Resistive sensor for water salinity

M. POPESCU[*], A. LŐRINCZI, F. SAVA, V. SAVU[a], D. SAVASTRU[a]
National Institute R&D of Materials Physics, 0771125-Bucharest-Magurele, P. O. Box MG. 7, Romania
[a]National Institute for Optoelectronics, INOE-2000, Bucharest-Magurele, P. O. Box   Mg-5 Romania

A simple electrical resistance sensor for monitoring of the coastal marine waters has been developed. The good sensitivity and reproducibility of the measurements make this sensor attractive for using in the research of the mixing of sweet (river) waters with the marine water, as well as the variation in the depth of the sea of the water salinity. Another advantage of the sensor is the possibility to monitor the water salinity by simply tracing the electrical resistance when the sensor is drawn at the surface or vertically in the sea and ocean waters.

The necessity of environment monitoring determined a large amount of scientific and technical research for the development of various types of sensors [1-12].

The marine and ocean waters contain a high amount of dissolved salts, especially natrium chloride (~ 35 g/l). In the coastal zone this average concentration is altered due to mixing of the sweet water (river water) with the marine salt ones. The mixing of two types of water determines a variable concentration of salt in water and this has as output the different fito-plancton development, as well as the extension of the habitat area for various types of fishes.

The problems of salt water intrusion, due to heavily pumped wells near a coast is often illustrated with a drawing of a freshwater lens on a homogeneous sand island. Hydrogeological surveys aimed to find the best location of ground water wells necessary for a future development of houses in given areas and investigate the possibility of salt water intrusion [13].

Outflow of groundwater and rivers to the sea has appeared to be both a problem and a possibility for water-planners. River outflow in winters could be loaded with fertilizers like nitrate, in some areas this are giving rise to unwanted eutrophication of the sea. This water problem has recreated an interest for planned use of the water resources in the coastal zone and actualized the need for the development of better method for mapping and monitoring the water quality in the coastal zone.

Desalination of seawater is important for many countries, as e.g. Israel. Therefore the true concentration of salt as a function of the place of the water absorbed and transmitted to the desalination plants, must be measured accurately.

Continuous monitoring of the water supply at the output of the desalination plant is necessary.

Schroder [14] discussed the electrical mapping and monitoring of the water quality in coastal areas, with specific examples from various regions of the earth.

Global methods have been used up today for mapping the waters in the coastal area, as for example the LIDAR method. In the paper [15] a detailed map of the region of Romanian coast of Black Sea is given and discussed. Barbini et al. [16, 17] discussed similar LIDAR results for Ross Sea.

We report here the construction and the testing measurement results for a simple resistive sensor for water salinity built on the principle of the change of electrical resistivity of the water as a function of the dissolved salts (mainly NaCl) in the sea water.

Details on the construction

An alumina plate provided with two gold electrodes has been chosen as basis for the sensor's body. Above this basis, a Teflon plate (0.5 mm in thickness) having in its centre a hole of diameter 6 mm has been fixed by using a special stainless steel piece (see figure 1).
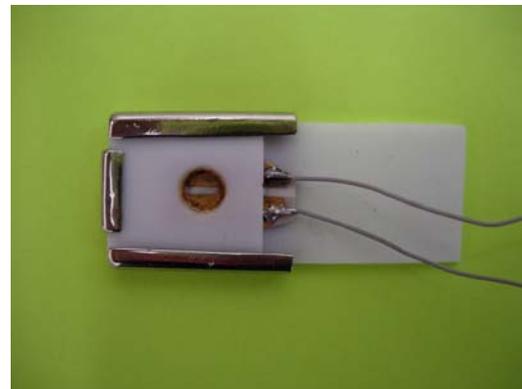

Fig. 1.The salt water sensor based on electrical resistance measutrements.

The water simple is put with the help of a pipette in the space defined on the sensor by the hole created into Teflon plate. The resistance between the two gold electrodes is influenced by the presence of water. For distilled water the resistance is very high, near to that of alumina plate. When natrium chloride is added to pure water the electrical resistance changes dramatically. The electrical resistance was measured accurately with the help of an ohm-meter device.

In order to avoid the penetration of the water under the Teflon plate, a special sealing procedure was applied. Special paste used in electronics to insulate thin copper wires was put on the contact area of the Teflon-electrode boundary, in order to avoid the water creeping.

After every measurement the water was removed and the sensor was washed in distilled water.

Results

The resistive sensor was tested against several solution of NaCl salt in pure (double distilled) water. The plot of the resistance against salt concentration is given in Fig. 2.
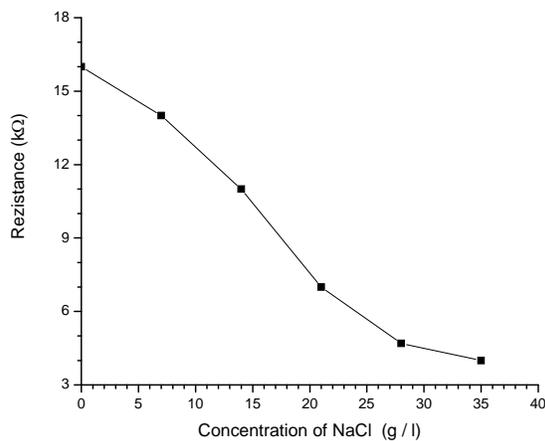

Fig. 2. The plot of the electrical resistance of the salinity sensor vs NaCl concentration in the test solutions.

The electrical resistance varies in large limits from pure water to average saline marine water. This variation allows for a quite fine determination of the rough salinity of the sea water, and for mapping of the mixing of the salted and unsalted river water in the region of the marine coasts. The scanning of the water mixing in depth of the sea can be also easily made.

As one can observe in Fig.2 the resistance of the sensor does not give a completely linear response to the change in salinity. To follow in more detail this response usually the differential sensitivity of a sensor is used, which is defined as the first derivative of the plot in Fig.1 and is given by Eq.1:

$$S_c = \frac{dR_{\text{det}}}{dc}. \qquad (1)$$

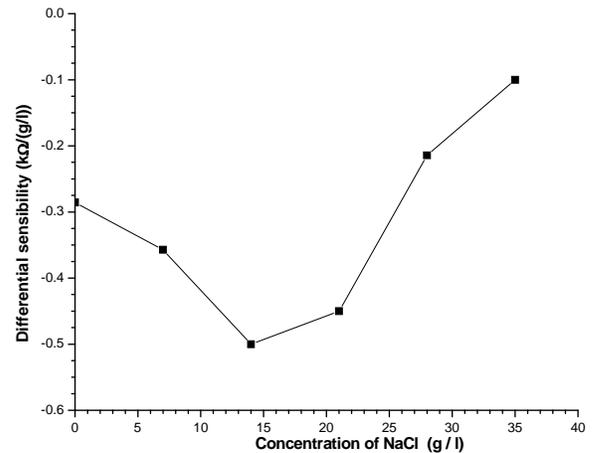Fig. 3 shows below the shape of the differential sensibility of the sensor:

Fig.3. Differential sensibility of the sensor.

Based on the differential sensibility of the sensor usually it is used the relative concentrational sensitivity of the sensor, which one obtain through scaling the diffrential sensibility to it's extreme value, as given by Eq. 2:

$$s(c) = \frac{S_c}{S_{c\,m}}, \qquad (2)$$

where S_c is the current diffrential sensitivity, while $S_{c\,m}$ is its extreme value, as plotted on Figure 3.

As a result one obtain the relative concentrational sensitivity, which is also called the characteristic curve of the sensor. Figure 4 shows the characteristic curve of the sensor for measured concentration domain:
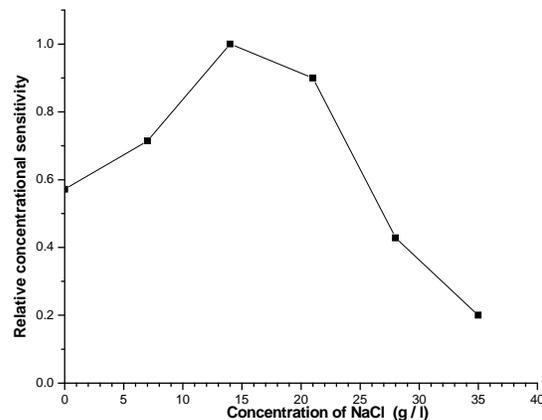

Fig. 4. The relative concentrational sensibility i.e. The characteristic curve of the sensor

It is worth to observe, that the deviation from the liniarity of the resistive response at the lower and upper extremities of the concentration in Fig. 2 is transposed into a pronounced maximum in the characteristic curve on Fig. 4.

Let us also notice, that this characteristic curve of the sensor has its maximum around the salinity of ~ 15 g/l, and a good response (> 80 % of the maximum's value) in relative sensibility for the concentration domain of approximately 9 – 22 g/l.

Conclusions

The resistive sensor for water salinity conceived and constructed by us is simple and robust. The obtaining results on test solutions are reproducible. The sensor is suggested for the monitoring of the salinity of the coastal waters of seas both at the surface and in depth. A continuous monitoring is also possible if the immersed sensor is shifted uniformly on the water surface or vertically, in the depth of the sea.

Acknowledgement

References

[1] Yu. G. Vlasov, E. A. Bychkov, A. V. Legin, Chalcogenide Glass Chemical Sensors, Talanta, **41**(6), (1994).
[2] N. Schroeder: "Resistivity at Sea" in CRC Handbook of Geophysic Exploration at Sea, R. A. Geyer Editor.
[3] SCOPE, 2001: Scope project final report http://www.SCOPE.RUC.DK

[4] A. Vaseashta, J. Irudayaraj, J. Optoelectron. Adv. Mater. **7**(1), 35 (2005).
[5] S. Andreev, J. Koprinarova, P. Dimitrova, J. Optoelectron. Adv. Mater. **7**(1), 317 (2005).
[3] E. Hristoforou, J. Optoelectron. Adv. Mater. **8**(5), 1691 (2006).
[6] C. Baban, Y. Toyoda, M. Ogita, J. Optoelectron. Adv. Mater. **7**(2), 891 (2006).
[7] N. Iftimie, E. Rezlescu, P. D. Popa, N. Rezlescu, J. Optoelectron. Adv. Mater. **7**(2), 907 (2006).
[8] A. G. Petculescu, J. Optoelectron. Adv. Mater. **8**(1), 217 (2006).
[9] G. C. Constantin, G. Perrone, S. Abrate, N. N. Puscas, J. Optoelectron. Adv. Mater. **8**(4), 1635 (2006).
[10] K. P. Kornev, I. P. Korneva, J. Optoelectron. Adv. Mater. **7**(5), 2359 (2005).
[11] M. Stankova, X. Vilanova, J. Calderer, I. Gracia, C. Cané, X. Correig, J. Optoelectron. Adv. Mater. **7**(3), 1237 (2005).
[12] E. Sotter, X. Vilanova, E. Llobet, M. Stanbkova, X. Correig, J. Optoelectron. Adv. Mater. **7**(3), 1395 (2005).
[13] N. Schroeder, H. Obro, Nordic Hydrology 7 (1976).
[14] N. Schroeder, in Tecnologia de la Intrusion de agua de mar en acuiferos costeros: Paises mediterraneos, IGME, Madrid 2003.
[15] M. Zoran, E. Anderson, J. Optoelectron. Adv. Mater. **8**(1), 247 (2006).
[16] R. Barbini, F. Colao, R. Fantoni, L. Fiorani, I. G. Ogladnikov, A. Palucci, J. Optoelectron. Adv. Mater. **7**(2), 1091 (2005).
[17] R. Barbini, M. Cabrini, F. Colao, R. Fantoni, L. Fiorani, S. Fonda Umani, N. V. Kolodikova, L. Lazzara, A. Palucci, P. Parmiggiani, J. Optoelectron. Adv. Mater. **8**(4), 1565 (2006).

_____
[*]Corresponding author: mpopescu@infim.ro