Performance of the Falling Film Chlor-Alkali Cell equipped with Carbon-free Oxygen Depolarized Cathode

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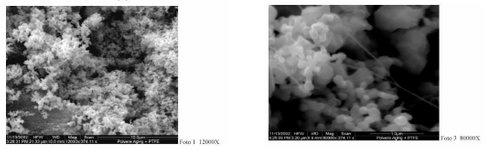
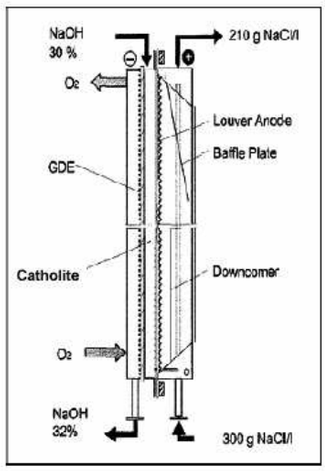
The use of Gas Diffusion Electrodes was introduced in the early 1980s as a feasible technological approach for the reduction of power consumption in the Chlor-Alkali process .
This result can be achieved by substituting the traditional cathodic reaction :
$2H_2O + 2e = H_2 + 2\ OH^-$ (1) $E° = - 0.828$ V
with the following one :
$2H_2O + O_2 + 4e = 4\ OH^-$ (2) $E° = + 0.401$ V
where , with the combined use of gas consuming electrodes (called for this particular application Oxygen Depolarized Cathodes : **ODC**) and oxygen gas as reactant , hydroxil ions are produced without producing hydrogen , resulting in a significative energy saving (a practical reduction of the power consumption of about 30% vs. the traditional process is easily attainable in a short term operation) .
The results of a joint research program , presently ongoing in this field between Gruppo DeNora and UHDE GmbH will be presented .
The type of structure used in an early stage of development was the so-called **ESNS** type electrode , manufactured by *E-TEK Inc.* , now ***E-TEK*** Division of **DeNora North America , Inc**. , Somerset , NJ .
The original structure , based on a silver catalyst particles supported on active carbon (Vulcan XC-72) , has been intensively tested in the "gas pocket" configuration , and subsequently modified , searching for practical solutions to the known phenomena of deactivation :

- **Electrode flooding** , due to progressive loss of hydrophobicity , and intrusion of the catholyte into the electrode's pores , also favored by the differential pressure existing between the gas side and the liquid side of the electrode .
- Progressive **corrosion** of both **carbonaceous components** and **silver catalyst** , followed by silver redistribution
- **Sensitivity to uncontrolled shut-down**

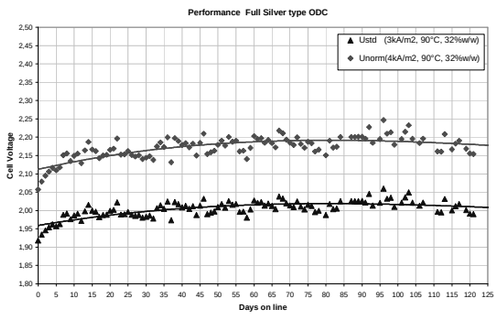
All these reasons suggested to concentrate the attention to a different type of electrode design , based on a **carbon-free catalyst** , that is an evolution of the past ESNS configuration .
The catalyst presently used is based on a mixture of micronized silver particles and PTFE binder .
The manufacture of the catalyst is rather critical , and requires an accurate control of the production parameters .
The scaled-up procedure is today suitable for the production of reproducible catalyst batches of 1 kg size .
The Ag particles show a very uniform size distribution , and contain a limited amount of Hg (lower than 5%) that is introduced to increase their stability to corrosion , as demonstrated by RDE analysis of the catalyst powder .
The average particle size is in the range from 10 to 50 nm as detected by XRD analysis . Typical SEM images of the catalyst are given below :



The catalyst is incorporated into a gas diffusion electrode structure , that contains a Ag net used to support the catalyst mass and distribute the current . The construction of the electrode is simple , and no structural differences exist at the moment between the gas and the liquid side .
This electrode structure is presently under long term test , at the Gersthofen (DE) test facility , using the Falling Film Chlor-Alkali cell design , schematically described below :



Some results obtained to date , in an experimental cell having an active surface of 0,16 m^2 , representing a full-height section of an industrial electrolizer , are given in the following graph :



The most important achievement of this type of configuration is the stability of the system also during uncontrolled shut-down , providing that the cell is protected with a polarization rectifier . Some results of the systematic approach used to understand the behavior of the system during various possible conditions occurring during shut down will be discussed , including some interpretation of the operating data , mainly during the first days of cell operation .
Some economical considerations will be finally given , including a comparison with an alternative approach to recover energy , that foresees the use of the hydrogen produced by the traditional Chlor-Alkali process as fuel for PEMFC stacks .