Country Report: Indonesia
The Use of Low Energy Electron Accelerator For Processing of Liquid Matter in Indonesia

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Introduction

The basic idea of research and development (R & D) activities in radiation processing is to strengthen and broaden the linkage between industry and research institute, with the gain of economic growth of the country. In Indonesia, R & D of radiation processing using electron accelerator cover polymerization, sterilization, wire and cables, heat shrinkable tube and sheets, pre-vulcanization of tire rubber components and radiation curing. Some of the processes have already commercial. Based on some advantages either technical, safety and economical factor make the use of electron accelerator more feasible compared with γ-ray of Co-60. Development of new technology of electron irradiation system can be applied for processing of liquid such as natural rubber latex. The new procedure to produce pre-vulcanized natural rubber latex free from nitrosamine and protein by using γ-ray or electron beam has been developed. The low and medium energy electron accelerator with special designed for radiation processing of liquid especially for vulcanization of natural rubber latex is needed in the near future. The use of radiation (electron beam and gamma ray) for radiation processing in general, and radiation processing of liquid matter in particular will be reported in this paper.

Radiation Facilities

Research and development in the Industrial Processing Division of The Center for Research and Development of Isotopes and Radiation Technology (P3TIR - BATAN) mostly are for radiation processing i.e., polymerization, sterilization, food preservation, processing of industrial material and industrial dosimetry. One of the facilities is a pilot scale of latex irradiator using gamma-rays of Co-60. In 1984, a radiation curing of surface coating of wood panels using low energy electron accelerator (300 keV, 50 mA) has been installed in 1984 at Center for Research and Development of Isotopes and Radiation Technology. The pilot plant was designed for training and demonstration, studying both technical and economic evaluation of the technology and also for radiation services [1]. The second electron accelerator i.e. EBM GJ 2 (2 MeV, 10 mA) was installed at the same

location in 1993. The use of this accelerator is mainly for R & D of crosslinking process such as crosslinking of wire and cable, and heat shrinkable tube and sheets. Now, the facility is also used for sterilization services of wound dressing. There are two companies that already used for commercial purpose. Sterilindo Co. carried out gamma irradiation for food preservation and sterilization. A private company, namely PT. Gajah Tunggal at Tangerang has installed a low energy electron accelerator (500 keV, 20 mA), which was the first manufacturer of rubber tired using electron beam machine. The facilities, purpose, location and year of installation are tabulated on Table 1.

Table 1. Electron accelerator facilities in Indonesia

Location	Year installed	Manufacturer	Voltage & Beam current	Purpose of use
1. P3TIR-BATAN	1984	Nissin High Voltage	300 keV & 50 mA	- R & D - Wood Surface Coating (Services)
2. P3TIR-BATAN	1993	SXFEM, China	2 MeV & 10 mA	- R & D - Wire and cable - Sterilization
3. Gajah Tunggal Comp.	1998	Nissin High Voltage	500 keV & 20 mA	- Vulcanization of Tire

Research and Development

Solid Materials

Determination of the best results of cross-linked LDPE and PVC has been carried out in the experiment using various energy of electron beam. Addition of anti oxidant after cross-linked using 300 keV electron beam increases heat- and oxidative- resistance of LDPE for cable insulation. The effect of flame retardant (halogen compound) i.e. chloroparafin, tetrachloro bisphenol-A, PVC and antimon trioxide to the rate of flammability of polyethylene have been observed [2,3]. Electron accelerator with energy of 300 keV was also used for grafting of polyethylene terephtalate (PET) in the form of textured fabrics acrylamide and methylol acrylamide monomers at total dose of 5 Mrad. The properties of grafted PET exhibit good thermal stability, crease resistance instead of stress-strain and with some improvements of hydrophilic properties such as increasing in moisture regain, dyeability to anionic and cationic dyes [4]

The most advantage of radiation sterilization has been successful application if steam sterilization cannot be used. In this case, radiation method plays an important role in replacing ethylene oxide that is having difficulty in meeting toxic safety requirements. Ethylene oxide is a very toxic, flammable and carcinogenic material.

The energy electron or gamma-rays can be used to lower the degree of polymerization of cellulose. By treating using electron beam, pulp shows higher reactivity resulting in decreased amounts of chemicals required, such as CS_2, NaOH and H_2SO_4 which can reduced the release of toxic chemical to the environment.

Liquid Materials

In 1984, research and development using electron beam radiation has been started since the erection of wood surface coating pilot plant at Center for Research and Development of Isotopes and Radiation Technology (P3TIR), Jakarta. The pilot plant consists of low energy electron accelerator (300 keV, 50 mA) and a number of wood coating and wood handling equipments. Instead of R & D, this facility was used for radiation surface coating services to the several companies [5].

R & D were focused in radiation curing of surface coating of wood products, due to the availability of wood as raw materials. Plywood, parquet flooring, particle board, and other commercial timbers have been used for R & D. Production cost has been calculated based on the production test of radiation surface coating of wood panels i.e. plywood, particle board, parquet flooring either using EB or UV radiation. It's concluded that radiation curing of surface coating using EB only feasible for mass production scale [6-8].

Another application of radiation in the treating of liquid materials is for crosslinking of natural rubber latex. Indonesia as a one of the leading natural rubber producing country has developed R & D the radiation vulcanization of natural rubber latex (RVNRL). Natural rubber latex is well known as a raw material for various kind of goods in many fields of industry and human life, especially for medical rubber goods, such as surgical gloves, condom, balloon, catheter, rubber tube and bag for spygmomanometer, etc. A serious problem in particular for the medical rubber products are nitrosamines and protein content. Nitrosamines are regarded as highly carcinogenic while protein causes the type I allergy. A lot of papers have been published with radiation vulcanization natural rubber latex (RVNRL) using gamma radiation but a few researches on RVNRL using electron beam. Sensitizer CCl_4 as amount as 4 % for radiation crosslinking of natural rubber latex using 300 keV electron beam reduces the optimum dose from 250 kGy to about 120 kGy. The new process to solve the problem is by changing from sulphur vulcanization to the radiation vulcanization using gamma or electron beam radiation. By this method, centrifuged pre-vulcanized latex was free from nitrosamine and protein, which can be used directly for producing condom, surgical gloves, rubber tube for spygmomanometer etc. [9,10]. Research and development for production of pre-vulcanized natural rubber latex and its products prepared by gamma radiation in factory scale have been done through National Research Cooperation (RUK VII, 2001-2002). This type of research cooperation was carried out between Research Center (National Nuclear Energy Agency-BATAN, Jakarta, Research

Unit for Biotechnology of Estate Crops, Bogor), University (Medical Faculty of Indonesia University, Jakarta) and Company (Government Estate Crop VIII, Jalupang, PT. Mitra Rajawali Banjaran, Bandung, PT. Sugih Instrumendo Abadi, Padalarang, and Latirra Home Industry, Serpong). Results of the research cooperation show that the quality of pre-vulcanized latex meets for production of several products such as condom, surgical gloves and spygmomanometer with free from nitrosamine and protein allergen. Based on the results, research cooperation will be continued with the program of trial production of pre-vulcanized natural rubber latex and its product free of nitrosamine and protein allergen (Year 2003-2004). It is recommended the use of low or medium energy electron accelerator for production of pre-vulcanized natural rubber latex. Several industries have already used RVNRL for their rubber products as seen on Table 2.

Research and development in the case of radiation processing of liquid matter using electron beam instead of natural rubber just started. One of the experiments is the use of electron beam for radiation of polysaccharides. Polysaccharides is one of the biopolymer which was abandon in the earth, easy to find and cheap. More specific liquid as the objects of research are starch, chitosan and other natural polymers such as carrageenan and alginate. These kinds of substances are usually used for wound dressing, growth promoter, cosmetics, pharmaceutical, food etc.

Conclusion

Based on the broad application and advantages of irradiation system, it is required to make feasibillity study (technical and economical aspect) the use of low energy electron accelerator for radiation processing of liquid matter such as natural rubber latex. This step is in line with the results and future program of National Research Cooperation between Government Institution and Private Company in the field of RVNRL in Indonesia. The development of more feasible and economical of electron accelerator and more efficient process are the important factors to reduce the production cost. Research cooperation among electron accelerator manufacturer, research center and related company in the FNCA member country plays an important role to enhance the application of electron accelerator to industrial sector.

Table 2. Several small, medium and big industries using NVNRL since 1983.

Location	Product	Year
Jakarta	Finger joint[1], baloon[1], adhesives[1]	1983-2002
West Java -Bogor -Cianjur -Bekasi -Padalarang -Bandung	 Gloves[1], baloon[1] Gloves[1] Gloves[2], rubber tread[2] Spygmomanometer[2]	 1987-1990 1983-1985 1987-1990 2000-2003
Banten -Serang -Tangerang	 Gloves[2] Surgery gloves[1]	 1998
Central Java -Semarang	 Baloon[1]	 1995
Yogyakarta	Souvenir[1]	2000
East Java -Surabaya	 Dot[2]	 1996
Export -Germany -Vietnam	 Dot[2] Gloves[2]	 1987 1990

[1] = small and medium industry

[2] = big industry

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