CHAPTER I

INTRODUCTION

1.1 Background

Polymer nanotechnology represents a new subject in nanoscience. Presently, polymer nanocomposites have gained a great attention in many research areas because of their good properties which are synergistically derived from two components. For conventional composites, polymers have been successfully reinforced by glass fibers or other inorganic materials. However, in these reinforced composites, the polymer and other additives are not homogeneously and thoroughly dispersed on a nanometer level. If nanometer dispersion could be achieved, the physical and mechanical properties might be further improved when compared with pristine polymer or conventional composites. The term of nanoparticle refers to a crystallite or primary particle measuring less than 100 nm in size, e.g., carbon black, fumed silica, and clay, which have been used as fillers in many applications such as automotive parts, semiconductor, house appliance, etc. Using nanoparticles in composite materials can enhance tensile strength and modulus, increase chemical resistance, and improve UV resistance and abrasion resistance; therefore, nanocomposites have been widely studied by various preparation methods. Among these nano-fillers, a clay mineral is a potential nanoscale additive because it consists of silicate layers in which the fundamental unit is a 1 nm of thickness planar structure. The most common type of clay using for nanocomposites formation is montmorillonite clay (MMT) because it is abundant in nature and cheap. Most polymer nanocomposites exhibit these improvements in performance at relatively low clay loading (typically 2-10 wt.%) [1].

Acrylonitrile-butadiene-styrene (ABS) comprises of rubber particles or butadiene phase dispersed in styrene-acrylonitrile phase or SAN matrix. It is a widely used engineering thermoplastic material due to good mechanical properties, chemical resistance, and easy processing characteristics. Applications for ABS include housewares (refrigerator doors, sewing machine, hair-dryer housings, luggage, furniture frames), housing and construction (pipe, conduit, fittings, bathtubs and shower stalls), transportation (automotive instrument panels, light housings, grilles), etc. However, one of the disadvantages of ABS is its inherent flammability [2].

Thailand is an agricultural nation. There are biological matters left after agriculture-based industrial processing such as rice husk from rice mills more than 7 million tons per year [3] and corn cob husk from corn fields more than 1.1 million tons per year [4]. These agricultural wastes have been used as fuel or raw materials for preparation of silica [5], but have not been sufficiently utilized so far. Many researchers have interested and studied on the applications of rice husk and corn cob husk at present because it can help decreasing quantity of agricultural wastes. Nowadays, Thai industry has to import flame retardants from Europe and America in order to utilize in various industries such as automotive parts, fire-fighting clothes, building construction, etc. Therefore, this work will emphasize on the synthesis of flame retardant from natural resources such as corn cob husk and rice husk for ABS. This is not only helpful for reducing production cost of flame retardant but also for utilizing and reducing agricultural wastes and increasing values of agricultural wastes. It is expected that the modified waste products can be used as fillers in ABS to enhance its mechanical properties, thermal properties, and flame retardancy.

Flame retardant chemicals such as halogenated compounds, nitrogen compounds, silicon compounds, and phosphorus compounds are incorporated into organic polymer to promote fire safety by slowing or hindering the ignition of fire. The ideal flame retardant additive is colorless, easily blended, compatible with the substrate, cheap, and low toxicological effects. The modes of action of flame retardant additives involve several mechanisms, for example, producing large volumes of noncombustible gases when the polymer decomposes, forming a protective barrier that insulates polymer from the transfer of heat from the flame, increasing heat capacity of the polymer, reducing the fuel content below the lower limit of flammability, and reacting in the combustion process by breaking up themselves into simple constituents and thereby competing with the combustion. The selection of a flame retardant additive is complicated by environmental concerns; therefore, halogenated flame retardant is limited to use because it can form toxic by-products such as dioxins while heating [6]. The trend of flame retardant additives used in the future is reasonable cost and enhance the polymer properties. Therefore, the silicon compounds or silicon-based materials are potential flame retardant additives chosen for this research.

Silica consists of hydroxyl groups on its surface which results in strong filler-filler interactions. These interactions lead to an aggregation of silica itself, which was attributed to poor dispersion in polymer matrix. Moreover, the silanol groups on surface of silica cause polar materials, therefore they easily absorb moisture or water on silica surface and poorly dispersed in polymer matrix. In order to improve dispersion of silica in matrix, silane coupling agents should be selected for surface modification of silica particles.

Silatranes are selective to use as flame retardant additives because of their intriguingly molecular structure, biological activity and patterns of chemical reactivity by biologists and pharmacologists [7, 8, 9]. Normally, their structure is pentacoordinate silicon compounds derived from the reaction of trialkanolamines such as triethanolamine with trifunctional silanes such as ($RSi(OMe)_3$) to yield highly crystalline, monomeric pentacoordinate silanes. The intriguing aspect of this structure is the existence of a transannular bond between the silicon and nitrogen atoms which results in high reactivity of chemical reagents. Thus, the designing of materials used in this research, silatranes, organomontmorillonite clay, and modified silica are employed as flame retardant additives inevitably for ABS system. This is of great interest in new route to save energy, solve pollution problem, and improve of both flame retardancy and mechanical performance of ABS by working at a nanoscale for additive incorporation.

1.2 Objectives of Research

The goal of this research was to improve flame retardancy of ABS with silicon compounds derived from agricultural wastes that offered potential as novel flame resistant materials. Therefore, this research aimed to prepare flame retardant ABS/organomontmorillonite nanocomposites by melt blending technique using flame retardant synthesized from agricultural wastes. Two types of silica extracted from rice husk and corn cob were used as starting materials for silatrane complex synthesis. In addition, two types of silane coupling agent (i.e., vinyltrimethoxysilane (VTMO) and 3-aminopropyltrimethoxysilane (AMMO)) were employed for improving filler dispersion in polymer matrix. Next, the silatrane complex and other fillers (i.e., silane modified silica and organomontmorillonite) were blended with ABS by melt blending technique using twin-screw extruder. The ratios of ABS, silica, silatrane, and OMT were prepared in different compositions in order to study the effect of filler type and filler loading on flame retardant and mechanical properties of ABS composites.