CHAPTER 1

INTRODUCTION

Motivation

Rice is primary source of food for billions of people. Due to the world's main rice producer, the amount of rice husk generated from rice production has been increasing in Thailand, and has been become an important byproduct management problem. According to the global rice production, more than 5,400 million tons of rice husk are produced each year in Thailand[1]. At least half of them find no utilization and are disposed of. Therefore, much effort has been made at finding alternative and meaningful applications of this byproduct. Nowadays, there are few companies utilizing rice husk as fuel to generate energy by burning rice husk, but the utilization of rice husk in other industrial applications has been limited. Huge amounts of rice husk left are disposed by combustion or dumping. However, a disposal of rice husk by open heap burning is not acceptable on environmental grounds and generates undesirable atmospheric pollutants. And dumping of rice husk in a landfill site is undesirable because the anaerobic decomposition may result in the collapse of the landfill site that may, in turn, result in a potential leakage of toxic waste into the environment[2]. To protect environment and decrease landfilling of rice husk, therefore, the increase in utilization of this byproduct is a best method to reduce a disposal problem and also increase revenue for rice producers.

Rice husk ash (RHA) is a solid waste product from the power generating industry or disposal by combustion. It is suitable for recycling due to its high silica content, high external surface area, porous and lightweight. However, silica in waste RHA can exist in both amorphous and crystalline (mostly cristobalite) forms depending its heat treatment history. The silica in rice husk is amorphous and transforms to crystalline silica when it is heated at high temperatures. The transformation temperature is affected by its chemical purity and particle size. In practice, waste RHA in an amorphous form is difficult to obtain from all local resources due to the difference in chemical properties and heat treatment. In Thailand an enormous quantity of industrial waste grade RHA has been produced which has directly affects upon the environment and imposes adequate storage problems and concerns. The IARC (International Agency for Research on Cancer) announced in 1997 that crystalline silica forms, such as quartz and cristobalite belong to "Group 1" of hazardous materials which is the same group as asbestos. Accordingly, respirable crystalline silica is recognized as materials which can cause respiratory and other tissue damage including of cancer. Therefore, the proper treatment of rice husk before utilizing can protect a health of human.

Although, there is a high content of RHA in Thailand, it is only used as a secondary or replacement material in Portland cement and building brick. Research and development in the utilization of RHA in other applications have not been carried out on industrial scale. Nowadays, several approaches have been made for proper utilization of RHA, either to reduce the cost of disposal or to minimize the environmental impact. One of the approaches is the conversion of RHA to zeolite which has wide applications.

Zeolite is a hydrated crystalline aluminosilicate with open three-dimensional framework structures. It is conventionally prepared by the hydrothermal treatment of the gel containing silica, alumina, alkali cation, organic template and water[3, 4]. Since RHA contain mainly amorphous silica, thus, it is possible to utilize RHA as a raw material for the synthesis of various types of zeolite. Among the various types, ZSM-5 is a material of great interest and is used in a large quantity, due to its unique shape selectivity, solid acidity, ion exchangeability, pore size, thermal stability and structure network[5]. It has been widely used as catalysts and adsorbents in petroleum and petrochemical industry[6-8]. Generally, commercial ZSM-5 is produced from commercial silica sources in the form of gel, sol and amorphous fumed silica[9, 10]. Nevertheless these silica sources are quite expensive, toxic to human and some reagents are not easy to use[11]. Although there have been research documents encouraging the utilization of SiO_2 from RHA for the synthesis of various types of zeoite[2, 9, 12-19], the reported experimental results so far are equivocal in their potential suitability and optimal methods for utilization, due in part to the differences in the nature of the "as-prepared RHA" and the composition of the precursor gel. To increase the potential for utilization of the rice husk, this research is dealing with an attempt to produce ZSM-5 with a simple and low cost production route using silica from RHA.

In addition to protection the environment by conversion of rice husk to ZSM-5 zeolite, the application of photocatalysis using semiconductors is one potential route. Among the metal oxide semiconductors suitable for photocatalytic processes, titanium dioxide (TiO_2) is the most widely used as photocatalyst in photocatalytic oxidation for organic pollutants in air and water due to its high photocatalytic activity, nontoxicity, low cost and its chemical stability in the reaction conditions[20-23]. TiO_2 in anatase phase has attracted considerable attention in wastewater treatment due to its excellent properties, but poor adsorption and difficulty in removal of spent catalyst from the treated water lead to great limitation in exploiting the photocatalyst to the best of its photocatalytic activity[24-27]. On this basis, a great effort has been focused in developing supported TiO_2 catalysts offering a large surface area, together a better in recovery properties. Recently, nanocomposites have been a popular research topic. The composites of nano-TiO_2 and porous material supports with large surface area have received much attention because of their adsorption-supported photocatalytic properties[28-45]. To improve the potential application of wastewater treatment and ZSM-5 synthesized from RHA, supporting TiO_2 nanoparticles on the ZSM-5 surface has attracted interest due to the high surface area and unique uniform pore of ZSM-5.

Objectives

- To prepare rice husk ash in the form of amorphous silica with high surface area
- To synthesize ZSM-5 zeolite using silica source from rice husk ash
- To produce photocatalytic material from TiO_2 and ZSM-5 for decolourization of waste dye solution

Scope

The scope of this research covered the study on the preparation of amorphous silica from local rice husk by acid leaching and burning method. The obtained RHA was used as a silica source to synthesize ZSM-5 zeolite with a wide range of SiO_2/Al_2O_3 molar ratios by hydrothermal heat treatment under autogenous pressure. In this synthesis, tetrapropylammonium bromide was used to control the framework structure of ZSM-5. Moreover, the synthesized ZSM-5 was impregnated in TiO_2 sol to produce TiO_2/ZSM-5 composite. This composite material was applied for the decolorization of dye solution under UV irradiation.

Benefit

- An effective environmental problem-solving
- Decrease the quantity of waste product from rice production
- Increase in the potential of both utilization and value of rice husk