

Electrolytic procedures for secondary drinking water disinfection

Differences and similarities

Electrolytic procedures for microbiological drinking water disinfection in domestic installations were presented and discussed at the 5th Medical Technology Congress in Würzburg last year. The procedures concerned are anodic oxidation and electrochemical activation or electrodiaphragmalysis. Both procedures are already on the market and are currently the subject of a hearing at the German Technical and Scientific Association for Gas and Water (Deutsche Vereinigung des Gas- und Wasserfaches e. V.; DVGW) (W229, "New Disinfection methods and procedures" the first hearing took place on 10/11 February 2005, in Bonn). The following article explains how both procedures compare.

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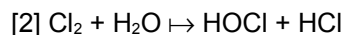
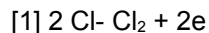
These procedures are relatively new in the area of drinking water disinfection and a certain degree of knowledge of electrophysics and chemistry is demanded in understanding them. As a result, operators, but also health authorities, still find it difficult to evaluate these procedures. Unfortunately, in the past, manufacturers with facilities that work according to the principles of electro-chemical activation contributed little to the understanding of this process. It would appear that the concern was that this would provide the competition with too much information about their own level of expertise. However, this behaviour did, in fact, lead to rejection and scepticism in expert circles.

In order to introduce some objectivity to the discussion, the peculiarities of both procedures and the differences between the facilities of various manufacturers will be briefly described here. In the following text, the procedures are referred to as anodic oxidation and electrochemical activation. The term electrodiaphragmalysis is misleading and should not be used. It has been used in the chemical industry for over 100 years and refers to a special production procedure in which the basic chemical substances chloric gas and alkaline leachate are produced through the electrolysis of salt.

Differences Exist

Anodic oxidation and electrochemical activation are procedures that ultimately produce hypochloric acid (HOCl) for drinking water disinfection from common salt and drinking water. The main technical procedural differences between anodic oxidation and electrochemical activation are summarised in the table.

In anodic oxidation, hypochloric acid (the microbiocidal agent) is created through the intermediate product chloric gas. Chloric gas (Cl₂) is created through oxidation (removal of electrons) of chloride anions (Cl⁻) in the anode [1]. The chloric gas released in this way further reacts with water molecules to produce hypochloric acid and hydrochloric acid [2].



Hydrogen gas that was not removed¹ and the creation of hydrochloric acid make the treated drinking water corrosive. This situation has to be taken into account, in particular in the case of raw materials (pipes, fittings etc.) made of rust-proof steel and hot-dipped galvanised steel (stainless steel with low molybdenum content, or, as the case may be, raw materials galvanised in a hot-dip procedure).

Hospitals have to attend to drinking water disinfection with a great deal of caution. The discussion surrounding individual procedures creates the basis for the highest level of hygiene in practice.

¹ In the electropotential series in which metals are categorised from left to right according to increasing electron cohesive/binding power, peroxide is to the right of zinc, chrome, iron, nickel and lead, i.e. it can oxidise these metals.

Facilities working according to the principle of electro-chemical activation consist of two hydraulically separated parts: the production facility and the dosage appliance. In the production facility, a saturated brine is first produced in a sample from drinking water (most often fully desalinated) and common salt (mostly pure evaporated salt). A pump with a mixing valve dilutes the brine with (fully desalinated) drinking water to a salt content of 0.5 to 3 percent and transports it into the electrolysis chambers.

The anodic fraction (anolyte) is collected in a storage container (ten to 100 litres) and the cathodic (catholyte) fraction is discarded. The dosage appliance dips into the anolyte storage container with a lance and transports the anolyte to the injection area in the pipeline by way of a dosage pump. The solution with the flowing drinking water is 1:300 to 1:1.000. The dosage pump is controlled either via a water contact meter or an active chlorine-recording cell. The addition can be made in the cold and/or warm water line. The creation of hypochloric acid occurs during the electrochemical activation in the anode area through the reaction of chlorine and hydroxyl radicals [3].



The prerequisite for this is a neutral pH level in the anodic chamber. Chloric gas is produced if acidic anolyte is produced and only neutralised with alkaline catholyte after leaving the electrode chamber. The control of the electrolysis chambers, the construction of these chambers and the quality of the materials used are decisive for the composition of the anolyte (each manufacturer/operator uses its own descriptions for its anolyte).

There are tube-shaped (radial electric field) and flat (homogeneous electric field) electrolysis chambers. In the first, the anode can be arranged inside or outside. The electrodes are made from stainless steel or titanium, and are available coated (metal oxide) or uncoated.²

The thin, ion-selective diaphragm is usually made of rare mixed metal oxides from the fifth and sixth chemical period and is of great importance for the production process. Furthermore, various manufacturers (there are a good half dozen on the German market now) use different hydraulic controls for the electrolysis chambers. The flow of diluted brine is either divided and conveyed to the anodic and cathodic chambers simultaneously, or flows completely through first either the anodic or the cathodic chamber. According to the process control, more or less peroxide gas is produced in the cathodic chamber. It must be removed separately or can outgas from the anolyte storage container. The flow speeds and contact times with the electrodes also have a decisive effect on the anolyte quality. The electrical work W [4], performed on the diluted brine in the electric field depends on the disk tension, the intensity of the current and the contact times.

$$[4] W = U \times I \times t$$

Speeds and contact times influence the result

Because the intensity of the current follows fluctuations in the ion concentration, more electronic input is required in order to keep the electric action W , and thus the energy input, in the diluted brine constant. Disruptions to the process alter the electric activity W and thus influence the composition of the anolyte. Thus, for example, a reduction of the flow speed (equal to increased contact time) can lead, via deposits on the electrodes, to a reduction in the pH-level in the anolyte and to the creation of chloric gas and hydrochloric acid. Anolyte should always leave the electrolysis chamber neutral ($\text{pH } 7.0 \pm 0,5$), because acidic surroundings generally encourage the production of chloric gas. Chloric gas is also produced if the diaphragm is broken, for example through water pressure. As is the case in anodic oxidation, this results in the mixing of anolyte and catholyte.

The microbiocidal effect of anolyte is far greater than the effect of simple hypochloric acid with a comparable concentration. Why? The electric input W provided does not lie fully in the chemical reaction processes and in the heat released. A part is stored as internal potential energy in the molecules of the solution, thereby lowering their activation energy for chemical reactions.³ The large number of process parameters that influence the composition of the anolyte show clearly that not all anolytes are the same. For this reason, the manufacturer must submit a chemical analysis of his anolyte. If the constancy of the anolyte is not

² the permanent titanium coating is high technology.

³ I. L. Gerlovin's Fundamental Field Theory provides the physical theoretical background

otherwise ensured, this analysis should be tested at regular intervals in installed facilities. These requirements are also necessary in the interests of consumer protection. Drinking water is a comestible and, as such, falls within the provisions of the German Foodstuffs and Commodities Act (LMBG).

	Anodic oxidisation	Electrochemical activation
Location of electrodes	in a bypass of the drinking water pipe (cold water line)	in a separate production facility
Protection of electrodes against calcification	Periodic polarity inversion	regular rinsing and decalcification, use of fully desalinated water and pure common salt
Reaction products arising on the electrodes	enter directly into drinking water and are mixed downstream	are separated by a diaphragm between the electrodes
Creation of hypochloric acid	Chloric gas results from the mixture of reaction products. This, together with water, produces hypochloric acid and hydrochloric acid	Hypochloric acid is produced directly on the anode and used as anodic fraction (anolyte) for drinking water disinfection
Peroxide gas (arises at the cathode)	Apparatus necessary for collection and removal	Can outgas in anolyte storage container
Effect of disinfection	systemic	systemic
Declaration of ingredients	The substances released into the drinking water cannot be ascertained in operation, the procedure as such must be approved.	The chemical ingredients of the anolyte can be determined even during operation. Samples can be taken from the storage container at all times

A comparison of anodic oxidation and electrochemical activation: There has already been a hearing at the DVGW (Deutsche Vereinigung des Gas- und Wasserfaches e.V. – German Technical and Scientific Association for Gas and Water) on the advantages and disadvantages of both methods.