THE DIRECTIONS IN PEACEFUL USE OF NUCLEAR ENERGY IN AZERBAIJAN

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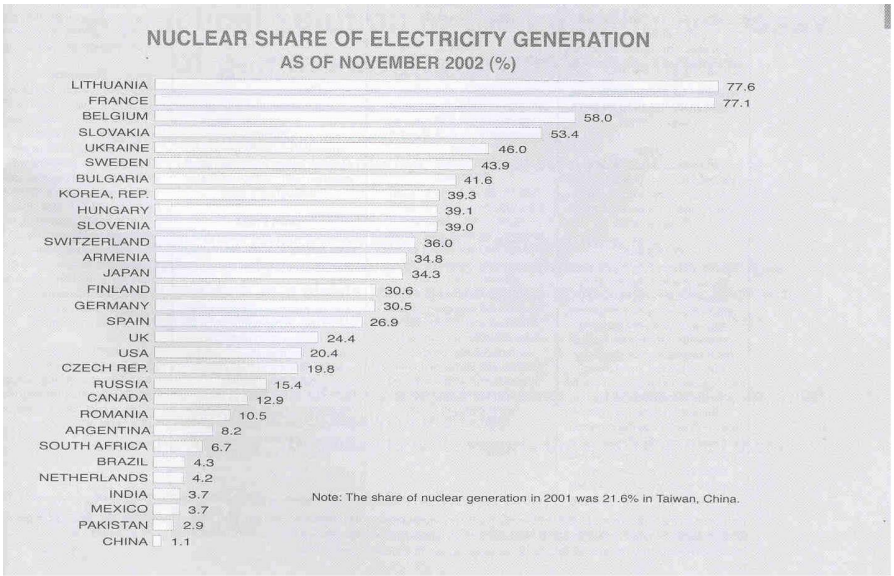
Nuclear energy is very perspective energy source in worldwide from the point of view nuclear energy resources, preparedness the technology of use, variety, reliability and environment protection. Therefore, during last years after Chernobyl accident the growth rates of nuclear energy have considerably increased.

Today, the following problems could be related to the peaceful applications of nuclear energy:

1. The upgrading of technological systems for both the uranium mining and processing in order to reduce up to minimum the impact to the environment. During last years the total uranium production is approximately equal to 35448 tons (according to official data, March 1998). However, the quantity of wastes that are discharged in the environment is huge. So, according to the data of 1993 just in Kazakhstan during exploitation of uranium-ore deposits was produced 219 million tons wastes that have total activity 250 thousands Ci.
2. The development of new types reactors:
   - more effective operating conditions (fast neutrons - breeder reactors, high-temperature reactors and etc.);
   - more safety working conditions;
   - to reduce the quantity of wastes are discharged to the environment and thus to minimize impact to the environment
3. The development of more effective ways for spent fuel reprocessing and radioactive wastes burial.
4. The development of new types materials and equipment that will capable to provide more safety operation of nuclear reactors.
5. The carrying out of deep expertise at existing nuclear reactors; the accident risk assessment; the development and modeling of appropriate operation scenarios.

The following diagrams show existing situation with electric energy production using nuclear energy /1/.



NUCLEAR POWER STATUS AROUND THE WORLD

	REACTORS IN OPERATION		REACTORS UNDER CONSTRUCTION	
	NO. OF UNITS	TOTAL NET MW(e)	NO. OF UNITS	TOTAL NET MW(e)
ARGENTINA	2	935	1	692
ARMENIA	1	376		
BELGIUM	7	5712		
BRAZIL	2	1901		
BULGARIA	6	3538		
CANADA	14	10018		
CHINA	5	3715	6	4878
CZECH REPUBLIC	5	2560	1	912
FINLAND	4	2656		
FRANCE	59	63073		
GERMANY	19	21283		
HUNGARY	4	1755		
INDIA	14	2503	8	2693
IRAN			2	2111
JAPAN	54	44289	3	3696
KOREA, DPR			1	1040
KOREA, REP. OF	18	14890	2	1920
LITHUANIA	2	2370		
MEXICO	2	1360		
NETHERLANDS	1	450		
PAKISTAN	2	425		
ROMANIA	1	655	1	650
RUSSIA	30	20793	2	1875
SOUTH AFRICA	2	1800		
SLOVAKIA	6	2408	2	776
SLOVENIA	1	676		
SPAIN	9	7524		
SWEDEN	11	9432		
SWITZERLAND	5	3200		
UNITED KINGDOM	33	12498		
UKRAINE	13	11207	4	3800
UNITED STATES	104	97860		
WORLD TOTAL*	**442**	**356,746**	**35**	**27,743**

* The total includes six reactors totalling 4884 MW(e) in operation and two units, 2700 MW(e) under construction in Taiwan, China.
Table reflects status as of November 2002.

In addition to power engineering nuclear energy could be used in other purposes, as for instance:

- Energy supply of power-consuming processes such as metallurgy, petroleum-refining; chemical and other branch of industry;
- Getting universal energy carriers;
- Radiation technology;
- Power-plants for transport vehicles;
- Military purposes;
- Medicine

Since 1960, the scientific researches on peaceful applications of nuclear energy have been started in Azerbaijan. The main directions of these works are the following:

- Radiation modification of materials, such as polymers, sorbents, catalysts, dielectrics and etc.;
- Radiation-petroleum processes;
- Radiation polymerization;
- Radiation- heterogeneous processes;
- Radiation chemical processes of hydrogen and hydrogen containing gas production from water, coals, oil residues, hydrogen-sulphide and natural gases.
- Radiation-catalytic processes production hydrogen and hydrogen containing gas from water and water containing mixtures;
- Radiation processes of crops processing;
- Using nuclear-analytical methods in biology, material science, medicine and technique;
- Using isotope sources in medicine;
- Radiation-chemical processes for solving environmental problems;
- Radioactive well logging methods.

Ionizing Radiation Sources

The following isotope sources of ionizing radiation have in Azerbaijan Republic:

- Institute of Radiation Problems of Azerbaijan National Academy of Sciences – there are complex facility of gamma radiation sources on the basis of ^{60}Co and ^{137}Cs as well as the accelerated electrons plant. These tables show detail specification of these sources

Table 1 – gamma radiation sources

No.	Radioactive source	Quantity	Date of manufacture	Specific activity Ci
1.	URJ-^{60}Co	1	1969	3019
2.	MRX-γ-25-^{60}Co	1	1974	907
3.	RXUND-20000-^{60}Co	1	1975	285
4.	"Kolos"-plant-^{137}Cs	1	1975	2600
5.	RXM- γ-20-^{60}Co	1		215.5
6.	Radium-226	1		0.018

Table 2 – the accelerated electrons plant

No.	Name of radioactive source or plant	Date of manufacture	E-electron	Power
1.	ELU-4	1978	4.5 MeV	~ 1 kVt

- The Ministry of Health – there are isotope sources of ionizing radiation on the basis of ^{60}Co, ^{137}Cs, ^{226}Ra, ^{99}Tc, ^{131}I and X-ray units;
- The Ministry of Agriculture – there are isotope sources of ^{137}Cs;
- State Oil Company of Azerbaijan Republic - there are isotope sources of ^{137}Cs, ^{241}Am, $^{241}Am+Be$ and neutron generators;
- Private company on investigations of defects in oil pipelines – there is a defectoscope using ^{192}Ir.

Main Results

1. Radiation-thermal cracking of individual and oil hydrocarbons has been carried out. /2-4, 16/

$$R\text{-}H \xrightarrow{T} \text{low-molecular hydrocarbons} + \text{olefins} + H_2 + \text{isomeric hydrocarbons}$$

T = 473 – 773K; Radiation sources are γ-rays, accelerated electrons.

Advantages:

1. Decrease of temperature in 100-150K
2. Increase of output of olefinic hydrocarbons up to 30%
3. Increase of output of isomeric products up to 15-20%
4. Decrease of gas and coke discharge

2. New schematic technological scheme has been proposed and the regulation for radiation-chemical processing liquid fractions of pyrolysis processes has been developed with the purpose of obtaining oil-polymer resin and aromatic hydrocarbons. /5-9/

Oil fraction

$T=130-190^0C$ ⟶ resins + aromatic hydrocarbons

γ-rays ^{60}Co
D=1000 – 3000 kGray
Resin output ≈ 20 – 20%

3. Radiation-chemical method for obtaining styrene by ethylbenzene dehydration has been developed.

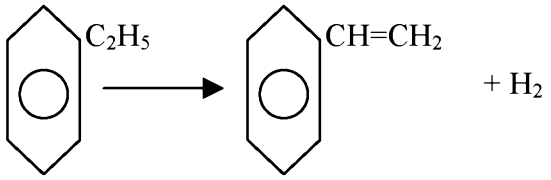


Table 3 – Composition of radiolysis products depending on temperature at electron energy 5.0 MeV

Experiment conditions				Content, weight %				
Temperature, ^0C	Current intensity of electron beam, microampere	Feed rate of raw, ml/h	Volume rate, $Hour^{-1}$	Styrene	Ethyl benzene	Benzene	Toluene	Non identified
450	40	60	0.4	18.8	74.5	3.0	3.1	0.5
460	40	60	0.4	21.9	63.0	6.2	7.6	1.3
480	40	60	0.4	28.2	49.3	9.1	10.3	3.1
500	40	60	0.4	30.1	42.9	11.0	12.2	3.8

V. Hydrocarbon fraction containing α-olefines has bee obtained as a result of radiation-chemical cenversion processes of oil-gasoil kerosine- fraction. /6, 10/

C_nH_{2n+2} ⟶ C_nH_{2n} (α-condition) + H_2

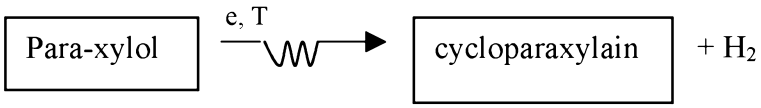
Surface-active substances have been obtained on the basis of α-olefines that were produced under action of accelerated electrons and at $T = 300 - 450^0C$.

VI. Radiation dehydrochlorination processes of dichlorethane have been developed. /11-12/

$C_2H_4Cl_2$ ⟶ (e) $C_2H_2Cl_2 + H_2$
(vinyl chloride)

$n\ C_2H_2Cl_2$ ⟶ $(-CH_2Cl-CH_2Cl-)_n$
(polyvinyl chloride)

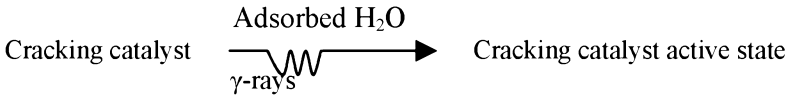
VII. Paraxylol radiation dehydration process. /13-14/



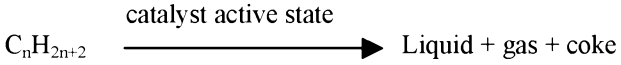
Technology for use of cycloparaxylain as a new material for space apparatus, coating semiconductors with effective protection layer has been developed.

VIII. Radiation-catalytic cracking process of individual hydrocarbons and oil-gasoil kerosine-fraction has been developed.

a) The methods for increasing activity and selectivity of catalysts are used in the hydrocarbons cracking process have been developed. /15/

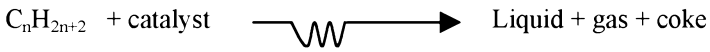


The activation occurs at T = 296K, under γ-radiation dose D ≤ 500 kGray.

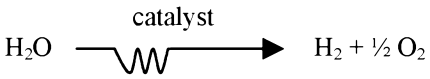


Conversion in liquid products occurs at T = 623K. at this fractional conversion of raw is equal to 60-65%. Output of isohydrocarbons is decreased in 25%, gas output is increased in 2.5 times, coke output is increased in 50%.

b) Scientific basis of radiation-catalytic cracking processes have been developed.



IX. Scientific basis of heterogeneous processes for obtaining hydrogen from water and – CH_4 + H_2O – systems have been developed. /17-20



Scientific basis for selection of catalyst used in radiation-catalytic processes have been developed. Optimal regime and catalyst have been selected.

X. The process of coal gasification has been developed as a result of radiation-chemical processes investigations in various environments for different types of coal and graphite.

The process of active coal sorbent obtaining has been developed.

XI. Application of radiation technology at solving ecological problems.

- The technology for purification discharged into the air gases from harmful components such as

SO_2, No_X has been developed.

- Radiation methods for purification of natural gas from H_2S has been developed.

XII. Radiation-chemical vulcanization and modification methods for different types rubber and rubber products have been developed. The mechanical properties and stability of rubber products are obtained by radiation-chemical method to the effect of aggressive environment were better in comparison with customary obtained products.

XIII. Modification of physical properties for polymeric dielectrics, ferroelectrics, semiconductors and oxide dielectrics under ionizing radiation has been carried out.

XIV. Modification of physical properties for polymeric dielectrics, ferroelectrics, semiconductors and oxide dielectrics under ionizing radiation has been carried out.

N	Carried out researches	Observed events and results
1	Converted Ge has been irradiated by accelerated electrons and then annealed	The conductivity of Ge is changed at lighting. The effect depends on primary density of defects, temperature and lighting intensity.
2	GaAs has been irradiated by accelerated electrons and then cooled at different temperatures	The transition of conductivity from high ohmic state to low ohmic state is observed under cooling of irradiated GaAs up to 80 K.
3	Irradiation of Si and Ge photocells by electrons	Radiation resistance of Si and Ge photocells is increased
4	Irradiation of GaTe, GaS, GaS (Er) by γ-rays	Under irradiation by light doses of γ-radiation the hole density in GaTe, GaS, GaS (Er) is decreased and under small doses is possibility to increase hole density
5	Irradiation of B_2O_3, BeO, Al-Si, SiO_2 oxide dielectrics, ferroelectrics by γ-rays	Energetic levels of radiation defects have been determined. Low dose effects is observed. Interrelation between defect formation energy and E_g is determined. The methods for control of defect formation, recombination, localization and surface diffusion processes have been developed.

XV. Main directions of radiation-biological technologies

- Different preliminary irradiation methods of plants (seed, cucumber, cotton and etc.) with the purpose of increasing the crop capacity have been developed;

-The regularities of low dose irradiation influence on plants development have been studied;

-Scientific basis of preliminary irradiation influence on the development and productivity of silkworm have been determined

XVI. The regulation of chemical, temperature and ionizing rays' influence to the nuclear reactor's materials was revealed. The protection of heat generating elements' materials of the nuclear reactors being cooled by water in contact with heat conducting and the radiation heterogeneous processes' role in the catastrophic oxidizing processes were determined. The radiation heterogeneous processes in contact between water and metal makes the metal oxidizing protection faster and the beginning time of catastrophic oxidizing less. That's why the ways of metals' durability increasing while working in the active zones of the nuclear reactors were researched. The formation of monolith oxide layer with the existing oxidizing fragments increases the durability of the metals such as Zr and stainless steel 2.5 times.

$$Zr + H_2O \xrightarrow[\text{oxidizing process in the reactor}]{} Zr\text{-}ZrO_{2-x} + 2H_2 \quad \text{(defective oxide layer)}$$

$$Zr + H_2O \xrightarrow{\text{oxidizing}} Zr - ZrO_2 \text{ (durable oxide layer)}$$

The results gained assume importance to prepare the nuclear reactors' being cooled by water normal and crash regime scenario and the radiation science of materials.

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