EFTTRA, A EUROPEAN COLLABORATION FOR THE DEVELOPMENT OF FUELS AND TARGETS FOR THE TRANSMUTATION

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ABSTRACT

In the frame of the research programmes on the transmutation of long lived nuclides, many experimental or theoretical investigations have to be carried out within European collaborations, owing mainly to the costs of such studies. Therefore, a group named "Experimental Feasibility of Targets for Transmutation" (EFTTRA), has been formed, with participants from CEA (France), ECN (The Netherlands), EDF (France), KFK (Germany) and ITU (European Commission), to organise joint experiments for the study of materials for the transmutation. So far, it was decided to focus the work on the transmutation of ^{99}Tc (metal), of ^{129}I (compound), and of Am (in an inert matrix). Irradiations will take place in parallel in the Phenix fast reactor in France, and in the high flux thermal reactor HFR in the Netherlands. These experiments, together with the related post-irradiation examinations, constitute the first phase of the EFTTRA collaboration. In subsequent phases, EFTTRA will contribute to the development of fuels and targets.

INTRODUCTION

In the field of the research on nuclear wastes management, the problem of the long-lived radioactive nuclides requires careful thought. The possibility of separating and transmuting these long-lived radioactive nuclides, with the aim of reducing the radiotoxicity of the final waste, has to be investigated. To carry out such experimental or theoretical investigations in the frame of an international collaboration presents many advantages, one of them being to split the costs of the studies. Therefore, the decision to form a group devoted to technical problems, together with European partners, was taken.

BUILDING-UP OF EFTTRA

Following the Second Meeting of the Working Group on Targets and Fuels organised by ITU on June 1992 in Karlsruhe [1], participants from CEA (France), ECN (The Netherlands), EDF (France), KFK (Germany) and ITU (European Commission), decided to start a collaboration with the aim of setting up joint experiments for the study of materials for the transmutation. The group was named "Experimental Feasibility of Targets for Transmutation" (EFTTRA), and meets regularly since September 1992. A contract has recently been signed, and the support from the Human Capital and Mobility programme of the European Commission is under consideration.

The experimental programme itself, which is divided into phases, is defined in common ; the tasks are distributed according to the potentialities of the partners, and described in technical annexes corresponding to each phase. The balance of the contributions of the different partners is an essential condition for a smooth development of the collaboration ; each partner should bear the costs for his own actions, unless specific arrangements, agreed upon by all partners, are made to restore the equilibrium of the different contributions. More generally, it was decided to share the costs for the purchase of basic materials, for transport, and for the waste treatment. The extension of the collaboration to further partners willing to contribute to the experimental programme, is open, provided they agree with the terms of the contract.

EFTTRA PROGRAMME

The goal of the EFTTRA collaboration is the study of materials for transmutation, including the fabrication and characterisation of fuels and samples, their irradiation, and the test of their in-pile behaviour. The work should be limited to the basic study of fundamental aspects of the problem. Being the subject of other programmes, the reprocessing and the partitioning as such are not concerned by EFTTRA, but their interrelation with transmutation should of course be taken into consideration. The same remark applies to strategies, where the type of reactor to be used for transmutation is, among others, an important parameter.

The first meeting reflected the concern of the participants to deal with concrete, precise problems : after an evaluation of the needs, and of the subjects already studied otherwise, three topics were finally selected, namely the behaviour of americium, technetium and iodine under irradiation, in the frame of the heterogeneous recycling route ; the homogeneous recycling of Am is the field of other international collaborative efforts, as illustrated for example by the irradiation experiments SUPERFACT 1 [2] and SUPERFACT 2 (in preparation). Irradiations of ^{99}Tc (metal), of ^{129}I (compound), and of Am (in an inert matrix) were discussed. The first phase of the EFTTRA collaboration was defined as the irradiation of Tc samples, ^{127}I compounds, and "empty" (without Am, but partially using U to simulate Am) inert matrices, and the related post-irradiation examinations. The irradiations take place in parallel in the Phenix fast reactor in France, and in the high flux thermal reactor HFR in the Netherlands. Possibly, the thermal reactor Osiris will be used at a later stage for some additional experiments, for simulating PWR conditions. In subsequent phases, and more generally, with a feed-back from the results obtained besides on the reprocessing and the partitioning, EFTTRA will contribute to the development of fuels and targets. The phases of the collaboration being defined by objectives, and not by dates, an overlapping of different phases is possible. Fig.1 shows a tentative planning of the EFTTRA activities.

The objective of the irradiation of Tc is the knowledge of its behaviour under irradiation, the determination of the importance of the self-shielding effect, and a first estimation of the transmutation rate. Concerning I, samples of PbI_2, CeI_3, and NaI (replacing the initially foreseen YI_3) will be irradiated in HFR, for a verification of the transmutation rate, and for an investigation of the chemical interaction with the cladding.

The comparison of the production of plutonium isotopes through transmutation of actinides for UO_2 based fuels (homogeneous recycling) and for MgO targets (heterogeneous recycling) shows that for the same transmutation rate, the produced plutonium is lower by a factor of 2 in the case of an inert matrix. Therefore, the possibility of utilising inert matrices for the transmutation of Am is worth investigating. The irradiation of several candidate matrices, scheduled for 94/95 in Phenix (MATINA irradiation) [3], will serve as preliminary tests (in some cases with uranium to simulate actinides), mainly of their behaviour under irradiation ; it will allow the selection of the matrices which will be used for a later irradiation experiment with Am.

STATE OF THE ART

Irradiation of Tc and Iodine compounds in HFR

In April 1994, the irradiation of 3 technetium samples and 6 iodine compounds has started in the HFR in Petten (Fig.2). The technetium samples, fabricated at ITU, consist of casted metallic rods which are encapsulated in 15-15 Ti stainless steel. For the iodine compounds, three different metal iodines have been selected on the basis of an analysis of their neutronic and physico-chemical properties : cerium triiodide (CeI_3), sodium iodide NaI, and lead diiodide (PbI_2). The samples, fabricated at ECN, are also encapsulated in 15-15 Ti stainless steel. The thermal neutron fluence rate in the core position is about 2 $10^{18}m^{-2}s^{-1}$, the irradiation temperature is about 430°C. At this temperature, PbI_2 is in a molten state. The irradiation will be stopped after 8 HFR cycles, in January 1995. The expected transmutation rates are about 5% for the technetium samples, and about 3% for the iodine samples.

After irradiation, the samples will be distributed among ITU, CEA and ECN for post-irradiation examination (PIE). The examinations of the three technetium samples will focus on the material behaviour (swelling), the examination of the iodine samples on the interaction of the samples and the cladding. In addition, the transmutation efficiency will be determined by the analysis of the produced ruthenium (radial distribution and absolute quantities) in case of technetium and of the produced xenon in the plenum of the iodine capsules.

Irradiation of matrices in Phenix

The rig containing the candidate inert matrices (MATINA experiment) for Am transmutation (heterogeneous recycling mode), has been mounted in the Phenix reactor for irradiation ; Phenix has diverged in September 1994, and operation at 2/3 of the power should start before the end of 1994. Fig.3 shows the arrangement of the pins in the Phenix rig.

Five ceramics (oxides, nitrides), and four refractory metals have been selected according to their thermodynamic, physico-chemical, and mechanical properties and to the (scarce) knowledge on their behaviour under irradiation. Al_2O_3 and MgO have been chosen for their good basic properties, in spite of a large swelling under irradiation ; MgO being soluble in the conditions of the PUREX process, and inert with the sodium, appears to be the best candidate for the fast reactors. For the PWRs, the best oxide seems to be the spinel ($MgAl_2O_4$), because of its good behaviour under irradiation.

Additional studies on the matrices

New matrices, not included in the MATINA experiment, have been proposed as candidate for the fabrication of Am targets. For these matrices, a lack of knowledge of their properties hindered a strait forward irradiation in Phenix ; preliminary out-of-pile studies are required, and have been started at ITU, with a financing by EDF. A bibliographic study let to a first selection of these new matrices ; ion implantation experiments have been started for a better understanding of possible irradiation damages both in matrices already selected for MATINA (like spinel), and in new matrices. At a later stage, compounds of these matrices with Am will be examined for defects after 1 year storage.

Irradiation of Tc in Phenix

The irradiation of 3 Tc samples, identical to the samples of the HFR irradiation will be irradiated in Phenix from 1995 to 1998 (ANTICORP 1 irradiation). The fabrication by ITU of these 3 samples should be completed by the beginning of 1995, depending on the progress in the operation of the Phenix reactor.

CONCLUSION

The EFTTRA collaboration has now reached its cruising speed, with the first irradiation experiments on their way ; the results of each experiment will be reported separately as soon as available. EFTTRA demonstrates the possibility for European partners, to share their resources on a fair basis in order to reach well defined common goals in relation with practical problems. Regular meetings allow an up-dating of the experimental programmes, on the basis of an exchange of information on the latest technical developments in the given field or in correlated fields. The adaptation to the evolution of the individual programmes of the partners, concerning for exemple new priorities, or the budget, is also an important point of discussion ; actually, the time scale of this research project is larger than that of most of the individual programmes of the partners. The way EFTTRA operates seems to be an answer to this paradox.

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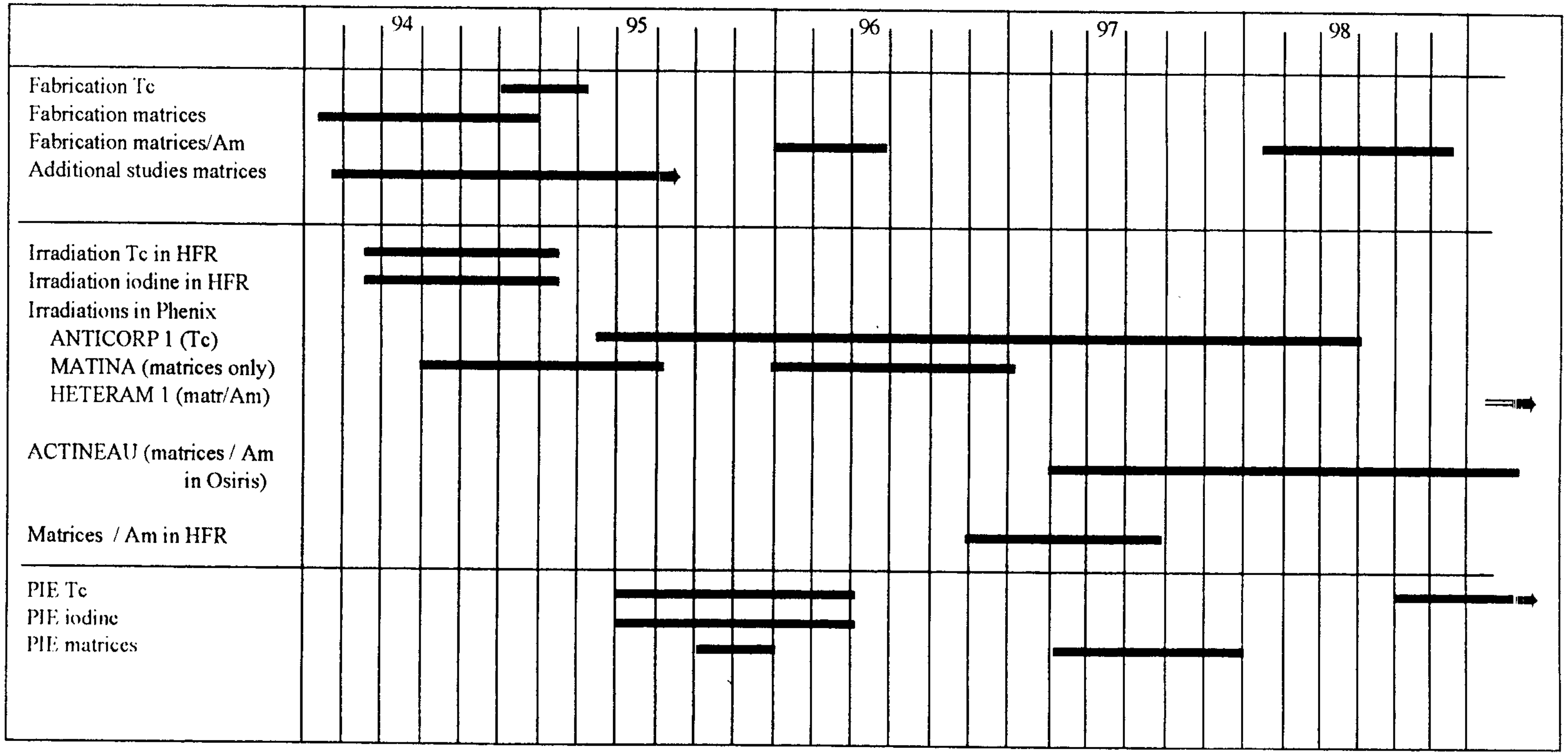

Figure 1 : Planning EFTTRA (tentative)

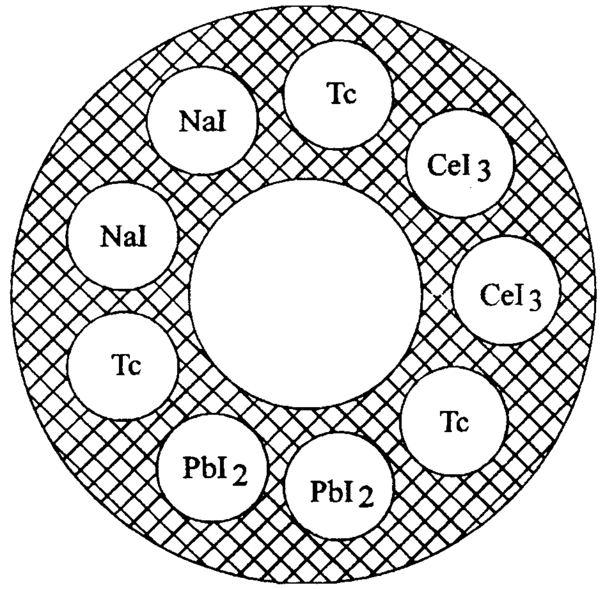

Figure 2 : Position of the samples in the rig for the irradiation of Tc and iodine compounds in HFR

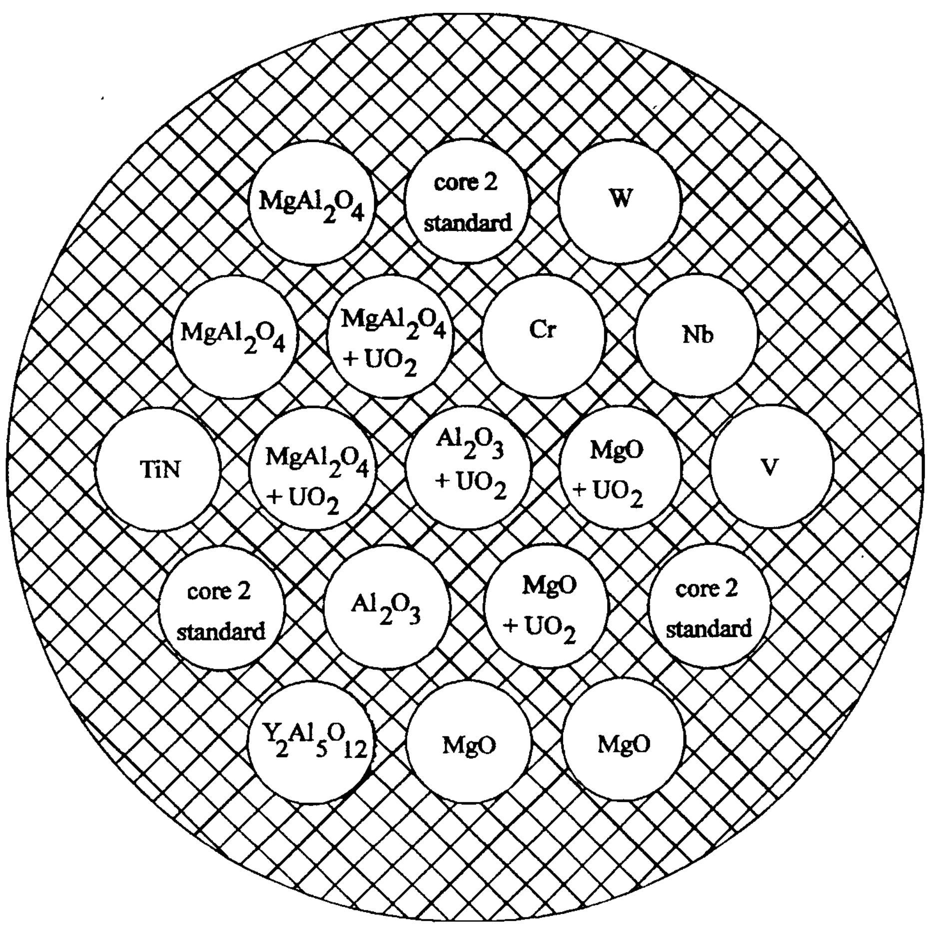

Figure 3 : Arrangement of the samples in the Phenix rig for the MATINA experiment