In-situ long - range alpha particles and X-ray detection in Pd thin film-cathodes during electrolysis in Li_2SO_4/H_2O

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Introduction/Objective

- Long-range alphas with energy 8.0 –14.0 MeV were measured earlier at D(H)-desorption from Au/Pd/PdO:D(H).
- Essential X-ray emission should be a signature of massive nuclear reactions that could produce excess heat.
- In-situ measurement of energetic particles,X-ray emissions with CR-39 detectors and calorimetry during electrolysis.

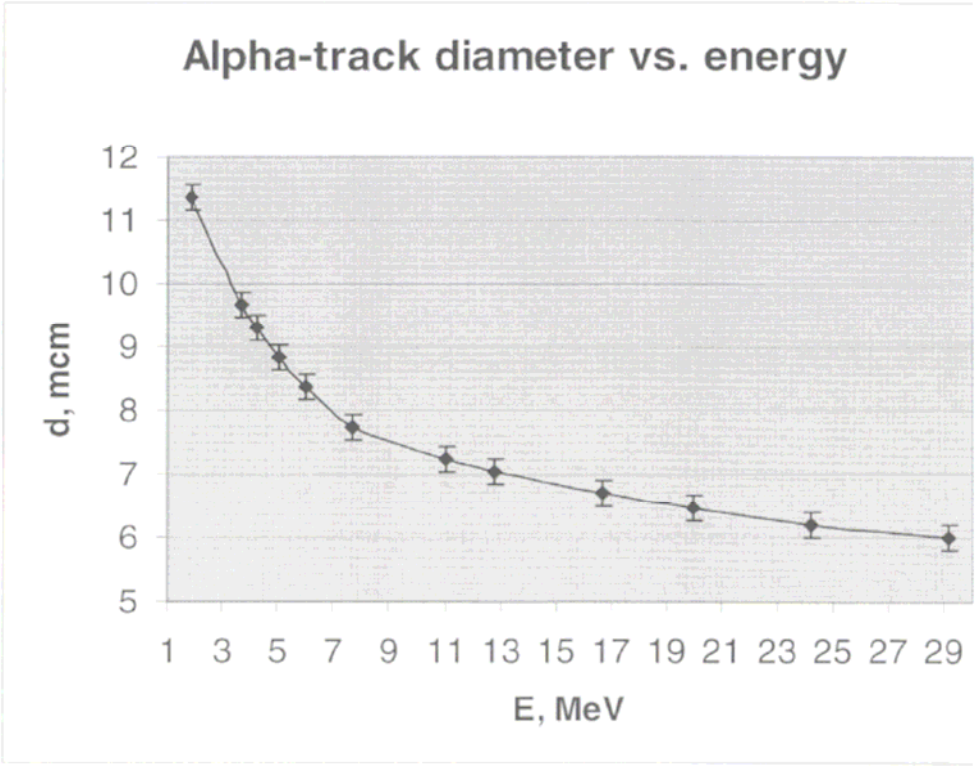
CR-39 track Detectors

- CR-39 detectors "Landauer" rad-track; S=2.0x1.0 cm^2 attached to Pd/Ni thin film cathode(Foreground); to substrate side or/and immersed in electrolyte in the cell (Background). Low initial Bg before electrolysis: N(Bg) < 40 track/cm^2.
- In special experiments used CR-39 covered with 25 μm Cu-film to identify type of emitted particle

CR-39 treatment and calibration

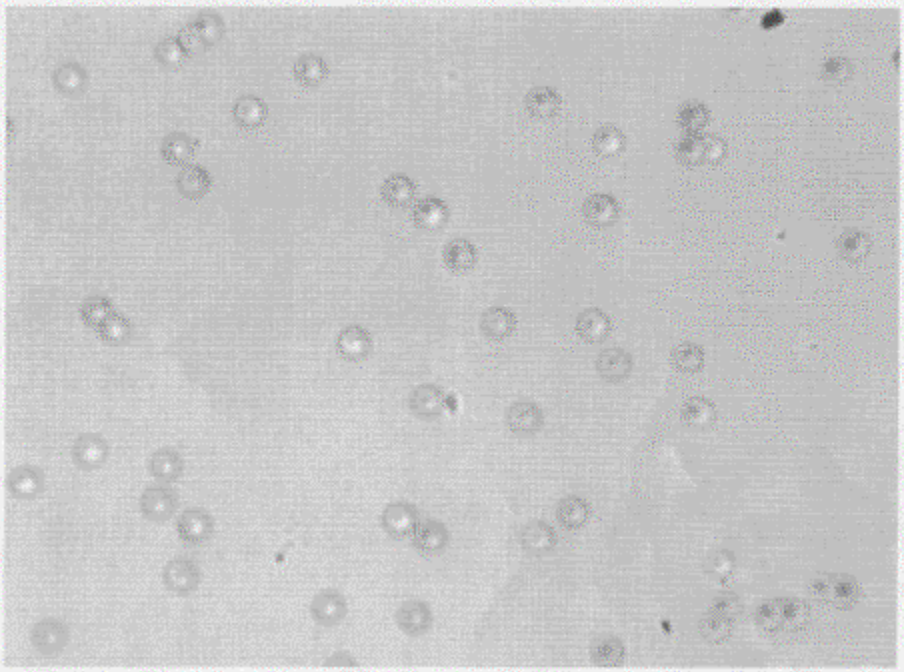
- After exposure detectors were etched in 6N-NaOH at t=70°C during 7 hrs. and investigated with optic microscope
- Calibration: for alphas E < 8.0 MeV – alpha-sources; for E ~8.0-30.0 MeV Cyclotron of LNR, JINR, Dubna; for protons 0.75-3.0 MeV Van-DeGraaf accelerator, RINF, MSU, Moscow

Alpha calibration

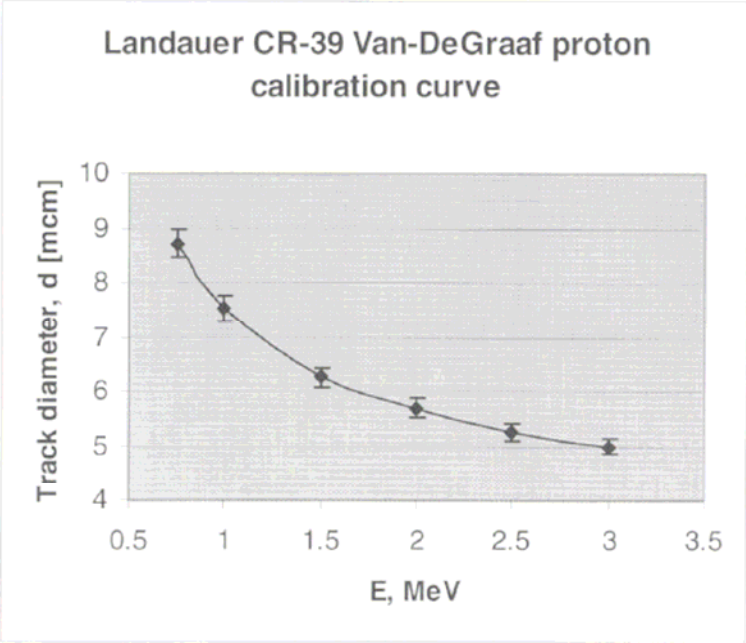


LENR

Tracks from 12.0 MeV α-particles; image area S= 0.2x0.2 mm, (X 700)



Proton Calibration



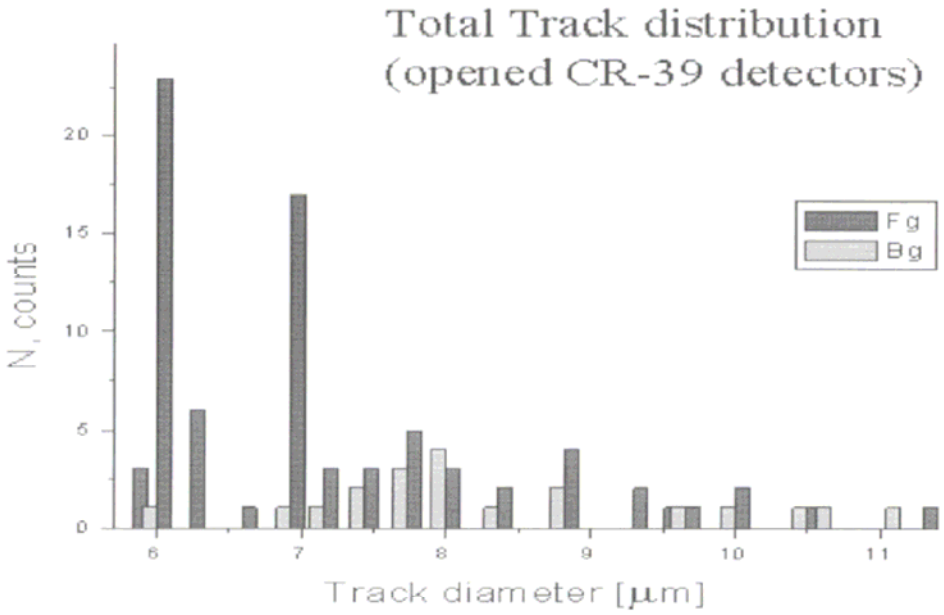
X-ray detection

- TLD: LiF (2.0x2.0x1.0 mm^3) – sensitivity ~ 1 mrem; Al_2O_3:C (2.0x2.0x0.2 mm^3)-sensitivity 0.2 mrem shielded by 50 μm PE-film and fixed at Pd-film surface. Background detectors at the bottom of electrolytic cell
- Initial Background (before runs) for LiF – 4.0 mrem, for Al_2O_3 – 10.0 mrem.

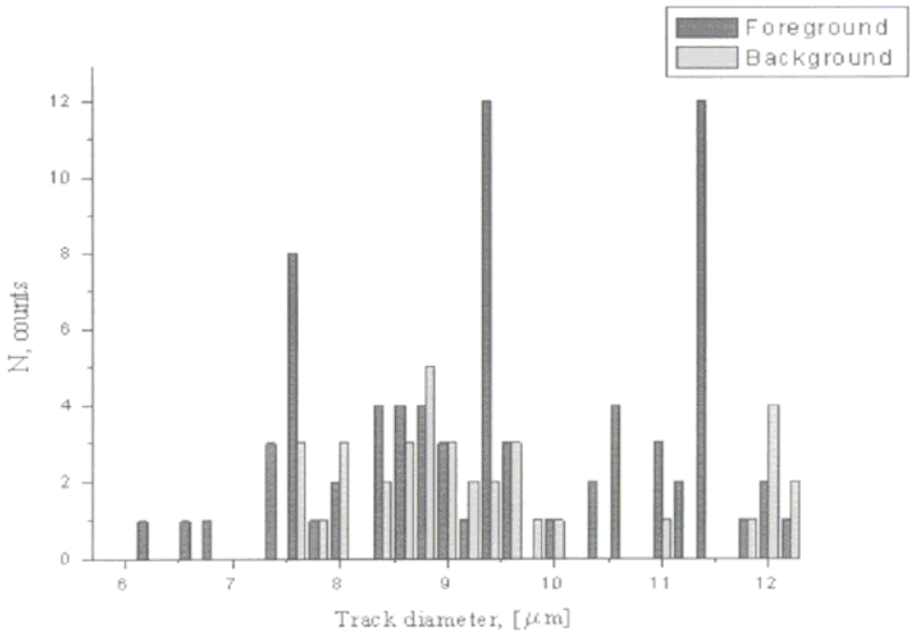
Experimental Results

- Two significant peaks at 7.0 μm and 6.0 μm observed only in Foreground runs with opened CR-39 detectors.
- Almost no counting for tracks with d < 7.5 μm in Background runs.
- With Cu-film shielded CR-39 7.0 and 6.0 μm peaks disappeared. But 3 other peaks ranging from 7.5 to 11.4 μm remain after Background subtracting.

Histograms of track distributions with opened CR-39 detectors



Histograms of track distributions with Cu-shielded CR-39 detectors



X-ray results

- Reproducibility of results is not satisfied. Best result with LiF TLD for Pd/glass-sample (fractured) with Background subtraction:

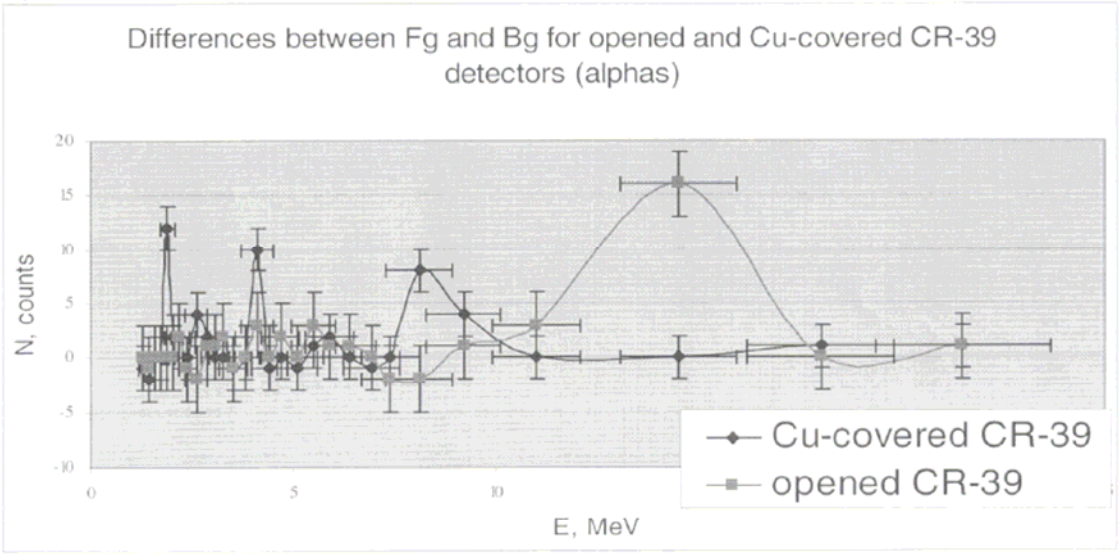
  $\Delta n_x = 2.0 \pm 1.0$ mrem,

  This dose consistent to 5.0-10.0 keV X-ray quanta yield upper limit $Y_x \leq 5.0\ s^{-1}xcm^{-2}$. Expected X-ray production from alpha and proton emission is: $N_x \sim 0.4\ s^{-1}xcm^{-2}$.

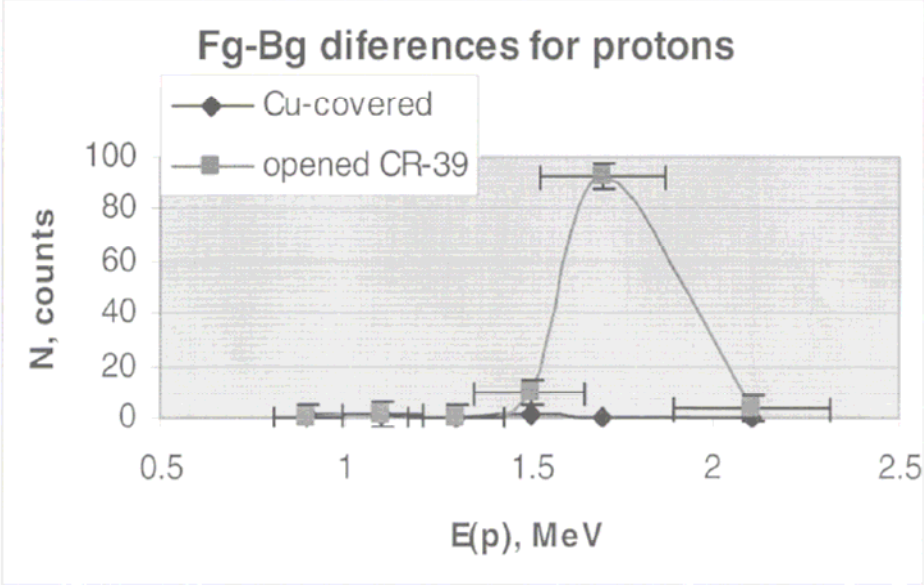
Discussion

- Tracks with d=7.0 μm could be either 13.5 MeV alphas or 1.25 MeV protons
- Tracks with d= 6.0 μm could be either ~29 MeV alphas or 1.7 MeV protons
- 25 μm Cu-foil totally absorbs all alphas with E < 9.0 MeV and protons with E < 2.4 MeV.

Alpha-tracks with Background subtracting



Proton tracks with Background subtracting



Discussion II

- Disappearance of 6.0 μm peak for CR-39 covered with Cu-foil indicates to 1.5-2.0 MeV protons. $\langle n_p \rangle = (1.15 \pm 0.10) * 10^{-3}$ $s^{-1}cm^{-2}$
- Shift in 7.0 μm peak (opened detector) to 9.0-11.0 μm is a proof of 13.5 ± 2.5 MeV alphas in Foreground.
- Yield of 13. 5 MeV alphas at efficiency:

  $\varepsilon = \frac{1}{2}(1-\sin\theta) = 0.13$; ($\theta = 48°$)

  $\langle n_\alpha \rangle = (2.2 \pm 0.3) * 10^{-4}$ $s^{-1}cm^{-2}$.

Conclusions

- During the electrolysis of Pd/Ni thin films in Li_2SO_4/H_2O electrolyte alpha particles with estimated energy 13.5±2.5 MeV and protons ~ 1.7 MeV were detected.
- Excess heat production does not always correlate with charged particle emissions
- Upper limit of X-ray emission rate during electrolysis doesn't exceed several 5-10 keV s^{-1} x cm^{-2}. No massive nuclear reactions.