-4-carboxylic acid | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 40 | 260 | 99.3 |
| Folic acid | $S_1$ | 100 mg | I | 15 | 1.54 | 30 | 257 | 94.0 |
| 3-Acetamido-2,4,6-triiodobenzoic acid sodium salt | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 20 | 239 | 99.0 |
| Sodium iodomethamate | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 20 | 244 | 99.1 |
| Mercurochrome | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 60 | 255 | 93.2 |
| Nalidixic acid | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 25 | 260 | 98.6 |
| Nicotinic acid | $S_1$ | 500 mg | I | 15 | 2.31 | 30 | 264 | 107.2 |
| | | | II | 20 | 1.54 | 30 | 262 | 107.8 |
| Orotic acid sodium salt | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 20 | 288 | 99.8 |

Table III. Electrodialytic Extraction Data of Amines

| Compound | Sample | | Carrier solution | Extraction condition | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | | Current density (mA/cm²) | Flow rate (ml/min) | Extraction time (min) | | |
| Acrinol | $S_1$ | 100 mg | II | 20 | 0.63 | 120 | 270 | 98.9 |
| | | | | 30 | 0.63 | 90 | 270 | 99.7 |
| | | | | 40 | 0.63 | 60 | 270 | 98.4 |
| Alimemazine tartrate | $S_1$ | 100 mg | II | 20 | 1.54 | 15 | 253 | 101.3 |
| Aminopyrine | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 30 | 259 | 100.3 |
| Carbazochrome | $S_1$ | 100 mg | II | 25 | 1.54 | 90 | 358 | 99.9 |
| Chlorpheniramine maleate | $S_1$ | 300 mg | II | 20 | 1.54 | 30 | 265 | 101.3 |
| Dequalinium chloride | L (1000 μg/ml) | 0.5 ml | II | 20 | 1.54 | 30 | 329 | 99.1 |
| Dihydrostreptomycin sesqui sulfate | L (14.6 mg/ml) | 1 ml | III | 20 | 3.27 | 45 | 496[a)] | 100.5 |
| Ergometrine maleate | $S_2$ | 100 mg | II | 20 | 0.72 | 30 | 315 | 92.2 |
| Ethionamide | L (1000 μg/ml) | 0.5 ml | II | 20 | 1.54 | 30 | 280 | 98.6 |
| Isonicotinic acid hydrazide | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 30 | 267 | 100.0 |
| Methylene blue | $S_1$ | 100 mg | II | 20 | 0.72 | 60 | 294 | 102.0 |
| Nicotinamide | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 30 | 262 | 99.8 |
| Noscapine | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 30 | 315 | 100.0 |
| Oxarmin | L (1000 μg/ml) | 0.5 ml | II | 20 | 1.54 | 30 | 242 | 99.0 |
| Papaverine hydrocholride | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 60 | 253 | 100.0 |
| Procaine hydrochloride | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 35 | 293 | 99.6 |
| Procaineamide hydrochloride | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 30 | 280 | 100.0 |
| Prothionamide | L (1000 μg/ml) | 0.5 ml | II | 20 | 1.54 | 30 | 280 | 98.8 |
| Qunidine sulfate | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 20 | 251 | 99.5 |
| Quinine hydrochloride | L (1000 μg/ml) | 0.5 ml | II | 20 | 2.31 | 15 | 251 | 98.9 |
| Quinine sulfate | L (1000 μg/ml) | 0.5 ml | II | 20 | 2.31 | 15 | 251 | 99.5 |
| Tetracycline hydrochloride | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 45 | 273 | 98.5 |
| Thiamine hydrochloride | $S_1$ | 250 mg | II | 20 | 1.54 | 30 | 247 | 99.7 |
| Thiamine mononitrate | $S_1$ | 250 mg | II | 20 | 1.54 | 30 | 248 | 98.2 |
| Pyridoxine hydrochloride | $S_1$ | 250 mg | II | 20 | 1.54 | 30 | 292 | 103.9 |

a) nitroprusside method

3. **Electrodialytic Extraction of Organic Acids**——Organic acids which are conventionally used as drugs were used in this experiment. These are shown in Table II. Each specimen was prepared according to the procedure of 1.1) or 1.3), and designated as $S_1$ or L. The quantities of these acids were indicated in weight or volume as shown in Table II. After electrodialytic extraction the effluent was diluted to the appropriate volume with the fresh carrier solution and the absorbance was determined at the individually specified wavelength.

4. **Electrodialytic Extraction of Amines**——Twenty five organic amines shown in Table III were used. Each specimen was prepared according to the procedure of 1.1), 1.2) or 1.3), and designated as $S_1$, $S_2$ or L. The quantities of these amines were indicated in weight or volume as shown in Table III. After electrodialytic extraction the concentration of effluent was determined spectrophotometrically at the individually specified wavelength. Dihydrostreptomycin was extracted with a mixed solution of 0.1 M acetic acid and 0.1 M sodium acetate at pH 6.0 and was determined colorimetrically following the method of F. Monastero[3]. The reagent used was prepared by mixing equal volumes of 10% sodium nitroprusside, 10% potassium ferricyanide and 10% sodium hydroxide in the order. A deep red color which changes to light green after standing at room temperature for approximately 30 minutes is formed. To make the reagent, 1.0 ml of this light green solution was diluted to 100 ml. 10.0 ml of this reagent is added to 10.0 ml of the effluent and after standing for 5 minutes, the absorbance was measured at 496 m$\mu$. The same operation was carried out with water as a reagent blank.

5. **Electrodialytic Extraction of Sulfonamides**——Nineteen sulfonamides shown in Table IV were used. Each specimen was prepared according to the procedure of 1.1) or 1.3) and designated as $S_1$ or L. The quantities of these were indicated in weight or volume as shown in Table IV. After electrodialytic extraction the effluent was diluted to the appropriate volume with the fresh carrier solution and determined with a spectrophotometer at the individually specified wavelength.

Table IV. Electrodialytic Extraction Data of Sulfonamides

| Compound | Sample | | Extraction condition | | | | Determined at (m$\mu$) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | Carrier solution | Current density (mA/cm$^2$) | Flow rate (ml/min) | Extraction time (min) | | |
| N′-Acetylsulfanilamide sodium salt | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 25 | 258 | 99.5 |
| Homosulfamine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 15 | 228 | 99.6 |
| Phthalylsulfathiazole | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 20 | 265 | 99.7 |
| Sulfadiazine | $S_1$ | 200 mg | I | 15 | 2.31 | 30 | 243 | 98.9 |
| | | | II | 20 | 1.54 | 60 | 267 | 99.5 |
| Sulfadimethoxine | $S_1$ | 200 mg | I | 15 | 1.54 | 45 | 270 | 93.9 |
| | | | II | 20 | 1.54 | 180 | 270 | 99.0 |
| Sulfamerazine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 258 | 99.4 |
| Sulfamethazine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 260 | 99.6 |
| Sulfamethizole | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 263 | 99.7 |
| Sulfamethomidine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 267 | 99.0 |
| Sulfamethoxazole | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 258 | 99.9 |
| Sulfamethoxypyridazine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 255 | 99.3 |
| Sulfamonomethoxine | $S_1$ | 200 mg | I | 15 | 2.31 | 30 | 264 | 96.9 |
| | | | II | 20 | 0.63 | 90 | 274 | 96.4 |
| Sulfanilamide | $S_1$ | 300 mg | I | 15 | 2.31 | 45 | 253 | 91.8 |
| | | | II | 20 | 1.54 | 60 | 260 | 100.6 |
| N′-(3,4-Dimetylbenzoyl)-sulfanilamide | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 35 | 258 | 99.7 |
| Sulfaphenazole | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 251 | 99.7 |
| Sulfapyridine | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 250 | 99.2 |
| Sulfathiazole | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 258 | 100.0 |
| Sulfisomidine | $S_1$ | 200 mg | I | 15 | 1.54 | 60 | 267 | 88.3 |
| | | | II | 20 | 0.63 | 45 | 282 | 94.1 |
| Sulfisoxazol | L (1000 $\mu$g/ml) | 1 ml | I | 15 | 1.54 | 30 | 255 | 99.9 |

6. **Electrodialytic Extraction of Amino Acids**——Thirteen amino acids shown in Table V were used. Each amino acid was dissolved in 0.5 M acetic acid and diluted to a suitable concentration according to the

3) F. Monastero, *J. Am. Pharm. Assoc.*, 41, 322 (1952).

procedure of 1.3) and designated as L. Tryptophan and tyrosin were extracted using 0.5 M $NH_4OH$ as the carrier solution, and determined with a spectrophotometer as shown in Table V. Glycine and phenylalanine were extracted for 1 hour and the effluent was determined with JLC-2A amino acid autoanalyzer (Japan Electron Optics Laboratory Co., Ltd). by the ninhydrin method. The other amino acids were extracted under the conditions of Table V, fractions were obtained every 5 minutes. 1 ml of 0.5 N NaOH was added to each fraction and the total volume was adjusted to 10 ml by addition of 0.5 M acetic acid. Each amino acid was determined with an autoanalyzer (Technicon Co., Ltd.) by a flow chart shown in Chart 1 following the method of Komano, *et al.*[4] The extraction was continued until no amino acid was detected in five minutes effluent and the total recoveries were obtained by adding the quantities of amino acid present in all previous fractions.

Table V. Electrodialytic Extraction Data of Amino Acids

| Compound | Sample | | Carrier solution | Extraction condition | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | | Current density ($mA/cm^2$) | Flow rate (ml/min) | Extraction time (min) | | |
| β-Alanine | L (4.5 mg/ml) | 1 ml | II | 20 | 1.54 | 15 | 420[a] | 94.0 |
| Arginine | L (4.2 mg/ml) | 1 ml | II | 20 | 1.54 | 15 | 420[a] | 100.0 |
| L-Glutamic acid | L (4.4 mg/ml) | 1 ml | II | 20 | 1.54 | 40 | 420[a] | 96.3 |
| Glycine | L (1.0 mg/ml) | 1 ml | II | 20 | 1.54 | 60 | 570[b] | 96.8 |
| L-Isoleucine | L (5.2 mg/ml) | 1 ml | II | 20 | 1.54 | 25 | 420[a] | 98.0 |
| Leucine | L (5.2 mg/ml) | 1 ml | II | 20 | 1.54 | 30 | 420[a] | 104.0 |
| Methionine | L (4.5 mg/ml) | 1 ml | II | 20 | 1.54 | 40 | 420[a] | 96.0 |
| Phenylalanine | L (1.0 mg/ml) | 1 ml | II | 20 | 1.54 | 60 | 570[b] | 99.0 |
| L-Serine | L (4.2 mg/ml) | 1 ml | II | 20 | 1.54 | 20 | 420[a] | 102.5 |
| Threonine | L (3.6 mg/ml) | 1 ml | II | 20 | 1.54 | 30 | 420[a] | 98.0 |
| Tryptophan | L (1.0 mg/ml) | 1 ml | I | 15 | 1.54 | 20 | 282 | 99.6 |
| Tyrosine | L (1.0 mg/ml) | 1 ml | I | 15 | 1.54 | 15 | 243 | 99.8 |
| Valine | L (4.7 mg/ml) | 1 ml | II | 20 | 1.54 | 40 | 420[a] | 100.8 |

a) TNBS method b) Ninhydrin method

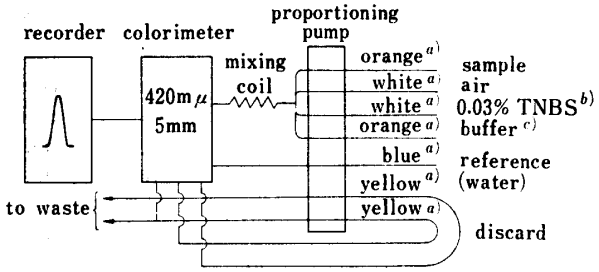


Chart 1. Flow Chart for Amino Acid Analysis

a) I.D. of tube orange: 0.035 inch, white: 0.040 inch, yellow: 0.056 inch, blue: 0.065 inch
b) 0.03% TNBS: 0.03% aqueous solution of trinitrobenzene sulfonic acid was acidified slightly with hydrochloric acid.
c) buffer: Adjusted to pH 9.6 by adding solid boric acid to 0.05M aqueous sodium borate solution.

**7. Electrodialytic Extraction of Barbiturates**——Nine barbiturates shown in Table VI were used. Each specimen was prepared according to the procedure of 1.1) or 1.3) and designated as $S_1$ or L. The quantities of these were indicated in weight or volume as shown in Table VI. After extraction the effluent was diluted to the appropriate volume with the fresh carrier solution and the absorbance was determined at the specified wavelength.

**8. Electrodialytic Extraction of Miscellaneous Drugs**——Phenols, saccharides, phosphates, a sulfonic acid and an arsenous acid shown in Table VII were used. Each specimen was prepared according to the procedure of 1.1) or 1.3) and designated as $S_1$ or L. The quantities of these materials were indicated in weight or volume as shown in Table VII. After electrodialytic extraction the effluent was diluted to the appropriate volume with the fresh carrier solution and the absorbance was determined at the specified wavelength. Glucose was determined by the anthrone method.[5]

4) T. Komano and T. Okuyama, *Kogyo Kagaku Zasshi*, **72**, 465 (1969).
5) T. Tamura, *Japan Analyst*, **10**, 64 (1961): Take 5 ml of the sample, cool with ice water and add dropwise 10 ml of 0.2% anthrone in 95% sulfuric acid from a burette. Heat the mixture in a boiling water bath for 8—10 minutes, cool to room temperature and measure absorbancy of 625 mμ using the reagent as a blank.

Table VI. Electrodialytic Extraction Data of Barbiturates

| Compound | Sample | | Extraction condition | | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | Carrier solution | Current density (mA/cm²) | Flow rate (ml/min) | Extraction time (min) | | |
| Allobarbital | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 20 | 242 | 100.0 |
| Amobarbital | $S_1$ | 300 mg | I | 15 | 1.54 | 30 | 241 | 100.6 |
| | | | IV | 20 | 1.54 | 45 | 241 | 99.5 |
| Barbital | $S_1$ | 300 mg | I | 15 | 1.54 | 30 | 241 | 99.7 |
| | | | IV | 20 | 1.54 | 45 | 241 | 98.8 |
| Cyclobarbital calcium | $S_1$ | 200 mg | I | 15 | 1.54 | 30 | 242 | 99.8 |
| | | | IV | 20 | 1.54 | 30 | 242 | 98.1 |
| Hexobarbital | $S_1$ | 300 mg | I | 15 | 1.54 | 15 | 246 | 100.5 |
| | | | IV | 20 | 1.54 | 60 | 246 | 93.3 |
| Methylthiouracil | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 30 | 261 | 99.3 |
| Pentobarbital sodium | $S_1$ | 300 mg | I | 15 | 1.54 | 30 | 242 | 95.3 |
| | | | IV | 20 | 1.54 | 45 | 242 | 97.9 |
| Phenobarbital | $S_1$ | 300 mg | I | 15 | 1.54 | 30 | 243 | 98.7 |
| | | | IV | 20 | 1.54 | 30 | 242 | 96.3 |
| Thiopental sodium | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 30 | 306 | 99.2 |

Table VII. Electrodialytic Extraction Data of Miscellaneous Drugs

| Compound | Sample | | Extraction condition | | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | Carrier solution | Current density (mA/cm²) | Flow rate (ml/min) | Extraction time (min) | | |
| N-Acetyl-*p*-aminophenol | L (1000 μg/ml) | 0.5 ml | I | 15 | 1.54 | 30 | 260 | 98.6 |
| Thymol | L (2000 μg/ml) | 1 ml | I | 15 | 1.54 | 30 | 293 | 98.1 |
| Glucose | L (2000 μg/ml) | 1 ml | V | 40 | 0.63 | 90 | 625[a] | 99.6 |
| Rutin | L (1000 μg/ml) | 1 ml | V | 40 | 1.03 | 120 | 271 | 96.6 |
| Betamethasone-21-disodium phosphate | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 20 | 245 | 99.7 |
| Riboflavin phosphate sodium salt | $S_1$ | 100 mg | I | 15 | 1.54 | 30 | 262 | 97.7 |
| | | | II | 20 | 1.54 | 60 | 268 | 97.0 |
| Isonizazid methanesulfonate sodium salt | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 35 | 275 | 95.9 |
| N-Carbamoylarsanilic acid | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 15 | 248 | 100.2 |

*a*) anthrone method

Table VIII. Drugs Resistive to Electrodialytic Extraction

| Compound | Sample | | Extraction condition | | | | Determined at (mμ) | Recovery (%) |
|---|---|---|---|---|---|---|---|---|
| | Type (conc.) | Quantity (weight or volume) | Carrier solution | Current density (mA/cm²) | Flow rate (ml/min) | Extraction time (min) | | |
| Evan's blue | $S_2$ | 50 mg | VI | 40 | 1.54 | 90 | 570 | 79.7 |
| Sulfaguanidin | L (1000 μg/ml) | 1 ml | I | 15 | 1.54 | 60 | 261 | 23.8 |
| Caffeine | L (1000 μg/ml) | 1 ml | II | 20 | 1.54 | 60 | 273 | 33.4 |
| Sucrose | L (2000 μg/ml) | 1 ml | V | 40 | 0.63 | 120 | 625[a] | 23.7 |
| Hydrocortisone acetate | L ([b]) | 1 ml | I | 15 | 1.54 | 60 | 250 | 82.6 |
| Prednisolone | L ([b]) | 1 ml | I | 15 | 1.54 | 30 | 250 | 68.2 |

*a*) anthrone method *b*) saturated solution

9. **Drugs Resistive to Electrodialytic Extraction**——Electrodialytic extraction data of some resistive drugs are shown in Table VIII. Each sample was prepared according to the procedure of 1.2) or 1.3) and designated as $S_2$ or L. The quantities of these materials were indicated in weight or volume as shown in Table VIII. After electrodialytic extraction the effluent was diluted to the appropriate volume with the fresh carrier solution and the absorbance was determined at the specified wavelength.

## Result and Discussion

In order to evaluate the electrodialytic extraction method, a large number of drugs were extracted with this apparatus.[1] As a result, it was found that many drugs could be extracted with a few carrier solutions. In the previous report 0.5 M acetic acid was used as an acidic carrier solution and then in this work it was also found that 0.5 M $NH_4OH$ was suitable as a basic carrier solution. The specific conductivity of 0.5 M ammonia is about $1.0\times10^{-3}$ mho/cm which is similar to that of 0.5 M acetic acid. Organic acids could be extracted by using 0.5 M $NH_4OH$ as the carrier solution as shown in Table II.

Amines could be extracted by using 0.5 M acetic acid as the carrier solution as shown in Table III. Dihydrostreptomycin was extracted with a buffer solution of pH 6.0 prepared by mixing 0.1 M acetic acid and 0.1 M sodium acetate. This was because this solution was convenient for the determination.

Sulfonamides could be extracted by using either 0.5 M $NH_4OH$ or 0.5 M acetic acid as the carrier solution as shown in Table IV. Generally the rates of extraction of these drugs are slower than amines.

Amino acids could be extracted easily by using either 0.5 M $NH_4OH$ or 0.5 M acetic acid, as shown in Table V. Although amino acids could be extracted more easily with 0.5 M $NH_4OH$ than 0.5 M acetic acid, many amino acids were extracted by using 0.5 M acetic acid as the carrier solution because of the difficulties of the determination of amino acid in the presence of ammonia.

Barbiturates could be extracted by using 0.5 M $NH_4OH$ or carrier solution containing 0.05 M of (tris-hydroxymethyl)-aminomethane and 0.01 M of NaCl, as shown in Table VI.

With regard to the other drugs, phenols, borate complexes of glucose and rutin,[6] betamethasone-21-disodium phosphate, riboflavine sodium phosphate, sodium isoniazid methanesulfonate and N-carbamoyl arsanilic acid could be extracted by selecting suitable carrier solutions as shown in Table VII.

Generally, nonionizing drugs are difficult to extract electrodialytically, steroids are representative compounds in this category. Also, Evan's blue, sulfaguanidine, caffeine and sucrose could not be extracted quantitatively as shown in Table VIII.

It was found from the above result that not only many drugs were extractable but also most of them were extractable by using either one of the carrier solutions, that is 0.5 M acetic acid or 0.5 M $NH_4OH$.

**Acknowledgement** The author wishes to express his deep gratitude to Prof. Z. Tamura, Faculty of Pharmaceutical Sciences, the University of Tokyo, for his helpful discussions and encouragement. The author is grateful to Dr. M. Shimizu, Director of this laboratories, for his kind encouragement and for permission to publish thid work. Thanks are also due to Mr. T. Ishii and Mr. K. Hirata for their technical assistances throughout this work.

6) M. Shimizu, *Yakugaku Zasshi*, **71**, 882 (1951).