Foreword

Advances for Future Nuclear Fuel Cycles

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The Conference Atalante 2004, Advances for Future Nuclear Fuel Cycles, was held in Nîmes, France, on June 21–24, 2004. It provided an international forum for the presentation and discussion of cutting-edge research on nuclear fuel and waste management research, with a focus on the nuclear fuel cycles for the future.

Recent studies show that the world production of primary energy should steadily increase in the next 50 yr, in particular because of the increase in the population on Earth and the rapid economic development in several regions of the world (China and India, among others). In parallel to this trend, key issues for future world energy policies are the mitigation of greenhouse gas emissions by the development of sustainable carbon-free, or low-carbon, energy technologies and the security of the energy supply.

In this context, the present nuclear energy technology (Generation II and III systems) already plays a vital role in limiting the emission of carbon dioxide and greenhouse effect gases and provides a contribution to the world energy mix that does not rely on fossil fuels. Therefore, Generation II and III systems are likely to contribute significantly to global power production during the next several decades.

Furthermore, the long-term significance of nuclear energy in the reduction of greenhouse gas emissions could be greatly increased by introducing sustainable nuclear energy technologies (Generation IV)—that is to say technologies that will allow an efficient use of the available uranium resources—while minimizing the amount, the thermal load, and the toxicity of nuclear waste in geological disposal, following the as-low-as-reasonably-achievable principle.

To reach these objectives, it will become necessary to employ closed fuel cycles in conjunction with fast neutron reactors. Major research and development efforts are needed to explore new concepts for nuclear energy generation that make better use of fissile material and generate less waste. One other major issue requiring intensive research and development programs remains a broadly agreed-upon approach to waste management.

All these issues require expertise and improved knowledge of the processes involved in the behavior of fuels in reactors or transmutation targets and in the treatment of spent fuel as well as a comprehensive understanding of the processes governing the behavior of high-level waste in a geological repository.

Accordingly, the Atalante 2004 conference covered the following topics:

Topic 1. Actinides and Fission Products Basic Physicochemistry

Topic 2. Recycling Processes

Topic 3. Waste Management.

Topic 1. Actinides and Fission Products Basic Physicochemistry

Advanced research in actinide sciences is recognized as one essential endeavor for further development of a dynamic, competitive, and sustainable knowledge-based nuclear industry. As a general trend of nuclear science and technology, the assessment of the behavior of nuclear systems relies more and more on basic scientific understanding of each component, down to the nanometer and atomic scales. This requires high development of basic knowledge, with a strong interplay between experimentation and modeling, taking advantage of the fast progress both in theory and computing capabilities. Reinforcing this interplay is for instance a major objective of the Theoretical User Lab established within ACTINET, the European Network for Actinide Sciences.

Three papers in this issue exemplify this process: S. Hilaire et al., "Electronic Structure of High Oxidation State Actinide Species: Theoretical and Experimental Approaches"; D. Guillaumont et al., "Modeling Selectivity in Liquid/Liquid Extraction"; and M. Miguirditchian et al., "Complexation of Lanthanide(III) and Actinide(III) Cations with Tridentate Nitrogen-Donor Ligands: A Luminescence and Spectrophotometric Study."

Topic 2. Recycling Processes

In return, basic research and modeling efforts need to be supported by state-of-the-art experimental facilities—for instance, the Atalante facility itself—providing adequate characterization capabilities both at the microscopic scales and at the process scales. This is relevant for all potential processes involved in the considered fuel cycles, including the behavior of innovative fuels and targets containing minor actinides.

Three papers in this issue can be considered in this context: Ch. Hellwig et al., "FUJI: A Comparative Irradiation Test with Pellet, Sphere-Pac, and Vipac Fuels"; S. Pillon and J. Wallenius, "Oxide and Nitride TRU Fuels: Lessons Drawn from the CONFIRM and FUTURE Projects of the 5th European Framework Programme"; and O. Conocar et al., "Promising Pyrochemical Actinide/Lanthanide Separation Processes Using Aluminum."

Topic 3. Waste Management

Building a broadly agreed-upon approach and a comprehensive understanding of the processes governing the behavior of high-level waste disposal systems is another major issue. The science of very long-term behavior relies on a strong analysis of the major mechanisms ruling the phenomenology and on modeling to support time extrapolation to the long-term future. For example, nuclear glasses have been extensively studied and shown to be highly efficient matrices.

This type of analysis is exemplified on various materials in the three following papers: F. Jorion et al., "Zirconolite for Minor Actinide Containment and Alpha Irradiation Resistance"; I. Bardez et al., "Development and Characterization of Rare Earth–Rich Glassy Matrices Envisaged for the Immobilization of Concentrated Nuclear Waste Solutions"; and A. Ledieu et al., "Contribution of Monte Carlo Modeling to Understanding the Alteration of Nuclear Glasses by Water."