

**International Atomic Energy Agency**  
**Radioisotope and Radiation Technology**  
**Applications for Industry and Environment**

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**Seminar on**  
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**for Diplomats**  
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**Programme-I: Radioisotope Production and Radiation Technology**

## Radioisotope and Radiation Technology Applications for Industry and Environment

### Radioisotopes:

- Atoms that contain an unstable combination of neutrons and protons.
- Atoms containing this unstable combination regain stability by shedding radioactive energy.
- The radioactive decay process of each type of radioisotope is unique and is measured with a time period called a half-life.
- All isotopes are not radioisotopes.
- The combination can occur naturally, as in radium-226, or by artificially altering the atoms using **nuclear reactors** or **accelerators (Cyclotron)**

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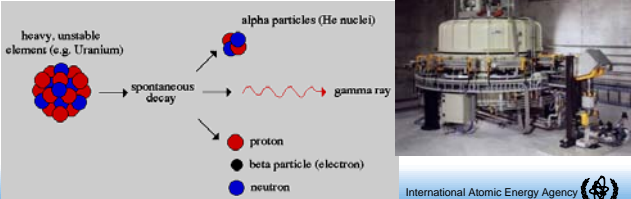
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## Radioisotope and Radiation Technology Applications for Industry and Environment

### Ionising radiation:

- Radiation which can knock electrons out of atoms.
- Alpha and beta particles, neutrons, X-rays and gamma rays are examples of ionising radiation.
- Sources: radioisotopes, accelerators



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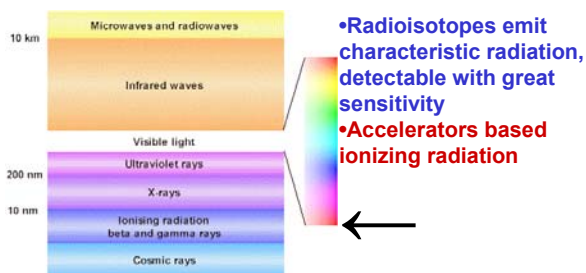
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## Features of radioisotopes and radiation and basis for their applications

### ELECTROMAGNETIC WAVES



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Radioisotope for Medicine

The radioisotopes in medicine:

- Radiopharmaceuticals
- Solid source, called a sealed source

Radiopharmaceuticals use is much more than sealed source.

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Radioisotope for Medicine

- Radiopharmaceuticals are used mainly for diagnostic imaging and to a less extent for therapy
- Radiopharmaceuticals for imaging are broadly of two classes: gamma and Positron Emission Tomography (PET) imaging
- More than 70% of the gamma imaging investigations use Tc-99m. Another 20% of use is covered by Tl-201 mainly for cardiac studies. The remaining use consists of In-111, Ga-67, I-123, Kr-81m, I-131, Xe-133 and others.
- F18-fluoro deoxy glucose (FDG) accounts for more than 90% of PET imaging with the remaining 10% accounted by C-11, N-13 and O-15 compounds. Interest in PET is growing in many developing countries in the recent years.

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Radioisotope for Medicine

- Radiopharmaceuticals have established uses in the treatment of hyperthyroidism, arthritis, thyroid cancer, certain other cancers and palliation of bone pain due to secondary cancer. This is also an area of currently active research and development.
- Radioactive sealed sources are widely used for radiotherapy of cancer. More than 1500 Co-60 teletherapy machines are estimated to be in use worldwide.
- The main radioisotopes used in brachytherapy are Ir-192, I-125 and Pd-103. More than 3000 brachytherapy centres are estimated to be in operation worldwide.

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## Radioisotope and Radiation Technology Applications in Industry and Environmental Safety

- Radiation can destroy microbes (bacteria):**  
*Radiation sterilization of medical products; disinfestation of food and agricultural products; sewage sludge for safer disposal (and even possible use as fertilizer)*
- Radiation can initiate chemical reactions:**  
*Radiation processing applications for polymerization, modification of material properties, treating effluents (flue gas, wastewater) to become innocuous*
- Radiation technology applications for industry:**  
*Process monitoring, QC, trouble-shooting, radiography, nucleonic gauge, gamma scanning*

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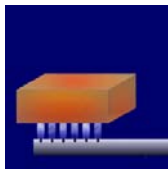
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## Radiation processing technology

- Radiation penetrate through matter
- Attenuation of radiation by matter interposed
- Radiation can be back scattered



heat  
How we treat materials ?



radiation  
UV – sunlight  
MV – oven  
EM - radiation

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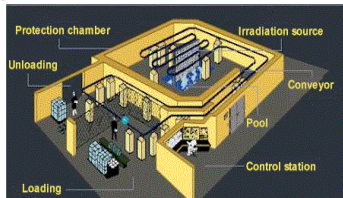
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## Sources for Radiation Processing in Industrial Scale Operations

- Gamma radiation sources:  
High intensity  $^{60}\text{Co}$  sources from 0.1MCi to >2MCi



- Electron Accelerator (EB):  
**Energy:**  
 low (300-700keV),  
 medium (2-3MeV)  
 high (5-10MeV) and  
**Power:**  
 Medium (20-100kW)  
 High (0.5-1MW)  
**Electron mode**  
**X-ray mode**



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### Global Status of Radiation Processing Facilities

- **Gamma irradiator plants** More than 160  
>20% are of >1MCi Co-60 capacity
  - **Electron accelerators** ~1400  
~300keV to 10MeV energy of electrons and  
10kW to 1 MW power
- About 650 plants in USA and more than 300 plants in Japan installed during the past 30 years.

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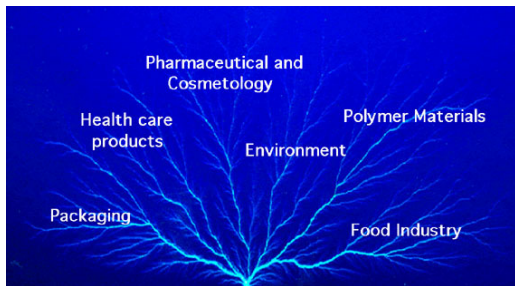
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### APPLICATION OF RADIATION



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### Radiation Sterilization of Healthcare Products

- Radiation processing is a cold process with several advantages over the traditional methods. 25kGy (2.5MRad) of dose, internationally well accepted, for extremely high sterilization factor.
  - ❖ High reliability
  - ❖ Processing in the final packaging form
  - ❖ No residual toxic substances
  - ❖ Suitable for most of the heat sensitive products
- Automated, continuous irradiation facility with only one parameter to be controlled.

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## STERILIZATION



- Medical devices
- Packing
- Labware
- Raw materials
- Some cosmetics and pharmaceutical goods



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## X-RAY BLOOD STERILIZER



Self-contained dry-storage gamma irradiator suitable for research and small irradiations

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## HIGH QUALITY MATERIALS

Industrial Radiation Chemical Processing/ Manufacture – **Value addition to products / processes**



- Cross-linking of polymers
- Curing of polymer coatings & Graft polymerization
- Polymer degradation
- Gem stones
- Bio-materials
- Medical products - Hydrogels

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## RADIATION CROSSLINKING

- Total hip replacement



Ultra-high molecular weight polyethylene (UHMWPE)



The "artificial(knee) joint generally has two components, one made of metal which is usually cobalt -chrome or titanium. The other component is a plastic material called polyethylene

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## Hydrogel burn/wound dressings by radiation synthesis and sterilization

- Sterile cover
- Cooling effect
- Regulates O<sub>2</sub> supply
- Healing progress fast
- Less scar formation

### INGREDIENTS

- Poly Vinyl Alcohol
- Natural Polysaccharide like Agar
- Distilled Water

### Advantages

- Cross linking + sterilization in one step
- Bio-compatible materials
- Cost effective



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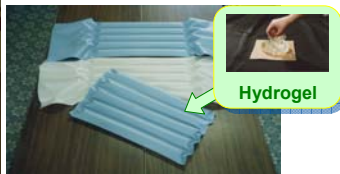
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## Radiation-processed Products of Natural Polymers for Application in Healthcare



### Commercial name: Non-bedsore

- Advantages of gel mat
1. Keeps body temperature for long time
  2. Disperses body pressure

- Advantages of gel
1. Biodegradable hydrogel
  2. Non-toxic (very safe)

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



Effect of low-molecular-weight chitosan/alginate mixture on plant growth

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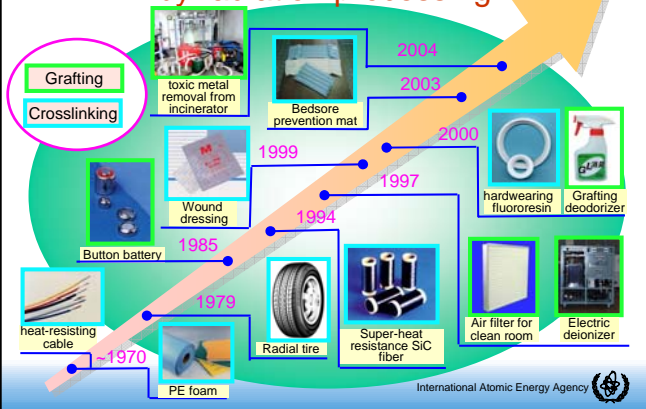
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**Industrial applications of polymer modified by radiation processing**



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**FOOD IRRADIATION**

- Inactivation of harmful organisms in food ingredients
- Inactivation of salmonella food poisoning micro organism
- Extension of refrigerated shelf life
- Control of parasites and insects
- Inhibition of sprouting



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