



**RAS/1/014**

**Supporting Radiation Processing for the Development  
of Advanced Grafted Materials for Industrial  
Applications and Environmental Preservation(RCA)**

**37th Regional Meeting of National RCA  
Representative, Pakistan**

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# PROJECT OBJECTIVE

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- ✘ **Objective:** To produce advanced grafted products for industrial applications and for mitigating environmental pollution by using radiation processing.
- ✘ **Specific Objectives:**
- ✘ To mitigate environmental pollution by the removal of toxic elements and harmful compounds using radiation grafted products.
- ✘ To produce advanced radiation grafted products for industrial applications in the form of membrane, gel, fibre, hybrid coating, etc.
  
- ✘ **Participation:** All MSs except AUL, NEP, NZE and SIN;
- ✘ MAL as LCC
- ✘ **Duration:** 2013-2015

# Roles of Nuclear Technology

1. Gamma or electron beam irradiation can be used for grafting of membranes, fibres, films or pellets. Radiation grafting is effective for in-depth grafting as well as for surface grafting, easy to control the degree of grafting and high efficiency as compared to chemical grafting.
2. New grafted materials and its products have many applications such as separation of precious metals, removal of toxic metals, organic compounds and odours, as filter, fuel cell membranes and many others.

# OUTCOMES

OUTCOMES	INDICATORS	Verification
1. Radiation grafted products developed for environmental and industrial applications.	<ul style="list-style-type: none"><li>➤ Super water absorbent</li><li>➤ Rare metal separator</li><li>➤ Fuel cell membrane and battery separator</li><li>➤ Toxic metal removal from water effluent</li></ul>	Progress report Trade report Patent Journal Publication

# OUTCOMES

OUTCOMES	INDICATORS	Verification
2. Radiation grafted products applied in industrial and environmental	<ul style="list-style-type: none"><li>➤ Protocols established</li><li>➤ Technical and economical evaluation performed</li><li>➤ Processes up-scaled</li><li>➤ Technology transferred</li></ul>	Progress report Trade report Patent Journal Publication

# OUTCOMES

OUTCOMES	INDICATORS	Verification
3. Strengthened project implementation, review and assessment at the regional and national level	<ul style="list-style-type: none"><li>➤ Formation of national project team</li><li>➤ Regional and National Work Plan</li><li>➤ Annual Project progress Meeting</li><li>➤ Exchange of information and documentation with FNCA</li></ul>	<ul style="list-style-type: none"><li>▪ Member Countries progress report every 6 months and annually</li><li>▪ PLCC report</li><li>▪ Minutes/report of meeting</li><li>▪ IAEA document</li><li>▪ End user agreement</li><li>▪ Guidelines developed by MS or FNCA</li></ul>

# ACTIVITIES

ACTIVITIES	INDICATORS
1.1 Plan and implement project activities	<ul style="list-style-type: none"> <li>• Identification of project team members</li> <li>• Adoption of Regional and National Work Plan</li> <li>• Schedule of meetings</li> <li>• No. of RCA members and non members of FNCA attending the FNCA meetings</li> </ul>
2.1 Plan and conduct regional and national training courses in radiation grafting for environmental and industrial applications	All participating countries timely submit qualified personnel for each respective training.
3.1 Prepare, review and adopt harmonized radiation grafted protocol	Suitable experts are timely identified and engaged in drafting of the protocol
4.1 Implement activities to promote networking as well as support NPCs to attend meeting and conference (such as FNCA meeting), if possible back to back with project related meetings	<ul style="list-style-type: none"> <li>• Participating in EXPO/Seminar/ Conference</li> <li>• Signing of MoU</li> <li>• No. of seminars/ workshop/ training course conducted</li> <li>• No of interested clients</li> </ul>

# OUTPUTS: Project Progress and Achievement 2013/14

OUTPUTS	Performance Indicators 2014
<b>1.0 Effective project coordination and implementation</b>	<ul style="list-style-type: none"><li>• Progress reports every six months:<ul style="list-style-type: none"><li>➤ Jan – June 2014 received from IAEA MS</li><li>➤ July – Dec 2014 received from IAEA MS except Myanmar , Korea and Pakistan</li></ul></li> <li>• Activity implementation<ul style="list-style-type: none"><li>➤ 1 IAEA/RCA Regional Training Course</li><li>➤ IAEA/RCA (RAS1014) Midterm Meeting</li><li>➤ Technical meeting on radiation graft protocol</li></ul></li></ul>

## 1.0 IAEA/RCA MID-TERM REVIEW MEETING, COLOMBO, SRI LANKA, 23 - 27 JUNE 2014, RAS/1/014

- ✘ The meeting was hosted by the Atomic Energy Authority (AEA), Sri-Lanka in cooperation with the International Atomic Energy Agency (IAEA). It was attended by 16 participants from 13 RCA member states (MSs) Bangladesh (1), China (1), India (1), Indonesia (1), Japan (1), Korea (1), Malaysia (1), Myanmar (1), Pakistan (1), Philippines (1), Sri Lanka (4), Thailand (1) and Vietnam (1), 7 observers.
- ✘ The IAEA was represented by Ms. Agnes Safrany (Technical Officer)

**IAEA/RCA Mid-Term Review Meeting, Colombo, Sri Lanka, 23 – 27 June 2014,  
RAS/1/014**



# OUTPUTS: Project Progress And Achievement 2013/14

OUTPUTS	Performance Indicators 2013/14
2.0 Trained personnel in radiation grafting technique	<ul style="list-style-type: none"><li>• <b>IAEA/RCA Regional Training Course on Advanced Radiation Grafting of Polymeric Matrices for Environmental and Industrial Applications, 14-18 April 2014, Ho Chi Minh City, Vietnam.</b></li><li>• <b>Lectures related to grafting techniques, characterization, and grafted materials – given by IAEA experts (Drs. Guven and N. Seko) as well as locals</b></li></ul>



IAEA/RCA Regional Training Course on Advanced Radiation Grafting of Polymers for Commercial and Industrial Applications

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# OUTPUTS: Project Progress And Achievement 2014

OUTPUTS	Performance Indicators 2014
3.0 Adopted harmonized radiation graft protocol	<ul style="list-style-type: none"><li>• Technical Meeting on Radiation Graft Protocol IAEA/RCA RAS/1014/9002/01 Workshop on Harmonized Radiation Graft Protocol, Vienna, IAEA 24 -28 March 2014</li><li>• <b>Draft of radiation graft protocol has been prepared and distributed to NPC of RAS/1014 for comment and recommendation.</b></li></ul>
IAEA Expert Mission to IAEA/RCA MS RAS/1/014	<ol style="list-style-type: none"><li>1. Thailand IAEA expert mission Dr. Noriaki Seko on radiation grafting, January 20-24, 2014</li><li>2. Indonesia  IAEA expert mission Dr. Noriaki Seko on radiation grafting, 24-28 February 2014</li></ol>

# Activities for 2015

Regional Training Courses	Host Countries and Dates
1. RTC: Regional Training Course on Advanced Characterization Methods of Grafted Polymeric Matric	Malaysia 9 -13 February, 2015
2. Regional Training Course on Application and Up Scaling of Radiation Grafting for Environmental and Industrial Applications	China 13-17 April, 2015 To be implemented.
3. Regional Executive Meeting for End-user and Policy Makers on Radiation Grafting for Industrial Applications and Environmental Preservation	Japan 7 – 11 Sept. 2015 To be implemented.
4. IAEA/RCA Final Progress Review Meeting of RAS/1/014	Thailand 30 Nov. 4 Dec. 2015 To be Implemented

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Bangladesh (4 products)	<ol style="list-style-type: none"> <li>1. Glycidyl methacrylate (GMA) grafted onto PE and modified with disodium iminoacetate for <b>absorption of chromium and copper.</b></li> <li>2. Application of AAc-g-PVP for <b>dye removal</b></li> <li>3. Acrylic acid (AAc) grafted onto <b>cotton</b></li> <li>4. AAc grafted onto carboxymethylcellulose (CMC) for <b>soil conditioner</b></li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p>
China People of Republic (4 products)	<ol style="list-style-type: none"> <li>1. Ion Exchange Membranes Synthesized by Radiation-induced RAFT grafting ETFE/PVDF g styrene sulfonate and N,N-dimethylaminoethyl methacrylate for <b>Vanadium Redox Flow Battery</b></li> <li>2. Cellulose-based <b>adsorbents</b></li> <li>3. Graphene-based adsorbent for Adsorption and reduction of Cr(VI)</li> <li>4. Silica-based <b>adsorbents</b></li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p>

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
India (3 products)	1. VBTMATC & Polyacrylate grafted onto cotton fibrils to induce <b>anti-bacterial property and dye removal</b>	R&D
	2. Radiation induced grafting of DADMAC on PE	R&D
	3. PDADMAC encapsulation in PES microcapsules by gamma radiation for the <b>extraction of anions.</b>	R&D
Indonesia (3 products)	1. Hydrogel copolymerization chitosan with acrylamide for <b>metal toxic adsorbents</b> - Cu, Mn, Cr, Fe, Pb, Co, Zn, Ni.	R&D
	2. AAc grafted onto cellulose from rice straw and crosslink by EB and N,N'-methylenebisacrylamide (MBA) as <b>crosslinking agent</b>	R&D
	3. Acrylic acid grafted onto <b>bacterial cellulose</b> (Nata de coco)	R&D

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Japan (2 products)	<ol style="list-style-type: none"> <li>1. Anionic fibrous catalyst by grafting PE with 4-chloromethylstyrene and chemically modified with trimethylamine (TMA ), follow with transesterification of triglyceride (TG) with ethanol, for <b>biodiesel production</b></li> <li>2. Pilot-scale production fibrous As-adsorbent of 30 cm × 20 m per one batch was synthesized by loading zirconium (Zr) on a fibrous phosphoric acid type grafted adsorbent (FPA) .</li> <li>3. Process development of emulsion grafting with low energy EB irradiation</li> </ol>	<p>R&amp;D</p> <p>Bench scale</p> <p>Bench scale</p>
Malaysia (4 products)	<ol style="list-style-type: none"> <li>1. Glycidyl methacrylate (GMA) grafted onto kenaf fibre for <b>toxic metal adsorbent</b></li> <li>2. GMA grafted onto Nylon fibre and functionalized with n-methyl glucamine for <b>boron adsorbent</b></li> <li>3. Development of anionic exchange catalyst from natural fiber for the <b>synthesis of biodiesel</b></li> <li>4. Radiation Modified Polymeric Material for <b>Active Packaging Applications</b></li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D.</p>

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Myanmar (2 products)	<ol style="list-style-type: none"> <li>1. Starch acrylate <b>superwater absorbent</b></li> <li>2. Rice straw acrylamide for <b>Controlled Release Fertilizer</b></li> </ol>	<p>R&amp;D</p> <p>R%D</p>
Republic of Korea (3 products)	<ol style="list-style-type: none"> <li>1. AAc grafted onto PLCL nano fibre and immobilized with bioactive molecules for 3D modification of dual-layered nano/micro-fibrous scaffolds for <b>vascular tissue engineering</b></li> <li>2. PEEK polymer grafted PVBSA <b>fuel cell membrane</b></li> <li>3. Hydrophilization of a <b>porous PTFE supporter</b> by radiation grafting, PTFE-g-p(AN-co-SAS).</li> <li>4. Establishment of demonstration <b>radiation facility</b> for pre-comm. large items developed by radiation technology</li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p> <p>Pilot plant rad. facility</p>

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Pakistan (3 products)	<ol style="list-style-type: none"> <li>1. Acrylonitrile grafted onto silane modified sepiolite (clay) as compatibilizer followed with chemically modified into amidoximated form for <b>removal of toxic metal</b> from waste water.</li> <li>2. Acrylonitrile grafted onto PE and PP and modified with amidoxime for <b>removal of toxic metal</b> from industrial waste water.</li> <li>3. Utilization of irradiated <b>PP waste</b> for grafting</li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p>
Philippines (4 products)	<ol style="list-style-type: none"> <li>1. <b>Pineapple fibers-g-PGMA</b> functionalized with amine group has ability to adsorbed Pb(II) and Cu(II) ions .</li> <li>2. Grafting of <b>water hyacinth fibers</b> with GMA and functionalized with amine or sulfonic acid group for adsorbed Cu<sup>2+</sup>, Pb<sup>2+</sup> and Cr<sup>3+</sup></li> <li>3. Abaca-Polyester <b>Nonwoven Fabric (APNWF)</b> grafting with GMA and amination with EDA for Cu and Ni uptake.</li> <li>4. <b>Grafting of piña/polyester</b> with GMA</li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p>

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Sri Lanka (3 products)	<ol style="list-style-type: none"> <li>1. Super Water Absorbent (SWA) acrylic acid grafted <b>cassava</b> specially focused on minimizing cross linking during grafting</li> <li>2. Acrylic acid grafted on non woven polypropylene for Nano Zero Valent Iron <b>metal adsorbent</b></li> <li>3. Acrylic acid grafted chitosan films as <b>heavy metal adsorbent</b></li> </ol>	<p>R&amp;D</p> <p>R&amp;D</p> <p>R&amp;D</p>
Thailand (3 products)	<ol style="list-style-type: none"> <li>1. <b>Superabsorbent polymer (SAP)</b> from polyacrylamide grafted onto carboxymethyl cellulose (CMC) with crosslinking agent, N,N'-methylene bis acrylamide (MBA) for controlled release of potassium nitrate</li> <li>2. SAP from grafted of AAc onto cassave starch for controlled release of agrochemicals</li> <li>3. <b>Metal Adsorbent</b> from Poly(methyl acrylate)-Grafted Cassava Starch via Gamma Irradiation functionalized with hydroxamic acid group</li> </ol>	<p>R&amp;D</p> <p>Pilot Scale</p> <p>R&amp;D</p>

# RCA MS CURRENT ACHIEVEMENTS of RAS/1/014

Country	Outcomes	Status
Vietnam (3 products)	1. Study on radiation grafting polymerization of acrylic acid onto bentonite used as <b>bioactive carrier</b> ;	R&D
	2. Study on radiation grafting of acrylic acid onto radiation crosslinked <b>chitin or chitosan</b> for adsorbing radioactive Cesium;	R&D
	3. Study on radiation grafting of glycidyl methacrylate onto <b>jute fiber</b> .	R&D

# PUBLICATIONS (UP TO JUNE 2014)

- ✘ China – 11 papers and 3 patents
- ✘ India – 4 papers
- ✘ Malaysia - 3 papers and 3 patents
- ✘ Philippines – 3 papers
- ✘ Sri Lanka – 4 papers
- ✘ Thailand – 2 papers
- ✘ Pakistan – 1 paper
- ✘ Indonesia – 3 papers
- ✘ Bangladesh – 1 paper
- ✘ Japan – 3 papers
- ✘ Korea – 3 papers, 2 patents

# SUMMARIES

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- ❑ Output RAS/1/014 activities 2014 have been implemented
- 1 RTC, basic radiation grafting and advance radiation grafting, in Ho Chi Minh City, Vietnam, 14 - 18 April 2014,
- Mid-Term Review Meeting, Colombo, Sri Lanka, 23 - 27 June 2014,
- Technical Meeting on Radiation Graft Protocol, Vienna, IAEA, 24 -28 March 2014
- 2 expert missions to Thailand (Dr. N. Seko) January 20-24, 2014 and Indonesia (Dr. Noriaki Seko) 24-28 February 2014

## ...COND.

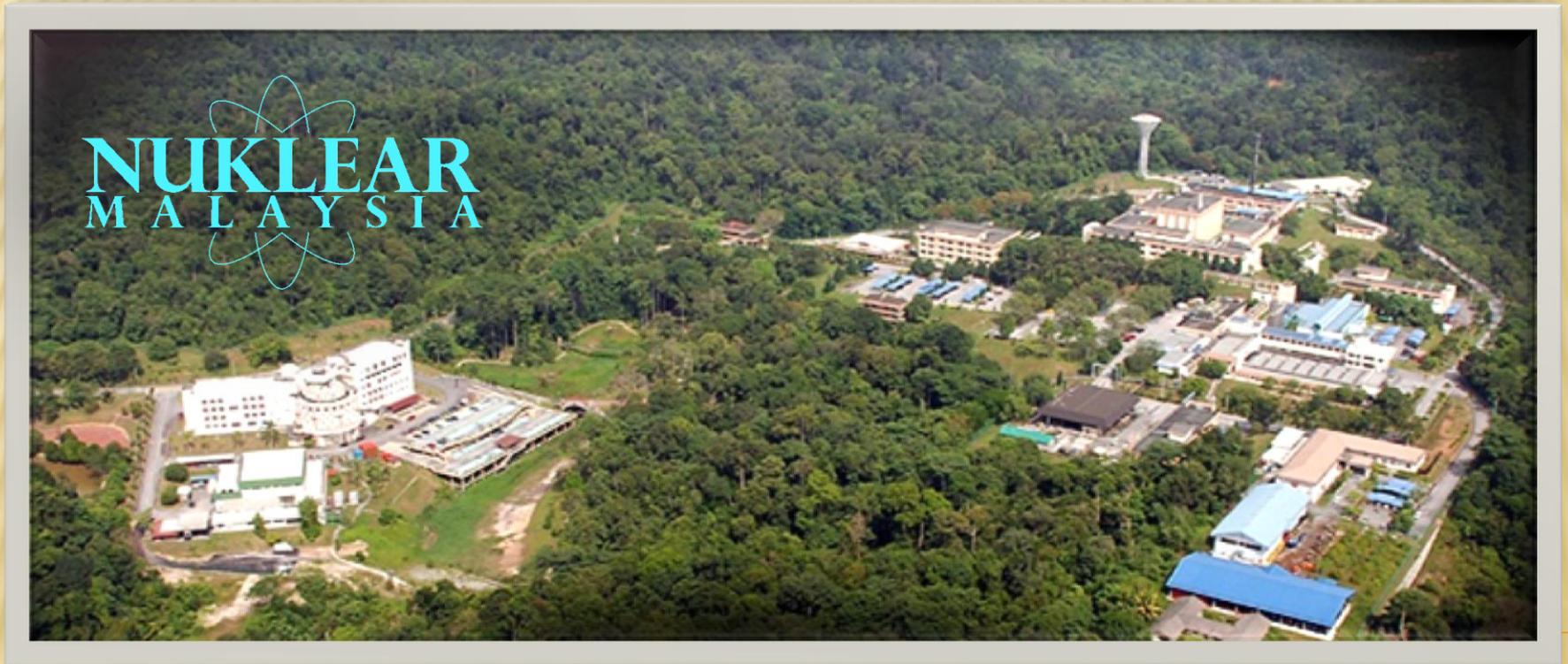
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- ❑ Project produced 43 products, 2 pilot scale productions, 38 paper publications and 8 patents on grafting products.
- ❑ RCA and FNCA collaboration: FNCA WS activity at Jogjakarta 9<sup>th</sup> Feb. 2015 was not attended by LCC RAS/1/014 and also IAEA experts of non FNCA MS. However, IAEA is looking forward to continued collaboration and support activities organized by FNCA.

# WAY FORWARD FOR RAS/1/014

- ✘ Japan, Thailand and Korea have successfully carried out the up-scaling and in process of transferring the technology to end users. However, most of other MSs under this project are still under R&D stage which means an extension is needed in order to see the full impact of RAS/1/014.
- ✘ Previous RAS/8/109 has successfully developed products, carried out field test and managed to transfer the technology to end user.
- ✘ MSs agreed to participate and support the New RAS Project (2016-2017) and carry out activities with partner end-users.
- ✘ For successful implementation of RAS/1/014, MSs are recommended to identify and focus on specific grafted materials according to their national needs which may be carried out and developed in the next RAS cycle, pending approval by IAEA
- ✘ **New Proposal to extend RAS/1/014: Development and up-scaling of radiation processed advanced grafted materials for industrial waste water clean-up.**

**TERIMA KASIH / THANK YOU**



**MALAYSIAN NUCLEAR AGENCY**  
**MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION (MOSTI)**