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Experimental Evidence of a Neutron Flux Generation in a Plasma Discharge Electrolytic Cell

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Abstract. A substantial neutron flux generated by plasma excitation at the tungsten cathode of an electrolytic cell with alkaline solution is reported. A method based on a CR-39 nuclear track detector coupled to a boron converter was used to detect the neutrons. This method is insensitive to the strong plasma-generated electromagnetic noise that made inconclusive all the previous attempts to identify neutrons in electrolytic plasma environment by means of electric detection techniques.

Introduction

Extensive experimental studies on different unexpected phenomena occurring in electrolytic plasma cells with alkaline water solutions have been conducted by Mizuno et al. starting from 1997 [1-2], followed by other researchers working on Mizuno-type electrolytic cells [3-6]. It has been reported that plasma generated under high voltage electrolysis (generally above 120 V, depending on electrolyte density and temperature) and confined on the cathode (e.g. tungsten, platinum) produces:

1. a large amount of heat that seems to exceed the input electric power [1-6];
2. new chemical elements on the cathode surface and/or in the electrolyte, which cannot be considered contaminants because their isotopic distribution is drastically different from the natural one [1,2,6].

The theoretical interpretation of the physical mechanism responsible for the unusual phenomena developed in electrolytic plasma cells is discussed by us in another presentation at this conference [7]. Up to date, even without a clear understanding of the physics behind the generation of new chemical elements an important role was intuitively recognized to the thermal neutrons. In fact, it is well known that thermal neutrons can destabilize the equilibrium of the atomic nuclei, because they can easily join the nucleus without suffering a Coulomb repulsion. Several measurements of neutron flux near plasma discharge were attempted using electrical detectors (BF_3, He_3), but the strong plasma-generated electromagnetic noise made them inconclusive [1]. Therefore, up to date no clear evidence of neutron generation has been reported and there is no understanding of the mechanism by which new chemical elements are generated during plasma discharge.

In this paper, experimental evidence of neutrons generation by a plasma discharge in an electrolytic cell is reported. The neutrons detection method is based on the use of a CR-39 nuclear track detector coupled to a boron converter, which is unaffected by artifacts derived from plasma-generated electromagnetic noise that made questionable previous attempts to detect neutrons in electrolytic plasma environment.

Experimental set-up

A modified Mizuno-type electrolytic plasma cell was used for the experiments. The schematic of the experimental set-up is shown in Fig. 1. The cell consists of a double wall Pyrex vessel of 100 mm internal diameter and 220 mm height. The vessel was closed by a polytetrafluoroethylene, PTFE (Teflon®), cover provided with three main holes, two for the electrodes and one for the thermocouple, and some venting outlets. The cathode was a tungsten rod (Goodfellow, 99.95% purity) of 3 mm diameter and 200 mm length, partially covered at the upper extremity by a ceramic casing (Al_2O_3) which allows the control of the electrode length exposed to electrolysis. The anode was a steel mesh (0.8 mm wire diameter, 2 × 2 mm^2 mesh surface) rounded in cylindrical shape (40 mm height, 220 mm length) wrapped around the cathode. The electrolytic solution was made of 0.5 M analytical-grade (Farmalabor) potassium carbonate, K_2CO_3, in 700 ml of double-distilled water (solution pH > 10). The cell was DC powered and the input electric power was measured by an energy analyzer (Elcontrol VIP System) connected to a power regulating system. An electronic interface system and a versatile LabVIEW™ software were specifically developed for data acquisition and online monitoring of the experimental parameters: voltage and current in the cell (measured and stored with 20 kHz sampling frequency), temperature and water flux in the cooling equipment.

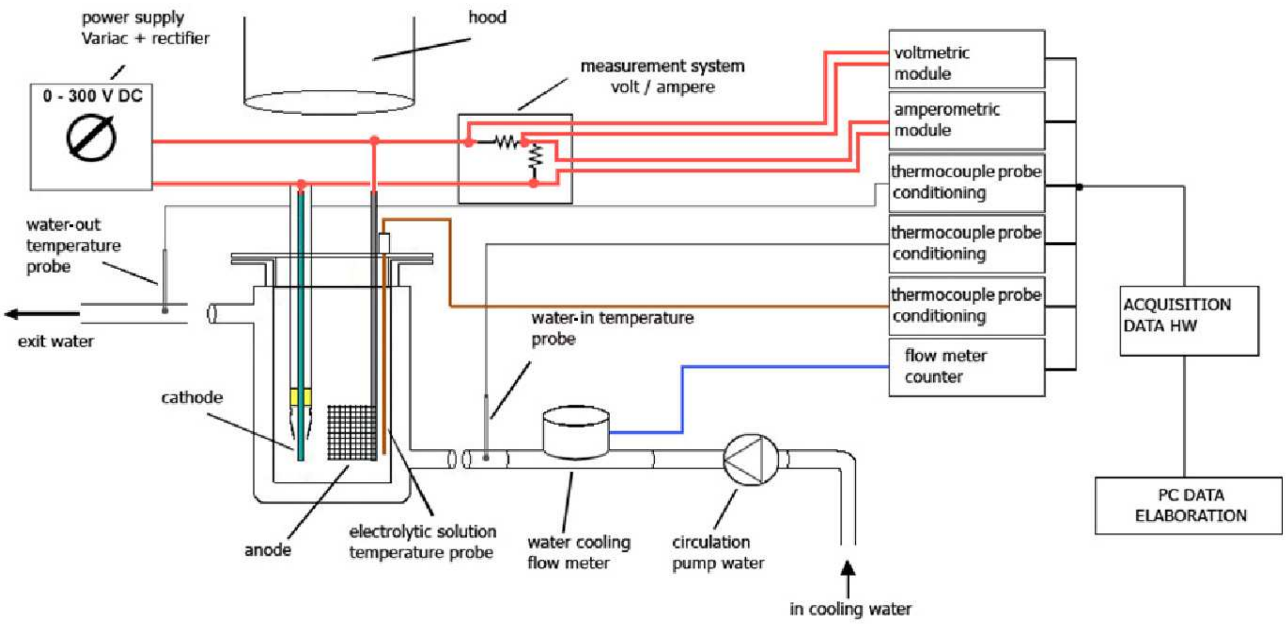

Fig.1 Experimental set-up for the generation of a plasma discharge in an electrolytic cell.

The method used to identify the plasma generated neutrons was based on a CR-39 nuclear track film-shaped detector coupled to a boron converter. The CR-39 (allyl diglycol carbonate) detector (10 × 10 × 1 mm^3 active volume) was inserted into a polystyrene cylinder (hermetically sealed) which was covered by analytical-grade boric acid grains, H_3BO_3, (Farmalabor, 99.9% purity, 0.5 mm average grains size), used as neutron converter (Fig. 2). The detector was positioned into the electrolyte, in proximity of the plasma discharge. Through the $^{10}B(n,\alpha)^7Li$ nuclear reaction [9-12], the neutron flux is converted by H_3BO_3 into α particles detectable by the CR-39 sample.
The detector was calibrated by exposure to a reference, certified neutron flux generated by an *Am-Be* neutron source under metrology laboratory conditions. 20 detector samples were exposed to the known flux of thermal neutrons (120 $n \cdot s^{-1} \cdot mm^{-2}$) for different exposure times: 1 min., 5 min., 20 min., 40 min., 60 min., and 0 min. (blank sample). All the samples were analyzed by an optical digital microscope and 10 digital images were recorded for each detector. A dedicated software was

used to count the tracks from the recorded images and to calculate the average number of tracks for the same exposure time. The calibration curve of the CR-39 detector - tracks density vs. exposure time to the thermal neutron flux - was determined.

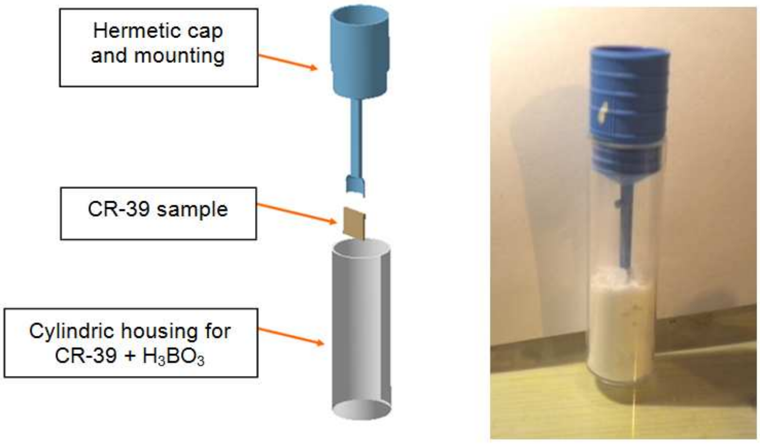

Fig. 2 Neutron detector scheme (left) and photo (right).

Experimental results

The CR-39 detectors exposed to the plasma discharge recorded a significant number of tracks, while the 'blank detector samples', positioned far from the cell activity (> 5 m), but in the same room, did not detect any relevant tracks. The values of the track density measured after detector's exposure to two plasma discharges under 290 V and 2.5 A, for 500 s, are similar to the density value measured after 50 min. exposure to the calibration flux of thermal neutrons (Fig. 3). From the calibration curve, an average thermal neutron flux of 720 $n \cdot s^{-1} \cdot mm^{-2}$ generated by the plasma discharge was estimated in the region of the CR-39 detector.

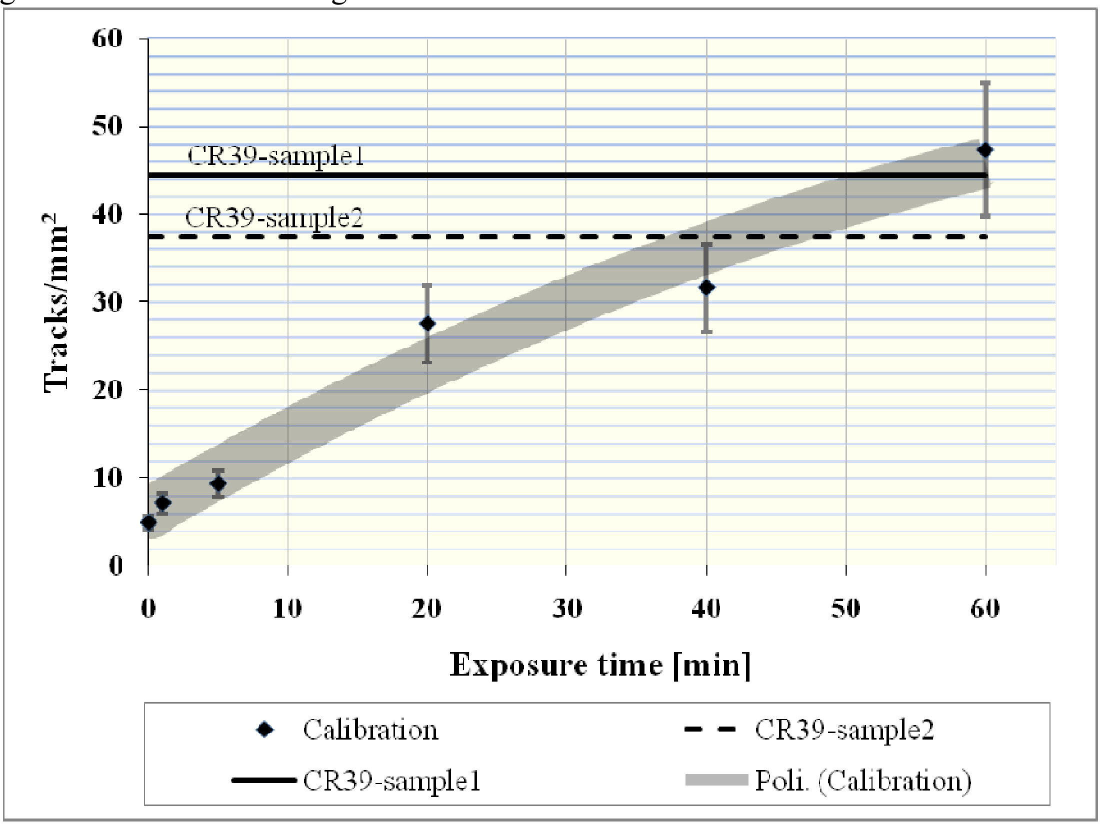

Fig. 3 Track density vs. exposure time for the calibrated CR-39 detector and for the plasma exposed CR-39 Sample1 and CR39 Sample2.

Conclusions

A neutron detection method based on a CR-39 nuclear track detector coupled to a boron converter was successfully employed to show neutron generation by plasma discharge in an electrolytic cell with alkaline solution. An average of 720 $n \cdot s^{-1} \cdot mm^{-2}$ thermal neutron flux was estimated in the proximity of the plasma discharge, at the tungsten cathode of the electrolytic cell, while the blank detector sample shows no tracks. This method can give only a rough estimation of the plasma generated neutron flux, owing to the reduced cross section of the sequential events required to produce a track on the CR-39 detector. Nevertheless, the proposed method clearly evidences a thermal neutron flux generation in this low energy system.

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