Preliminary Assessment of Elastomer and Bitumen Processing Assisted by Microwave Energy for Immobilization of Radioactive Waste

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This paper presents a preliminary assessment of immobilization of radioactive waste by using asphaltic/elastomeric matrices, compounded by bitumen and production leftovers of ethylene vinyl acetate (EVA) and microwave energy. The purpose was to improve their chemical and physical properties and then reduce any possible dispersion of the waste in the environment during the stages of intermediate storage, transportation and final disposal. The samples of bitumen and EVA were irradiated at IPEN-CNEN/SP in a microwave device (2450MHz), varying the irradiation time and microwave power. In order to get the most homogenous matrix formulation the following process parameters were analyzed: irradiation time (1min up to 10min), microwave power (1000W, 2000W and 3000W), the bitumen/EVA ratio and the temperature of the samples (controlled by using a thermocouple). They are being characterized to assure the efficiency of the method, according to ASTM standards for: density, DSC (Differential Scanning Calorimetry), leaching test, penetration and hardness test.

Introduction

The nuclear technology has been developed in many areas, allowing its upgrade on energy supply, defense and medicine. However, the use of this resource has aroused a serious matter: the radioactive waste. Once nuclear materials are produced and consumed, subproducts are formed, such as dangerous chemical and radioactive compounds.

The management of radioactive waste is not simple and several treatment processes have been studied to ensure that the material is handled safely. The priority is to improve the immobilization of the residues in stable matrices, regardless their radiation level.

The storage of those residues depends on the composition, activity level and disposal options for the final product. Also it must be done by applying chemically stable materials as immobilization matrices in order to avoid as much leaching and dispersion of compounds as possible, and keep their insulation during their entire decay.

Several immobilization techniques have been employed to encapsulate the radioactive waste such as bituminization processes and polymer immobilization [1].

The bituminization process has been widely used to embed low and intermediate level radioactive waste. Bitumen is a generic term that covers a wide range of high molecular weight hydrocarbons. Its main characteristics that make it suitable as a matrix are insolubility in water, high resistance to water diffusion, plasticity, good rheological properties, good ageing feature, high load capacity and prompt availability at reasonable cost. However, since it is an organic material, bitumen has the following disadvantages and restrictions when it is used as a solidification matrix: the low melting temperature and the possibility of combustion in case of accidental fire [2].

In Brazil, a research group from Centro de Desenvolvimento da Tecnologia Nuclear (CDTN-CNEN/MG) developed a technique by using an extruder with two rotating horizontal screws, where the bitumen matrix is processed. It aimed both the treatment of low and intermediate level radioactive waste generated by the operation of nuclear plants and application of radioactive materials in research, nuclear medicine and industry. [3].

Application of polymers to immobilize radioactive waste has been performed in many installations worldwide. Different kinds of polymers have been used and further studies have been developed to improve cost effectiveness, process and product quality. Here are a few examples of those polymers: epoxy resins, polyesters, polyethylene, polystyrene and copolymers, urea formaldehyde, polyurethane, phenol-formaldehyde and polystyrene. The advantages of those processes are good leaching resistance for many polymers, the large variety of polymers available and moderate to stable biodegradation resistance. However some polymers may be affected by excess water and others are attacked by organic solvents, in the radioactive waste [2].

The present work shows the preliminary study of the EVA (production leftovers) and bitumen processing assisted by microwave energy, to manufacture matrices for future embedding of radioactive waste. It aims to improve the chemical and physical properties of the matrix and consequently reduce possible dispersion of these substances in the environment during the stages of intermediate storage, transportation and final disposal. This study also contemplates the development of the technology of immobilization by using the microwave process.

Materials and Methods

Sample Preparation

The samples of bitumen and EVA (figure 1) were weighed (30g up to 110g) separately in a scale model LC2 (*Marte Balança e Equipamentos*). The blend of bitumen/EVA had the following composition: 50wt% up to 85wt% of bitumen and 15wt% up to 50wt% of EVA. The radioactive waste could be immobilized in the bitumen/EVA matrix.

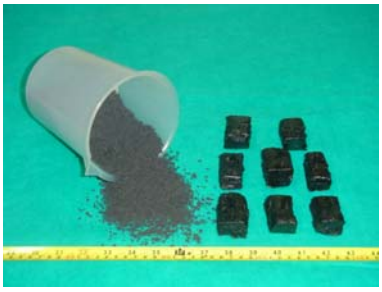

Figure 1 - Samples of EVA and bitumen, no irradiated.

Sample Irradiation

The microwave heating occurs when the electromagnetic waves penetrate the material and release energy as heat. The polar molecules vibrate at high frequency allowing their reorientation and alignment with the frequency of the microwave field. The most important characteristics of microwave technology are the rapid and selective heating and environmentally clean process with low pollutant emission. [4]

First of all, the samples of each compound and the blend of bitumen/EVA (30g) were placed in a ceramic crucible and irradiated during 1min up to 15min, in commercial domestic microwave oven (800W).
In a second stage, 50g up to 110g of each compound and a blend of bitumen/EVA were carried out in a high frequency microwave device (2450MHz, developed by IPEN-CNEN/SP group and installed in the Polymer Laboratory) for 1min up to 10min, varying the microwave power (1kW, 2kW and 3kW) with temperature monitoring by using a thermocouple. The microwave device consists of a magnetron valve, a wave guide and a cavity where the samples are irradiated. The cavity has a system to release reaction gas and a device to collect samples. A digital controller allows the control of the irradiation time and power applied in the sample. After the irradiations were over the samples were collected and conformed in small cans (figure 2).

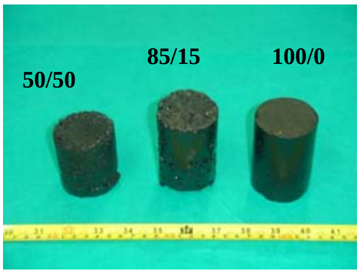

Figure 2 – Bitumen wt%/EVA wt% matrices, after irradiation.

Results and Discussion

The first irradition tests using 30g of each compound and the blend of bitumen/EVA were performed to evaluate the samples visual appearence and the flame resistance (flash point). The bitumen is an inflammable material and its flash point is about 300^{o}C [3]. During those tests the temperature of the samples reached around 190^{o}C. This value is lower than its flash point showing that it is a safe method for processing this kind of blend.
The following tests were performed to evaluate the homogeneity of the blend of bitumen/EVA in different composition, irradiation time and microwave power applied. This property depends on the absorbed energy by this blend and its capacity to be conformed to the die. The resultant matrices have been characterized. Concerning the homogeneity tests the best results obtained were for the composition of 85wt% bitumen/15wt% EVA by using 3000W microwave power for 5min. The homogeinity tests of the matrices were carried out without the radioactive waste. It will be added in the best matrix composition next stage.
Finally, the possibility of incorporating the radioactive waste in the matrix processing assisted by microwave for its immobilization will be analyzed as well as the characterization results.

Conclusion

The efficiency of microwave technology for immobilization of radioactive waste has been evaluated and its application on this area is still in the first stages of development. Also the best blend ratio must be defined and many bench tests have to be carried out. In fact, it should be pointed out that many parameters must be analyzed on this study since radioactive waste needs careful handling and the microwave energy promotes fast, uniform and selective bulk heating in the material. The preliminary results showed a way to determine the blend linkage grade as well as the reliability of the obtained data. Probably the use of EVA has optmized the operating temperature range of the microwave process and an improvement of the physical properties. Concerning the radiation level, the blend stability will be studied to define the maximum amount of waste that could be incorporated in this matrix.

References

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