

Experimental Studies on Disinfecting and By-products Formation During Electrochemical Water Disinfection

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Electrochemical disinfection by a single pass of water through an electrochemical cell has been considered for more than 50 years by many authors. Several cell constructions were developed and tested under practical conditions but no long time exploitation did become to be known. The reasons for this are mainly the lack of suitable electrodes that do not cover with calcareous deposits from water components and which are sufficiently stable against the periodic change of electrode polarity. The problem of legionellae bacteria resistance which can not be solved by electrochemical disinfection was also neglected in some attempts of application. Only in the recent past research work was carried out to quantify microkinetics during direct drinking water treatment in an electrochemical flow-through cell [1]. Unfortunately, a non-selective amperometric sensor was used to detect active species.

The results described here were obtained in a special research project for finding the optimal conditions of direct water electrolysis with a non-divided electrochemical reactor.

It could be found from polarization measurements and from studies of the concentration – time dependence for generated species and for micro-organisms lethality (*E. coli*, *bacillus subtilis*, *Saccharom. Cer. K.*) that a direct electron transfer electrode/micro-organism is not probable. For example, micro-organisms in the concentration range of 10^4 /ml completely died only during 30-40 minutes after a single pass through the cell. Higher chloride concentrations in the water improve the efficiency of disinfecting species production. Tab. 1 shows for a typical flow-through experiment with a cylindrical cell containing a stack of four parallel electrodes (activated titanium, 4 cm x 10 cm) the reached production rate of active chlorine.

Tab. 1 Active chlorine formation in dependence on chloride concentration in a flow-through cell

Cl ⁻ concentr. (mg/l)	12	25	50	100	200	500
act. chlorine (mg/min)	0.9	1.5	2.2	4.3	7.9	13.0

It is obvious that even for very small chloride contents an active chlorine production can be obtained which is sufficient for normal drinking water disinfection. All components were analyzed with a Macherey & Nagel photometer and special analysis sets.

The choice of the electrode material is the decisive factor for a large production of disinfecting species that are mainly produced on the anode. Fig. 1 presents experimental results with respect to analyzed total chlorine and hydrogen peroxide in dependence on the cell current. The results were obtained in discontinuous laboratory reactors with different anodes but at the same REYNOLDS number conditions. Platinum electrodes proved to be not effective. A better total chlorine production was possible on the diamond anode and the best results could be obtained with a modified mixed

iridium oxide anode (MIO). The formation of hydrogen peroxide is marginal on all electrodes.

Another subject of research was the formation of disinfecting by-products such as AOX and TXM. This is a general problem for all disinfecting methods using active chlorine components. Systematic studies were carried out, for example, with humic acids added to the water. The AOX concentration depends approximately linearly from the humic acid concentration for a constant active chlorine concentration. Another influence factor is the reaction time. AOX concentration increases significantly with time. In special experiments water from several origins (river water, lake water, synthetic water samples) were subjected to the electrolysis with the following determination of the ratio AOX/TXM. The calculated values were between 3 and 4 for artificially prepared samples and between 8 and 10 for waters from lakes and rivers.

In other experiments the influence of iron ions on the active chlorine production could be quantified.

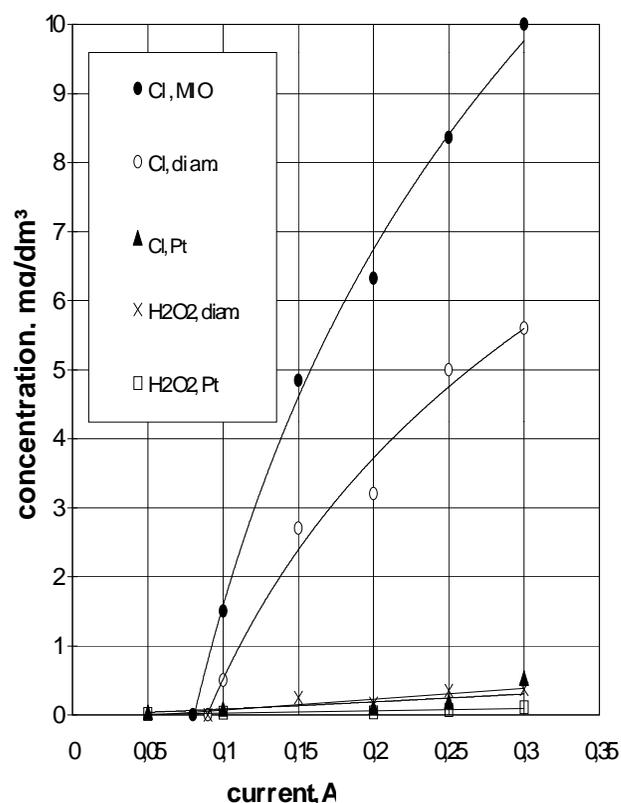


Fig. 1 Formation of total chlorine and hydrogen peroxide during drinking water electrolysis on different electrode materials in dependence on cell current

ACKNOWLEDGMENTS

The authors thank the BMBF and the AIF for financial project support, Dr. A. Rittel (Anhalt University) and Dr. Fryda (Fraunhofer Institute Braunschweig) for experimental help.

REFERENCES

- Kraft, A. et al: Journ. Appl. Electrochem. 29 (1999) part I and II, 861 and 895 ff.
- Bergmann, H.; Yurchuk, T, Schoeps, K.: Proceedings 51. ISE Meeting Warsaw 2000