CHAPTER I

INTRODUCTION

1.0 Introduction

The first completely synthetic plastic, phenol-formaldehyde, was introduced by Baekeland in 1909, nearly four decades after Hyatt had developed a semisynthetic plastic-cellulose nitrate (Chanda and Roy, 1993). In 1927 poly(vinyl chloride) (PVC) and cellulose acetate were developed, and 1929 saw the introduction of urea-formaldehyde (UF) resins (Chanda and Roy, 1993). The development of new polymeric materials proceeded at an even faster pace after the war. Epoxies were developed in 1947, and acrylonitrile-butadiene-styrene (ABS) terpolymer in 1948 (Chanda and Roy, 1993). The next two decades saw the commercial development of a number of highly temperature-resistance materials. More recently, other new polymer materials were introduced, including several exotic materials which are mostly very expensive.

There are hundred of homopolymers commercially available today. Since one type of polymer does not possess all the physical and mechanical properties desired in a finished product, blending of polymers were introduced to meet the requirements. The continuing pressure to improve productivity and quality has generated the research in polymer blends. Blending also offers the possibility of tailor-make products to meet specific end needs. For this reason, much attention was received from academia and industry and thus blending of polymers are experiencing significant growth. From the economic point of view, blend development is far less costly and time consuming than the development of new polymers (Datta and Lohse, 1996).

This present study focuses on the blending of ABS with PVC. The large diversify of end uses makes ABS one of the most successful of the engineering thermoplastics available. It is a bridge between commodity plastics (e.g., polystyrene) and higher-performing engineering thermoplastics (e.g., polycarbonate). Its position in terms of both properties and price between the more highly priced, high performance engineering plastics and the lower priced commodity plastics makes ABS the material of choice for many applications (Adams *et al.*, 1993).

ABS resins are composed of over 50% styrene and varying amounts of butadiene and acrylonitrile. Styrene provides rigidity and ease of processability, acrylonitrile offers chemical resistance and heat stability, and butadiene supplies toughness and impact strength. ABS having high rubber content possesses higher impact strength than those with low rubber content. Increase in rubber content results in greater ductility of these blends. Large-volume applications for ABS resins include plastic pipe and automotive and appliance parts. Although ABS has many desired properties as engineering thermoplastic, its still has some limitation for example, easily burn with high flammability value and poor resistance to outdoor UV light (Chanda and Roy, 1993).

ABS itself is already a blend of polybutadiene and styrene acrylonitrile (SAN). It can be further blended with other materials to introduce new and improve resin grades. Thus, the scope of possible applications is broadened (Jin *et al.*, 1998), and resulting in overall demand growth for ABS. Demand in the U.S. for ABS is projected to advance 4% per year through 2006 to 1.6 billion pounds, valued at $3.1 billion (Freedonia Industry Study, 2002).

The low price of PVC renders its use desirable in many applications. Besides, this material is popular with its inherent flame retardancy and UV stability. When blended with ABS, the result is a material with good impact strength, toughness and inherent flame resistance (Hofmann, 1985). ABS/PVC is used in a wide variety of applications which include electrical components, appliances, business machine housings and automotive parts (Manson and Sperling, 1976). The inherent flame retardancy of PVC makes it suitable for applications where the more expensive flame retardant ABS could be employed (Landrock, 1983).

Blending of ABS with other polymers is widely reported. Many studies have been carried out on ABS/Polycarbonate (PC) blend (Chiang and Hwang, 1987; Lee *et al.*, 1988; Steeman and Maurer, 1994; Ogoe *et al.*, 1996; Jin *et al.*, 1997; Balakrishnan and Neelakantan, 1998; Lim and Bertilsson, 1999 and Choi *et al.*, 2000) Among the interesting finding of these studies are that ABS provides the benefits of economics, processability and more reliable impact resistance, while PC contributes the improvements of tensile, flexural, thermal properties and flammability to the blends.

The study on ABS/PVC blend had received less attention compared to ABS/PC blend. According to Adam *et al.* (1993), ABS/PVC blend possessed U.S. annual consumption growth rate (1990-1996) of 12-18% or 3-9% higher than ABS/PC blend (Growth rate: 9%). Thus, more research study should base on ABS/PVC blend since it has a convinced growth rate but less research study is being reported.

The studies on polyblend of PVC and ABS were conducted by Maiti *et al.* (1992). PVC compositions ranging from 50 to 100% were used. Maiti *et al.* discovered that this polyblend possesses advantages like the tensile strength and rigidity of PVC and impact strength of ABS. TGA analysis revealed a substantial improvement in thermal stability of PVC/ABS blends over that of PVC.

The compatibility enhancement of ABS/PVC blends was also conducted by Jin *et al.* (1998). The composition for PVC was ranging from 50 to 100 %. When a compatibilizer, SAN 25 was added into the blend, the compatibility was enhanced and about twofold increase of impact strength was observed.

Bensemra and Bedda (2001) studied the properties of PVC/ABS blends. Blends with variable composition, 0 to 100 wt % PVC were used. The researchers concluded that addition of plasticizer, di(ethyl-2hexyl) phthalate into the blends greatly improved the impact properties where the higher the PVC content, the higher the impact value.

Besides studying the mechanical properties of ABS/PVC blend, flammability of the blend was also investigated by Carty and White (1994). According to Alexander (2000), the annual loss of life and the property caused by fire around the world is extraordinary, since thousand of death and billion of property were loss each year. Most of the fires involve the combustion of polymeric materials. So, the method to reduce the flammability of polymers and hence reduced the loss of life and the property has been the subject of increasing interest over the past several years. As mentioned, one of ABS main drawbacks is its inherent flammability and therefore a need exist to improve this property by incorporation of halogenated polymers, such as PVC.

In the study conducted by Carty and White (1994), ABS/PVC blends containing up to 30 phr of PVC were examined. In this work, addition of PVC into ABS has successfully reduced the flammability of ABS, where the LOI value increased from 18.3% to 33.8%. The flame retarded ABS currently has a great deal of interest in the computer and business equipment market. Alexander (2000) also mentioned that European regulators were considering requiring flame retarded polymer in electronic equipments and other products.

1.2 Problem Statement

As mentioned earlier, the studies on ABS/PVC blend have received less attention compared to PC/ABS blend. The previous studies on PVC/ABS blends concentrate mainly on the use of ABS as the added polymers, with PVC as the main component (Maiti *et.al*, 1992; Jin *et.al*, 1998; Bensemra an Bedda, 2001). The present study will focus on the effect of adding PVC into ABS. The effect of adding PVC of different molecular weight into different types of ABS (with different ratios of monomer content) has not yet been reported. It is expected that both, PVC molecular weight and polybutadiene content in ABS will influence the properties of

ABS/PVC blend. The study on blending acrylic grafted PVC with ABS has also not been reported. This proposed study hopefully will further the knowledge in the area of ABS/PVC blend and extend the applications of ABS.

1.3 Objectives

The main objectives of the proposed research are as follows.

- to study the effect of PVC molecular weight and content, and acrylic grafted PVC on the mechanical and flammability properties of ABS/PVC blends.
- to study the effect of different grades and composition of ABS on the mechanical and flammability properties of ABS/PVC blends.
- to determine the optimum ABS/PVC content in terms of mechanical properties, flammability, and cost.

1.4 Scope

The study involved preparing various samples of ABS/PVC at blend composition of 100/0, 90/10, 85/15 and 80/20. A mixer, single screw extruder and injection moulding were used for sample preparation. The types of the testing and analysis are as follows:

(a) Mechanical Properties

Two types of mechanical properties were conducted, that is Pendulum Izod impact and flexural test.

Pendulum Izod impact was used to determine the impact strength of each blend.

Flexural test was also carried out to determine the stiffness of the ABS/PVC blend.

(b) Flammability

Oxygen Index Test was used to determine the flammability properties of the blends.

(c) Thermal Properties

Heat deflection temperature (HDT) was used to determine the temperature at which it loss the rigidity.

(d) Material Characterization Test

DMA (Dynamic Mechanical Analysis) was used to correlates the T_g with the miscibility of the blends.

SEM (Scanning Electron Microscopy) analysis was carried out to correlate the surface fracture with the impact strength results.

MFI (Melt Flow Index) test was conducted to obtain the melt flow rate and to determine the processibility of the ABS/PVC blends.