# CHAPTER 1

# INTRODUCTION

## 1.1 Scientific Background and Rationale

The plastic industry has experienced a phenomenal growth during the last decade and became the most widely used material, surpassing even steel. Today plastic industry's utilization is greater than those of steel and aluminum combined. Plastics are now used in every segment of business and in the daily life. They are found either in the form of the entire product as containers, and fast food packaging or in a combination with other materials; as parts of transportation vehicles, computers, tools, recreational equipment, etc.

The significant increase in plastics production and product generation has brought in a similarly significant increase in plastic disposal. Clearly, plastics waste, whose major source is packaging, is one of the contributors to the waste management problem. Polystyrene plastic is among the most dominant packaging materials in today's society and not being capable of self-decomposition. Similar to other packaging products, when products from PS reach the end of their useful life, most are discarded in open dumps, landfills, or as simple litter. These materials have the disadvantage of not being degradable.



Plastics such as polystyrene foam presents disposal problems. Polystyrene foam is under attack particularly because of its use in hot-drink cups and as packaging for fast foods. There is a trend to the use of cardboard in place of foam for these applications. However, on a weight basis, more cardboard than foam is required. In fact, it was reported that a paper cup contains a greater amount of wax than the entire mass of a polystyrene foam cup. Such wax (low-molecular-weight polyethylene or parafin wax) also presents a disposal problem [1].

Extensive studies are being carried out to develop plastics that are either photodegradable or biodegradable. This is being done either by the use of additives or by the development of new or modified structures that degrades by various mechanisms. Photodegradable plastics contain either a photosensitive additive, such as a transition metal salt, or a comonomer containing a photosensitive group. Complete oxidation degradation would give carbon dioxide and water. However, the rate of degradation of conventional plastics containing various additive systems is still so low that at best there is only a partial solution to the litter problem.

The addition of starch to polystyrene plastics has been promoted as a technique to give biodegradability. As the organism consumes the starch, a glucose-based natural polymer, surrounding the plastic that will lose its structural integrity, enhance other degradation mechanisms and eventually decline in mechanical properties. Nonetheless, as the amount of starch is increased, the degradability characteristics will increase; the mechanical property is subsequently decreased. In this thesis, we prepared starch-*g*-polystyrene copolymers by a simultaneous irradiation technique from a $^{60}$Co-source and graft copolymers were used as part of the styrene-based polymer for the study of degradation of starch-polystyrene plastic.

## 1.2 Objectives

The objectives of this research are the following:

1. To determine a suitable condition for the synthesis of starch-*g*-polystyrene copolymers by a simultaneous irradiation method.

2. To study the degradation of the cassava starch/its graft copolymer blended polystyrene plastic.

### 1.3 Expected Benefits Obtained from Development of the Research

The benefits for the development can be:

1. To obtain starch-*g*-polystyrene graft copolymers, to be used with the virgin polystyrene to increase the degradation of polystyrene plastic.

2. To obtain a fast degradation method for polystyrene plastics.

### 1.4 Scope of the Investigation

In this research, the necessary procedures are as follows:

1. Literature survey and in-depth study of this research work.

2. Preparing the graft copolymers of styrene and cassava starch via gamma radiation by a simultaneous irradiation method, through the optimum quantity of total dose (kGy) at a specific dose rate so as to select the suitable and appropriate reaction conditions.

3. Extracting the homopolymer (polystyrene) of the crude product.

4. Characterizing the graft copolymer obtained from 3:
   a) Determination of percent add-on of the graft copolymer.
   b) Determination of percent conversion of the monomer.
   c) Determination of the homopolymer formation.
   d) Determination of grafting efficiency of the grafted polystyrene.
   e) Determination of grafting ratio of the graft copolymer.

5. Studying the effect of nitric acid on the grafting of styrene onto cassava starch.

6. Compounding the plastic materials (polystyrene, the graft copolymer, additives) by a two roll-mill machine and making a plastic sheet with a compression molding machine.

7. Degradation testing:
   a) Sample natural exposure test.
   b) Soil burial test.
   c) UV irradiation test.
   d) Gamma radiation test.
   e) Biodegradation test.

8. Physical and mechanical properties testing:
   a) Tensile property and elongation at break.
   b) The extent of degradation by the carbonyl index.
   c) Thermal property of the target plastic sheets.
   d) Molecular weights and distribution.
   e) Resistance of the plastic to bacteria.

9. Summerizing the result and preparing the report.

## 1.5 Content of the Thesis

The content of this thesis comprises five chapters. Chapter 1 involves an introductory remark of the present research, which gives reasons and goals of the work. Details of the subsequent theoretical consideration and literature reviews are described in depth in Chapter 2 for those who wants to understand the history and trends of the part investigated. Resulting from the literature, a novel research can be prepared. Chapter 3 involves the procedure of grafting of styrene onto cassava starch by a simultaneous irradiation technique and the resulting graft copolymers were used as part of the styrene-based polymer to increase the degradation of polystyrene plastics. The results and discussion of the work are described in Chapter 4, the degradation behavior was followed by monitoring tensile property, the extent of degradation detected by the carbonyl index, the average molecular weights and molecular weight distribution, and the thermal properties of the plastics of outdoor exposure, soil burial test, gamma radiation, and UV irradiation. The test of biodegradability resistance of PS and composite PS sheets to bacteria, *Bacillus coagulans* 352, was also studied. The conclusion and suggestion of this work are given in Chapter 5, this work shows that the inclusion of cassava starch-*g*-polystyrene graft copolymer with the polystyrene plastic, besides the well-known additives of pro-oxidants of metal stearate and fatty acid, is a very significant factor to increase the degradation of polystyrene plastic. The PS plastic after outdoor exposure needs a less activation energy to become totally degraded. This research also implies a combined treatment to reach a fast degradation, for example, a first treatment of outdoor exposure followed by a soil burial test.