

CHROM. 7854

## PURIWAT® APPARATUS\*

### A SYSTEM OF ION-EXCHANGE CELLULOSES FOR THE PRODUCTION OF HIGH-PURITY WATER

ZS. HORVÁTH

*Institute of Inorganic and Analytical Chemistry, L. Eötvös University, H 1443 Budapest, P.O. Box 123 (Hungary)*

---

#### SUMMARY

PURIWAT apparatus produces high-purity water for special purposes from distilled or deionized water. Contaminants at the parts per million level can be removed by passing the water through a column of sandwiched ion-exchange cellulose as filtering media. The volume of water to be purified can be programmed and the apparatus operates without supervision. The filtering media is disposable, and fillings for the purification of 50 or 100 l of water are available. The output of high-purity water is up to 6 l/h. When analysed by neutron activation analysis, the purified water is especially low in copper (0.0025 ppb\*\*), while the contents of other heavy metals are less than 0.01 ppb.

---

#### INTRODUCTION

Advances in microelectronics, photography, trace chemical analysis and pharmaceutical syntheses are placing very high demands on water quality<sup>1</sup>. The quality of water obtained by the usual techniques of deionization or distillation is inadequate for these purposes because of the high levels of certain elements (principally trace metals) and organics. Research laboratories impose additional requirements of freedom from specific materials, leading to a need for the so-called selectively pure water<sup>2</sup>.

Distilled or deionized water contains a level of 100 ppb of metal impurities. Distilled water from a commercial metallic still is high in copper. For example, the distilled water in our laboratory analyzed by neutron activation analysis contains 5-50 ppb of copper, 10-60 ppb of iron, 0.2-100 ppb of zinc and 500 ppb of sodium. The quality of water is variable, depending on the quality of the feed water and the extent of corrosion of the still. This distilled water was purified by the PURIWAT apparatus, which is a new system for the production of high-purity water.

\* PURIWAT® apparatus is manufactured by Gép-és Műszeripari Szövetkezet Co-operative for the Machine and Instrument Industries, 7130 Tolna, Hungary.

\*\* Throughout this article the American billion (10<sup>9</sup>) is used.

## EXPERIMENTAL AND RESULTS

It was shown in our recent investigations that ion-exchange celluloses in the form of loose fibres are very effective for the rapid removal of heavy metal impurities from distilled water. The purification, as proved by neutron activation analysis, was effective up to parts per  $10^{12}$  concentrations<sup>3</sup>. Some types of dissolved organic compounds could also be removed from deionized water by ion-exchange celluloses<sup>4</sup>. Organic compounds dissolved from resins by water and metal contaminants in a colloidal form (Al, Cr, Sn, Pb, Fe, Cu, Ni, Zn) and particulates (dust, resin) in distilled or deionized water could be removed by ion-exchange celluloses. The chelate-forming ion-exchange cellulose iminodiacetic acid ethylcellulose prepared recently by us<sup>5</sup> had the advantage over cationic and anionic ion-exchange celluloses that it formed chelates of high stability with the metallic contaminants in distilled water. It was shown that instead of a series of columns, consisting of alternate beds of loose fibres of cation- and anion-exchange cellulose, a new type of column system, which we called a "sandwich system", was more effective for the removal of the trace contaminants in distilled or deionized water.

The principle of the sandwich system of ion-exchange celluloses is as follows. In a special sequence, cation-exchange carboxymethylcellulose, anion-exchange diethylaminoethylcellulose and chelate-forming ion-exchange iminodiacetic acid cellulose are sandwiched in a column. The water to be purified is allowed to pass through the sandwiched ion-exchange celluloses, the so-called filtering media, at a rate of 1–1.5 l/h·cm<sup>2</sup>. The PURIWAT apparatus holds a column consisting of the sandwiched ion-exchange celluloses as filtering media. The constructional materials of the apparatus that are in contact with the water are polyethylene and polymethacrylic ester. The housing or column holding the filtering media is made of polymethacrylic ester.

Fig. 1 shows the schematic diagram of the principle of operation of the PURIWAT apparatus.

Component 1 is the storage tank for the distilled or deionized water to be purified, 2 is the diaphragm tap and 3 is the centrifugal pump. When the diaphragm

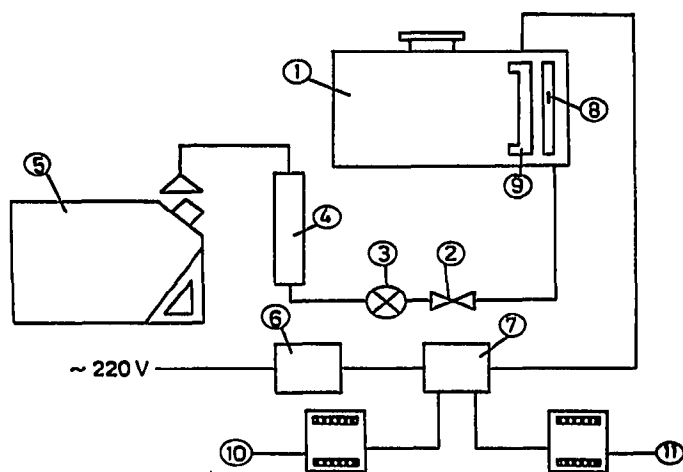


Fig. 1. Schematic diagram of the PURIWAT apparatus.

tap is opened and the operating switch is switched on, the centrifugal pump begins to deliver the water to be purified. The water passes through a plastic cartridge (4), which contains the sandwiched ion-exchange celluloses. A plastic can (5) serves to hold the effluent, the high-purity water. Components 6 and 7 are the supply unit and the relay. A magnetic float (8) indicates the decrease in the level of water in the storage tank. The volume of water flowing out of the storage tank is measured by a volume-measuring level sensor (9). The pulses given for each litre delivered are written out by a capacity indicator (10) and by a programme indicator (11) in the form of figures. The volume of water necessary for a certain purpose can be programmed on a programme indicating unit (11) and this automatically ensures operation without supervision. When the filtering media is exhausted, the apparatus programmed for the capacity of the filtering media produces sound and light signals and the centrifugal pump stops. The cartridge filling is disposable, and fillings for the purification of 50 or 100 l of distilled or deionized water are available. The filling can be exchanged within 1 min by pulling out the base connection, unscrewing the cartridge, discarding the old filling and replacing it with the new one. The output of high-purity water is up to 6 l/h.

## DISCUSSION

The high-purity water produced from our laboratory distilled water by the PURIWAT apparatus was analyzed by neutron activation analysis. The metal content of the distilled water before passing it through the column is given in the Introduction. The purified water was especially low in copper content (0.0025 ppb). The iron content was 1, zinc 0.02–0.05 and sodium 20–30 ppb. The concentration of other elements such as calcium, cobalt, manganese, nickel, lead and antimony was less than 0.01 ppb, less than the sensitivity of the method for these elements.

Conductivity determinations cannot be used for the measurement of the purity of high-purity water as some elements that are present in particulate or colloidal form in the parts per  $10^9$  or  $10^{12}$  concentration range are undetectable<sup>1</sup>. For the evaluation of effluent quality, sensitive analytical methods such as neutron activation analysis and possibly flameless atomic-absorption spectroscopy are adequate. In the purified water, residues from the apparatus and degradation products of the ion-exchange celluloses after the purification of 100 l of distilled or deionized water could not be detected by the methods applied; the oxygen demand was measured by the potassium permanganate method and the transparency was measured up to the far UV region.

The PURIWAT apparatus produces an extremely high quality of high-purity water with the lowest levels of heavy metals and other contaminant ions that can be reached at present by the purification of distilled or deionized water. The high-purity water produced by the PURIWAT apparatus can be used in every research activity that demands extremely pure water, for example, in semiconductor, protein, enzyme and pharmacological research, in bacteriology, thin-layer chromatography, flame-emission and atomic-absorption spectrophotometry, making up analytical-grade reagents and for other purposes.

## REFERENCES

- 1 R. C. Hughes, P. C. Mürau and G. Gundersen, *Anal. Chem.*, 43 (1971) 691.
- 2 G. Iwantscheff, *Das Dithizon und seine Anwendung in der Micro- und Spurenanalyse*, Verlag Chemie, Weinheim/Bergstr., 1972, p. 23.
- 3 Zs. Rempert-Horváth and M. Ördögh, *Mikrochim. Acta*, (1972) 491.
- 4 J. D. Guthrie, *Ind. Eng. Chem.*, 44 (1952) 2187.
- 5 Zs. Horváth and Gy. Nagydíósi, *J. Inorg. Nucl. Chem.*, in press.