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# STATUS AND FUTURE TRENDS OF RADIATION PROCESSING IN BRAZIL

LUGÃO A.B.; ANDRADE E SILVA L.G.

Institute for Energy and Nuclear Research - IPEN/CNEN-SP, p.o. box 11049, 05422-70, Sao Paulo , Brazil

## ABSTRACT

Electron-beam and gamma irradiation of polymers are widely applied in Brazil today. The main applications are: - radio-induced crosslinking of wire and cable for automobile and appliance industry; - heat shrinkable tubes for appliance, automobile and electronic; - heat shrinkable packing for food processing industry; - sterilization of medical supplies and so on. Nevertheless, there are only a few industrial facilities about 20 years old in full operation at present and there are some new low energy machines for food packing. The reason for such absence of investment in this area was studied and the relation between automobile and appliance production with radiation processing was fully demonstrated for Brazil case. In conclusion, it was shown that the industry of radiation processing of polymers is likely to experience a strong growth based on the continuous increase in the production of automobiles and appliances. The R&D activities of IPEN are an important support for developing the necessary technology and developing the necessary confidence in the radiation as tool for economical and social growth.

## KEYWORDS

irradiation, electron-beam, gamma, polymers, automobile, appliance, wire, heat-shrinkable, sterilization, food.

## INTRODUCTION

About 20 years ago, the main facilities for radiation processing were installed in Brazil. There were installed three gamma facilities for sterilization of medical products, one electron-beam for services, mostly on wire and cable at IPEN (public Institute) and one low energy electron-beam for curing of coatings on wood boards. Shortly after that, another electron-beam was installed at one wire and cable industry, and two others were installed for heat-shrinkable packing, but at the same time the machine for curing was closed due to problems with the production technology. Since then, very few has changed, only two years ago more two machines were installed for heat-shrinkable packing and another was installed at the service center of IPEN. New facilities were planned for gamma sterilization. The purpose of this work is to review the status of R&D and the status of industrial processing in the last few years. The focus is the radiation processing of polymers in order to understand the 10 years period without any new radiation processed products in Brazil. Of course, it is also a primary goal to forecast the trends for the next few years.

## RADIATION PROCESSING

The main radiation sources used in radiation processing re Co-60 and electron accelerators. Usually accelerators are used for high doses production on small thickness products. Co-60 are used usually for the irradiation of high density and large volume products. The main areas of radiation processing of polymers are curing and crosslinking. One of the first accelerators in the world to be installed for curing of coatings on wood boards was in Brazil, about 20 years ago. However, there were no proper technology available at that time in the country for oligomers or for the treatment of the substrate and

the production was completely shut down. Nowadays, the industry of curing by radiation is growing very fast in Brazil, but only using UV curing. This paper is focusing mostly the ionizing radiation for polymer processing, therefore crosslinking of polymers is the main area. Table 1 below show the main applications of radiation crosslinking and its status.

Table 1. Status of radiation crosslinking in Brazil

| Application | machines | comments |
|---|---|---|
| insulation of wire and cable | 1 | 1.5 MeV, 50mA, Dynamitron, full time operation for the automobile industry |
| polyolefin foam | 0 | no perspectives so far |
| heat shrinkable tubing | 0 | one high energy machine but it was returned to the main site due to scale considerations |
| heat shrinkable packing | 5 | low energy machines and fast growing market with 2 machines installed in the last 2 years |
| tire rubber sheet | 0 | perspective for 2 machines in the short run |
| service center and P&D | 2 | two 1.5MeV, 15mA and 50mA for P&D and wire cable |
| Total | 8 | |

The main applications for radiation crosslinking are connected with the automobile and appliance industry, mostly in Brazil where the military, electronic and aircraft industry are very small. The trend, however, for both, automobile and appliance industries, is of tremendous growth in the next few years. Figure 1 shows the historical series and trends for automobile industry.

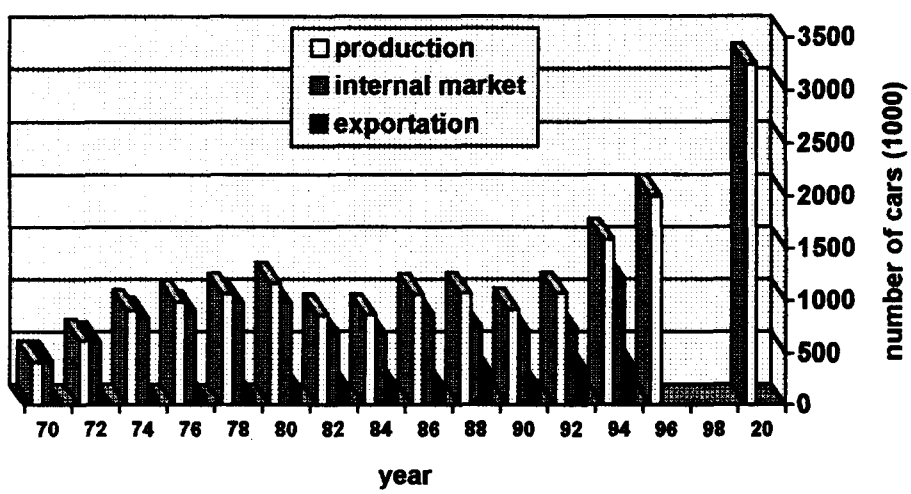


Figure 1. Historical series for automobile industry

Figure 1 shows that the automobile market underwent through a continuous increase from 1970 to 1980. After that, one can observe a deep decrease, and only in 1992 the production recover the same level of 1980. However, from 1992 to 1996, it is clear a intense increase in the production. The same behaviour, or even more intense, could be observed in the appliance numbers. The reason is the same for both industries, i.e., the workers start to have access to their first car or modern refrigerators or others, as a result of the monetary stability and recent economical growth. Many important automobile and appliance industries are expanding their activities very fast and others are settling important projects for new products, with up to date technology, considering even the external market in near future.

A closer view of figure 1 show a not surprising fact, the behaviour of the automobile market follow the same pattern of radiation processing in Brazil. Of course this is not a coincidence, it show that the radiation crosslinking market is directly linked with automobile and appliance ones, not only in Japan (Makuuchi, 1996) but also in Brazil.

## P&D IN RADIATION PROCESSING OF POLYMERS

The research on radiation crosslinking, grafting, degradation and curing is conducted actively in Brazil. The main center dedicated to this mission is IPEN. Nevertheless, some other universities are also working on this subject or related ones. The main research lines are:

*Radiation Vulcanisation of Natural Rubber Latex*

It is well know the advantages of this technology (Makuuchi & Markovic, 1991), however, one could consider it even more relevant for the Amazon jungle in Brazil and other Latin-American countries. The Amazon jungle is known as the birth of ***Hevea Braziliensis***. However, the importance of native rubber decreased continuously and also the relative importance of NR production from plantation in Brazil. During the last two decades the poverty in that region increased dramatically for many reasons. As a consequence, it increased the destruction of the native forest by introducing new economical activities not sustainable, i.e., not compatible with the environment, for instance, livestock, extraction of wood, mining etc.

The natural rubber industry is a fully compatible economical activity for Amazon basin region. The extraction of NR can benefit of it by selling differentiated products completely free from nitrosamines with the most special latex in the world, the latex from native trees. The jungle will benefit from it, as the workers from extraction (seringueiros) will not need to destroy the jungle to get their sustainability. The seringueiros are know as ***soldiers of the jungle*** as they walk many km everyday taking care of it. The margins of the jungle can support very productively the huge plantation necessary to commercial scale. The margins are being burned at very fast pace to implement big livestock activities. The NR activity is a economical alternative to that region and RVNRL can also contribute to promote its products in the international market. IPEN is developing the RVNRL process to achieve those goals.

*Wound Dressing*

The technology of wound dressing production by the so called Rosiak's method was successfully transferred inside an IAEA program by its inventor Dr. Janusz M. Rosiak (Rosiak, 1995 and Lugao, 1987). The Brazilian membrane have equivalent properties to the commercial product sold in Poland. Now, the R&D is focusing the adaptation of its production process for Brazilian conditions, i.e. improvement in mechanical properties and improved understanding of its diffusion properties. It is also under way the implementation of the biocompatibility studies requested by the Brazilian's authorities.

*Improvement on the Rheological Properties of PP*

PP is one of the most important plastic commodities in the world. However, it lacks melt strength properties. The enhancement of the melt strength is necessary to achieve much faster processing speed and more homogeneous products. Radiation is a known process to improve it. IPEN is developing a proprietary process to produce higher melt strength at lower cost

## OTHER P&D ACTIVITIES

Many other polymers activities are under way:

- use of radiation as a tool for monomer stability studies;
- development of polyolefin foam;
- development of new compounds for wire and cable industry;
- stabilization of PVC;
- development of PP with improved resistance to radiation, etc.

It is important to point out the efforts of IPEN, represented by M.C.R. Yamasaki, in the inducement of the foundation of Technical Association of Cure EB/UV and supporting its activities since then. The technical Association of EB/UV Cure have promote the electron-beam and UV curing by organizing workshops, seminar, technical courses and so on.

There are also very sound R&D efforts on the environmental area, the main activities at IPEN concentrate in waste water Treatment by radiation and flue gas treatment. The waste water project is a IAEA model project for Latin America. Another area of P&D in radiation processing is food treatment. There are a very intense program under way at IPEN. Those subject are out of the scope of this paper.

## FINAL REMARKS

The relation between automobile and appliance production was fully demonstrated for Brazil case. The radiation processing of polymers industry is likely to experience a strong growth base on the continuous increase in the production of automobiles and appliances. The R&D activities of IPEN are an important support for developing the necessary technology and developing the necessary confidence in the radiation as tool for economical and social growth.

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