JP0450539

5.6 Country Report: Malaysia

The Applications of Electron Accelerator: Liquid, Thin Film and Gases

Khairul Zaman Hj. Mohd Dahlan, Kamaruddin Hashim and
Zulkafli Ghazali
Radiation Processing Technology Division,
Malaysian Institute for Nuclear Technology Research (MINT),

Introduction

The current industrial application of nuclear technology such as radiation processing fits in well into the country's development program. Radiation processing is one of the industrial processes that can be used for cross-linking, grafting, elimination of microorganisms, modification of organic compounds, cleaning of environmental waste – liquid, solid and gases and etc. The radiation processing technology can be an integral part of the manufacturing line for the production of flame/fire resistant wire and cable, heat shrink tube, hot water tube, heat shrink film for packaging, sleeve, composite materials, viscose rayon and many other profile and molded products. It has been proven as unique and commercially viable process. On the other hand, the materials used for radiation processing are specifically compounded. Therefore, research and developmental work carried out at MINT focuses on the development new applications of indigenous natural polymers and development of blends and composites compounds for specialty products such as high scratch and abrasion resistance materials, flame and fire resistance materials, nano-structured materials etc. At the same time, electron accelerator is also seen as an attractive alternative for treatment of environmental waste that will not resulted in a production of secondary waste.

Table 1. Some possible materials process and output expected from research activities at MINT.

Materials	Process	Output Product/Application
Natural rubber **Oil palm** **Polysaccharide** **Thermoplastic** **Thermoset Composite**	• Blending/Composite • Modification/ synthesis • Compounding, extrusion • Injection molding • Coating/lamination • Gamma vulcanization, • Electron beam cross-linking, grafting, curing • Radiation degradation	• Composite profiles, film, foam, membrane, sheet • Injection molding of modified and composite • Hydrogel for bio-medical and health care products • Modified natural polymer for agricultural applications • Biodegradable foam and films for packaging
Environmental pollution - SOx and NOx from power stations and incinerator. - Industrial waste water and drinking water - incinerator gases	• cleaning the gases and water.	• Clean air release to the atmosphere • Clean drinking water and treated industrial wastewater

Challenges and Opportunity

Malaysia is rich of natural polymer such as natural rubber and rubber based materials, palm oil and palm oil based materials, starch from sago and cassava, chitin and chitosan from shrimp shelves. These materials are currently being used in the country and the technology to support the production and utilization of the materials are well established. Being natural polymer, they are environmental friendly and biodegradable and they are well known as 'green polymer'. With the current low market price of these materials, it is more prudent to diversify its usage and to give more value added to the materials. Currently MINT is conducting research in the following areas.

Radiation processing of thin film/membrane;

- Sago hydrogel
- Sago film
- Commercial membrane for fuel cells
- Synthesis of high abrasion and scratch resistance coating materials

Textile and food & beverage industries in Malaysia are amongst the industries that create a significant volume of wastewater. Most of the companies belong to this industrial sector are small and medium in size. Their locations are scattered throughout the country. However, in certain industrial areas such as in Seberang Prai, Pulau Penang and Batu Pahat, Johor, there is a concentration of textile companies. In average, the volume of wastewater generated per day is between 150 – 1,000 cum. However, for a few large-scale textiles companies, the volume of wastewater is up to 4,000 cum per day. All companies have wastewater treatment plants as required by the environmental regulation. However, the main problems for almost all the treatment plants are difficulty in maintaining COD level below 100 mg/L for the effluent and disposable of sludge. This project was started a year ago at the laboratory stage using electron beam for treatment of wastewater from a textile company. However, there three types of liquid waste that will be under study in future which are as follows;

Radiation processing of liquid;

- Textile industrial waste water
- Food & beverage waste water
- Drinking water

Status of Reserch

Electron beam irradiation of thin sago hydrogel film

Research on development of hydrogel from sago starch for wound dressing was conducted between MINT and JAERI for 5 years and has completed in December 2002. In this work, the thickness of hydrogel used was in the range of ~ 3 mm and it is cross-linked by using electron beam accelerator at 1.0 MeV. For the subsequent work under the FNCA activity, the usage of low voltage electron accelerator (Curetron, 200 keV) was emphasized and a study was conducted with the following objectives;

- a minimum possible thickness of hydrogel that can be prepared and practically utilized and
- a minimum voltage required to sufficiently cross-linked the films with a single sided irradiation.
- to characterize the properties of the thin films

The following result in Figure 1 shows that the appropriate thickness of hydrogel film that has an optimum water absorption capacity is at ~100 μm. At higher thickness, gel fraction increase slightly, however, the swelling ratio or water absorption capacity drop significantly which is usually associated with the increase in cross-linking density. However, in this case whereby water is the main constituent of hydrogel (>80 %), it is believed that there is a reduction in OH functional groups capability of the compounds in hydrogel to attract water molecules.

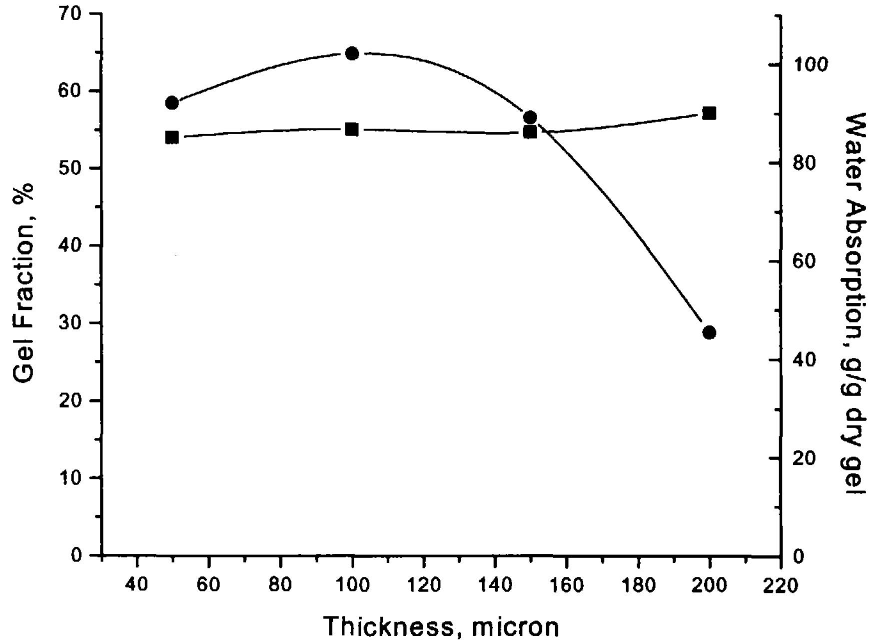


Figure 1: Effect of thickness on gel fraction and water absorption of sago hydrogel, at 6 mA beam current and 25 kGy irradiation dose by Curetron 200 keV

Another important phenomena when hydrogel is irradiated that it is dose rate or beam current dependence. Figure 2 shows the effect of electron beam currents on the gel fraction of 200 μm hydrogel films using 200 keV electron accelerator. This indicates the role played by the primary radicals of irradiated water in the process of crosslinking of hydrogel. At beam current 8.0 mA, irradiated hydrogel gives the optimum gel fraction. However, as the dose increase from 25 to 100 kGy, the gel fraction of the hydrogel at various beam currents increases. Consequently, the tensile strength of hydrogel also increase with the increase of irradiation dose.

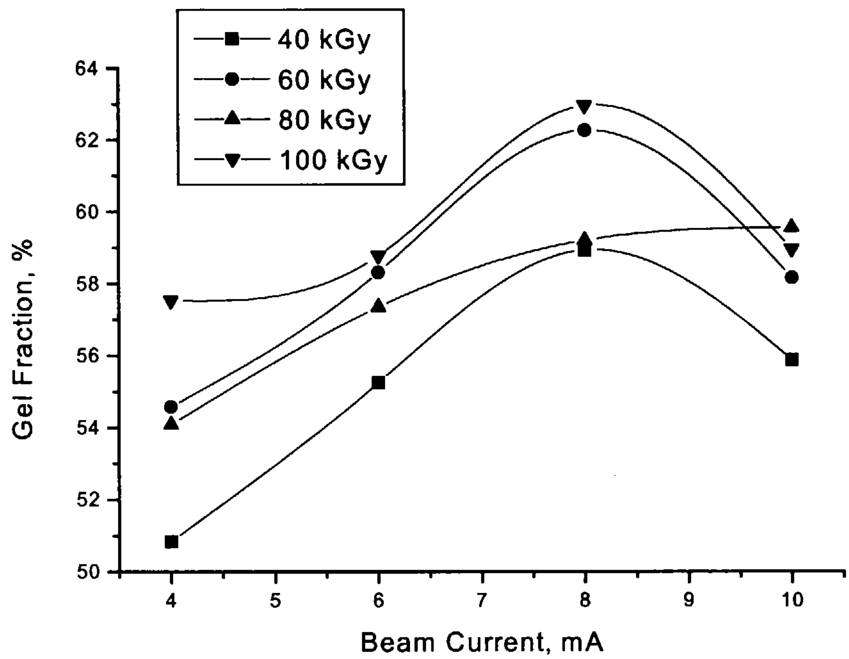
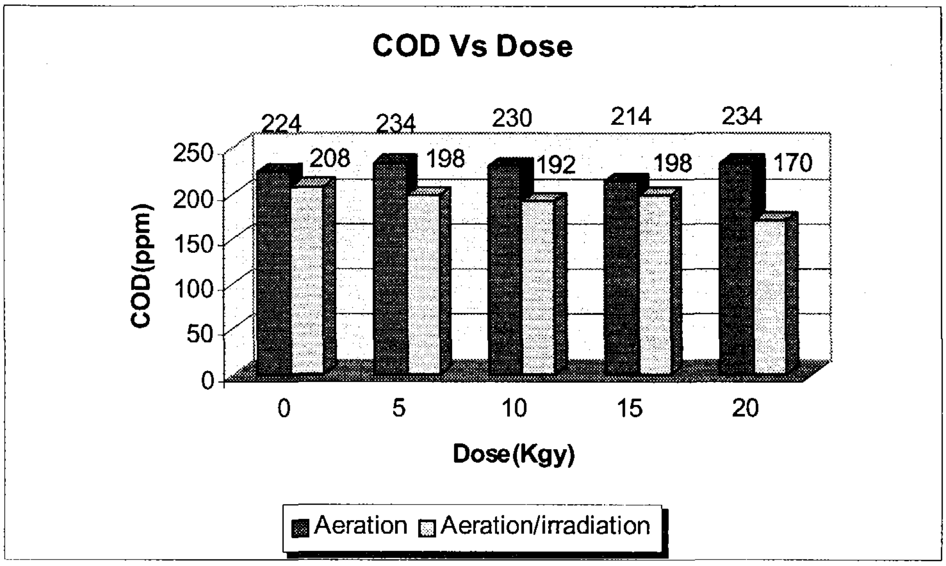


Figure 2: Effect of electron beam and irradiation dose on gel fraction of 200 microns thickness sago hydrogel.

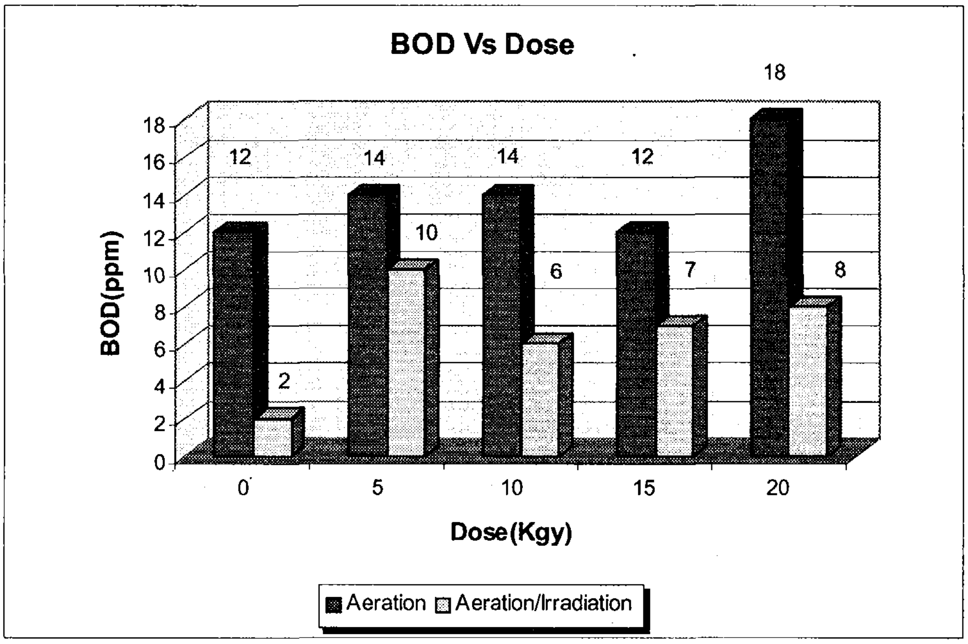
Electron beam irradiation of textile industrial wastewater

Following the visit and recommendation of Dr. Bumsoo Han of Korea in 2001, a project was initiated to study the possibility to treat wastewater from the textile industry in Malaysia. This project was presented and proposed to be included in the FNCA activity during the meeting of FNCA in February 2002.

The following are some of the results of research that have been carried out using the industrial wastewater from a textile company in Malaysia. As has been mentioned earlier, the main problem of the effluents from the textile industry in Malaysia is the level of COD which is double than the permissible level. In the preliminary study it shows that electron beam radiation in the presence of air is capable of reducing COD level. Oxygen in the air has facilitated the reduction of the chemical substances in the wastewater. However, the max reduction so far achieved at 20 kGy was ~27.4 %. Further process is necessary given the high level of the chemical substance in the wastewater as indicated by the presence of 234 ppm of COD.



However, for BOD the level is well below the permissible level which is 50 ppm. The conventional technology by aeration is sufficient to reduce further the level of BOD. By treating the wastewater with electron beam irradiation and in the presence of air, the BOD level drop by more 50.0 %.



Conclusion

As indicated by the results of the above study, low energy electron beam accelerator of 200 keV to 500 keV can be utilized to irradiate thin hydrogel film in the range of 60 to 500 μm thickness. However, the industrial applications of this technology will depend on its applications. For thin films, cosmetic use such as faced mask is possible. The production of sago hydrogel for cosmetic used is in the process of commercialization in Malaysia.

As for electron beam treatment of industrial wastewater in particular the effluent from the textile industry is still at infancy. Further work is necessary in order to have a base line data before the commercialization is taken place.

Malaysia has also embarked on the electron beam treatment of flue gases and has completed the semi-pilot scale study by using 1.0 MeV electron accelerator voltage and 400 cum flue gas generated from diesel generator. This study was conducted together with the TNB Research, the research institute belongs to the electrical power company in Malaysia. For technology transfer and commercialization, MINT is planned to promote this technology to Independent Power Producers (IPP) in Malaysia.