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5.1 Country Report: China

Recent Status of EB Applications in China

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Abstract

The advantages of energetic electron beam (EB) made it an attractive method for radiation processing of materials. In the present paper, the recent status of R&D of EB applications in China has demonstrated briefly.

1. Introduction

Radiation processing using X-, γ-rays or electron beams (EB) has been demonstrated on a large commercial scale to be a very effective means of improving end-use properties of various materials. Practical applications for radiation processing of materials have been evolving since the introduction of this technology nearly fifty years ago. In recent years, much more attention has been paid on EB applications because of that EB facility is easy to control & maintenance, and of favorable safety in operation, high efficiency and high purity in the materials processing. These advantages made EB has extensive applications in various fields such as electronic & electrical industries, chemistry, materials science, agriculture, biological & medical science, wastewater remediation.

Since 1980s, Chinese scientists started EB applications in commercials. A great effort has been made and a significant progress was achieved. In this paper, we present the recent status of EB applications in China by some typical examples.

2. R & D of EBs

2.1. Development of electron accelerators (Commercial products)

Since the 1980s, a series of types of electron accelerators have been developed for commercial applications. In the 1980s and 1990s and the present, the main parameters being achieved are 2 MV @ 25 mA and 2 MV @ 40 mA, respectively. At the present, electron accelerators with (2 MV, I>40 mA) and (10 MV, I~0.5 mA) are in commercial products. Furthermore, high power EB accelerators with 1.2 MV @ 80 mA and 300 kV @ 2~3 A have been achieved in Lab. Figure 1 shows an overview of 1.2 MV @ 80 mA EB accelerator made by Institute of Modern Physics (IMP), CAS.

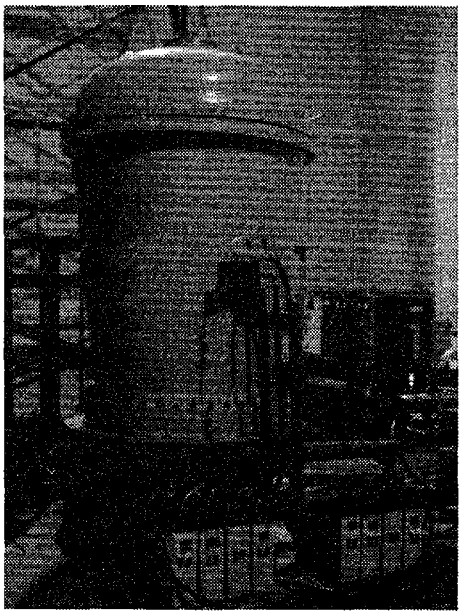

Figure 1. An overview of Electron Accelerator made by IMP

2.2. Main fields of EB applications

In China, energetic electron beams have been used in various purposes. The main fields of EB applications are as the follows:

(1) Electronic & electrical industries (e.g., semiconductor devices, cable, ···);
(2) Materials science (e.g., cross-linking, radical & graft polymerization, coating, packaging, ···);
(3) Agriculture (e.g., hydrogel hybrid-type organs, breed irradiation modification, ···);
(4) Biological & Medical applications;
(5) Environmental protection (e.g., Flue gases treatment, ···);
(6) Food preservation (sterilization, packaging, ···).

3. Typical examples of EB applications

3.1. Flue gases treatment

Some methods that could remove conventional nutrient pollutants (reactive phosphorus, reactive sulphur, and reactive nitrogen) as well as toxic contaminant anions (ammonium perchlorate) even at extremely low concentrations, from wastewater effluents, chemical & power plant funnels have been used in the aquaculture, agricultural, municipal, nuclear, and defense industries. Here we paid more attention on flue gases treatment.

There is one industry demonstration project in operation in Chengdu (Enteck) for flue gases treatment. Figure 2 shows its technological process. This project was mainly

used to treat SO_2, NO, CO_2 etc.

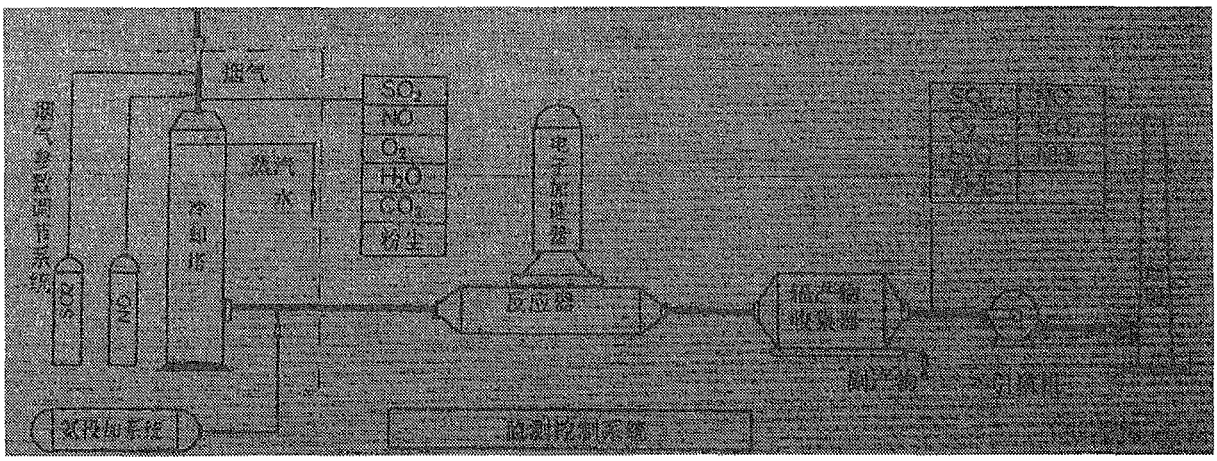

Figure 2. Technological process of industry demonstration project in Chengdu (Enteck)

There are also two industry demonstration projects under construction in Beijing and Hangzhou city, with flue gases volume of 3.0×10^5 Nm^3/h and 6.3×10^5 Nm^3/h for the 100 MW and 200 MW coal power station respectively. New flue gas treatment method is optimized in Tsinghua University.

3.2 Electronic & electrical products

As an example, EB irradiation has been widely used in the industrial companies producing cables & wires. There are 30-40 EB setups running in industrial companies to treat shrinkable tube, cross-linking cable, heat-resistant and insulation plastics, and so on. More than 5 new facilities per year are to be installed in company. Table 1 gives a list of Applications of EB setups in Chinese Industries.

Table 1. Application of EB setups in Chinese Industries

HV	EB	Owner's Name	Year	Maker	Application
3 MV	40 mA	Jilin Radiat. Chem. Inst.	1984	RDI	Shrinkable tube
2.2 MV	25 mA	Tianshui Cable Co.	1989	BINP(1) & IMP(2)	Cross-linking cable& wire
2 MV	20 mA	Yantai Cable Co.	1991	IHEP (3), IMP & SINP (4)	Irradiation Cable
3 MV	10 mA	Inst. Engineering Physics	1987	Nissian HV Ltd.Co	Shrinkable tube
2 MV	30 mA	Xi'an Wire Co.	1993	RDI	Wire
2.5 MV	30 mA	Inst. Radiat. Protection, Taiyuan	1993	BINP & IMP	Shrinkable tube, Cable, Form Plastic
2.0 MV	10 mA	Sichuan Cable Co.	1993	SPC(5)	Cable
2.0 MV	10 mA	Chengdu Shuangliu	1993	SPC	Shrinkable
3.0 MV	30 mA	Shrink Co.	2000	ViVilad	Tube
2.5 MV	20 mA	Changshou Cable Co.	1994	SINP	Cable
2.5 MV	20 mA	Liyang Cable Co.	1994	SINP	Cable
1.5 MV	40 mA	Xinhua Cable Co.	1995	BINP	Cable
1.5 MV	30 mA			& IMP	
2.5 MV	40 mA	Guangdong Cable Co.	1995	RDI	Cable
2.5/1.5 MV	30 /40 mA	Inst. Changcun Chem.	1994	BINP	Shrinkable Tube
2 MV	20 mA	Inst. Nucl. Tech.	1995	BINP & IMP	Shrinkable Tube
2.5 MV	30 mA	Kunming Cable Co.	1995	SINP	Cable
2.5 MV	33 mA	Shanghai Cable Co.	1995	RDI	Cable
2.5 MV	40 mA	Huangshi Cable Co.	1995	RDI	Cable
2 MV	10 mA	Shenyang Special Cable Co.	1995	SPC	Cable
2 MV	10 mA	Dayu Shrink-tube Co.	1995	SPC.	Shrink tube
2 MV	10 mA	Tianjin Tech-Phys Inst.	1995	SPC	Shrink tube
2 MV	10 mA	Yangzhong cable Co.	1995	SPC	Cable
2 MV	10 mA	Jiangxi Cable Co.	1996	SPC	Cable
2.5 MV	30 mA	Shanghai-minhang Cable Co.	1996	BINP & IMP	Cable
2.5 MV	20 mA	Tianjin Cable Co.	1997	IHEP	Cable
2.5 MV	40 mA	Lanxi Cable Co.	1997	BINP & IMP	Cable
2.5 MV	25 mA	Huaian Cable Co.	1997	SINP,	Cable
2.5 MV	30 mA	Zhengzhou Cable Co.	1998	Vivilad	Cable
2.5 MV	25 mA	Zhunhua Cable Co.	1999	SINP	Cable
2.5 MV	30 mA	Shenzhen Special Plastic Product Co.	2000	BINP Russia	Shrinkable Tube
2.5 MV	20 mA	Shijiazhuang Cable Co.	2001	IHEP	Cable
2.5 MV	40 mA	Guangdong Cable Co.	1995	RDI	Cable
2.5 MV	40 mA	Guangdong Cable Co.	1995	RDI	Cable
2.5/1.5 MV	30 /40 mA	Inst. Changcun Chem.	1994	BINP	Shrinkable Tube

BINP(1): Burker Institute of Nuclear Physics, Russia, IMP(2): Institute of Modern Physics, CAS,
IHEP(3): Institute of High Energy physics, CAS, SINP(4): Shanghai Institute of Nuclear Physics, CAS,
SPC(5): Shanghai Xianfeng Company

3.3. Biological & medical applications

Most EBs on biological & medical applications are focused on hydrogels for the purposes of cosmetic, wound dressings, drug delivery systems, orthopedics applications, dental and ophthalmic applications. For example, hydrogel dressing can protect injured skin and keep it appropriately moist to speed heals process. Its function is much like that of gauze and hydrocolloid dressings, their common properties being absorbing liquids exuded by the body, preventing infection from external bacilli, nonpoisonous, soft and with high adhering properties, high permeability, sterilizing power, etc. But only hydrogel dressing have the following exceptional characteristics: accelerated healing, painless removal of the dressing, no residue, hence no need for physiological salt solution washing, transparency allows observation of the healing process, etc. These properties are unavailable using old-fashioned gauze and hydrocolloid dressings. Hydrogel dressing as a new technique is used more and more in surgical in China. In order to improve the quality of the hydrogel products and enlarge the application, numerous research groups make in process of developing novel hydrogel products with special functions. Figures 3 and 4 give two examples of hydrogels studies in laboratories.

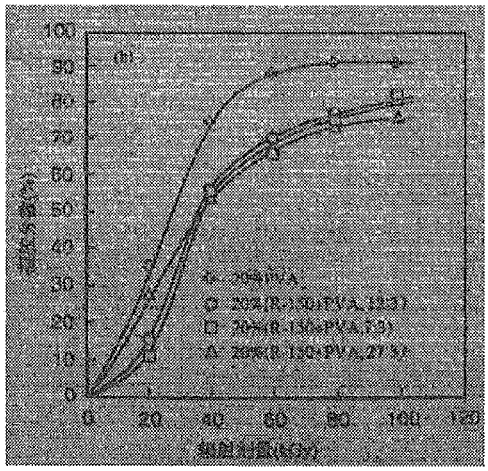

Figure 3. Graft proportion of PEO R-150 with PVA varying with EB irradiation dose (Suzhou Medical College).

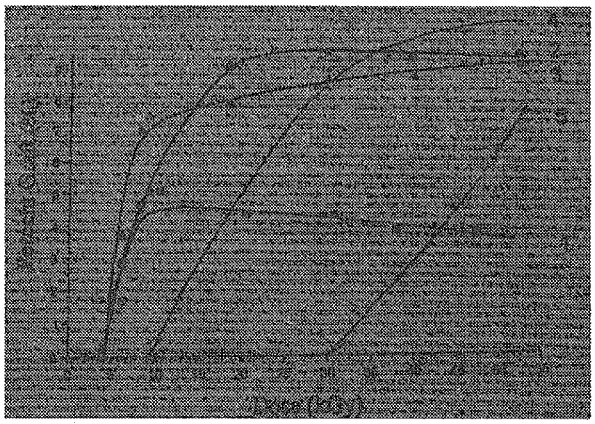

Figure 4. Graft proportion of powder HDPE with different monomers vs. dose. 1-Acrylic Acid, 2–HEMA, 3-glycidyl methacrylate (GMA), 4-diethylene glycol diacrylate (DEGDA), 5- pentaerythritol triacrylate (PETA). HDPE=High Density PolyEthylene (Beijing Normal Univ.).

4. Summary

EB applications were increasingly interested in China. By collaboration of institutes (e.g., SIAP (Shanghai), IHEP (Beijing), IMP (Lanzhou), CAEP (Sichuan)) with industries and companies, the link between R & D of EB facilities & products has been enhanced and enlarged. R&D to develop 100 - 500 kW high power electron accelerators for flue gas treatment and other applications are in progress. Furthermore, 5-10 MV high energy electron accelerator is under developing to replace ^{60}Co source for sterilization, food, chips that is supported by company.