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(54) **AUTO-SAMPLER**

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(57) **ABSTRACT**

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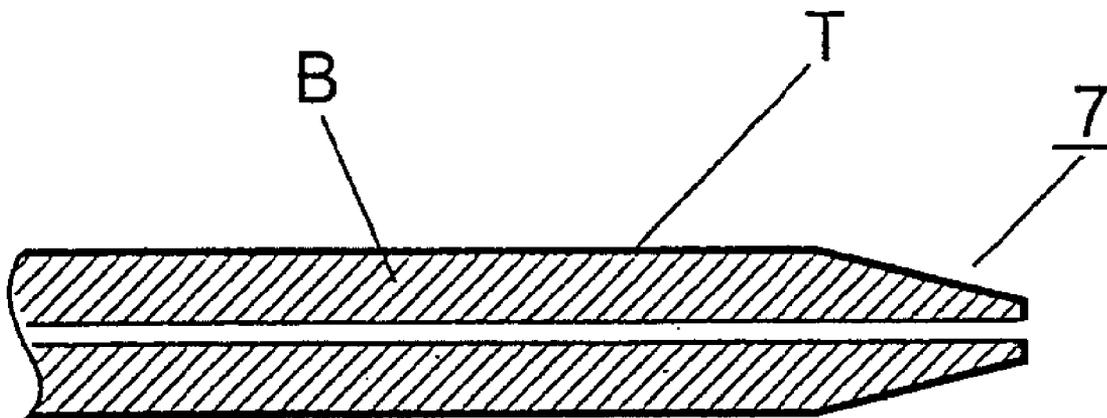
An auto-sampler successively collects liquid samples from plural sample containers through a metallic needle. A surface of the needle is coated with a coating material having a chemical activity smaller than that of a parent metal material of the needle, and the coated surface is polished to have an average roughness of 10 to 20 nm. The coating material may include a precious metal or synthetic resin plated or deposited on the parent metal material, or a quartz thin film formed by chemical vapor deposition on the parent metal material. The coating film on the needle is polished with a mechanical or chemical polishing method.

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(30) **Foreign Application Priority Data**

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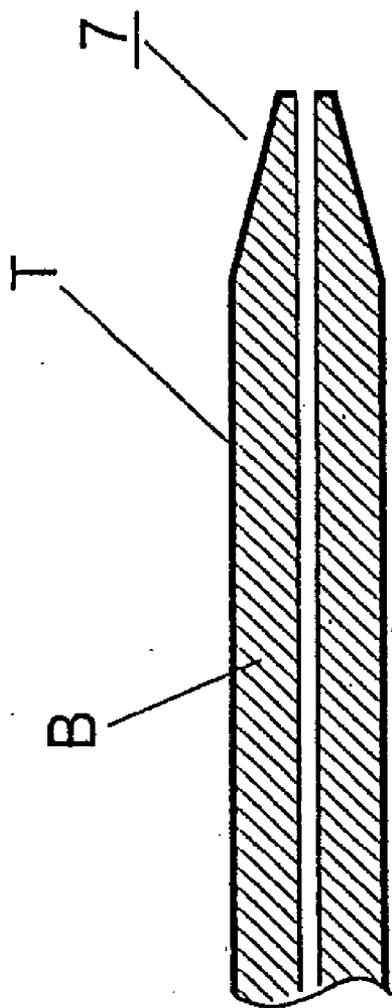


Fig. 1(A)

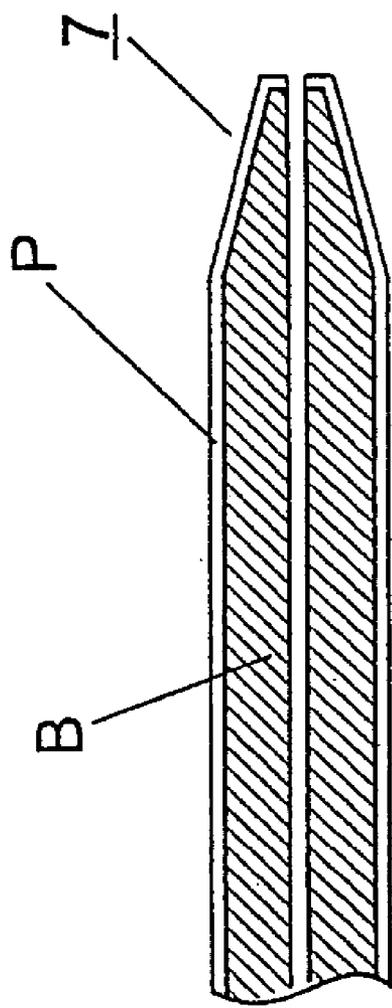


Fig. 1(B)

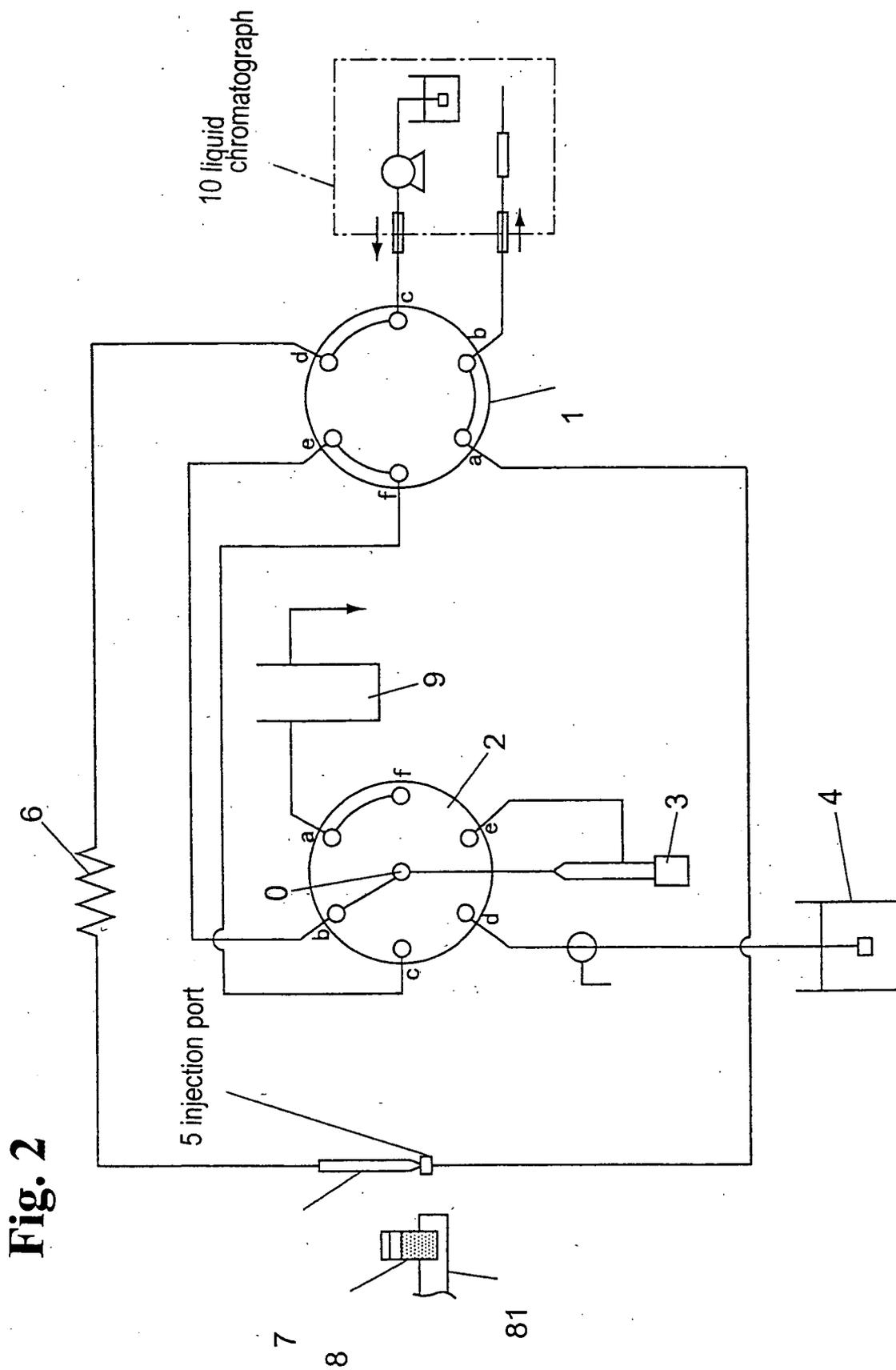


Fig. 2

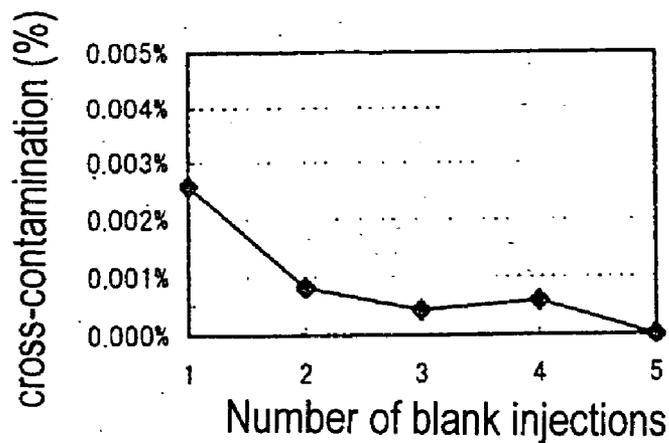


Fig. 3(A)

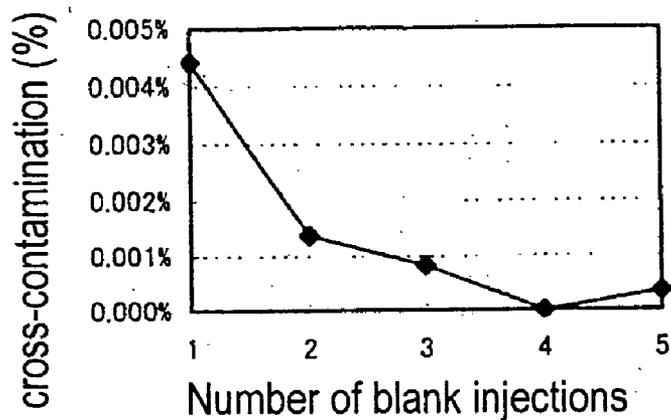


Fig. 3(B)

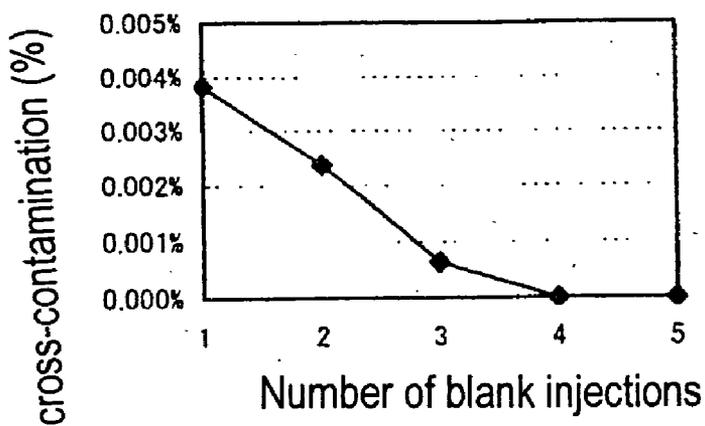


Fig. 3(C)

Fig. 4(A)

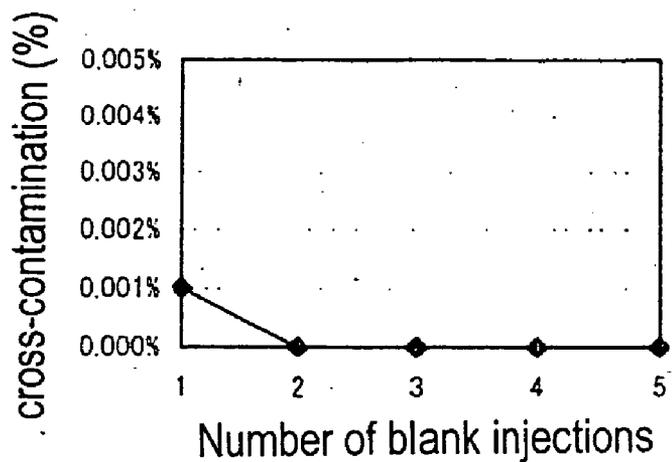


Fig. 4(B)

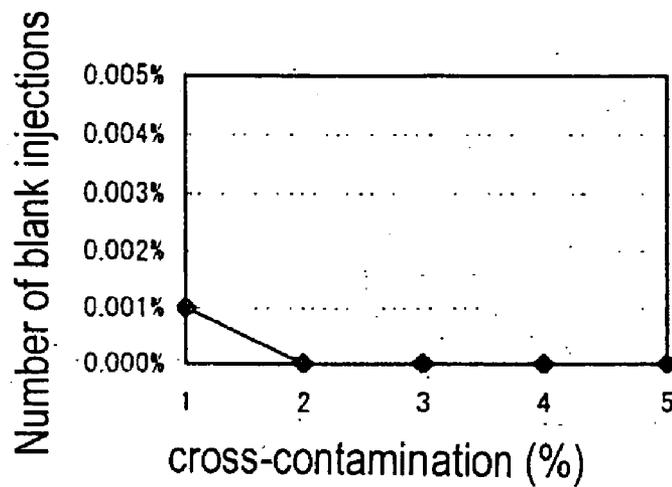
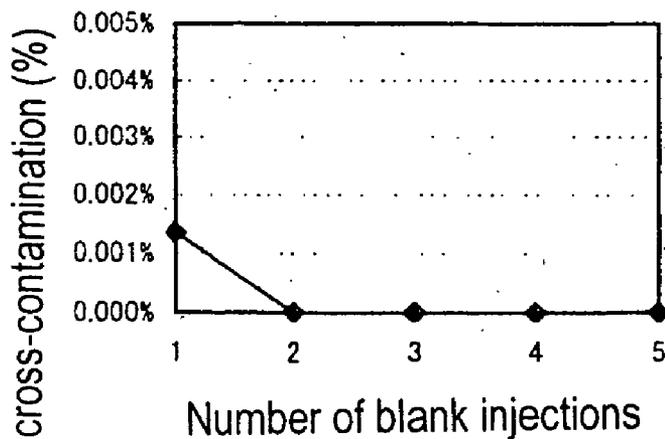


Fig. 4(C)



AUTO-SAMPLER

BACKGROUND OF THE INVENTION AND RELATED ART STATEMENT

[0001] The present invention relates to an auto-sampler of an analytical device such as a liquid chromatograph for analyzing liquid as an analytical subject. In particular, the present invention relates to an auto-sampler with a needle for sampling.

[0002] In an auto-sampler, it is necessary to clean a needle after collecting a certain sample. The cleaning process is important in order to prevent a previous sample from mixing into a next sample (cross-contamination). The needle is typically made of stainless steel, i.e., an alloy consisting mainly of iron. Accordingly, iron is microscopically exposed on a surface of the needle, and a certain ingredient in a sample may preferably adhere to iron due to a chemical property of iron. For example, an alkaline substance easily adheres chemically due to a hydroxyl group thereof attracted to iron on a surface of stainless steel. Once an ingredient of a sample adheres chemically, it is difficult to remove the ingredient even through physical cleaning with a cleanser of organic solvent. A trace amount of the ingredient may adhere to a surface of the needle even after cleaning. Accordingly, it is possible that the ingredient mixes into a next sample when the next sample is collected, thereby causing cross-contamination.

[0003] In order to prevent the cross-contamination, the needle is coated with a layer of precious metal, synthetic resin, quartz, or the like, thereby preventing the chemical adsorption phenomenon (see Patent Document 1).

[0004] Patent Document 1; Japanese Patent Publication (Kokai) No. 2002-228668

[0005] Even when the needle is coated with metal or resin for preventing the chemical adsorption phenomenon, it is possible that the needle has a rough surface depending on a process of metal plating or resin coating. As a result, small bumps and cavities may be formed on the surface of the needle. In this case, liquid may penetrate into a pleat of the bump or cavity and remain on the surface of the needle, thereby causing cross-contamination.

[0006] In view of the problems described above, an object of the present invention is to provide an auto-sampler having a needle with a coated surface and capable of preventing cross-contamination.

[0007] Further objects and advantages of the invention will be apparent from the following description of the invention.

SUMMARY OF THE INVENTION

[0008] In order to attain the objects described above, according to the present invention, an auto-sampler successively collects liquid samples from plural sample containers through a metallic needle. A surface of the needle is coated with a coating material having a chemical activity smaller than that of a parent metal material of the needle, and the coated surface is polished to have an average roughness of 10 to 20 nm. The coating material on the needle surface may include a precious metal or synthetic resin plated or deposited on the parent metal material, or a quartz thin film formed

by chemical vapor deposition on the parent metal material. The coating film on the needle is polished with a mechanical or chemical polishing method.

[0009] In the invention, the needle is coated with the coating material having a chemical activity smaller than that of the parent metal material. The coating film is polished to have a small surface roughness. Accordingly, it is possible to prevent cross-contamination caused by liquid remaining in bumps and cavities on the surface. A liquid chromatograph may use the needle of the present invention, so that it is possible to eliminate interference due to cross-contamination, thereby obtaining high sensitivity of analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIGS. 1(A) and 1(B) are sectional views showing needles of an auto-sampler according to an embodiment of the present invention, wherein FIG. 1(A) is a needle having a surface coated with platinum plating and polished, and FIG. 1(B) is a needle having a surface coated with a synthetic resin and polished;

[0011] FIG. 2 is a schematic diagram showing an auto-sampler of a liquid chromatograph according to an embodiment of the present invention;

[0012] FIGS. 3(A) to 3(C) are charts showing an effect of reducing cross-contamination in a case of a needle having a surface coated with platinum plating; and

[0013] FIGS. 4(A) to 4(C) are charts showing an effect of reducing cross-contamination in a case of a needle having a surface coated with platinum plating and polished.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0014] Hereunder, embodiments of the present invention will be explained with reference to the accompanying drawings. FIG. 2 is a schematic diagram showing an auto-sampler of a liquid chromatograph according to an embodiment of the present invention. In the drawing, reference numeral 3 denotes a plunger moving reciprocally with a mechanical force. Sample solutions to be analyzed are sealed in plural vials (small-capacity sample bottles) 8 in advance, and are placed on a rack 81. A needle 7 for collecting the samples from the vials 8 is connected to an injector valve 1 with a flexible loop tube 6 (loop). The needle 7 is also supported by a drive mechanism (not shown), and is capable of moving freely between the vials 8, a cleaning port 9, and an injection port 5 in accordance with a program.

[0015] A valve 2 is a rotary six-position valve for switching the flow channels of the liquids to be attracted and ejected by the plunger 3. Reference numeral 4 denotes a bottle of cleaning solution. The injector valve 1 is connected through piping to a liquid chromatograph apparatus 10, and introduces a sample solution into mobile phase liquid.

[0016] A process of sample injection using the analytical auto-sampler will be explained next.

[0017] (1) The injector valve 1 is adjusted so that ports e to d communicate. The valve 2 is adjusted so that ports 0 to b communicate as shown in the drawing. The needle 7 is inserted into the vial 8, and the plunger 3 is pulled to collect a prescribed quantity of the sample solution. The sample solution stays inside the loop 6, and does not reach the valve 2 or the plunger 3.

[0018] (2) The needle 7 is removed from the vial 8, and moved to the injection port 5.

[0019] (3) The injector valve 1 is operated into a state shown in the figure. The sample inside the loop 6 is introduced into the flow channel of the mobile phase liquid, thereby initiating liquid chromatographic analysis.

[0020] (4) After the needle 7 is cleaned and moved to the vial 8 containing the sample to be analyzed next, steps (1)-(3) above are repeated.

[0021] FIGS. 1(A) and 1(B) are sectional views showing needles of an auto-sampler according to an embodiment of the present invention. FIG. 1(A) is a needle having a surface coated with platinum plating and polished, and FIG. 1(B) is a needle having a surface coated with a synthetic resin and polished.

[0022] The needle 7 shown in FIG. 1(A), for example, is a flat-head type needle having an outer diameter of 1.2 mm, an inner diameter of 0.5 mm, and a flat tip with a diameter of 0.65 mm. A parent material B is made of stainless steel, and has a surface coated with a platinum plating layer T having a thickness of several μm to several tens of μm . The surface after plating is polished so that the surface roughness becomes smaller. An average roughness Ra is 10.14 nm, and an average roughness Rtm of 10 points of maximum roughness is 101.43 nm. The polishing process may be a mechanical process using abrasive grains, or a chemical polishing of treating the needle chemically.

[0023] In the mechanical polishing method, the needle may be polished by hand with abrasive grains affixed to a polishing cloth. In the chemical polishing method, the needle is immersed in an acid-based liquid to be chemically dissolved.

[0024] In the needle 7 shown in FIG. 1(B), instead of the metal plating, the parent material B is coated with a coating film P (thickness about 300 μm) of a synthetic resin, i.e., PEEK (polyetheretherketone) having excellent chemical resistance and mechanical strength. As the method of coating, a powder coating method can be applied. Considering a thickness of the synthetic resin coating film P, the parent material B must be made considerably thin in advance. PEEK is an organic material, and exhibits substantially no chemical adsorption. Further, because of excellent chemical resistance against various chemicals used in liquid chromatographs, PEEK is used as a piping material for liquid chromatographs, and is suitable for coating the needle 7 of the auto-sampler of liquid chromatograph. In this case, the needle is polished by hand with abrasive grains affixed to a polishing cloth, and the surface roughness same as that in the embodiment shown in FIG. 1(A) is obtained.

[0025] FIGS. 3(A) to 3(C) are charts showing an effect of reducing cross-contamination in a case of the needle having the surface coated with platinum plating (comparative example). The needle is coated with platinum plating with the method disclosed in Patent Document 1. FIGS. 4(A) to 4(C) are charts showing an effect of reducing, cross-contamination in a case that the surface of the needle 7 shown in FIGS. 3(A) to 3(C) is polished with the mechanical polishing (embodiment).

[0026] The comparative example had the average roughness Ra of 45.42 nm and the average roughness Rtm of the ten points of maximum roughness of 278.89 nm. The embodiment had the average roughness Ra of 10.14 nm and the average roughness Rtm of the ten points of maximum roughness of 101.43 nm.

[0027] In this experiment, strong alkaline chlorhexidine hydrochlorate was diluted in mobile phase liquid as a sample. A peak area A of the sample was obtained first. Then, only the mobile phase liquid (blank sample) was injected and a peak area B at the same holding time was measured. An extent of cross-contamination was measured as a ratio C (%) of B over A. The tests were repeated three times. In the charts, the horizontal axis represents the number of injections of blank solution, and the vertical axis represents the cross-contamination (%).

[0028] As shown in FIGS. 3(A) to 3(C) and FIGS. 4(A) to 4(C), in the case of the needle polished with the mechanical polishing, the cross-contamination in the first round of injection of the blank sample becomes smaller. Further, in the case of the needle without polishing, it was necessary to repeat the injection of the blank sample four or more times to reach a detection limit, whereas two blank injections were sufficient for the polished needle.

[0029] Accordingly, when the needle surface is coated with the coating material having a chemical activity smaller than the parent material and polished to reduce the surface roughness, it is possible to suppress the cross-contamination as compared with the case that the surface is coated only.

[0030] In the experiment, conditions of the liquid chromatograph are as follows.

[0031] Mobile phase: 100 mM phosphoric acid buffer containing perchloric acid (pH 2.6)/acetonitrile=55/45

[0032] Flow rate: 0.2 mL/min

[0033] Column: VP-ODS, diameter 2 mm, length 150 mm

[0034] Column oven temperature: 40° C.

[0035] Detector: UV 260 nm

[0036] Sample: chlorhexidine hydrochlorate 12 mg/10 mL mobile phase

[0037] Sample injection amount: 2 μL

[0038] In the comparative sample, the surface of the needle 7 was plated with platinum. A substantially same effect can be obtained by applying the present invention in a case that the needle is coated with PEEK or a synthetic resin film, and the needle is formed of a parent material other than stainless steel. The parent material and coating material are not limited to the embodiments. For example, a substantially same effect as with platinum can be obtained when the needle is plated with precious metals such as other platinum family elements or gold instead of platinum.

[0039] The dimensions of the needle 7 in the embodiments are just one example, and the present invention is not limited thereto. The surface roughness is not limited to that in the embodiment, and the average roughness Ra may be about 10 to 20 nm.

[0040] The present invention is generally applicable to auto-samplers in which liquid samples are successively collected from plural vials through a needle. The present invention is also applicable to auto-samplers of various analytical devices for analyzing liquid samples as well as the auto-sampler of liquid chromatograph.

[0041] The disclosure of Japanese Patent Application No. 2004-100328 filed on Mar. 30, 2004 is incorporated in the application.

[0042] While the invention has been explained with reference to the specific embodiments of the invention, the explanation is illustrative and the invention is limited only by the appended claims.

What is claimed is:

1. An auto-sampler for successively collecting liquid samples from plural sample containers, comprising:

a needle made of metal and coated with a coating material, said coating material having a chemical activity

smaller than that of the metal and a polished surface having an average roughness of 10 to 20 nm.

2. An auto-sampler according to claim 1, wherein said polished surface is made by mechanical polishing.

3. An auto-sampler according to claim 1, wherein said polished surface is made by chemical polishing.

4. An auto-sampler according to claim 1, wherein said coating material includes a precious metal.

5. An auto-sampler according to claim 1, wherein said coating material includes a synthetic resin.

6. An auto-sampler according to claim 1, wherein said coating material includes quartz.

7. An auto-sampler according to claim 1, wherein said coating material has a thickness greater than the average roughness and less than several tens of μm .

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