ISSUE NO. 305 | JUNE 2009

बी एआरसी न्यूज़लैटर

BARC NEWSLETTER

IN THIS ISSUE

In the forthcoming issue

Measurement of fission gas release from PHWR fuel pins

The Noble gases Xe and K which have different isotopic compositions, form approximately 15% of the fission product inventory in irradiated nuclear fuel. The measurement of these fission gases is an important issue in improving the overall performance of the fuel. The present article describes the fission gas measurement set-up installed at the PIED hot cells. The experimental details and results obtained from the tests carried out on fuel pins from 19-element UO_2 PHWR fuel bundles have been summarized in this article.

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BARC NEWSLETTER

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^{177}LU-EDTMP: A NEW RADIOPHARMACEUTICAL FOR PALLIATION OF BONE PAIN IN CANCER PATIENTS WITH SKELETAL METASTASES

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Introduction

Skeletal metastases or secondary cancerous lesions in bone, are common in patients suffering from breast, lung and prostate cancer, in the advanced stage of the disease. These metastatic lesions in skeleton, often lead to excruciating pain and other related symptoms such as: lack of mobility, neurological deficits, depression, anxiety, anger, fear of death etc., which adversely affect the quality of life. Though conventional treatment modalities such as administration of analgesics and external beam radiotherapy are prevalent practices, their disadvantages are manifold, owing to multiple side effects. Radionuclide therapy employing radiopharmaceuticals labeled with radionuclides, and which emit β^-/conversion electrons is an effective option for bone pain palliation and could provide significant improvement in the quality of life of the patients. The major challenge in developing effective agents for palliative treatment of bone pain arising from skeletal metastases, is to ensure the delivery of adequate doses of ionizing radiation, at the site of the skeletal lesions, with minimum radiation-induced bone marrow suppression.

^{177}Lu: A promising radionuclide for bone pain palliation

^{177}Lu is presently being considered as a potential radionuclide, for use in *in-vivo* targeted radiotherapy, owing to its favourable nuclear decay characteristics. ^{177}Lu decays with a half-life of 6.73 d, by emission of β^- particles with maximum energies of 497 keV (78.6%), 384 keV (9.1%) and 176 keV (12.2%) to stable ^{177}Hf. The emission of suitable energy gamma photons of 113 keV (6.4%) and 208 keV (11%), with relatively low abundances, provides an opportunity to carry out simultaneous scintigraphic studies, which helps to monitor the proper *in-vivo* localization of the injected radiopharmaceutical as well as to perform dosimetry studies. The high thermal neutron capture cross-section of [^{176}Lu (n,γ) ^{177}Lu] reaction (σ = 2100 β^-) ensures production of ^{177}Lu with sufficiently high specific activity, using even moderate flux reactors. Apart from this, the comparatively longer half-life of ^{177}Lu, provides a logistic advantage in delivering the radiopharmaceutical to locations far away from the reactors. Considering the lower decay loss as well as the possibility of large-scale production

flux research reactors, ^{177}Lu could be envisaged as an ideal radionuclide, for developing therapeutic radiopharmaceuticals, particularly in countries with limited isotope production facilities and poor logistics. Moreover, the tissue penetration range of the β^- particles from ^{177}Lu are adequately low which ensures minimum bone marrow suppression, a major advantage of this radiotherapeutic application.

EDTMP as carrier ligand for developing ^{177}Lu based agents for palliation of bone pain

Several classes of structurally different phosphonic acid ligands, chelated to different β^- particle emitting radionuclides, have been extensively studied for their bone uptake characteristics. The affinity of the co-ordinated phosphonic acid ligands for calcium, present in actively growing bones, is considered to be the factor responsible for their selective localization, into metastaticlesions. Multidentate polyaminopolyphosphonic acid ligands are known to form stable chelates with many metals, particularly with lanthanides. Therefore, ethylenediaminetetramethylene phosphonic acid (EDTMP) can be envisaged as an ideal carrier moiety, for the development of ^{177}Lu-based radiopharmaceuticals, for bone palliation.

Production of ^{177}Lu

^{177}Lu was produced by thermal neutron bombardment, on isotopically enriched (64.3% ^{176}Lu) Lu_2O_3 target, at a flux of 6 x10^{13} n/cm^2.s for 14 d in the Dhruva reactor. The irradiated target was dissolved in 1 M HCl by gentle warming, after allowing a cooling period of 6 h. The resulting solution was evaporated to near-dryness and reconstituted in double distilled water, whereby $^{177}LuCl_3$ was obtained, for use in all subsequent studies. ^{177}Lu was produced with a specific activity of 555-740 GBq/mg (15-20 Ci/mg) and radionuclidic purity of 99.98% at the End of Bombardment (EOB). Trace quantities of ^{177m}Lu were found to be only radionuclide impurities present in the processed ^{177}Lu and the radionuclidic impurity burden was determined to be 5.5 kBq of ^{177m}Lu / 37 MBq of ^{177}Lu (150 nCi/ 1 mCi) at EOB, which is only 0.02% of the total activity produced.

A typical gamma ray spectrum of the ^{177}Lu, recorded after radiochemical processing is shown in Fig. 1. The major gamma peaks were observed at 72, 113, 208, 250 and 321 keV, all of which correspond to the photopeaks of ^{177}Lu. This was further confirmed from the decrease of count rate values at those peaks in accordance with the half-life of ^{177}Lu.

Synthesis of EDTMP

EDTMP was synthesized by following a Mannich-type reaction, using orthophosphorus acid, 1,2-ethylenediamine and formaldehyde in strongly acidic medium. In a typical reaction, 1,2-ethylenediamine

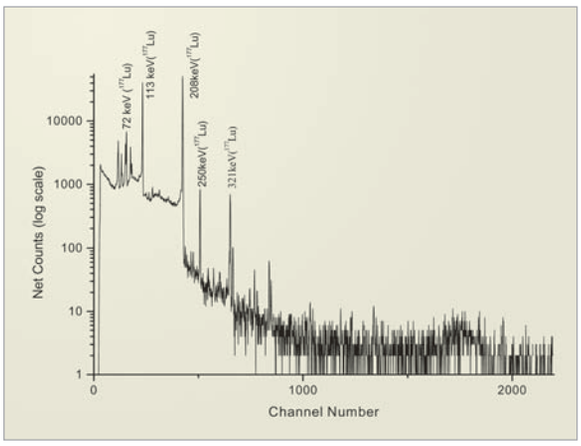


Fig. 1 : Gamma ray spectrum of ^{177}Lu at EOB

(0.60 mL, 9.55 mM) was added slowly to a solution of anhydrous orthophosphorus acid (3.3 g, 40.24 mM), in concentrated HCl (5 mL) and the mixture was allowed to reflux. Formaldehyde (36%, 3.6 mL) was added dropwise over a period of 15 min to therefluxing mixture. The refluxing was continued for another 2 h and subsequently the mixture

was cooled to room temperature. The reaction mixture wasconcentrated under vacuum and kept at room temperature whereby EDTMP was precipitated.

The crude product was recrystallized from hot water, whereby pure EDTMP (3.83 g, yield 92%, melting point 215°C) was obtained. The scheme for the synthesis of EDTMP is shown in Fig. 2.

Characterization of EDTMP

The characterization of EDTMP, synthesized in-house, was carried out by using standard spectroscopic techniques, such as Fourier Transform Infra Red (FT-IR) spectroscopy, proton-nuclear magnetic resonance (^{1}H-NMR) and ^{31}P-NMR spectroscopy. The

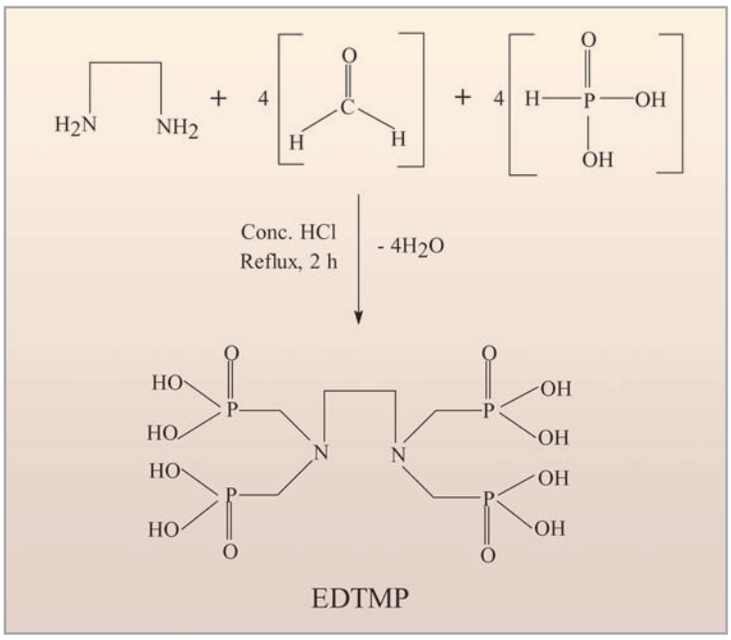


Fig. 2 : Scheme for the synthesis of EDTMP

FT-IR, ^{1}H-NMR and ^{31}P-NMR spectral data are given in Table 1. The peak multiplicities and integrations of the ^{1}H-NMR spectrum were consistent with the structure of EDTMP. An eight-proton doublet observed at δ 3.55 ppm in the ^{1}H-NMR spectrum of EDTMP, could be attributed to the coupling of the α-methylene protons with the adjacent phosphorus atom, indicating the formation of the α methylene phosphonic acid. The ^{31}P-NMR spectrum provides confirmatory evidence of the formation of EDTMP. A triplet observed at $\sim \delta$ 9.86 ppm (J = $\sim$12 Hz) indicated the coupling of the phosphorus atom with the α-methylene group. This triplet appeared as a singlet in the proton-decoupled ^{31}P-NMR spectrum, thereby confirming the formation of the -$CH_2PO(OH)_2$ group.

Preparation of ^{177}Lu-EDTMP

^{177}Lu-EDTMP was prepared by dissolution of EDTMP (35 mg, 80.28 μM), in 0.5 M $NaHCO_3$ solution (0.4 mL, pH $\sim$9). To the resulting solution, $^{177}LuCl_3$ (0.01-0.5 mL, 185 MBq-5.55 GBq i.e. 5-150 mCi of ^{177}Lu activity) was added, followed by the addition of the required volume of normal saline so that, the final volume of the reaction mixture was 1 mL. The pH of the reaction mixture was kept within the range of 5-8 and it was incubated at room temperature for 15 min, to facilitate complete complexation. After performing the standard quality control tests, the complex was passed through the 0.22 μ Millipore® filter paper to render the solution sterile and subsequently injected first in animals and later tested on human patients.

Quality control of ^{177}Lu-EDTMP

The complexation yield and radiochemical purity of ^{177}Lu-EDTMP was determined, by employing paper chromatography and paper electrophoresis techniques. In paper chromatography, carried out using ammonia:ethanol: water (1:10:20 v/v) as the eluting solvent, $^{177}LuCl_3$

Table 1: Characterization of EDTMP

FT-IR-Spectrum (ν cm^{-1})			
3308, 2633, 2311, 1668, 1436, 1356			
^{1}H-NMR			
	Multiplicity	**Shift (δ ppm)**	**No. of protons**
>N-C<u>H</u>$_2$-C<u>H</u>$_2$-N -N-[C<u>H</u>$_2$-P(O)(OH)$_2$]$_2$	Singlet Doublet, J=12.3 Hz	3.86 3.55	4 8
^{31}P-NMR (^{1}H-decoupled)			
-N-[CH$_2$-<u>P</u>(O)(OH)$_2$]$_2$	Singlet	9.86	

remained at the point of spotting ($R_f = 0$) while ^{177}Lu-EDTMP moved toward the solvent front ($R_f = 1$) under identical conditions. On the other hand, in paper electrophoresis carried out using 0.025 M phosphate buffer of pH 7.4 at a potential gradient of 30 V/cm for 75 min, $^{177}LuCl_3$ remained at the point of application, while ^{177}Lu-EDTMP moved towards the anode, indicating that the complex was negatively charged. These two methods were used for the determination of the complexation yield of ^{177}Lu-EDTMP. The ^{177}Lu-EDTMP complex was obtained with a radiochemical yield of >99% under optimized reaction conditions.

Biodistribution studies in rats

Biodistribution studies of ^{177}Lu-EDTMP complex were performed on normal Wistar rats, each weighing 200-250 g. The ^{177}Lu-EDTMP complex (~0.1 mL, ~3.7 MBq, ~100 μCi) prepared under optimized reaction conditions was injected through the tail vein and the animals were put to sleep by cardiac puncture, post-anaesthesia, at the end of 30 min, 3 h, 1 d, 2 d and 7 d, post-injection. Five rats were used for each time point. The organs / tissues were excised and the associated activity was measured in a flat type NaI(Tl) scintillation counter. The Femur was considered as a representative of the skeleton and the total skeletal uptake was calculated, by considering the skeleton to be 10% of the total body weight. Total uptake in blood and muscle were calculated, by considering that the tissue constitutes 7% and 40% of the total body weight respectively. Distribution of the activity in different organs / tissues was calculated as percentage of Injected Activity (IA) per organ and represented in Table 2. The percentage of activity excreted is indirectly ascertained, by subtracting the activity accounted in all the organs from the total activity injected.

The results of the biodistribution studies revealed significant bone uptake within 30 min, post-injection. The activity from the blood was almost completely cleared within 3 h post-injection and no significant accumulation of activity was observed in any of the major organs / tissues at that point of time. The overall skeletal uptake was found to remain constant ~45% IA till 7 d post-injection, upto which point the study was carried out. It was also observed that ~50% of the IA was cleared via urinary excretion within 30 min post-injection, indicating rapid renal excretion of the non-accumulated activity from the non-target organs / tissues.

Table 2 : Biodistribution pattern of ^{177}Lu-EDTMP complex in Wistar rats

Organ	%Injected activity (IA) / organ				
	30 min	3 h	1 d	2 d	7 d
Blood	1.32 (0.25)	0.36 (0.10)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Liver	0.36 (0.13)	0.26 (0.10)	0.25 (0.13)	0.22 (0.06)	0.18 (0.03)
Intestine	0.47 (0.06)	1.86 (0.20)	1.80 (0.18)	1.54 (0.48)	0.23 (0.04)
Kidneys	0.69 (0.15)	0.36 (0.04)	0.26 (0.11)	0.28 (0.06)	0.21 (0.05)
Stomach	0.13 (0.03)	0.04 (0.02)	0.03 (0.02)	0.07 (0.01)	0.01 (0.00)
Heart	0.05 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Lungs	0.10 (0.01)	0.02 (0.02)	0.02 (0.01)	0.00 (0.00)	0.00 (0.00)
Muscle	1.54 (0.35)	1.02 (0.48)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Spleen	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)
Skeleton	**40.48 (7.48)**	**43.50 (4.25)**	**46.25 (3.48)**	**45.53 (2.07)**	**45.28 (4.31)**
Excretion[#]	52.86 (5.94)	52.34 (7.68)	50.53 (9.17)	51.36 (4.07)	53.48 (4.71)

Figures in parentheses represent standard deviations (n = 5)

Imaging studies in rats

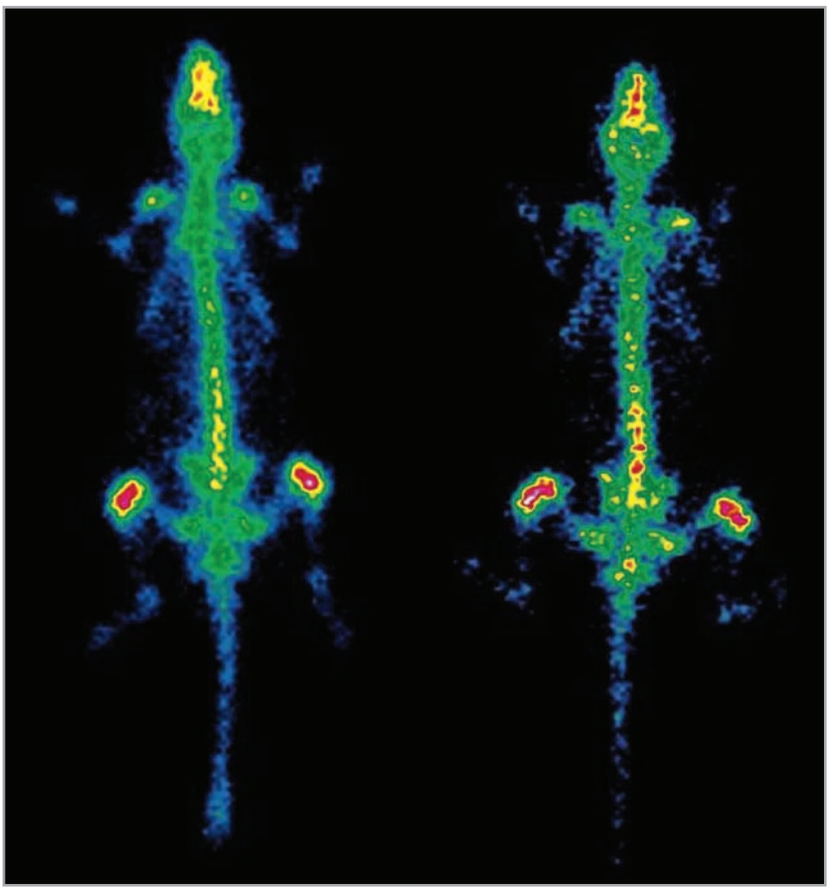
The biological behaviour of ^{177}Lu-EDTMP complex was also ascertained, by carrying out simultaneous scintigraphic imaging studies in normal Wistar rats. For imaging studies, ^{177}Lu-EDTMP complex (~0.1 mL, 18.5 MBq, 500 μCi) was injected through the tail vein of the animals, weighing ~250-300g. Sequential scintigraphic images were acquired in the single head digital Single Photon Emission Computed Tomography (SPECT) gamma camera, at 30 min, 1 h, 3 h, 1 d, 2 d, 4 d and 7 d post-injection, using a Low-Energy-High-Resolution (LEHR) collimator, to determine the *in-vivo* localization of the injected radioactivity. Prior to the acquisition of the images, the animals were anaesthetized using a combination of xylazine hydrochloride and ketamine hydrochloride. The gamma camera was previously calibrated for 208 keV gamma photon of ^{177}Lu, with ±10% window. All the images were recorded by acquiring 500 K counts using 256 x 256 matrix size. Blood samples were also drawn from the animals at the above-mentioned time points and counted, to ascertain ^{177}Lu activity, if any, present in the blood.

Significant uptake of the activity was observed in the skeleton within 1 h post-injection. Initially some activity was observed in the kidneys and bladder, which gradually decreased with time, indicating predominant renal clearance of the complex. No appreciable accumulation of activity was observed in any other major organs / tissues at that point of time. At 24 h post-injection, the total skeleton was clearly visible and no uptake was observed in any other organ. The blood samples drawn from the animals at 3 h post-injection and all subsequent time points, did not exhibit any appreciable radioactivity over the background, indicating complete clearance of the activity from the blood. The skeletal activity was found to be retained without any significant leaching till 7 d post-injection, upto which point the study was carried out. The scintigraphic images of Wistar rats recorded at 1 d

and 7 d post-injection are given in Figs. 3 (a) and (b), respectively.

Imaging studies in rabbits

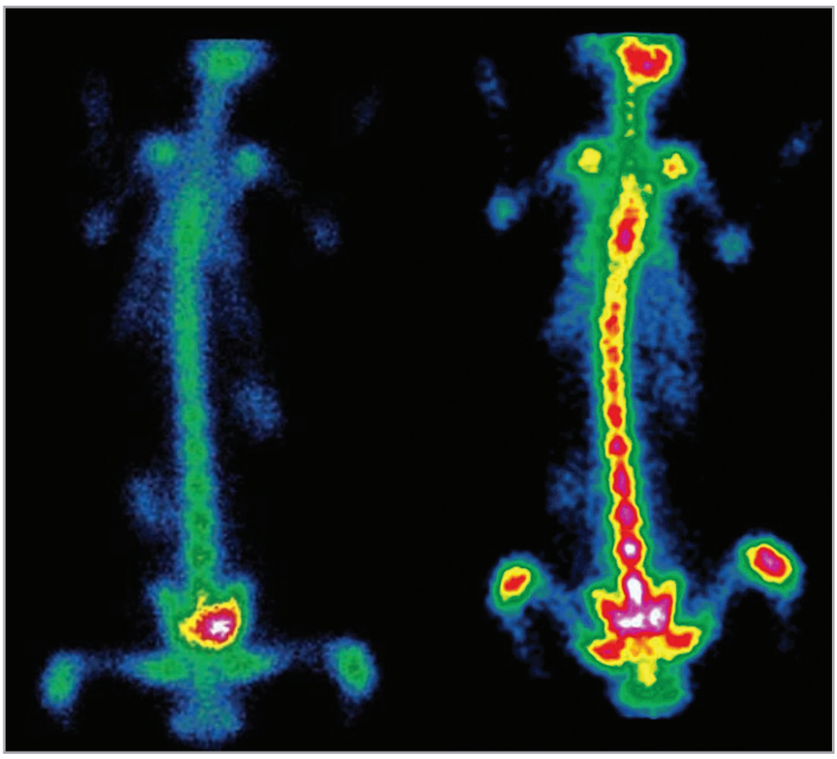
The distribution pattern of ^{177}Lu-EDTMP complex in New Zealand white rabbits was also studied, by carrying out serial scintigraphic imaging studies. For this purpose, ^{177}Lu-EDTMP complex (~0.5 mL, 148-185 MBq, 4-5 mCi) was injected intravenously into healthy adult New Zealand white rabbits, weighing 3-4 Kg through the ear vein. Sequential whole-body images were acquired in the single head digital SPECT gamma camera at 1 h, 3 h, 6 h, 1 d, 2 d, 3 d, 7 d, 14 d and 28 d post-injection, using a LEHR collimator. The gamma camera was previously calibrated for 208 keV gamma photon of ^{177}Lu with ±10% window. All the images were recorded by acquiring 500 K counts using 256 x 256 matrix size. Blood samples were drawn at the same time intervals mentioned above from the ear vein of the animals and counted for ^{177}Lu activity, to ascertain the blood clearance pattern.



(a) (b)

Fig. 3: Scintigraphic images of ^{177}Lu-EDTMP in Wistar rats at (a) 1 d and (b) 7 d post-injection

The uptake of the activity in the skeleton was observed within1 h post-injection and it became quite significant at 3 h post-injection. At that time point, the total skeleton was clearly visible in spite of some uptake observed in the kidneys. The image clearly showed no appreciable accumulation of activity in any other major organs / soft tissues. Within 24 h post-injection, the non-skeletal activity was completely cleared via urinary excretion. The skeletal activity was found to be retained till 28 d upto which point the study was carried out. The blood samples drawn from the animals did not show any appreciable radioactivity above the background from 3 h post-injection, indicating the fast clearance of the complex from blood. The scintigraphic images of Wistar rats recorded at 3 h and 2 d post-injection are given in Figs. 4 (a) and (b), respectively.



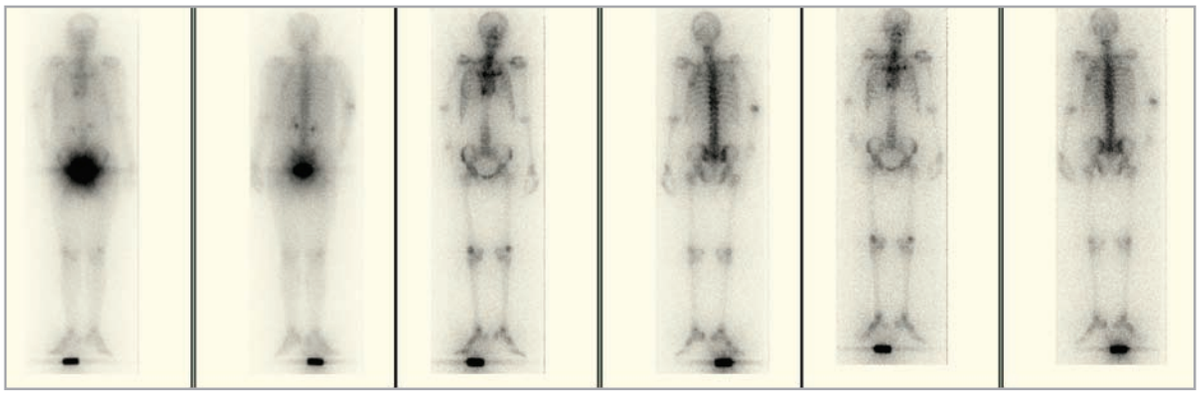
(a) (b)

Fig. 4 : Scintigraphic images of ^{177}Lu-EDTMP in New Zealand white rabbit at (a) 3 h and (b) 2 d post-injection

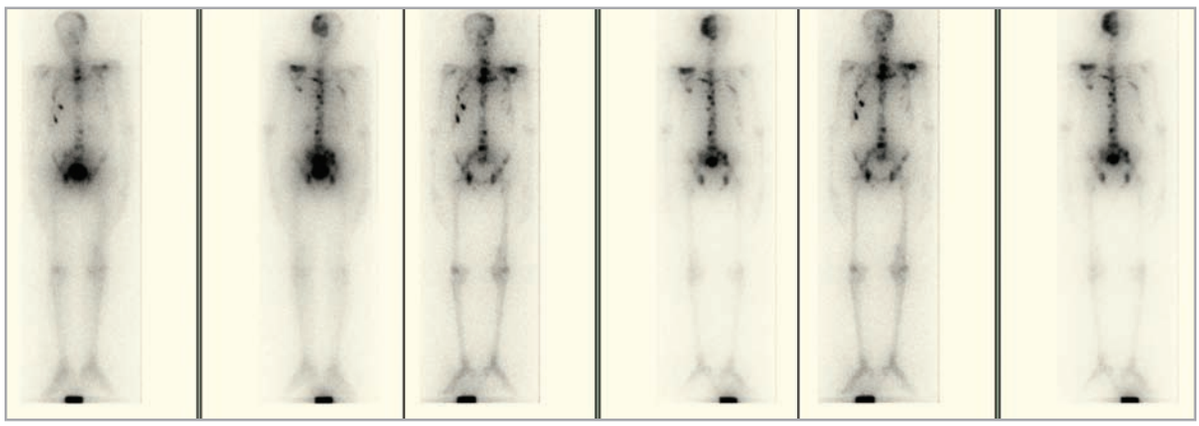
Pre-clinical dosimetry of ^{177}Lu-EDTMP in human patients

Pre-clinical dosimetry is essential in therapeutic radiopharmaceuticals for effective delivery of the radiation dose, so that the target organ receives maximum dose while the non-target sensitive organs receive less than the toxic dose. In case of ^{177}Lu-EDTMP, the target organ is skeleton while kidneys and bladder are the sensitive non-target organs, as the product is excreted via the kidneys. Pre-clinical dosimetry studies are conducted in patients with low amounts of activity to determine the distribution pattern of the agent and to estimate the dose to the target and non-target organs. Based on these studies, the dose to be administered for therapeutic efficacy is planned. Pre-clinical dosimetry of the ^{177}Lu-EDTMP complex was carried out on six human patients (age 60-75 years), suffering from advance prostate carcinoma with/ without skeletal metastasis. ^{177}Lu-EDTMP preparation (1 mL, 148-222 MBq, 4-6 mCi) was injected intravenously to the patients and the sequential whole-body images (planar anterior and posterior conjugate views) of the patients were recorded, using both 113 keV and 208 keV gamma photons of ^{177}Lu with $\pm$10% window at 30min (pre-void), 4 h, 8 h, 24 h, 48 h, 96 h and 144 h post-injection. Typical whole-body images of two patients, one having no metastasis and the other with extensive metastases,recorded at different times post-administration of ^{177}Lu-EDTMP, are shown in Figs. 5 (a) and (b), respectively.

Blood pharmacokinetics of the agent was studied, by drawing the blood samples at various time intervals post-administration and counting the ^{177}Lu activity, associated with the samples. Renal excretion pattern of the agent was determined, by collecting fractional urinary excretions e.g. 0-4 h, 4-8 h, 8-12 h, 12-24 h and 24-48 h post-administration and counting the radioactivity associated with the urine samples using well-type NaI(Tl) scintillation counter. ^{177}Lu-EDTMP was seen to accumulate quickly in the skeleton. This was evident from rapid clearance of the activity from the blood and rapid excretion of the non-accumulated ^{177}Lu-EDTMP through renal path. In brief, (49.10$\pm$9.70)% of the injected activity was in blood at 10 min post-injection, which fell to as low as (1.10$\pm$0.60)% at 24 h post-injection. Within 4 h, (30.26$\pm$14.32)% of the injected ^{177}Lu-EDTMP activity



(a)



(b)

Fig. 5: Distribution of ^{177}Lu-EDTMP in patients with (a) no metastasis and (b) with extensive metastases at 30 min, 1 d and 6 d post-administration (anterior and posterior views)

was observed to be excreted via urine and insignificant amount of radioactivity was found to be present in urine [(0.78±0.19)% IA) at 48 h post-administration. Thus, the product accumulated in the skeleton quickly within a few hours and remained there stably, irradiating the cancerous lesions.

In all the patients, the radiopharmaceutical showed good skeletal accumulation with insignificant uptake in non-skeletal organs / tissue. Though the skeletal accumulation was dependent on the individual patients as well as the extent of metastases, it was observed that 40-60% of the injected activity was accumulated in the skeleton. No clinical adverse reactions or side effects were reported.

The dose distribution pattern of the agent was calculated, using the OLINDA (Organ Level Internal Dose Assessment Code) 1.0 software. The high skeletal accumulation of ^{177}Lu-EDTMP resulted in a mean bone marrow dose of 0.80±0.15 mGy/MBq. The mean whole-body dose was found to be only 0.16±0.04 mGy/MBq, which is quite low

owing to the rapid urinary excretion of the radiopharmaceutical. The pre-clinical dosimetry studies generated preliminary dosimetry data of ^{177}Lu-EDTMP in human subjects, which formed the basis for Phase-I / II clinical trials of the agent.

Phase I / II clinical trials of ^{177}Lu-EDTMP

After the successful completion of pre-clinical dosimetry studies, Phase I / II clinical trials were initiated in human patients, suffering from metastatic bone pain due to prostate carcinoma, at the Department of Nuclear Medicine, All India Institute of Medical Sciences (AIIMS), New Delhi. Phase-I clinical trials involve dose escalation studies for the determination of Maximum Tolerable Dose (MTD) of ^{177}Lu-EDTMP, so that, maximum therapeutic efficacy could be attained keeping the bone marrow toxicity within tolerable limit. Phase-II clinical trials involve the determination of actual pain relief (pain score) experienced by the patients. For this, first a tracer dose of ^{177}Lu-EDTMP (111-148 MBq, 3-4 mCi) was injected in the patients to determine the percentage uptake in skeleton, which helped in determining the actual therapeutic dose to be injected in the patients. Subsequently, different doses of ^{177}Lu-EDTMP preparation were injected in the patients. For each dose of ^{177}Lu-EDTMP, 3 patients were chosen. The sequential whole-body images of the patients were recorded at the 30 min (pre-void), 4 h, 8 h, 1 d, 2 d, 4 d, 7 d and 14 d post-administration. A typical whole-body image of a patient injected with 2.59 GBq (70 mCi) of ^{177}Lu-EDTMP at 14 d post-infection is shown in Fig. 6.

Twelve male patients suffering from metastatic bone pain due to prostate carcinoma were injected with various doses of ^{177}Lu-EDTMP (2.59-5.55 GBq, 70-150 mCi) till date and the progress of the therapy was determined, by finding out the percentage relief in pain on weekly basis, following the standard protocol. No adverse effect due to the therapy has been detected in any of the patients and all of them

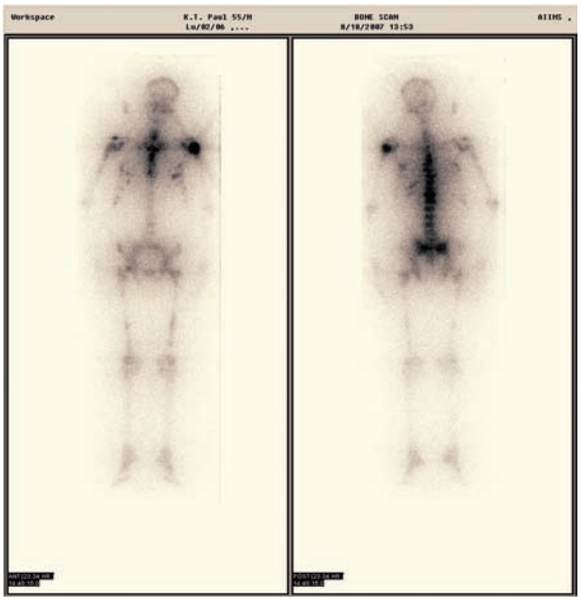


Fig. 6: Whole-body image of a human patient injected with 2.59 GBq (70 mCi) of ^{177}Lu-EDTMP at 14 d post-administration (anterior and posterior view)

experienced excellent pain relief. The onset of pain relief was reported within one week and significant relief from pain was experienced between the 7th and 8th weeks of administration of ^{177}Lu-EDTMP, by most of the patients. The study is presently being continued to determine the actual MTD and to study the pain relief pattern. A typical response shown by a patient after the administration of 2.59 GBq (70 mCi) of ^{177}Lu-EDTMP is given in Table 3.

After the completion of Phase I / II clinical trials, Phase III clinical trials involving multiple hospitals and medical centres will be initiated and the radiopharmaceutical is expected to be marketed through the Board of Radiation and Isotope Technology (BRIT), for regular supply to hospitals in the near future.

Conclusion

The preparation and evaluation ^{177}Lu-EDTMP constitutes the first concerted efforts of the Radiopharmaceuticals

Table 3 : Progress chart of ^{177}Lu-EDTMP therapy

Organ		Week-wise %relieve of pain								
		Pre-therapy status	1st	2nd	3rd	4th	5th	6th	7th	8th
Shoul-der	Right	0	20	40	60	75	80	85	NP	NP
	Left	0	15	25	50	70	75	80	NP	NP
Chest	-	NP	NP	NP	NP	NP	NP	NP	NP	NP
Spine	-	0	25	50	75	80	85	90	NP	NP
Hip	Right	0	25	50	75	80	85	90	NP	NP
	Left	0	25	50	75	80	85	90	NP	NP
Upper Limb	Right	0	30	40	70	80	85	90	NP	NP
	Left	0	20	30	50	60	70	75	NP	NP
Lower Limb	Right	0	30	40	70	80	85	90	NP	NP
	Left	0	20	40	60	70	75	80	NP	NP

NP = No pain or 100% relief from pain

Division and the clinical partners of AIIMS, in developing a new therapeutic radiopharmaceutical for bone pain palliation, for use in India. ^{177}Lu, a potential therapeutic radioisotope with multiple advantages, particularly from the aspect of logistic considerations, has been indigenously produced in BARC reactors. EDTMP has been synthesized in-house and the preparation of therapeutic doses of ^{177}Lu-EDTMP suitable for injection in human patients has been carefully standardized. Bioevaluation studies of this agent in animals and human patients have yielded promising results and Phase I / II clinical studies are currently underway. In the near future, ^{177}Lu-EDTMP, when supplied commercially, would serve as a cost-effective and a viable alternative to the existing agents, used currently for bone pain palliation in cancer patients, with skeletal metastases.

Acknowledgements

The Reactor personnel, Dr. S.V. Thakare and Mr. K.C. Jagadeesan have played a vital role in the production of ^{177}Lu and the authors are thankful to them for enabling this work. The authors thank acknowledge the International Atomic Energy Agency (IAEA) for giving the impetus to this work by bringing scientists and clinicians from all over the world together, in a Co-ordinated Research Project (CRP). Thanks are also due to the staff members of the BARC animal experimentation facility for their help with animal studies. The authors are grateful to Dr. V. Venugopal, Director, Radiochemistry & Isotope Group, for his constant support and encouragement.

All human studies of ^{177}Lu-EDTMP reported here, were carried out in collaboration with the Department of Nuclear Medicine, All India Institute of Medical Sciences, New Delhi

DEVELOPMENT OF AN AUTOMATED CHARGING SYSTEM FOR SPENT FUEL IN NUCLEAR RECYCLE PLANTS

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Nuclear Recycle Group (Projects)

Introduction

In the head-end system of a power reactor fuel reprocessing plant, spent fuel bundles stored under water in a fuel pool, are transferred to spent fuel chopper located inside a dissolver cell, through a lead-shielded charging cask, for further shearing of the bundles into small pieces. These cut pieces are dissolved in concentrated nitric acid for further processing, by the PUREX process. Fig. 2 shows the typical flow sheet of head-end system of a reprocessing plant.

Fig. 1 : Automated Charging Facility

In present plants, a batch of 10 fuel bundles are loaded into the charging cask. This charging cask is brought out of the pool and positioned on a motorized trolley, for docking the cask with a transfer port on the wall of the dissolver cell. Spent fuel charging (feeding) from the cask is done in two steps, first a semicircular cask liner is pushed into a set position and then the fuel bundles are pushed into the chopper. The total pushing stroke is about 12 m.

In the existing fuel reprocessing plants in India, handling of charging cask, under water loading/unloading of spent fuel bundles into the cask and fuel charging, are manual operations and are labour intensive. Introduction of automation at each stage of fuel handling has been planned, for reducing the operator fatigue, reducing the man-rem consumption and improving productivity. One such effort is the development and induction of the Automated Charging Facility (ACF) in fuel handling. This unit automates all operations carried out during charging of spent fuel bundles. One ACF has been developed, installed and tested at the Kalpakkam Reprocessing Plant (KARP) successfully and has been inducted into the plant for regular operation (Fig.1).

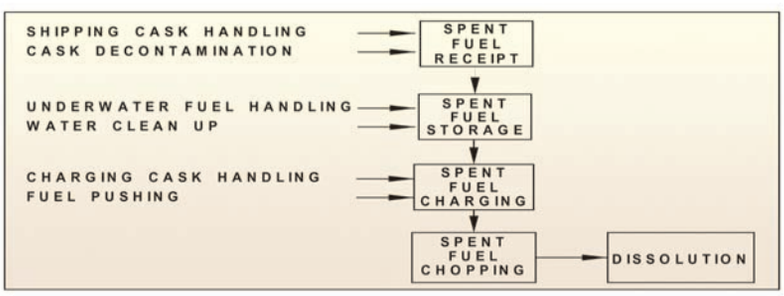


Fig. 2: Head end system of the Nuclear Recycle Plant

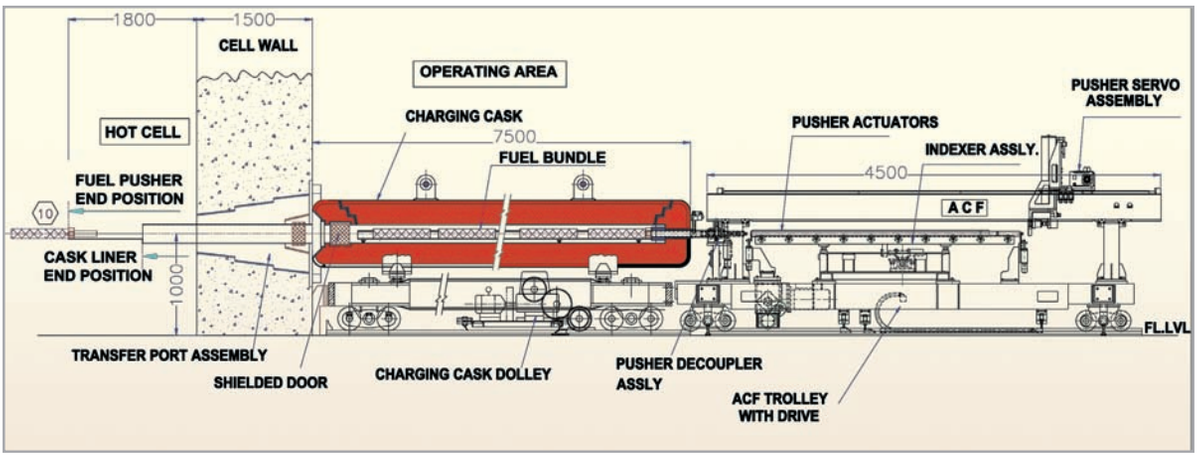


Fig. 3: General arrangement of the Automated Charging Facility (ACF) along with Charging cask

Description of the ACF

The ACF is essentially a trolley-mounted indexing pushing device, placed behind the charging cask dolley and run on the common set of rack and guide rails (Fig. 3). The system operates on a PLC controlled environment, which has a servo pusher, mechanical couplers for push rods and indexing system for alignment of push rods.

The following are the major operational steps to be carried out by the ACF:

- Charging trolley movement (Forward, Micro forward and Reverse)
- ACF trolley movement (Forward, Micro forward and Reverse)
- Operating Transfer Port Assembly (TPA) door (Open / Close)
- Operating Cask door (Open / close)
- De-locking and locking of cask liner and fuel pusher
- Coupling / decoupling of fuel pusher with fuel pusher actuator
- Coupling / decoupling of cask liner with cask liner actuator
- Liner pushing upto pre-determined distance (Forward / Reverse)
- Fuel pusher pushing into spent fuel chopper upto predetermined distance (Forward / Reverse).

In order to achieve all above functions, ACF has been built with following devices / sub-systems:

i) Linear Indexing Device (for cask liner actuator and fuel pusher rods)
ii) Servo Pusher
iii) Coupling and decoupling unit
iv) ACF trolley with drive
v) Control console.

The linear indexing device holds four liner and fuel pusher actuator rods on an X- table mounted on LM guides and moves the actuators from home position to pushing position. The actuation is done by a pneumatic cylinder with reed switches at end positions. A locking cylinder confirms the alignment after each indexing.

A servo drive (servomotor with two pole resolver) with rack and pinion transmission and Linear Motion (LM) guides have been used, for pushing of liner and fuel bundles. Two types of grippers have been mounted on servo drive, one for pushing of liner

actuator and the other for fuel pusher actuator. To place these grippers in position, a rotary indexer and vertical slide have been used. Rotary indexer has a pneumatic rotary actuator and vertical slide is operated on LM guides with the help of pneumatic cylinder.

The engagement of different pusher actuators is achieved by a two-jaw spring-loaded type automated coupling (Fig. 4). In normal position, the coupling is in locked condition (jaw open). A tapered actuator is used to unlock the coupling with the help of a pneumatic cylinder. The coupling unit is detachable type from the actuators, for its maintenance and / or replacement. The design has been tested for endurance and repeatability prior to acceptance for use in ACF. A test set-up for testing of the coupling is given in Fig. 5.

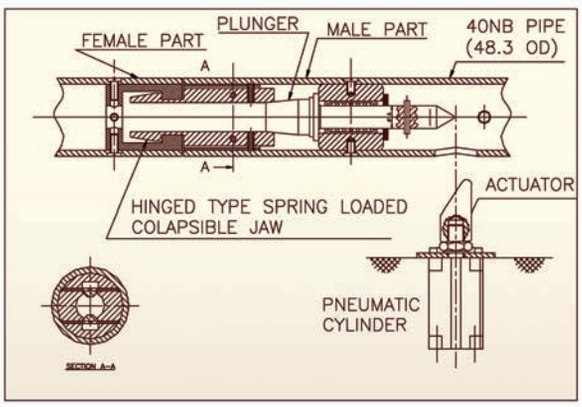


Fig. 4 : Automatic coupling

Operational Cycle

The ACF starts functioning after the charging cask is seated over the dolley and ends with the final retracement of pushers / liner actuators, their decoupling and bringing back the cask dolley to a set position.

Before the start of cycle, the liner and fuel pusher are in locked condition with the cask body. The automatic unlocking before start of cycle and re-locking at the end of cycle is done, by taking advantage of ACF trolley movement on the same rails and racks as that of charging cask dolley. Pneumatic cylinder actuated catches have been employed for this purpose.

ACF pushing mechanism, indexing device and associated components have been mounted on an electrically driven ACF trolley. A Variable Frequency Drive (VFD) has been employed for motion control of the trolley.

The control console system configuration uses a suitable CPU for PLC and a suitable station for Modbus.

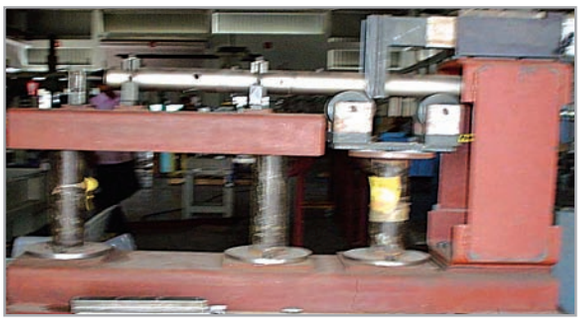


Fig. 5 : Test set-up for coupling

An MMI is mounted on this console for setting the parameters. PLC gives actuation signals depending on pre-conditions to be met for each subsequent operation as per the ladder diagram. The PLC has been programmed as defined by ladder diagrams with set inputs and outputs.

There are about 160 sequences of operation during one cycle of charging and these are repeated for subsequent charging. In the event of break down of any of these systems, the fuel charging can be continued manually using either the ACF unit or without the ACF as was practiced earlier.

Safety Features

The machine has various safety features. The servo pusher system has a force limiter for alarm and cut off

of the pushing, in case of any untoward situation. The travel / movement limit is obtained through position sensors, reed switches and encoders. Mechanical and electrical interlocks are provided for cask door, trolley and Transfer Port door. A series of postulated failure scenarios have been contemplated during the design stage so that unsafe actions and mal-function such as, power break-down during operation, failure of pushing mechanism drive, liner or fuel pusher in stuck-up situation, failure of limit switches, misalignment of liner actuator and pusher actuators for coupling with cask liner and fuel pusher are avoided.

Manufacturing, Testing and Installation

After completion of the detailed design stage and taking into consideration the suggestions of plant engineers, manufacturing was taken up with robust, reliable and high precision components. The most challenging part of the R&D was in developing a simple and effective automated coupling, to couple/de-couple two ends of fuel pushers automatically. A number of designs were worked out and the most suitable one was selected and employed in the ACF.

Fig. 6 : Testing of ACF in simulated condition

A test set-up was made at a manufacturer's shop to simulate the plant conditions of charging cask, cask dolley and transfer port assembly (Fig. 6). Dummy fuel bundles with dimensions and weight simulated were used, for testing the charging system. After satisfactory performance testing of the system for 100 cycles operations in 'auto- mode' and manual mode, the ACF was taken up for induction at KARP, Kalpakkam and rigorous dummy trials have been carried out after integrating ACF with existing cask dolly, charging cask and transfer port assembly. It was observed that there has been substantial reduction in the overall charging cycle time (by 50%).

Conclusion

The ACF developed and installed at KARP would reap large benefits in the long run. It has also given the confidence for induction of such systems in existing reprocessing plants and also in plants presently under construction.

Acknowledgements

The authors thank Mr. S.D.Misra, Director, NRG , Mr. S.Basu, Associate Director (P), NRG and Mr. R.G. Agarwal, Head, RTD for their keen interest, guidance and constant support in carrying out this development work. The authors are also grateful to the site engineers and staff at KARP for their active involvement during the trials at KARP.

LOW ENERGY RF LINACS AND ASSOCIATED TECHNOLOGIES: SUMMARY OF THE DAE-BRNS THEME MEETING

The DAE-BRNS Theme Meeting on Low Energy RF Linacs & Associated Technologies was organized at BARC during December 29-30, 2008, to exchange the experiences and expertise gained by different accelerator laboratories in the country. About 200 participants from different institutes attended the meeting. Dr. R.K. Choudhury, Head, Nuclear Physics Division welcomed the delegates to the meeting. He also outlined the genesis of such a theme meeting and the framework for the presentations on different topics of the meeting. In his introductory remarks, Dr. V.C. Sahni, Director, Physics Group, BARC and RRCAT, Indore traced the growth of accelerators in India and emphasized the need for collaboration among both national and international laboratories. He also mentioned the important contributions made by the Indian community to several international projects e.g. the Large Hadron Collider at CERN. Dr. S. Banerjee, Director, BARC inaugurated the meeting. He emphasized the importance of accelerators both for basic and applied research. He also discussed the importance of Accelerator Driven sub-critical reactor Systems (ADS) and the need to develop high current accelerators in view of our plan to use thorium in the third stage of the fuel cycle, for nuclear energy generation. Dr. P. Singh, Convener of the meeting presented the vote of thanks. He also gave the opening lecture entitled "LEHIPA project at BARC".

There were twenty six (26) invited talks presented during the meeting. They were arranged in the following seven sessions: 1) High current Accelerators; 2) Light/Heavy Ion Accelerators; 3) Ion Sources; 4) RFQ & DTL Design Issues; 5) RF systems; 6) Associated Technologies for High current DC power supplies, LCW, Beam diagnostics and monitoring systems; 7) Electron Linacs. Presentations were made on accelerator programmes / proposals at BARC, RRCAT, VECC, IGCAR, IUAC, CEERI, IPR and SAMEER. Detailed presentations were made on Microwave Ion Source & Low Energy Beam Transport (V.S. Pandit, VECC), Linac Development Programme for SNS (C.K. Pithawa, RRCAT), High Current Injector with High Performance HTS ECRIS (D. Kanjilal, IUAC), Fusion Material Irradiation Test Facility for Development of Fusion Material in India (S.K. Mattoo, IPR), Design and Development of RFQ and DTL Accelerator Cavities at IUAC (C.P. Safvan, IUAC). The RF activities at CEERI, Pilani (L.M. Joshi), RRCAT (M. Lad, P. Shrivasatava), BARC (Manjiri Pande) were also discussed in detail. Presentations were made on High Current Ion Sources (P. Roychowdhury, BARC, P.Y. Nabhiraj, VECC, V.K. Sanecha, RRCAT), Low Level RF Instrumentation (Gopal Joshi), RF couplers (Rajesh Kumar), Permanent Magnet Quadrupole (Sanjay Malhotra), Design Issues of RFQ (S.V.L.S. Rao) and Drift Tube Linac Structures (Arup Bandyopadhyay) , Beam Diagnostics for High Current Linacs (J.A. Gore), LCW Systems (S. Sengupta), ECR based injector at Mumbai Pelletron (P.V. Bhagwat), RFQ based Pulsed Neutron Source (R. Baskaran), RFQ Development for the RIB Project at VECC (A. Chakrabarti).

The meeting provided a suitable forum for discussion on the physics and technology of low energy high current linacs. The participants freely shared their achievements as well as problems faced in their projects and it is expected that this would lead to intense collaborations among various institutes.

Dr. S. Banerjee, Director, BARC, inaugurating the theme meeting

Dr. R. Ratheesh, C-MET, Thrissur pointed out that, under a BRNS project, a proprietary process called "SMECH process" was developed, for the fabrication of pore-free and dimensionally-stable, filled PTFE substrate. C-MET together with RRCAT, Indore has also developed temperature stable microwave substrates for the first time, for high power microwave amplifiers. These temperature stable PTFE / ceramic composites are currently not available in the market.

On the suggestion of the Chairman, AEC, a discussion was held, on the utilization of the LEP cryomodule received from CERN. Dr. K.C. Mittal (APPD, BARC) and Dr. Alok Chakrabarti (VECC) made presentations. Dr. Mittal said that the cryomodule could be configured as an accelerator of 40 MeV (for 6 MV/m) to 51 MeV (for 7.5 MV/m) for various applications. However, this would involve development of 1 MeV CW electron accelerator as injector, RF power source, beam diagnostics, power supply and control system for tuner, liquid Helium plant (800 litres helium required for one module) radiation building and other related infrastructural facilities. Similar views were expressed by Dr. Chakrabarti. It was felt by both the speakers that since this would require the development of large amount of infrastructure, a separate discussion was needed.

Dr. R.K. Bhandari, VECC, Kolkata, in his summary talk, appreciated the efforts of various groups and emphasized the need for collaboration among various institutes, working on different aspects of accelerators. He also emphasized the need to initiate theoretical / simulation studies, which take into account space charge effects. Dr. S.S. Kapoor pointed out that all efforts should be made to complete projects within the stipulated time and showed satisfaction with the progress made by Indian groups in these areas. He also remarked that as a result of our strength in nuclear sciences and the rapid progress in related technologies made in the last several years, the international community is looking up to India, for manpower and software / hardware support.

DAE-BRNS CONFERENCE ON "50 YEARS OF URANIUM METAL PRODUCTION" : A REPORT

Under the auspices of the Homi Bhabha Centenary year, a Conference on "50 years of Nuclear Grade Uranium Metal Production (UMFP-2009)" was organized by the Materials Group, BARC on 31st Jan. 2009 at the Central Complex Auditorium, BARC.

The conference was graced by eminent personalities of the department and also those who were associated with uranium metal and metallic fuel production including Dr. H.N. Sethna, Mr. S. Fareeduddin, Mr. P.K. Iyengar, Mr. Balaramamoorthy, Mr. B. Bhattacharjee and many others. There was an overwhelming response to the conference. In all, there were 400 delegates representing all DAE units associated with uranium processing in India.

Dr. A.K. Suri, Director, MG and Chairman, Organizing Committee, gave introductory remarks covering the history and the current status of uranium metal production activity and ore processing developmental work, done at the Materials Group, BARC.

Dr. S. Banerjee, Director, BARC welcoming the august gathering on the occasion of '50 years of nuclear grade uranium metal production'

Dr. S. Banerjee, Director, BARC formally welcomed the gathering and gave glimpses of forthcoming events proposed to be organized during the Centenary year and highlighted the unique features of BARC, a research and development unit with entire nuclear fuel cycle facilities starting from production of nuclear fuels to operation of research reactors, followed by recycle and reprocessing of irradiated reactor fuel.

Dr. Anil Kakodkar, Chairman AEC in his presidential address highlighted the basic importance of metallic fuel development which peaked during the early sixties of the Indian nuclear programme and was set to peak again with the growth of fast reactors for reducing the doubling time. He appreciated the special efforts taken by the Materials Group, in the production and processing of U compounds from various sources, especially developments related to the Tummalapalle ore deposits.

Dr. H.N. Sethna, Former Chairman, AEC, felicitating Dr. Anil Kakodkar, Chairman, AEC

Dr. Sethna, remotely inaugurating the facility 'RUMP'. Dr. A.K. Suri, Director, Materials Group and Mr. Fareeduddin, Former Additional

On this occasion, the Re-engineered Uranium Metal Plant (RUMP) was inaugurated by Dr. H.N. Sethna, Former Chairman, AEC. He emphasized the importance of international science and engineering co-operation in the Indian nuclear programme. Mr. Fareeduddin former Additional Director, BARC, in his key note address, explained the initial challenges faced in conducting metallothermic reduction and in continuation of subsequent production activities in early days. Organizing Secretary, Dr. (Ms.) S.B. Roy, Head, UED in her vote of thanks expressed her sincere gratitude to all senior colleagues for gracing the occasion and thanked the present members for their keen interest and support in metal production and in organizing the programme.

Reminiscences from senior colleagues were enlightening. It was a nostalgic event and virtually a trip down the memory lane with the legacy of Dr. Bhabha for the youngsters.

Invited lectures were delivered by Mr. Anjan Chaki, Director, AMD; Mr. R. Gupta, CMD, UCIL; Mr. S. Sivasubramanian, CMD, IREL; Mr. R.N. Jayaraj, CE, NFC; Mr. S.K. Ghosh, AD, ChE Grp., BARC on the recent developments on uranium exploration, mining, milling and refining for production of reactor grade uranium compounds. Health and safety in uranium mining and milling was discussed in detail by Raja Ramanna Fellow Mr. A.H. Khan. Technical developments in uranium metal production were discussed by Dr. (Ms.) S.B. Roy, Head, UED.

On this occasion a book on "50 years of Nuclear Grade Uranium Metal Production" was released by Mr. B. Bhattacharjee, Former Director, BARC and Member, National Disaster Management Authority.

Re-engineered Uranium Metal Plant (RUMP) at South Site, BARC

INTERNATIONAL CONFERENCE ON MEDICAL PHYSICS (ICMP- 2008) : A REPORT

The International Conference on Medical Physics (ICMP-2008) and the 29th Annual Conference of the Association of Medical Physicists of India (AMPI) was organized during November 26 - 29, 2008 at the Multipurpose Hall, Training School Hostel & Guest House BARC. The theme of the conference was "Advanced Technology of Radiation Medicine and Medical Physics Practice". About 650 delegates from India and abroad including 120 radiological / medical physics students from different universities of India, participated in the conference. ICMP-2008 was inaugurated by Dr. Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy (DAE). While delivering the inaugural address, Dr. Anil Kakodkar summarized the importance of ionizing radiation in daily life and contributions of DAE / BARC toward the cancer control programme of the country. He stated that there was a need to make available the advanced technology imaging and therapeutic equipment to rural areas, for the benefit of the masses. He also stated that sufficient number of trained technical manpower, for safe medical applications of ionizing radiation, is available in the country. However, there was a need to improve the working conditions at medical institutions in the rural sector and remunerate the specialists adequately, so that, the rural population can also get the services of highly skilled professionals. He also emphasized the need to restructure the training modules so that the trained manpower can efficiently use the advanced technology equipment for its intended applications. Mr. S. K. Sharma, Chairman, Atomic Energy Regulatory Board (AERB) presided over the inaugural function and released the Souvenir and Book of Abstracts. In the presidential address, Mr. S. K. Sharma highlighted the role of AERB in ensuring the safety and security of radiation sources. He also stated that though the radiation safety record in medical applications of ionizing radiation was very good, we should be cautious while commissioning high-end imaging and therapeutic equipment in clinical service. Prof. Bhudatt Paliwal, Director of Medical Physics, Department of Human Oncology and Medical Physics, University of

Release of Conference Proceedings - Left to right: Dr. S. D. Sharma, RPAD, BARC; Dr. Lisa Karam, NIST, USA; Dr. B. R. Paliwal, University of Wisconsin, USA; Dr. Anil Kakodkar, Chairman AEC; Mr. S. K. Sharma, Chairman, AERB; Prof. S. K. Kaul, President, AMPI; Dr. Y. S. Mayya, Head RPAD

Dr. Anil Kakodkar, Chairman, AEC and Secretary to the Government of India, DAE delivering the inaugural address during ICMP-2008

Wisconsin, Madison, USA presented the keynote address where he described in detail, the dosimetry problems associated with organ movements during Intensity Modulated RadioTherapy (IMRT). The keynote address highlighted the feasibility of a real time motion tracking methodology during the delivery of IMRT. Dr. Anil Kakodkar felicitated five Ex-BARC scientists and senior AMPI members (Dr. B. C. Bhatt, Dr. A. S. Pradhan, Dr. O. P. Massand, Mr. U. B. Tripathi and Dr. A. Shanta) for their contribution in the field of medical physics and the AMPI.

One hundred eighty five papers including AMPI Ramaiah Naidu Memorial Oration, 29 invited papers, 35 oral and 120 poster papers were presented during the conference. Mr. P. S. Viswanathan, Former Head, Department of Medical Physics, Tata Memorial Hospital, Mumbai, delivered the Seventeenth AMPI Ramaiah Naidu Memorial Oration (RNMO). The RNMO award is bestowed on an eminent personality who has a long working experience in the field of medical physics with a good track record of academics, research and clinical practice. The title of his deliberation was "Medical Physics in India: History, Development and Activities". During this talk, he described in detail the early days (1943) and current medical physics activities in the country including commercially available technology and indigenous developments. He also listed future directions in dealing with hi-tech equipment and emphasized the need for harmonization in medical physics training modules. The key feature of ICMP-2008 was joint AMPI-AROI (Association of Radiation Oncologists of India) scientific meeting on November 28, 2008 at Nehru Centre, Worli, Mumbai. The AMPI-AROI joint meeting was held in the backdrop of the unfortunate national tragedy of the 26/11 terrorist attack. The medical physics community lost two precious lives in this gruesome attack.

The joint meeting was the first of its kind, perhaps making it the defining moment in the history of medical applications of ionizing radiation in India. Both the clinical and physical aspects of recent radiation oncology techniques such as IMRT, IGRT, precision radiotherapy by Cyber Knife, adapted Telecobalt machines and Proton accelerators, Image guided brachytherapy and indigenous development of radiotherapy technology were presented during the joint meeting. The joint meeting was useful for radiation oncologists in improving their understanding of medical physics and the technological aspects of recent radiotherapy while it was equally beneficial for medical physicists to understand clinical requirements and associated complexities in implementing the hi-tech radiotherapy. The panel discussion on "Newer Technologies: Promises and Pitfalls" witnessed active participation of a large number of medical physicists and radiation oncologists. It was concluded during the discussion that technology was available for high precision radiotherapy and dose escalation but it should be used discriminately as a majority of cancers require palliative treatment by conventional techniques.

The scientific deliberations of ICMP-2008 covered the whole spectrum of medical radiation physics: Radiation Therapy Physics and Devices; Medical Imaging Physics

and Devices; Radiation Dosimetry and Standards; Radiation Physics; Radiation Biology; Time Dose Models; Commissioning, Quality Assurance and Audits; Clinical Aspects of Radiation Oncology; Clinical Aspects of Medical Imaging; Computational Tools in Medical Physics; Education and Training in Medical Physics; Radiation Protection and Safety. Presentations on recent developments in the technology of radiation medicine and methodology of imaging and radiation therapy were a special attraction. The oral and poster presentations were evaluated for the Best Oral and Poster papers. At the end of the conference "Improvement of ImatriXX in terms of spatial resolution and large field acquisition for patient specific IMRT verification" by Arun Singh Oinam et al, Radiotherapy Department, Postgraduate Institute of Medical Education and Research, Chandigarh and "Dosimetry of in-house designed circular cone for stereotactic treatment using MVCBCT" by Kamlesh Kumar Gupta et al, Department of Radiation Oncology, Ruby Hall Clinic, Pune were selected for the AMPI Best oral and poster papers, respectively.

The overwhelming participation of manufacturers dealing with medical radiation equipment, dosimetry systems, phantoms, computerized treatment planning systems and treatment accessories, was the other attraction at ICMP-2008. A number of recent technology equipment (Cyber Knife, 4-D medical linear accelerator, Gamma Knife Perfexion, Image Guided HDR Brachytherapy Systems) and dosimetry systems (2-D array with high resolution), phantoms (Dynamic phantoms to simulate organ movements), patient immobilization devices (SBRT immobilization systems) and other related products were demonstrated in 32 stalls arranged near the conference venue.

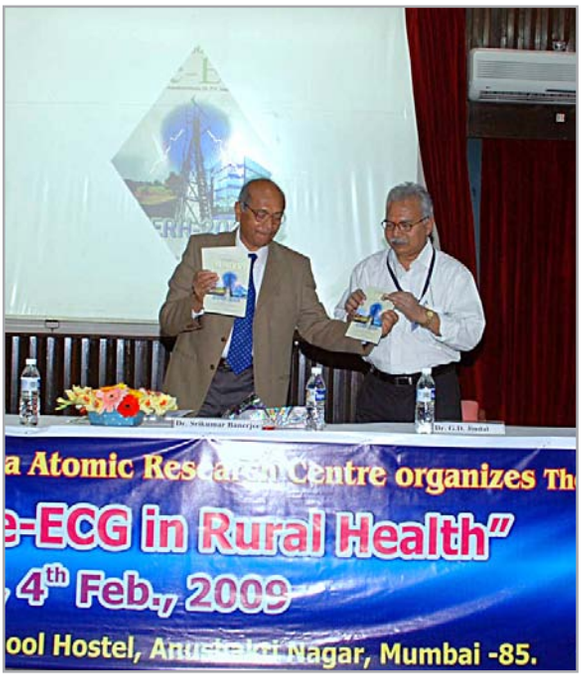
In summation, the conference deliberations were useful for radiation scientists, medical physicists, radiation oncologists, radiologists, radiobiologists, dosimetrists, radiation technologists and radiological protection experts.

APPLICATIONS OF TELE-ECG IN RURAL HEALTH (ATERH-2009) : A REPORT

The Theme Meeting on "Applications of Tele-ECG in Rural Health - 2009 (ATERH 2009)" was held at the Multipurpose Hall, Training School Hostel, Anushaktinagar, Mumbai on 4th February 2009. Around 175 participants from the medical fraternity, researchers and industry participated in the theme meeting. Dr. V. Karira, Head, Medical Division welcomed the dignitaries and the participants. It was inaugurated by Dr. Srikumar Banerjee, Director, BARC. In his inaugural address, Dr. Banerjee appreciated the innovative live demonstration of the technology in front of the medical fraternity, who would be the users of the system. He expressed his happiness over the successful conversion of a casual discussion into a full-fledged product, using the current mobile-based advanced technology. He also chalked out the road map of deploying this technology in the rural areas. He suggested incorporation of an expert system in the software, which could be useful in the absence of the medical experts. He wished the meeting a grand success. As a first step towards promotion of this technology, Dr. Banerjee released a "Handbook on Tele-ECG" as proceedings of the theme meeting to commemorate the occasion. The Inauguration session concluded with a vote of thanks by Dr. G.D. Jindal.

The first technical session of the theme meeting was chaired by Dr. K.B. Sainis, Director, Bio Medical Group, BARC. Dr. Alka K. Deshpande from Grant Medical College & J.J. Hospital, Mumbai recalled her proud association with the Electronics Division,

Inauguration of the theme meeting by Dr. Srikumar Banerjee, Director, BARC



Dr. Srikumar Banerjee releasing the "Handbook on Tele-ECG"

BARC on the joint development programme on biomedical instruments for the last thirty five years and gave an informative introductory talk on Electrocardiography, including the need for Tele-ECG. Dr. G.D. Jindal gave a talk on Tele Medicine and the Tele-ECG unit developed at BARC for rural health care. The last talk of the session was on "Analysis of ECG Signals" by Dr. T.S. Ananthakrishnan. He gave a good overview of the topic. Dr. Sainis concluded the session by appreciating the information given by the speakers on these new concepts. He urged the participants to ineract with the experts and clarify their doubts during the course of other sessions of the meeting.

The second session was chaired by Dr. K.K. Ghosh, Head, Medical Division & Telemedicine Division, DIT, New Delhi. In this session, Mr. Vineet Sinha and Mr. Sandeep Bharade gave a live demonstration of the Tele-ECG instrument. A volunteer, at Deonar West Zone dispensary, was connected to the Tele-ECG unit and his ECG was recorded through a mobile phone made available at the site. This was shown as a live telecast in the Multipurpose Hall. After complete data acquisition, the ECG was transmitted to the mobile phone of the expert, present at the Multipurpose Hall. This presentation was followed by another demonstration of LAN connectivity of the instrument suitable for hospital environment.

The panel discussion was the last session of the meeting, which was chaired by Dr. U.P. Phadke, Advisor, Deptt of Information Technology, New Delhi. The panel members included Mr. A.G. Apte, Head, Computer Division, BARC; Dr. Meenu Singh, Ministry of Health and Family Welfare, New Delhi; Dr. B. Sanjeev Rai, FMMC, Mangalore; Dr. Ashok Jaryal, AIIMS, New Delhi; Mr. Rohit Mehta, Head, L&T Medicals, Mysore; Mr. S.P. Chaganty, OSD & CTO, ECIL, Hyderabad; Dr. P.N. Jangale, MD, BARC; Dr. G.D. Jindal, ED, BARC and Dr. T.S. Ananthakrishnan, ED, BARC. In this session, important issues relating to the deployment of the Tele-ECG in rural health care were discussed. Other issues of biomedical instrumentation like requirement of web-based database on clinical observations, certification of biomedical instruments, financial support from the Board of Research on Nuclear Sciences etc. were also discussed.

The meeting concluded after an enthusiastic discussion among the participants.

बी एआरसी न्यूज़लैटर
BARC NEWSLETTER

भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान
BARC SCIENTISTS HONOURED

मुकेश गोयल, एस राजेन्द्रन एवं त्रिलोक सिंह को 4-6 दिसंबर, 2008 के दौरान आइआइएससी., बँगलुरू में आयोजित 22वें क्रैयोजनिक्स (एनएससी-22) की राष्ट्रीय परिचर्चा में सहयोगी शोध पत्रों(मौखिक एवं पोस्टर) की श्रेणी में सर्वश्रेष्ठ पुरस्कार से सम्मानित किया गया।

The paper entitled "Development of Plate and Fin Heat Exchangers" by Mukesh Goyal, S. Rajendran and Trilok Singh was awarded the Best Paper Award amongst the contributed papers (Oral and Poster) at the 22nd National Symposium on Cryogenics (NSC-22) held at IISc., Bengaluru from 4th December to 6th December 2008.


Mr. Mukesh Goyal

श्री मुकेश गोयल ने प्रशिक्षण केंद्र के 42वें बैच से भाभा परमाणु अनुसंधान केंद्र में हैं और कार्यभार संभालने के उपरांत पिछले 10 साल से क्रैयोजनिक टेक्नॉलोजी के विकास पर काम किया। आप 20के हीलियम रेफ्रिजरेटर्स, हीलियम लिक्विफायर्स के क्रिटिकल घटकों, उनके रूपांकन, विकास निर्माण एवं टेस्टिंग के हेतु कार्यरत हैं।

Mr. Mukesh Goyal has been working for the development of cryogenic technology for the last 10 years after joining BARC from 42nd Batch of training school. He is involved in the design, development, fabrication and testing of critical components for 20K helium refrigerators and helium liquefiers.


Mr. S. Rajendran

श्री एस. राजेंद्रन ने वर्ष 1991 में भाभा परमाणु अनुसंधान केंद्र में कार्यभार संभाला। इन्होने उच्च गति रॉटर तकनीक के विकास पर काम किया। इस समय आप 20के हीलियम रेफ्रिजरेटर्स हीलियम लिक्विफायर्स के लिये क्रैयोजनिक टेक्नॉलोजी के विकास पर कार्यरत हैं।

Mr. S. Rajendran joined BARC in the year 1991. He has worked for the development of high speed rotor technology. He is currently involved in the development of cryogenic technology for 20K helium refrigerators and helium liquefiers.


Mr. Trilok Singh

श्री त्रिलोक सिंह वर्ष 2004 से भाभा परमाणु अनुसंधान केंद्र में प्रारंभ हो रहे क्रैयोटेक्नॉलोजी प्रभाग की अध्यक्षता कर रहे हैं। इन्होंने उच्च गति रॉटर तकनीक के विकास पर काम किया है। आप 20के हीलियम रेफ्रिजरेटर्स हीलियम लिक्विफायर्स के लिये क्रैयोजनिक टेक्नॉलोजी के विकास पर कार्यरत हैं।

Mr. Trilok Singh is heading the Cryotechnology Division of BARC since its inception in the year 2004. He has worked in the field of high speed rotor technology. He is involved in the development of cryogenic technology for 20K helium refrigerators and helium liquefiers.

Portrait sketched by Dr. Homi J. Bhabha

Edited & Published by:
Dr. Vijai Kumar,
Associate Director, Knowledge Management Group &
Head, Scientific Information Resource Division,
Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India.
Editorial Management : Dr. (Ms.) S. C. Deokattey,
Computer Graphics & Layout : Mr. B.S. Chavan, SIRD, BARC
BARC Newsletter is also available at
URL : http://www.barc.gov.in