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Matson

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[54] **SAMPLING SYSTEM AND ANALYSIS CELL FOR STRIPPING VOLTAMMETRY**

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Related U.S. Application Data

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[51] **Int. Cl.⁵** G01N 27/26

[52] **U.S. Cl.** 204/153.12; 204/403; 204/418; 204/419

[58] **Field of Search** 204/153.12, 403, 418, 204/419

[56] **References Cited**

U.S. PATENT DOCUMENTS

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[57]

ABSTRACT

A combination sampling/electrochemical analysis cell comprises an enclosure having a hollow therein, at least one inlet leading to the hollow, a vent leading from the hollow, at least one testing electrode, at least one counter electrode, and at least one reference electrode, all disposed at least in part in the hollow. A testing reagent is also contained in the hollow.

3 Claims, 3 Drawing Sheets

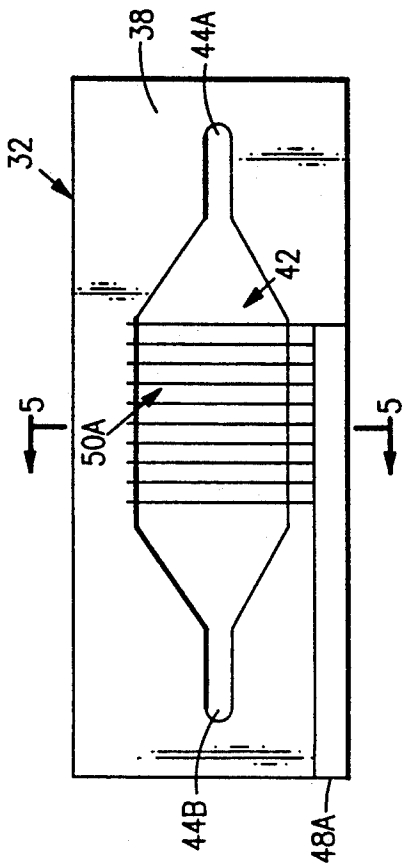


FIG. 4

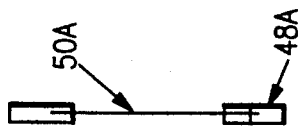


FIG. 5

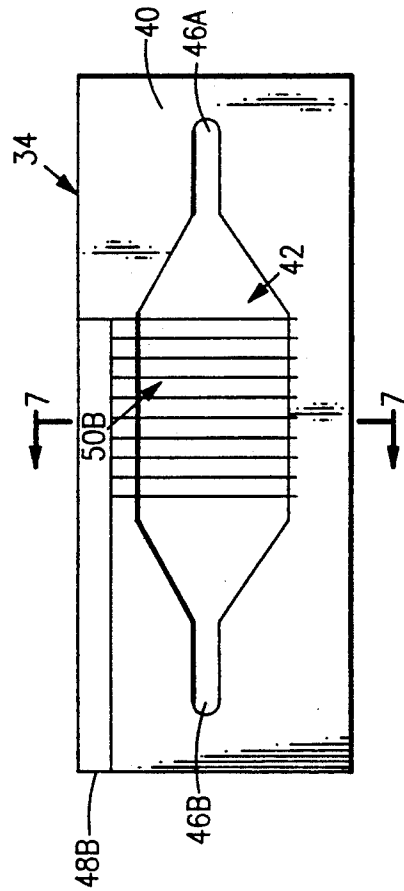


FIG. 6

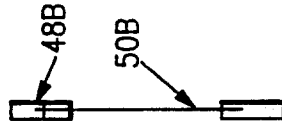


FIG. 7

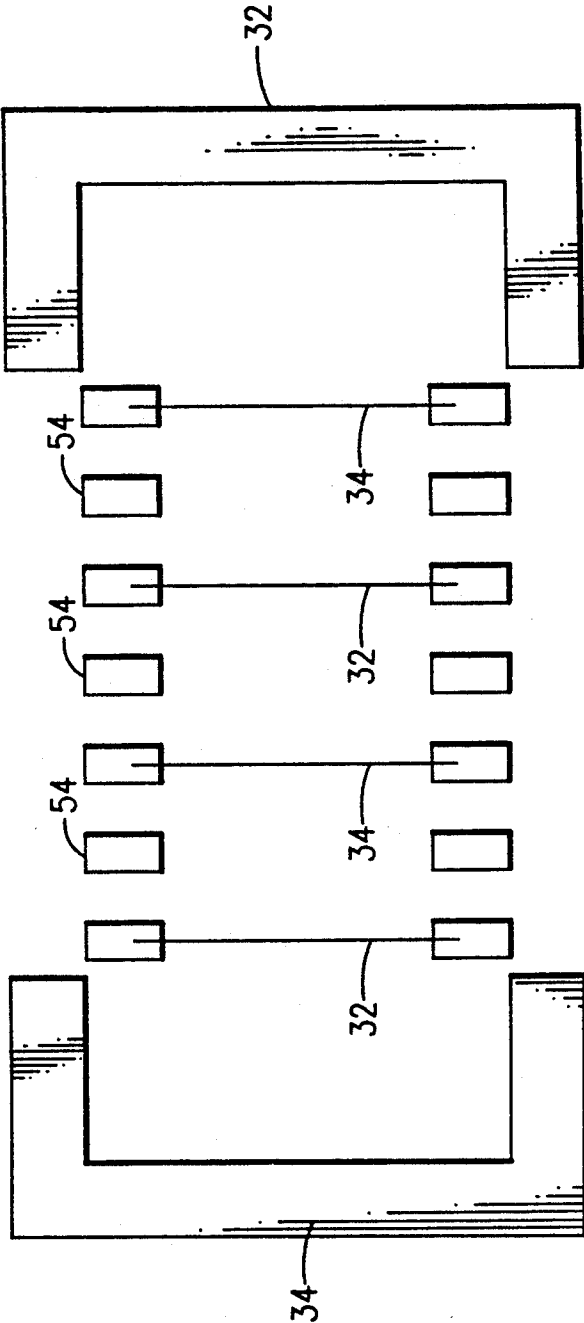


FIG.8

connection with one-time-use integrated sampling/analytical testing cells in accordance with the present invention, and provide improved exchange efficiencies as compared with conventional exchange materials.

Construction of the integrated sampling and analysis cell made in accordance with the present invention is straightforward. The clam shell halves 24, 26 may be formed, for example, by molding, and sheets 38A, 38B, 40A and 40B, and spacers 54 are formed by stamping. The electrode bus bars 48A, 48B are then deposited on sheets 38A, 38B, 40A and 40B, for example, by screen printing. The reference electrode 36 may be similarly deposited on one of the clam shells 24, 26. Carded carbon fiber electrode elements 50A and 50B are then laid in spaced position between sheets 38A and 38B, and 40A and 40B, respectively, with one end thereof in contact with bus bars 48A, 48B, and the sheets are fixed together by means of adhesive whereby to capture the carbon fibers therebetween, and form the counter and testing electrodes. The testing electrode is then treated with a measured quantity of reagent, and the reagent is dried-in-place. The counter and testing electrodes are then assembled in a stack with spacers 54 therebetween and the stack is loaded into one of the one-half clam shells. The other half of the clam shell is then assembled to the first half, and the clam shell halves are fixed together, for example, as by thermal welding.

In a particularly preferred embodiment of the invention, the integrated sampling/analytical cell comprises two test electrode arrays, and one counter electrode array of 8 μ carbon fibers, spaced at about 1000 fibers per inch, and the cell has a working volume of less than about 100 μ l. For example, the cell may have approximate internal dimensions of about 0.05 cm \times 0.5 cm \times 2.5 cm, giving an overall working volume of about 63 μ l.

A feature and advantage of the present invention is that the blood is subjected to analysis directly, i.e. without dilution as in the case of conventional anodic stripping techniques. This provides a 30:1 concentration enhancement which in turn results in enhanced sensitivity notwithstanding a decreased diffusion constant because of lower sample volume as compared with conventional anodic stripping techniques.

The invention is susceptible to modification. For example, as shown in FIG. 8, the integrated sampling/analytical cell may comprise a stack of a plurality of testing and counter electrodes 32 and 34, respectively. Employing a plurality of testing and counter electrodes may increase analytical accuracy and/or reduce response time.

Completing the integrated sampling/analytical cell in accordance with the present invention comprise contact means 62 such as contact pads for electrically connecting the testing electrode to a testing potential; contact means 64 for connecting the counter electrode or counter electrodes to a counter potential; and contact means 66 for connecting the reference electrode to a reference potential, all in accordance with the teachings of my previous U.S. patents as above mentioned.

The integrated sampling/analytical testing cell in accordance with the present invention has a number of advantages over prior art sampling and analysis tech-

niques. For one, the volume of the blood assay is defined by the internal geometry of the sampling/analytical testing cell and thus is independent of the volume drawn as long as the testing electrode is covered. This eliminates possible test inaccuracies, and eliminates the need to locate a patient in the event sufficient blood was not drawn in the initial sampling. Also, direct anodic stripping whole blood in accordance with the present invention has the effect of shifting the stripping peak 30-50 mv for the cathodic to copper, presumably because of the thirty-fold higher concentration of lead binding labile ligands. This effectively eliminates the effect of copper on the stripping curve envelope. And, an additional effect of reducing the variation in the envelope is the quiescent reduction of blood oxygen and other reducible blood moieties as compared with conventional anodic stripping techniques which may reintroduce oxygen, etc. through stirring. These two effects result in an underlying or blank envelope that requires compensation for curvature in the lead peak zone of less than about 0.5 microgram percent versus the current compensation of 8-12 microgram percent. Yet another feature and advantage of the present invention and which results from reduced cell/volume sensor area is that half times also are reduced.

Another feature and advantage of the present invention is that the electrode fibers which are oriented transverse to the test solution draw appear to prevent the draw of air, and thus bubbles, in the cell working volume under normal conditions. Alternatively, a small expansion volume shown in phantom at 70 in FIG. 1 may be provided in the inlet tube 28.

While the present invention has been described in connection with the sampling and analysis of testing lead levels in blood, it will be appreciated that the integrated sampling/analysis cells in accordance with the present invention may be employed in connection with a sampling and analysis of blood for a variety of metals, including cadmium, copper, zinc, thallium, silver, gold, bismuth and the like. Moreover, the integrated sampling/analysis cell in accordance with the present invention may be used for sampling and analysis of other bodily fluids such as urine, saliva, perspiration, tears, etc., or non-bodily fluids such as gasoline, water, etc. In such case, inlet tube 28 may be sized, for example, for injection of the fluids to be tested. In such case, inlet tube 28 may include a rubber stopper or the like.

I claim:

1. In a method of testing a blood sample for lead levels, the improvement wherein said blood is introduced, undiluted, directly into an electrochemical testing cell, and subjected to anodic stripping voltammetry analysis in the presence of a dried in place reagent.

2. In a method according to claim 1, wherein said reagent comprises a mixture of an organic acid and, a metal salt.

3. In a method according to claim 2, wherein said organic acid comprises monochloro acetic acid, and said salt is selected from the group consisting of LaCl₃, AlCl₃, CrCl₃, CaCl₂, HgCl₂ and mixtures thereof.

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