The National Centre for Research and Development

Management of Nuclear Graphite from HTR

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IAEA Headquarters, Vienna, Austria

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HTR’s as a potential source of industrial heat

- Polish Energy Policy until 2040 (PEP2040) mentions HTR’s as a potential source of industrial heat.
- In the scope of NCBR Strategic program of scientific research and development: "Social and economic development of Poland in the conditions of globalizing markets” (GOSPOSTRATEG): the proposal: ”**Preparation of legal, organizational and technical instruments for the implementation of HTR reactors”** was accepted for execution.
- On January 29, 2019, the Ministry of Energy signed a contract with the **National Center for Research and Development** (NCBR) to support the implementation of high-temperature reactor technology in Poland.
- Scientific consortium:
  - Ministry of Energy - coordinator
  - National Centre for Nuclear Research
  - Institute of Nuclear Chemistry and Technology
- Final goal is to build the first HTR reactor with a capacity of approximately 150-300 MWth
- Foreign partners will be involved in the project

Preparation of fuel assemblies

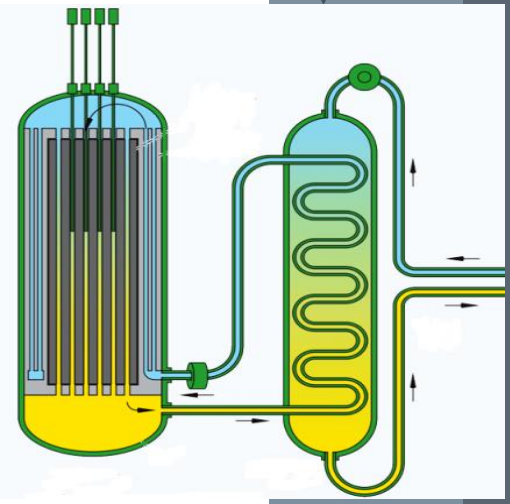
Uranium substrates →
Additives →
Preparation of spherical grains Ø~500µm Sol-gel method →
UO_2 kernels →

Applying CVD carbon layers →
TRISO →


Forming compacts →

Submission of a fuel assembly →

HTR FUEL ↓

Spent fuel ←


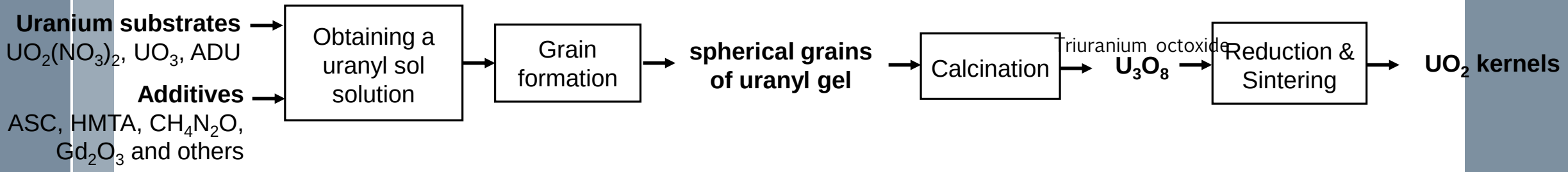
Preparation TRISO fuel

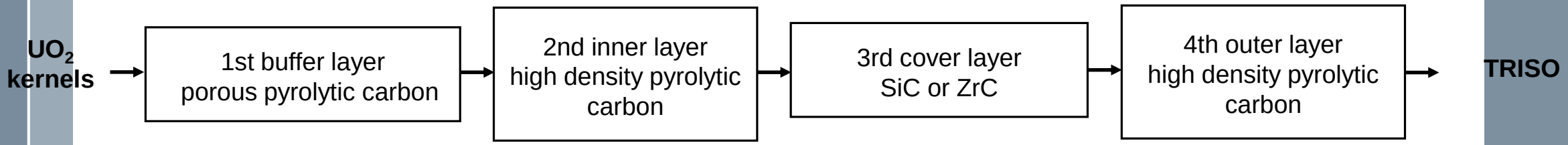
uranyl nitrate
uranium trioxide
ADU - ammonium diuranate

Uranium substrates
$UO_2(NO_3)_2$, UO_3, ADU

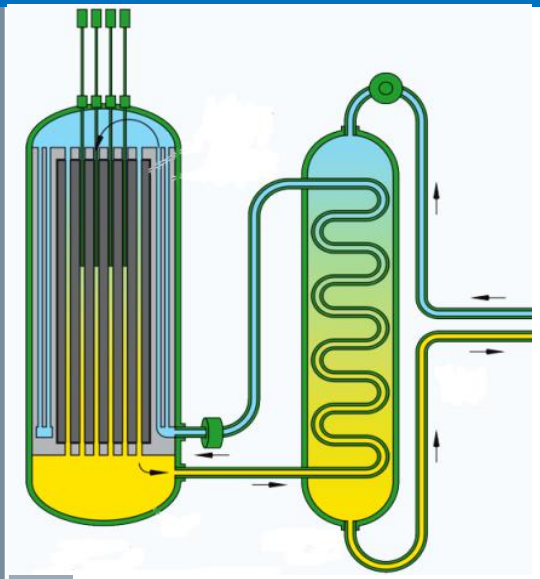
Additives
ASC, HMTA, CH_4N_2O, Gd_2O_3 and others

ascorbic acid
Hexamethylenetetramine
Urea





Issues of management of spent TRISO fuel and radioactive waste addressed in the project



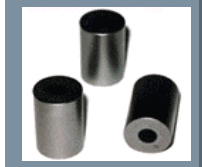
Graphite moderator with elements of spent uranium fuel



hexagonal graphite fuel elements

Spent fuel





Irradiated graphite



Prismatic concept
vs. Pebble bed

The objectives of the study:

- ✓ Providing the data to support the nuclear facility licensing process
- ✓ Data for a Safety Assessment Report on every phase of existence of the HTR





http://www.thtr.de/technik-hte-rea.htm

TRISO fuel back-end





Long-term storage on site or
direct disposal in a radioactive waste repository

Analysis of available techniques for preparing spent fuel for disposal

Selection of the final form for the disposal of spent fuel

Research on developing a methods for solidifying fuel surrogates in ceramic and vitreous materials

Spent fuel reprocessing with recycling of fissile components

Analysis of available techniques for actinide separation from spent fuel (solvent extraction; hybrid methods)

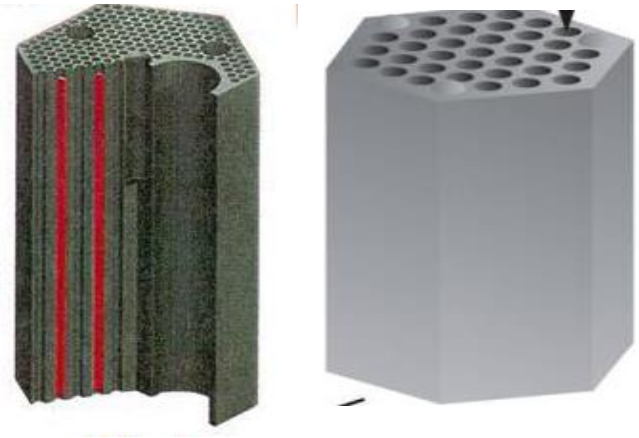
The tests with model spent fuel:
Removal of carbon coating from the kernel; separation of fissile components with the possibility of their reuse: hydrometallurgical methods for the separation of U and Pu (PUREX or TRUEX process; separation of minor actinides by solvent extraction)

Management of high-level waste from fuel reprocessing

Handling of irradiated graphite

The radionuclides of significance for the disposal of graphite in the RW repository:
H-3, C-14, Cl-36, Co-60, Sr-90, Cs-137, Eu-154.





Temporary storage or bulk disposal in a radioactive waste repository

Analysis of storage/disposal properties:

- Radiological characteristics
- Release into atmosphere (e.g. tritium)
- Leaching under repository conditions
- Heating under accidental conditions in the storage site
- Selection of the final form for disposal

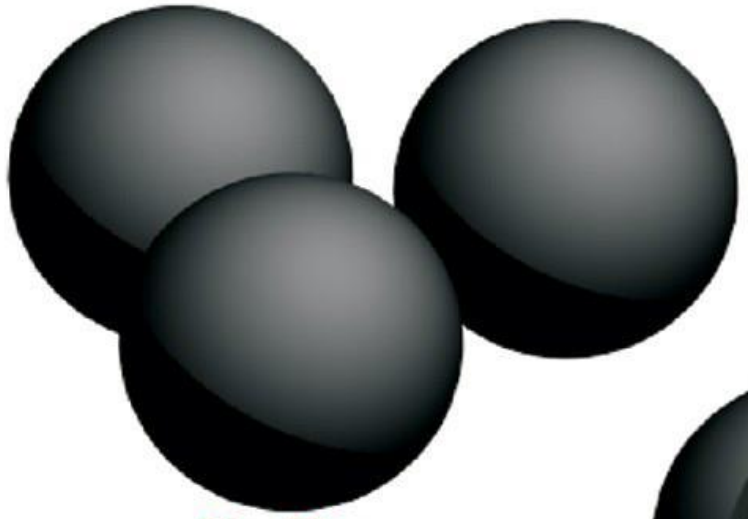
Treatment of irradiated graphite

Recycling and reuse of i-graphite or improvement of properties for disposal conditions: reduction of radiotoxicity, removal of adsorbed radionuclides, volume reduction of radioactive matter

Analysis of treatment methods, choice of the method of management of irradiated graphite from Polish HTR: thermal and chemical methods to remove adsorbed radionuclides; metal or ceramic coating

Possible tests using chemical methods

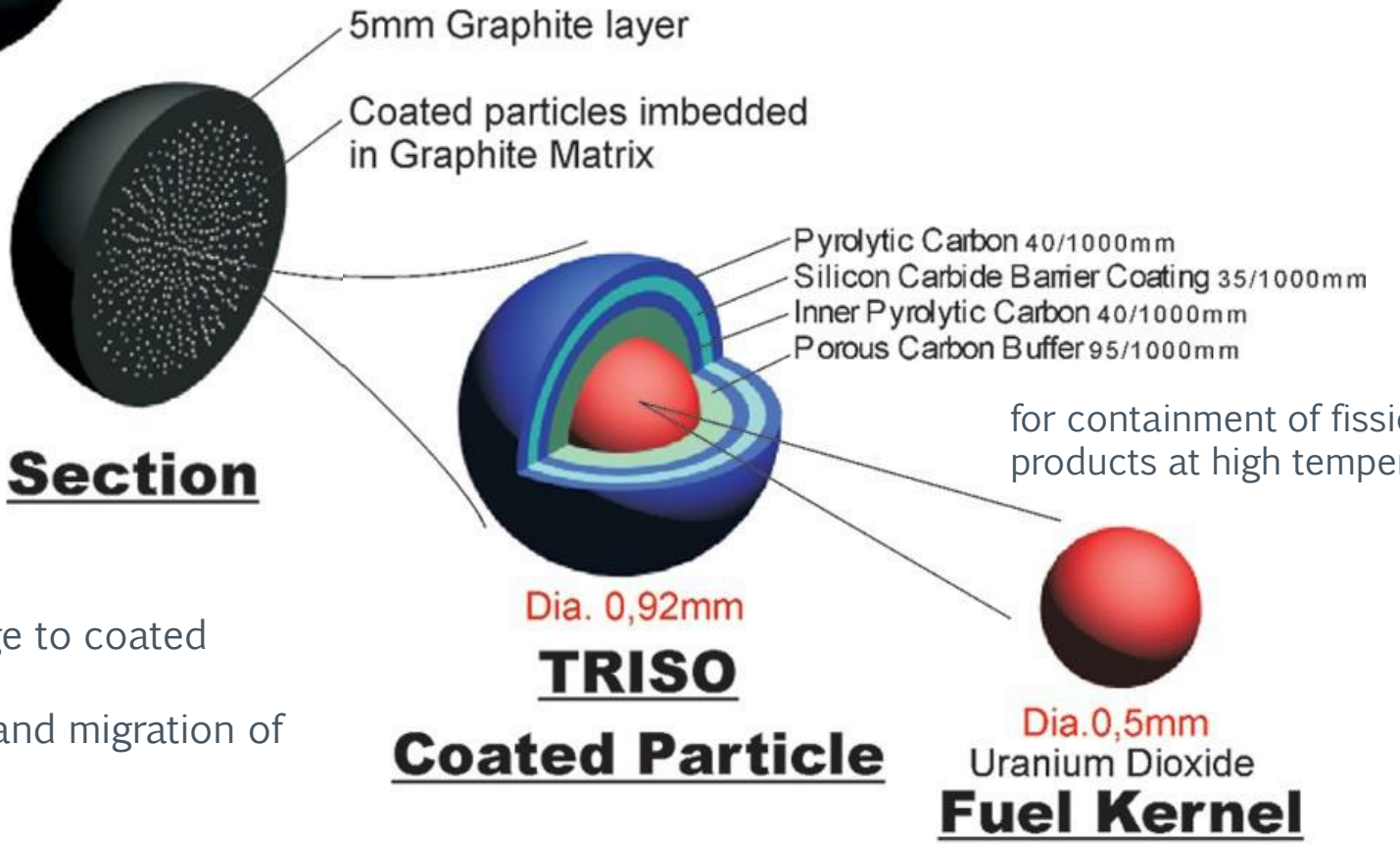
Pebble bed TRISO fuel life cycle



Dia. 60mm

Fuel Sphere

Goals to achieve when developing a method for producing fuel pellets:
- small size distribution
- small proportion of damaged pellets



Section

TRISO Coated Particle

Fuel Kernel

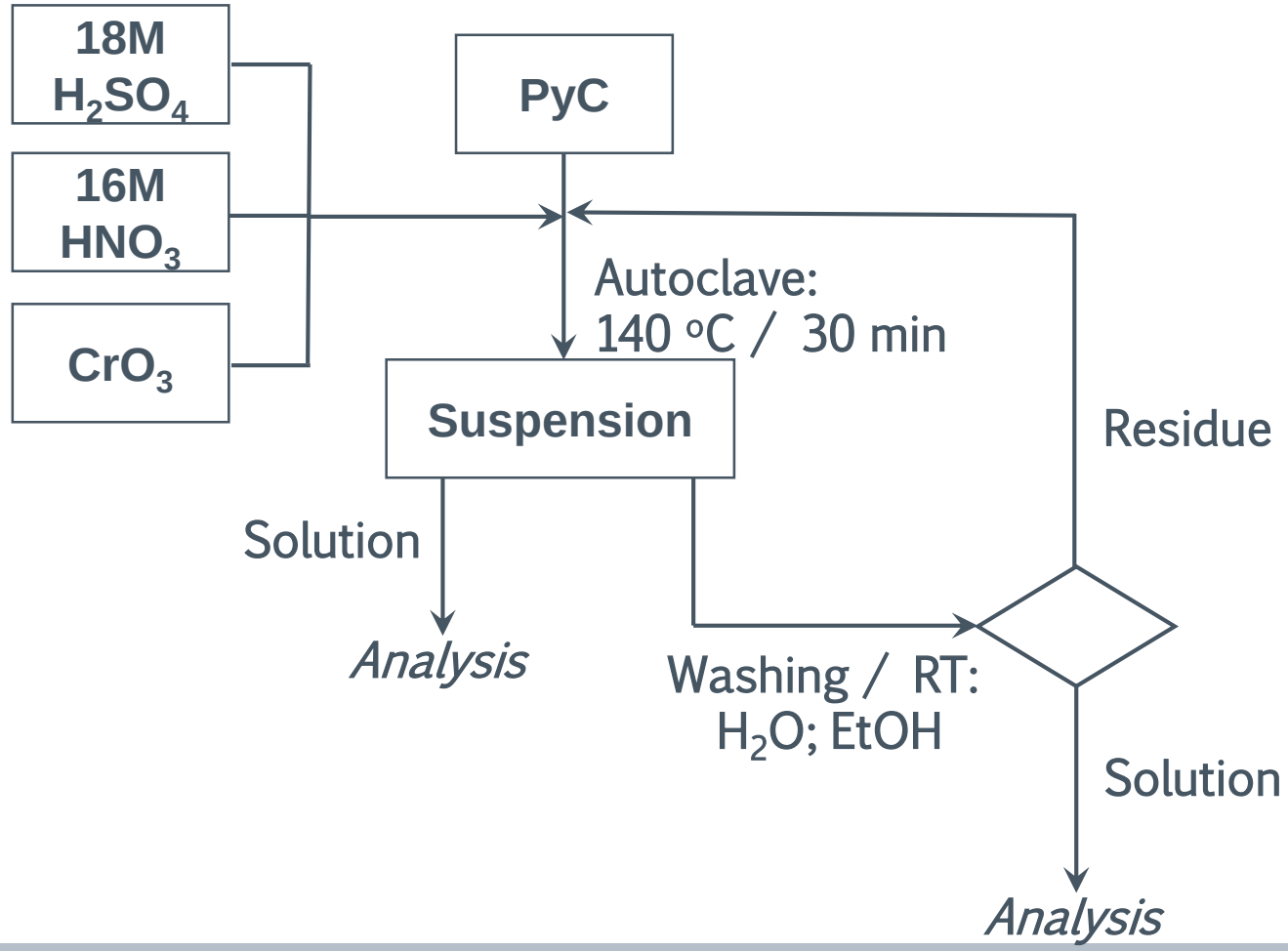
for containment of fission products at high temperature

- ✓ Research on the causes of damage to coated particles;
- ✓ Determination of the distribution and migration of fission products in coating layers;

Experiments

- ✓ Separating layers one by one;
- ✓ Determination of fission products in each coating removed

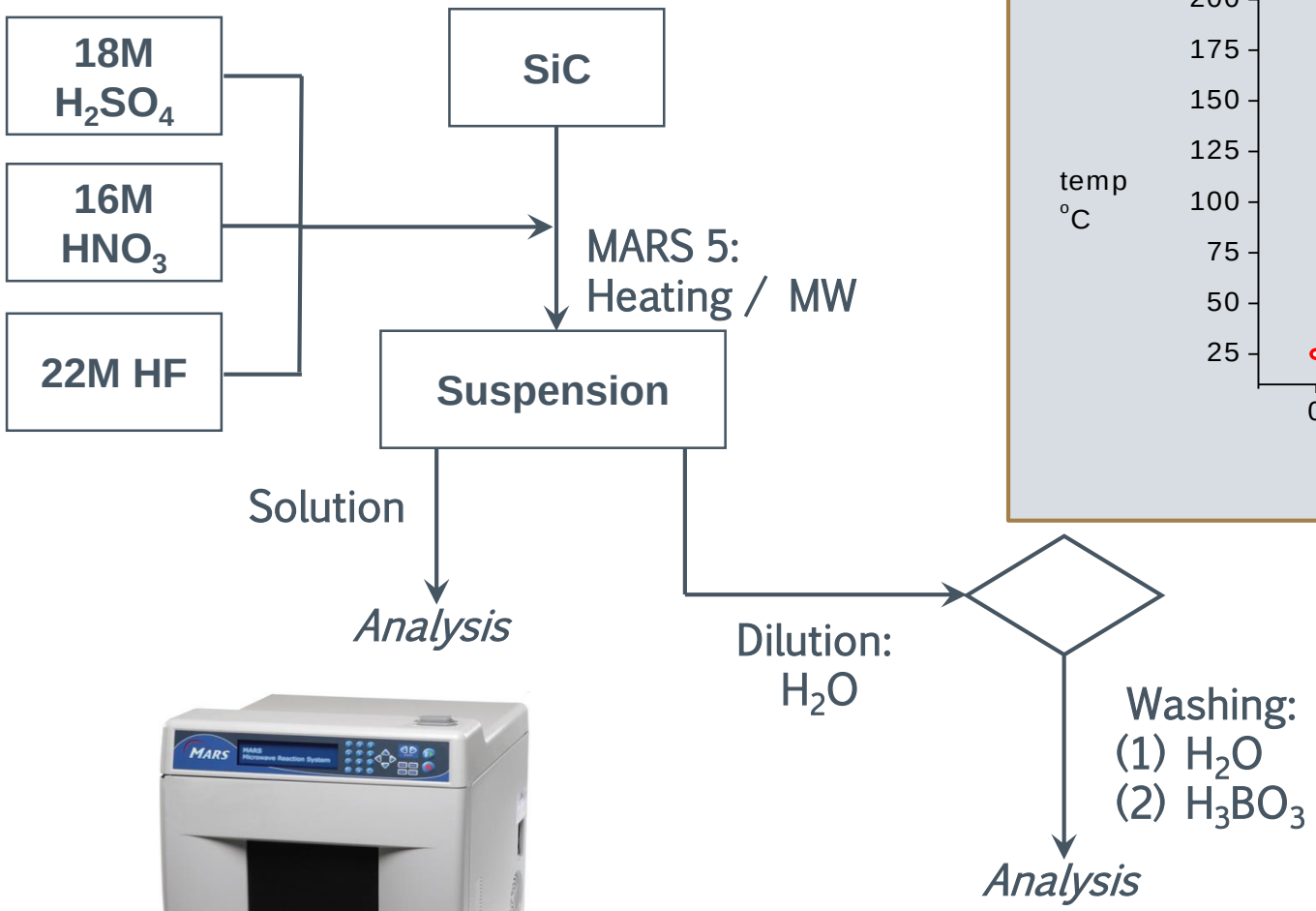
The testes using chemical methods: procedure for chemical etching of the outer pyrolytic carbon

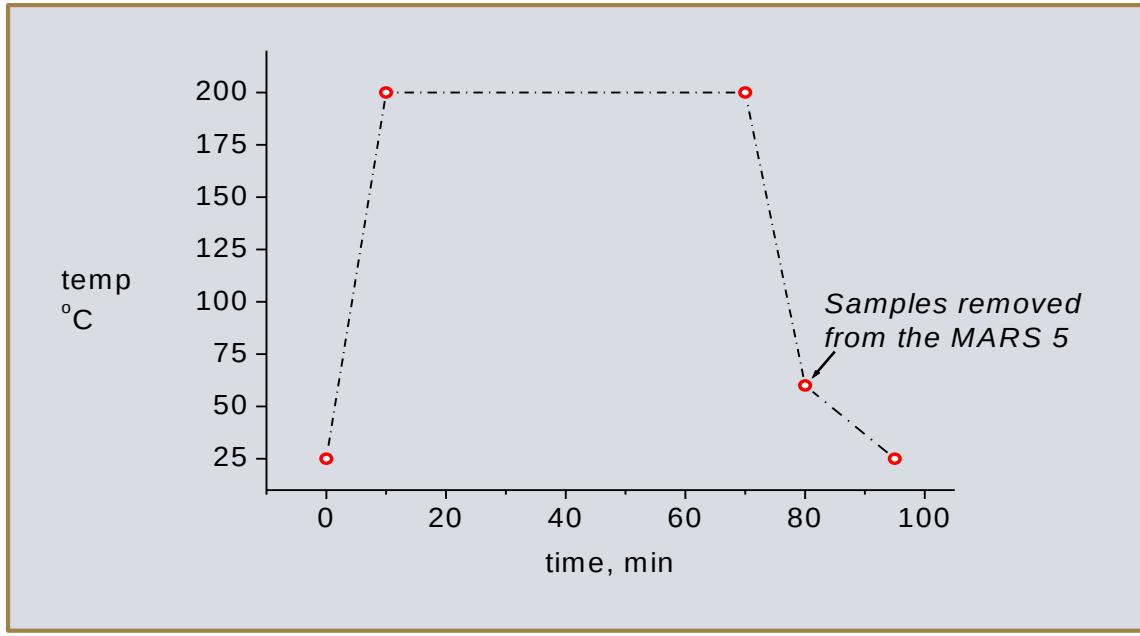




after K. P. Skolo, et al.Journal of Nuclear Materials, 420 (2012) 342-346

The testes using chemical methods: procedure for chemical etching of the silicon carbide layer





Microwave-assisted reactor system (**MARS 5**):
power setting - 500W at 2450 MHz

after K. P. Skolo, et al.Journal of Nuclear Materials, 420 (2012) 342-346

NUCLEAR GRAPHITE FOR HTR

Material studies

- Development of measurement procedures as well as selection and analysis of structural and functional properties of materials used in the construction of the HTR reactor (including: IG-110 and PGX graphite, ASR-ORB carbon, Hastelloy, etc.), determination of requirements that these materials must meet, analysis of required tests to assess their properties
- **Creating a material database for the needs of the HTR project**. Development of the procedures for measuring and analyzing experimental results for the purposes of selection and testing of material properties for HTR, including strength, bending resistance, thermal expansion, thermal conductivity, Young's modulus, dimensional changes tests, etc.
- The task will be implemented in cooperation with foreign partners with experience in testing materials for nuclear constructions, in particular materials used in HTR reactors

THANK YOU!

Thank you!

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