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Reproducible nuclear reactions during interaction of deuterium with oxide tungsten bronze

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The possibility of an essential increase of the rate of nuclear reactions with deuterium in solids being solid electrolytes with cation-electronic conductivity is shown. Monocrystals of oxide tungsten bronzes, on the surface of which are structures which provide the direction of the movement in the crystals of the deuterium ions created by anodic treatment, were used as such electrolytes. It is found that strictly maintaining the experimental parameters leads to completely qualitatively reproducible results: generation of neutrons and heat when deuterium is introduced into the system.

Beginning with the famous work of Fleischmann and Pons on cold fusion [1] the investigators of anomalous nuclear phenomena in condensed matter have not succeeded in getting 100% reproduction of their results on the observation of the emission of nuclear reaction products. All these experiments were carried out with solids on the basis of metal–hydrogen systems, neither the structure nor the crystallographic orientation being controlled. Unlike all other experiments carried out earlier to achieve a high level of reproduction we used principally new materials to investigate: monocrystals of oxide tungsten bronzes (OTB) of non-stoichiometric compounds, having the general formula Na_xWO_3 (fig. 1). The (100) facet of the crystal was a working surface and the channels of the rigid W–O sublattices were perpendicular to it. Alkali metal cations are located and can move in these channels. Depending on the alkali metal content in the OTB, in consequence of the change of the valency of tungsten in the W–O sublattice, the electronic conductivity of the OTB can vary greatly. This allows one to create structures with great differences in composition and the properties conditioned by it.

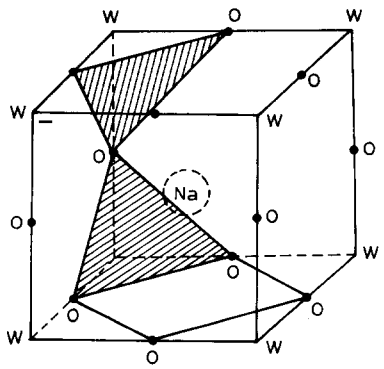

Fig. 1. The structure of Na_xWO_3.

Natrium may be extracted from the channels in

the surface layer of the bronze crystal and replaced by hydrogen ions (or deuterium ions) by electrochemical methods (anodic treatment in salt melts, water solutions or vacuum). The cationic radius of the hydrogen ions is less than that of natrium and their mobility in the grating channels is higher.

The main part of the experimental installation is a hermetic chamber of stainless steel (fig. 2). The anode and cathode consisting of tungsten plates situated beside each other are inserted into the chamber. A monocrystal of natrium tungsten bronze of composition $Na_{0.9}WO_3$ in the form of a plate $10\times10\times2$ mm^3 in size was placed on the anode. The plate was cut from a monocrystal grown by electrolysis of a polytungsten melt according to the technique worked out by two of us in such a way that the natural facet (100) was a working surface. At the mounting of the installation a gap of 2 mm between the working surface of the crystal and the cathode was kept. The chamber was adjoined to a vacuum system and a hydrogen dosage system.

The measurements of the neutron flow were taken by means of two independent blocks of counters (with four counters of SNM-42 type with paraffine retardant in each block). These blocks were placed at both sides of the chamber, their signals were summed by a digital recorder and were led out independently to the register tape. The total efficiency of the two blocks was about 1.4%. In the third channel was a scintillation detector with a polyethylene retardant with an efficiency of about 0.1%.

The crystal temperature was measured by a chromel–alumel thermocouple made of wires 0.1 mm in diameter, pressed to the lateral surface of the crystal.

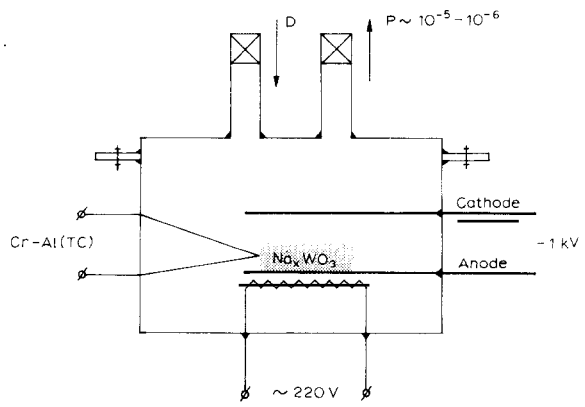

Fig. 2. Experimental chamber.

After placing the crystal on the surface of the anode the chamber was hermetized and evacuated up to 10^{-6}–10^{-5} mm Hg. After that the anode with the crystal was heated up to 720–760°C and a direct voltage of 500–1000 V was switched on between the anode and cathode and the passing current was registered. This anodic treatment lasted 1–5 h and the total amount of electric charge was 0.1–1.0 C. After switching off the current the crystal was cooled to room temperature and deuterium (or hydrogen) was introduced into the chamber till the pressure became 1 mm Hg. The moment of introduction was considered as the zero point of counting and was registered on the tapes that registered the neutron flow and temperature. The digital neutron recorder was restarted at the same moment. In 10 min the chamber was evacuated once more and the neutron flow and crystal temperature were being registered.

Then the cycle was repeated. Up to 15 cycles were carried out with one crystal.

Results. The neutron flow intensity after the deuterium introduction increases sharply, passes through a maximum and in 10–20 min the registration does not exceed the background (fig. 3).

One can always choose a two minute interval during the first 5 min, when the average intensity of the neutron flow exceeds the background by several times.

The same neutron impulse but with a smaller intensity is observed after beginning the pumping out.

Thus, for example, in one of the last series of four experiments with the same monocrystal (the total number exceeded by 100 those with positive results) the average neutron emission was fixed during 2 min at the infusion (800 ± 300 n) and the pumping out (650 ± 300 n) at signal to background ratios of 8 and 6 correspondingly. In one of the control experiments using a detector of another type developed by the collaborators of the Lugansk Machine-building Institute for this purpose the flow was held at $(3.6\pm1.3)\times10^4$ N/min. In the experiments with hydrogen no neutron flow above the background was found.

The increase of the crystal temperature takes place at the same time as the introduction of both hydro-

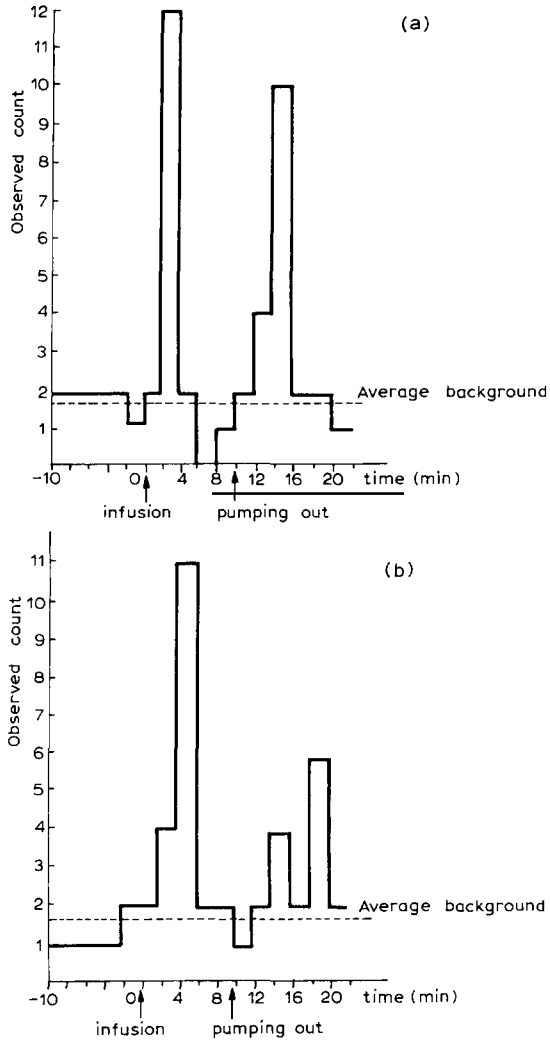

Fig. 3. Typical observed neutron production in two experiments.

gen and deuterium. The front of the temperature increase for deuterium is more steep, the temperature jump (ΔT) varies greatly, reaching sometimes 40–50°C for deuterium. In the series of experiments with the same crystal, in which after the deuterium infusion followed hydrogen infusion, then again deuterium and then hydrogen (5 experiments with each of the gases), it was determined that the temperature jump for deuterium is higher than that for hydrogen (fig. 4).

The main result of the work is that we have reached the level of qualitative reproduction of an experiment, at which repeated measurements with the monocrystal of OTB described earlier lead to the same result within 1 min: the generation of neutrons and heat in the experiments with deuterium and neutron generation stops 10–20 min later. Thus a single action causes the effect only once.

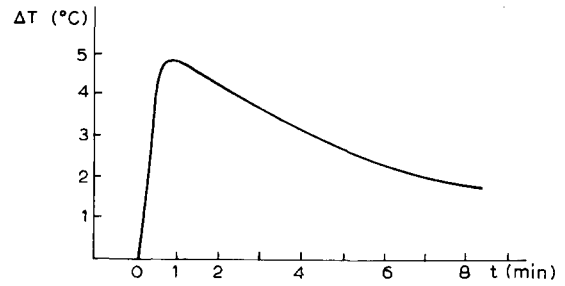

Fig. 4. Generation of heat in one of the experiments with deuterium.

If the reaction generating neutrons occurs at the expense of the deuterium absorbed by the crystal channels mentioned above, and the whole current in the anodic treatment is spent for the extraction of natrium, the number of deuterium atoms, N_1, absorbed by the crystal will be equal to the number of extracted natrium atoms (when 1 C of electricity Q passes),

$$N_1 = \frac{QN_A}{F} \approx \frac{1\ (\mathrm{C}) \times 6 \times 10^{23}\ (\mathrm{at/mol})}{96500\ (\mathrm{C/mol})}$$

$$\approx 6 \times 10^{18}\ \mathrm{D\ atoms}\,,$$

(F denotes 1 faraday, N_A is Avogadro's number). The average neutron emission rate per deuteron pair (DD) at infusion will be

$$A_1 \approx \frac{400/60\ (\mathrm{n/s})}{3 \times 10^{18}(\mathrm{DD})} \approx 2 \times 10^{-18}\ \mathrm{n\,s^{-1}\,(DD)^{-1}}\,.$$

Even if the neutron emission rate is attributed to all the deuterium in the working chamber ($N_2 \approx 6 \times 10^{19}$ D), then

$$A_2 \approx 2 \times 10^{-19}\ \mathrm{n\,s^{-1}(DD)^{-1}}\,.$$

The results of this work allow one to reach a new experimental level: the determination of the qualitative dependences between the process parameters, which will give an opportunity to find out the mechanism of the phenomenon observed and to discover ways of realization of the controlled process.

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References

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