IAEA activities in support of capacity development and application of Radioisotope Products and Radiation Technology

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Vienna, Austria

RECENT DEVELOPMENT AND APPLICATIONS OF NUCLEAR TECHNOLOGIES
Białowieża, Poland
15-17 September 2008

International Atomic Energy Agency (IAEA)

The IAEA is the world’s center of cooperation in the nuclear field. It was set up as the world’s "Atoms for Peace" organization in 1957 within the United Nations family.

The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies.

"The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world"

Article II of the Statutes of IAEA

Atoms for Peace, Health and Prosperity
**IAEA – Areas of Work**

- **Safety and Security:** international conventions, standards and guidance. **Aim:** to protect people and the environment from harmful radiation exposure

- **Safeguards and Verification:** inspectors verify that safeguarded nuclear material and activities are not used for military purposes

- **Science and Technology:** food, health, water, environmental and industry; areas where nuclear and radiation technologies can make a difference

**Nuclear Science and Applications: A part of IAEA’s Technology pillar**

The IAEA as a facilitator:

- **PROVIDE FORUM FOR CO-OPERATIVE RESEARCH**
- **COLLECT, VALIDATE, DISSEminate RELEVANT TECHNICAL INFORMATION**
- **SUPPORT DOCUMENTATION AND INFORMATION EXCHANGE**
- **PROVIDE TECHNICAL ASSISTANCE TO DEVELOPING MS**

**IAEA Activities – Major Channels of Functioning - Types & Purpose**

**CRPs**

- Coordinated Research Projects - R&D efforts;
- 10-15 groups share core competencies and complement expertise
- 3 RC Meetings over ~4 years
- Thematic Publications

**Thematic Meeting**

- Technical Meetings
- Consultancy meetings
- Cooperation to well-known international conferences
### IAEA Activities – Major Channels of Functioning - Types & Purpose

**Technical Co-operation Projects (TC)**

- Technology transfer and adoption;
- Part of MS development initiative;
- Shared goals and resources towards:
  - Infrastructure establishment or upgrading,
  - Specific technology implementation,
  - TC Regional Projects - Cooperation/Agreement:
    - Regional Training Programmes,
    - Regional Workshops.

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### Radioisotope Production and Radiation Technology Programme of IAEA

**Objectives:**

- To contribute to improved healthcare and facilitate safe and clean industrial development in MS through the use of radioisotopes and radiation technology and to strengthen national capabilities for producing radioisotope products and utilizing radiation technology for socio-economic development.

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### Radioisotope Production and Radiation Technology Programme of IAEA

- Radioisotope products and radiation technology are the basic needs for a wide range of nuclear applications in such fields as medicine, industry, agriculture and the environment. Their use has led to significant contributions towards sustainable development and improving the quality of life in developed as well as in a number of developing countries.
- The demand for the most used radioisotopes is generally increasing (5-10% per annum) and radiation techniques for medical and industrial applications are also showing similar continued growth.
- Many countries continue to seek the IAEA support in capacity building and strengthening their national infrastructure as a part of their development plans.
Radioisotope Production and Radiation Technology Programme of IAEA

**Sub programme:** Technology Support to Radioisotopes and Radiopharmaceuticals development and production:

- Supporting Development and Production of Radioisotopes and Generators for Medical and Industrial Applications.
- Diagnostic Radiopharmaceuticals.
- Therapeutic radiopharmaceuticals.

**Sub programme:** Radiation Technology for Cleaner Industrial Processes and Material Analysis and Development:

- Support to improve Industrial Process Management using Radioisotope and Radiation Technology.
- Radiation Technology for Advanced Materials Development.
- Remediation of Pollutants using Radiation Technology.

Radioisotope Production and Radiation Technology Programme of IAEA

Technology Support to Radioisotopes and Radiopharmaceuticals development and production

- Radioisotope products and radiation technology are the basic needs for a wide range of nuclear applications in such fields as medicine, industry, agriculture and the environment.

- Local production of radioisotope products:
  1. Radioisotopes
  2. Diagnostic Radiopharmaceuticals (emerging PET tracers such as Cu-64, I-124, Germanium-68/Gallium-68 generator).
  3. Therapeutic Radiopharmaceuticals (Re-188, Yttrium-90 and Lutetium-177).

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

- Improved high current liquid and gas targets for cyclotron produced radioisotopes (2003-2009).
- Development of therapeutic radiopharmaceuticals based on $^{177}$Lu for targeted therapy (2006-2010).
Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides (2000-2003)

Achievements:

- Tl-201
  - Improved plating technology
  - Improved target design enhancing the cooling of the targets
  - Targets that withstand up to 270 mA for 9 h with beam intensity of 0.5 mA/mm²
  - Better recovery of target materials
- I-123
  - Technology for plating Te on to Ni coated Cu target developed
  - Demonstration of the preparation of I-123 (and I-124) by using enriched Te targets by (p,n) reaction
- Pd-103
  - Electrodeposition and recovery of Pd developed
  - Methods for preparing brachytherapy sources developed

Participation: 10 MS institutions

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

Development of radioactive sources for emerging therapeutic and industrial applications (2002-2005)

Achievements:

- I-125, Pd-103 coated to different matrices such as silver and nickel wires, ceramic rods were developed.
- Miniature I-125 sources have undergone clinical trials in India in which 5 patients were treated.
- A nuclear research reactor based method for the production of Pd-103 was developed by the participant of the Russian Federation.
- Batch manufacturing of Ir-192 brachytherapy sources based on the technology developed under the auspices of the CRP started in Belarus.
- Technology for the preparation of miniature Yb-169 sources for industrial applications (NDT) was developed.
- Quality control tests of sealed sources developed. These include pre and post testing of the capsules, accurate activity measurements etc.

Participation: 10 MS institutions

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

“Comparative laboratory evaluation of therapeutic radiopharmaceuticals” (2003-2005)

Objective:

- Develop in vitro and in vivo models for evaluation of therapeutic radiopharmaceuticals

Specific objectives:

- To develop methods for labelling, purification and QC of therapeutic radiopharmaceuticals based on different carrier molecules and radionuclides
- To standardize in vitro methods for comparatively evaluating them for biological integrity, cell binding, serum stability, kinetics, internalisation and cytotoxicity
- To establish in vivo models for comparatively evaluating biodistribution, in vivo stability and therapeutic efficacy.

Participation: 15 MS institutions
Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

"Comparative laboratory evaluation of therapeutic radiopharmaceuticals" (2002-2005)

Achievements:
- Preparation of radionuclides, $^{177}$Lu
- Development of radiopharmaceuticals, $^{177}$Lu-DOTATATE and $^{177}$Lu-DOTATOC, $^{90}$Y-DOTATOC, $^{90}$Y-DOTATATE
- Acquired skills in tissue culture, cell binding assays, other in vitro assays, tumour development in nude mice, biodistribution studies in animal models etc.
- Publications: 49 in International Journals and in International Conferences

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals

Development of $^{99m}$Tc based small biomolecules using novel $^{99m}$Tc cores (2002-2006)

Objectives:
- Achieve high specific activity $^{99m}$Tc tracers for targeting low density targets
- Development of diagnostic radiopharmaceuticals based on small biomolecules.

Specific Objectives:
- Applying the recent advances in $^{99m}$Tc chemistry such as $^{99m}$Tc-carbonyl, nitrido, hyenic and mixed ligands for labelling of small biomolecules
- Develop a few promising $^{99m}$Tc labelled small biomolecules of high purity and stability for further investigations as potential radiopharmaceuticals.

Participation: 13 MS institutions

Achievements:
- Five different types of biomolecules explored:
  - RGD-peptides, Annexin derived peptides, fattyacids, quinazolines and glucose analogs for radiolabelling with $^{99m}$Tc
- Technology for the preparation of $^{99m}$Tc complexes developed
  - Carbonyl, nitrido, hyenic and mixed ligands cores
- $^{99m}$Tc(N)(Cys2-Ann13) showed apoptosis specific uptake needing further investigation
- 51 publications in International Journals and in International Conferences
- Two publications arising out of this CRP were among the hot 25 articles in Nuclear Medicine and Biology in 2006.
Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals
"Development of Generator technologies for therapeutic radionuclides" (2004-2008)

Objective:
• To develop $^{90}$Sr/$^{90}$Y and $^{188}$W/$^{188}$Re generators and standardize quality control techniques for generator eluted therapeutic radionuclides

Specific Objectives:
• Development of methodologies for the preparation of $^{188}$W/$^{188}$Re, $^{90}$Sr/$^{90}$Y generators
• Development of chromatography adsorbents (Zr/Ti polymers) having higher capacities and demonstration of their utility in the preparation of column generators for $^{188}$Re (and $^{99m}$Tc)
• Development of technologies for post elution concentration of $^{188}$Re (and $^{99m}$Tc)
• Development of quality control techniques for generator eluted therapeutic radionuclides.

Participation: 13 MS institutions

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals
"Development of Generator technologies for therapeutic radionuclides" (2004-2008)

Achievements:
• Protocol for the preparation of $^{188}$W/$^{188}$Re generator using bulk procured $^{188}$W of high specific activity (3-5 Ci/g)
• Several methods for the separation of $^{90}$Y from $^{90}$Sr developed (ion exchange, ion specific resins, supported liquid membrane, electrochemical generator)
• Quality control for $^{90}$Y by Extraction Paper chromatography-‘BARC method’ for estimation of $^{90}$Sr in $^{90}$Y
• Higher capacity adsorbents such as PZC and PTC for column generator production
• Post elution concentration techniques developed

Coordinated Research Projects on Radioisotopes and Radiopharmaceuticals
"Improved high current liquid and gas targets for cyclotron produced radioisotopes" (2005-2009).

Objective:
• Development of improved cyclotron target technology for production of C-11 and F-18.

Specific Objectives:
• Higher specific activities radioisotopes (F-18, C-11)
• Higher Beam Current Irradiations (F-18)
• Developing Diagnostic Tools for Target Monitoring during Irradiation
• Investigations for effective utilization of in-target chemistry
• Development of methods for recovery and reuse of enriched isotope targets.

Participation: 12 MS institutions
### Development of therapeutic radiopharmaceuticals based on $^{177}$Lu for targeted therapy (2006-2010)

**Objective:**
- Production and radiochemical processing of $^{177}$Lu
- Preparation of therapeutic radiopharmaceuticals
- Production and QA/QC of bone pain palliating agents using $^{177}$Lu and phosphonate ligands
- Development of $^{177}$Lu based primary cancer specific radiopharmaceuticals using carrier molecules such as antibodies, Peptides
- Development of $^{177}$Lu-Lipiodol for the treatment of hepatocellular carcinoma (HCC)

**Participation:** 16 MS institutions

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### Development of $^{99m}$Tc Radiopharmaceuticals for Sentinel Node Detection and Cancer Diagnosis (2007-2011)

**Objective:**
- $^{99m}$Tc radiopharmaceutical for sentinel node detection.
- Novel conjugation approaches such as 'click chemistry'
- $^{99m}$Tc cores for labelling biomolecules
- Nanoparticles for imaging cancer (e.g. liver cancer)

**Participation:** 18 MS institutions

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### Development of radiopharmaceuticals based on $^{188}$Re and $^{90}$Y for radionuclide therapy (2008-2012)

**Objectives:**
- To develop radiopharmaceuticals for targeted therapy using $^{188}$Re and $^{90}$Y
- To study the performance of generators with long lived parent radionuclides
- Validate the QC control procedures for estimating the purity of generator eluents.
Radioisotopes and Radiopharmaceuticals

Documents

- TRS: 432: ‘Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides’ 2004
- IAEA TECDOC-1340: Radioisotope handling facilities and automation of radioisotope production. 2004
- Beneficial Uses and Production of Isotopes, IAEA/DOCD. 2005
- IAEA DCPR-CD-ROM, Directory of Cyclotrons Used for Radioisotope Production in Member States. 2006
- IAEA TECDOC-1414: Development of kits for 99mTc radiopharmaceuticals for infection imaging. 2004
- TRS 496: Development of 99mTc Agents for imaging central neural system receptors. 2004
- TRS 498: Comparative laboratory evaluation of therapeutic radiopharmaceuticals. 2006
- TRS 499: Development of 99mTc based small bio molecules using novel 99mTc cores. 2007

Radioisotopes and Radiopharmaceuticals

Documents under preparation

- Cyclotron Produced Radionuclides: Principles and Practice
- Cyclotron Produced Radionuclides: Physical Characteristics and Production Methods
- Cyclotron Produced Radionuclides: Guidelines for facility Development
- Parent radionuclides for long lived Generators (90Sr, 188W, 68Ge, 82Sr)

Radioisotope Production and Radiation Technology Programme of IAEA

RADIATION TECHNOLOGY SUPPORT FOR CLEANER ENVIRONMENT AND MATERIAL ANALYSIS AND DEVELOPMENT

To enhance MS capabilities in:
- Applying radiation technologies for synthesis, modification and analysis of natural and man-made polymers
- Radiation processing of low-cost polymers and polymer waste into value-added products
- Improve industrial process efficiency
- Improve environmental safety
Coordinated Research Projects on Radiation Technologies

**Remediation of polluted waters and wastewater by radiation processing (2002-2006)**

- Remediation of polluted waters and wastewater by radiation processing (2002-2006)
- Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Selective Separation Purposes (2007-2011)
- Development of Radiation-processed Products of Natural Polymers for Application in Agriculture, Healthcare, Industry and Environment (2007-2011)

**Overall objectives:**
- To assess potential applications of radiation processing treatment in Member States in the area of water, wastewater and ground water treatment.

**Specific objectives:**
- Radiation-induced disinfection and decontamination of wastewater for agricultural and industrial reuse.
- Treatment of contaminated groundwater for remediation and eventual use of the water resource.
- Development of alternative methods for assessing the toxicity of treated water.

**Participants:** 10 MS institutions

**National Project:**

**The main output:** Installation of the first full scale EB facility in Korea (10,000m³/day) continuous operation → reliability → economic evaluation + TC

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**Achievements:**
- Economic feasibility study in comparing EB, UV and EB/ozone process was completed.
- Evaluation of the process for municipal wastewater treatment: destruction of organic compounds, elimination of estrogenic activity and reduction in the number of microorganisms simultaneously.
- Disinfection of sludge for beneficial use in agriculture had been demonstrated at full scale using gamma irradiation and the application of EB machines was studied.
- Studies was completed showing the degradation of dyes, pesticides and chemical organic compounds from industries origin.
- Fundamental studies were accomplished for several pollutant: determination of reaction rate constants, kinetic models describing the formation and destruction of reaction by-products with the objective to be used to guide analytical methodology and economic evaluation of the process.
### Coordinated Research Projects on Radiation Technologies

#### Controlling of Degradation Effects in Radiation Processing of Polymers

**Overall objectives:**
- To develop in participating laboratories reliable analytical methodologies concerning investigation of degradation effects of radiation on polymers.
- To develop procedures and chemical formulations enhancing or preventing degradation effects depending on the desired application of the process.

**Specific objectives:**
- Application of new and advanced analytical methods (optical and mass spectroscopy, chromatography, synchrotron radiation) for studying radiation effects in polymeric materials.
- Development of improved radiation resistant blends for manufacturing of medical products sterilized by radiation.
- Utilization of radiation degradation of natural polymers for manufacturing high-value added products such as medical grade cellulose.
- Controlling degradation effects by development of new and upgrading of existing radiation processing methods, e.g. irradiation in oxygen-free atmospheres.

**Participants:** 12 MS institutions

**Achievements:**
- Controlled degradation of synthetic and natural polymers (reduced MW and particle size for improved compatibility, improved solubility, recycling, enhanced adhesion, degradation at low doses, preparation of products with optimum MW for the selected application; degradation of Teflon, preparation of ion-track pores, lithography).
- Suppression of unwanted degradation (long shelf life for radiation sterilized polymers, choice of stabilizer, UHWM PE hip and knee replacements, cables in nuclear installations).
- Implementation of advanced techniques for understanding the mechanism of degradation (positron annihilation spectroscopy, Rutherford backscattering, elastic recoil detection analysis, NMR and GC/MS, identification of degradation products, mapping).

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### Coordinated Research Projects on Radiation Technologies

#### Electron Beam Treatment of Organic Pollutants Contained in Gaseous Streams

**Overall objectives:**
- To develop reliable analytical methodologies concerning investigation of degradation effects of radiation on VOC (volatile organic compounds) in the gaseous phase.
- Laboratory and pilot scale tests will be performed and mechanism of the process studied, both on experimental and theoretical ways.
- Technical and economical feasibility of the process will be evaluated towards its full scale applications.

**Specific objectives:**
- Studying radiation effects on VOC degradation in gaseous phase and investigation of by-products formation, application of new and advanced analytical methods (gas chromatography, GC/MS, FTIR, etc.);
- Laboratory and pilot experiments for flow systems.
- Modelling of the process based on kinetic data.
- Studying of hybrid processes (EB/catalyst, EB/microwave, EB/ozone etc.).
- Technical and economical evaluation of the EB technology for Persistent Organic Pollutants (VOC, PAH) emission control.

**Participation:** 13 MS institutions
Coordinated Research Projects on Radiation Technologies

Achievements so far:
• Analytical methodologies developed for VOCs analyses.
• Hybrid processes tested (EB/catalytic, EB/microwave and EB/ozone).
• Tests with flue gases from medical incinerator: toxic VOCs compounds.
• Tests with oil combustion flue gases: establishment of G-values of decomposition of VOCs.
• Tests with EB demonstration plant in Bulgaria: VOCs from petroleum combustion.
• Studies of modeling studies of VOCs behavior under EB irradiation: method MD-Molecular Dynamics (kinetic mechanisms and computer program in developing for simulation).
• Analyses of stack gases from industrial plants (odorous waste gases).

Coordinated Research Projects on Radiation Technologies
Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Selective Separation Purposes (2007-2011)

Overall objective:
- To use gamma rays, electron beams and swift heavy ions for grafting of various monomers onto natural and synthetic polymers for the development of novel adsorbents and membranes for environmental and industrial applications.

Specific objectives:
- Development of adsorbents for the efficient removal of heavy metal ions from contaminated wastewaters.
- Adsorbents suitable for the collection and recovery of significant metal ions.
- Development of adsorbents for removal of undesired anions from aqueous systems.
- Development of low-cost membranes with improved durability and performance characteristics for potential applications in fuel-cell fabrication.
- Development of methods for the preparation of membranes with 1-50 nm pore sizes and functionalized inner surfaces.

Participants: 16 MS institutions

Expected research outputs (Results):
- Development of new adsorbents with enhanced heavy metal ion uptake capacities.
- New fabrication methods of radiation-grafted specialty adsorbents for environmental and industrial applications.
- Synthesis of membranes with improved performance and durability potential applications in fuel cells.
- Production of radiation-grafted membranes with smaller pore sizes selective for proteins, polysaccharides and metal ions.
Coordinated Research Projects on **Radiation Technologies**

**Development of Radiation-processed Products of Natural Polymers for Application in Agriculture, Healthcare, Industry and Environment**

(2007-2011)

**Overall objective:**
- Widespread promotion and general application of radiation-processed natural materials, coupling radiation technology and end-users to derive enhanced benefits from these value-added natural materials.

**Specific objectives:**
- Identification of methodologies and QA protocols for investigating structure-property relationship particularly with respect to radiation induced changes in natural polymers.
- Investigating the anti-oxidant properties of low molecular weight natural polymers and assessing suitability for preservation of food and allied products.
- Field-testing the potential of radiation-modified polysaccharides as plant growth promoters, soil conditioners and for enhancing fermentation of agro-by-products.

**Participants:** 17 MS institutions

**Expected outputs:**
- Harmonization of QA protocols for characterization of radiation-induced changes in natural polymers.
- Development of protocols for use of radiation-modified polysaccharides as plant growth promoters and soil conditioners on a field scale so as to produce marketable products.
- The salient results of the CRP will be presented in International conferences and published in scientific journals and as IAEA technical report.

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Coordinated Research Projects on **Radiation Technologies**

**Nanoscale Radiation Engineering of Advanced Materials for Potential Biomedical Applications**

(2008-2012)

**OBJECTIVE**

- The use of radiation in the synthesis, modification, and characterization of advanced materials by nanoscale control of their properties.

**SPECIFIC RESEARCH OBJECTIVES:**

- To develop radiolytic methodologies for synthesis of nanoparticles and nanoscopic membranes, as well as to synthesize and modify nanoparticle surfaces by attaching organic ligands.
- To radiation synthesize polymeric, inorganic and hybrid nanocarriers, providing for controlled loading and improved releasing rate of drugs.
- To fabricate new stimuli-responsive surfaces by radiation induced grafting on the nanoscale for cell-sheet engineering with improved cell-matrix interactions and cell-function control.

The participant groups will address and contribute to one or more of the above topics.
Coordinated Research Projects on Radiation Technologies

Expected outputs:

- Methodologies to prepare and characterize nanogels, nanoparticles and nanoporous membranes, as well as to synthesize and modify nanoparticle surfaces by attaching organic ligands by radiation.
- Methodologies to radiation synthesize polymeric, inorganic and hybrid nanocarriers, providing a controlled loading and improved releasing rate of drugs.
- Demonstration of novel functional surfaces for cell-sheet engineering fabricated by utilizing advanced radiation technology, towards improved cell-matrix interactions and cell function control.
- Publication of the results under the IAEA Radiation Technology Series.

RADIATION TECHNOLOGY SUPPORT FOR CLEANER ENVIRONMENT AND MATERIAL ANALYSIS AND DEVELOPMENT

Planned Coordinated Research projects

- Radiation Processing of Composites
- Radiation Resistant Polymers for Value-Added Products and Packaging applications to Facilitate the Replacement of EtO Sterilization Method
- Treatment of Biohazardous Contaminants by Radiation Processing
- Radiation Processing for Remediation of Organic Pollutants in Solids and Aqueous Environment

RADIATION TECHNOLOGY SUPPORT FOR CLEANER ENVIRONMENT AND MATERIAL ANALYSIS AND DEVELOPMENT
Guidelines and Publications

- Under Preparation:
  - Guidelines for QA/QC in Radiation Processing of Materials
  - Guidebook on the Use of Mathematical Modelling in Electron Beam Processing
  - Industrial Electron Beam Processing (draft document ready)
Events held with the cooperation of the IAEA: 
(2006-2008)

- 14th IMRP 2006 - International Meeting on Radiation Processing (Malaysia)
- 11th Tihany Symposium on Radiation Chemistry (Hungary, 2006)
- IraP-2006 - 7th International Symposium on Ionizing Radiation and Polymers (Turkey)
- RadTech Asia 2007 - 11th International Conference on Radiation Curing (Malaysia)
- IraP-2008 - 8th International Symposium on Ionizing Radiation and Polymers (Brazil)
- 15th IMRP2008 – International Meeting on Radiation Processing (UK)

Radiation techniques for industrial process management

- Radiation techniques are used as powerful tools in industrial process management (IPM).
- Optimization and/or trouble-shooting.
- Visualization of multiphase flow in complex industrial systems:
  - Valuable opportunities in industries such as mining, sugar and cement manufacture and oil/petrochemical.
- Developing countries seeking to enhance quality assurance (QA) systems and safety of industrial processes.

Current CRPs:

- Evaluation and Validation of Radioisotopes Generators-Based Radiotracer for Industrial Applications. (2007-2011)
TECHNOLOGY TRANSFER
Technical Cooperation Programme

• National Projects
• Regional Projects
• More than 100 projects
• 5-7 regional projects

Examples of Regional TC Projects
• AFRA “Radioisotope Applications for Troubleshooting and Optimizing Industrial Processes”
• AFRA “Promoting Self-reliance and Sustainability of Non-destructive Testing Facilities”
• RAS “Establishing Quality Assurance and Good Manufacturing Practice of Medical Radioisotopes and Radiopharmaceuticals”
• RAS “Good Radiopharmacy Practice and Good Manufacturing Practice”
• RCA “Quality Assurance and Quality Control of Nuclear Analytical Techniques”
• RCA “Use of small accelerators as nuclear analytical tool in art and archaeology”

Examples of Regional TC Projects
• RCA “Modification of Natural Polymers through Radiation Processing”
• AFRA “Radiation Processing for Materials and Environmental Applications”
• ARCAL “Harmonization and Optimisation of Managerial and Operational Procedures in Industrial Radiation Facilities”
• EUROPE REGION “Quality Control Methods and Procedures for Radiation Technology”
• WEST ASIA REGION “Application of Radiation Technology for Materials Development”