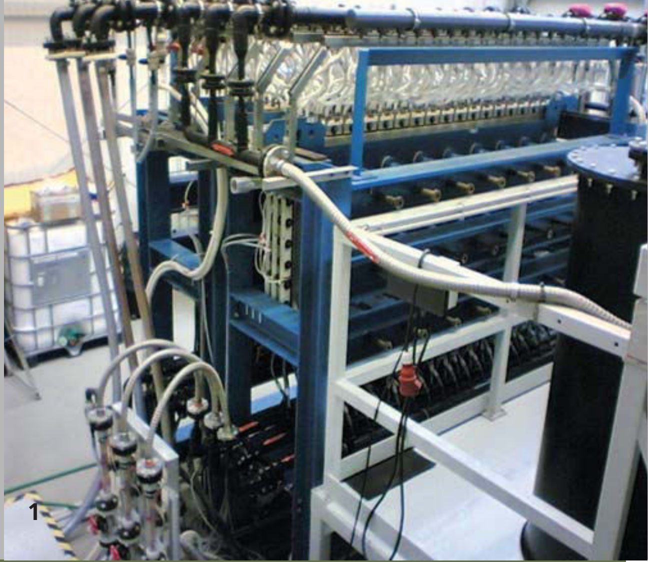

ELECTROCHEMICAL PROCESSES FOR WATER TREATMENT AND RAW MATERIALS RECYCLING

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Due to their selectivity, a relatively simple setup and good scalability, electrochemical processes have a substantial application potential in the areas of environmental and raw material technology.

For the treatment of highly mineralized, sulfate-rich mining waters, the RODOSAN® method was developed and tested on a technical pilot plant scale for different applications (Figure 1 and 2). It is a membrane electrolysis process, which allows for the extensively selective separation of sulfates while simultaneously converting them into usable products (sulfate fertilizer). For this reason, an unwanted water pollutant can be converted into a reusable material. This method represents an essential advantage in contrast to sparsely selective approaches, such as nanofiltration or reverse osmosis. Although water of drinking quality can be produced, the utilization of generated concentrates is still an unsolved problem in this case. In addition, such processes do not offer energetic advantages.

So far, a reduction of the salinity was possible up until 60 % on the technical pilot plant scale whereas on the bench scale, results of more than 80 % can be achieved in the meantime. Furthermore, heavy metal and aluminum ions are quantitatively separated and buffering capacity is produced. For this purpose, no process chemicals are needed.

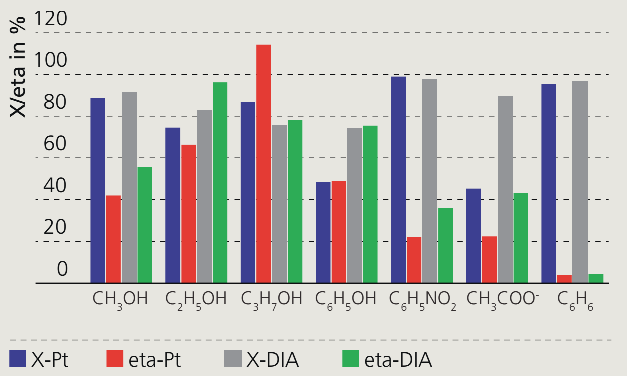
Initially, the treatment of calcium-rich waters caused problems due to considerable scaling in the membrane electrolysis cells. In the meantime, effective methods were developed and tested on the pilot plant scale. The process is primarily designed for the treatment of larger water volumes as typical for mining. However, the plants are modularly constructed so that a greater span width of plant sizes can be realized in practice (0.01–2 m^3/s). Alongside the treated water, produced fertilizer and H_2, CO_2 is used as process chemicals for the electrolysis to a considerable extent.

Membrane electrolysis processes are perfectly suitable for the destruction of persistent organic pollutants in contaminated waters. Numerous compound classes, e.g. nitroaromatics, are only partially degraded by means of alternative processes, such as photo- or ozonolysis. Biological degradation rarely takes place. In the case of electrochemical total oxidation, organic substances are completely converted to CO_2. In the process, the respective oxidized anions originate from heteroatoms, as illustrated in the following example (nitrobenzene):

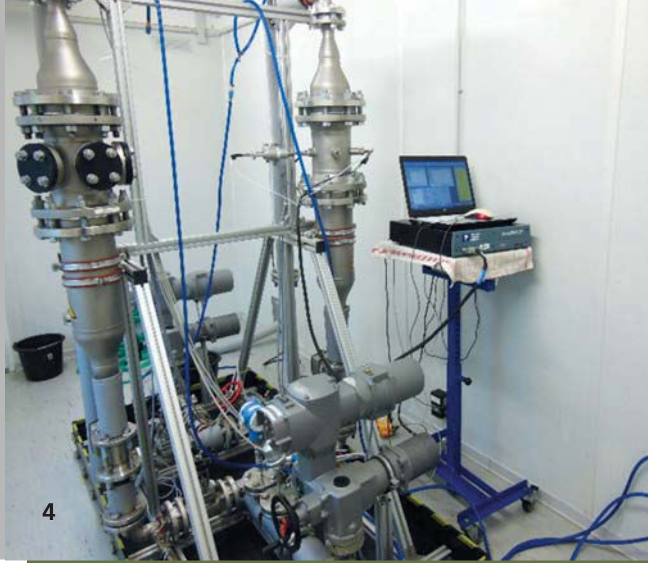
$$C_6H_5NO_2 + 13\,H_2O \rightarrow 6\,CO_2 + 31\,H^+ + NO_3^- + 30\,e^-$$

Meanwhile, the successful usability was shown for a complete series of application cases, partially up to the pilot plant scale (treatment of chemical waste waters, purification of contaminated ground waters containing residues of explosives, treatment of radioactive waste).

Conversions X and current efficiencies eta during the anodic oxidation after respectively 6 Ah



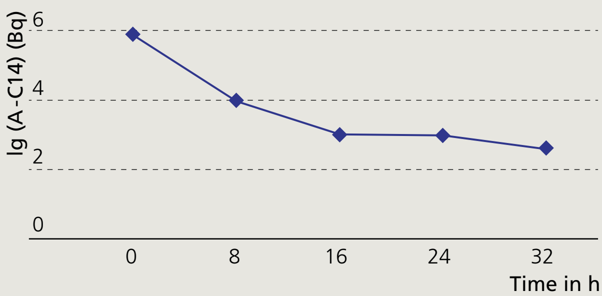
The latter is part of a current BMBF project with the goal of piloting (FKZ 02S9154). In this project, examinations concerning the influence of the electrode material and the reaction conditions on the conversion of various chemical compounds were



conducted on a broader basis. Here, boron-doped diamond proofed to be the superior anode material in most cases.

In the case of total oxidation of radioactive C-14 waste samples, whose composition is partially unknown in terms of material, a conversion was realized in first small scale tests (Figure 3), which allows for the disposal of the decontaminated liquid phase as conventional waste. In the process, the released C-14 CO_2 is transferred to alkaline earth carbonates suitable for final disposal in a downstream absorption step.

Time course of C-14 activity during the electrolysis of waste liquid

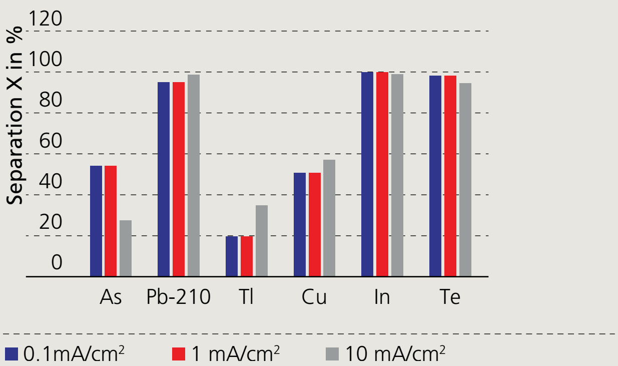


At the same time, the basis for recycling C-14 shall be established with this project.

The conditioning of thermal salt water in deep geothermics (BMWi project FKZ 0325696) is another application area, which focuses electrochemically on both the separation of radionuclides and the extraction of rare metals. Here, avoiding so-called scaling by means of naturally occurring radionuclides, such as Pb-210 and toxic heavy metals, has priority. Scaling in practice leads from operational malfunction through to safety-relevant component failure and to considerable additional cost for maintenance and disposal. The separation of unwanted components preferably downhole is the development objective. On the contrary, thermal salt waters partially contain rare metals in concentrations that basically allow for an extraction.

Within the scope of a funding project of the German Federal Environmental Foundation (FKZ 31916/01), both approaches are currently closely analyzed. The previous research results in model salt water show that both the electrochemical separation of toxic heavy metals and the deposition of rare metals, also regarding typically available concentrations <1 mg/l, are possible with mostly high yields.

Electrochemical deposition of scalents from model salt water, residence time per 240 s (10 mA/cm² = 120 s)



Particularly, the deposition of the critical nuclide Pb-210 appears to be very promising. Indium and tellurium can also be almost entirely separated. Regarding arsenic and thallium, further improvements are aimed at, being subject of further R&D activities. For the pending field tests, a mobile test with TÜV certification and mining-regulatory approval is available, which is also used for in-situ corrosion analyses (Figure 4).

The recovery of leaching chemicals from extracting secondary raw materials through electrodialysis and the development of electrochemical separation steps regarding the separation of rare earth elements and other rare metals are further fields of activity.

1 *Pilot plant for the electrochemical sulfate separation.*

2 *Overview of the plant site.*

3 *Laboratory test stand C-14 total mineralization.*

4 *Test stand deep geothermics.*

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