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# Phase Diagram of Zeolite Synthesized from Perlite and Rice Husk Ash

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**ABSTRACT:** This research aimed to synthesize zeolites from perlite obtained from Lopburi Province, Thailand, and from rice husk ash, under hydrothermal condition. The experiments were carried out in an autoclave with $SiO_2/Al_2O_3$ molar ratios of 1 to 40, NaOH concentrations of 1 to 4 N, and starting pressure of 1 atm. The rice husk ash and $AlCl_3 \cdot 6H_2O$ were used to adjust the $SiO_2/Al_2O_3$ molar ratio. The autoclave was heated with the rate of 1.5 °C/min to the set points of 140 and 170 °C at which it was kept isothermally for 2 h. The results showed that the products detected were analcime, Na-P1, and sodalite octahydrate. However, at very low $SiO_2/Al_2O_3$ ratio and NaOH concentration, no zeolite could be formed at 140 °C. The analcime could be formed at almost all conditions, except at low concentration of NaOH and the $SiO_2/Al_2O_3$ ratio below 25. Furthermore, the Na-P1 could be detected in every area except at high concentration of NaOH and high $SiO_2/Al_2O_3$ ratio at which only analcime and sodalite octahydrate were found. The sodalite octahydrate was formed preferably at high concentration of NaOH and high ratio of $SiO_2/Al_2O_3$. At temperature of 170 °C, the formation of analcime was enhanced, while the others seemed to be unaffected. Finally, phase diagrams of detected zeolites were constructed.

**KEYWORDS:** zeolite, perlite, rice husk ash, phase diagrams.

## INTRODUCTION

Zeolites are a well-defined class of crystalline of naturally occurring aluminosilicate minerals. They have three-dimensional structures arising from framework of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$, coordinated in a polyhedral structure linked by all corners. There are 39 naturally occurring zeolite species recorded and more than 100 species have been synthesized.[1] Because of their abundant utilization such as catalyst, ion exchanger, sorption agent, and water softener, there are many researches on synthesis of zeolites. The hydrothermal synthesis of aluminosilicate zeolites involves a few elementary steps by which a mixture of silicon and aluminum compounds, metal cations, organic molecules, and water is converted via an alkaline supersaturated solution into a microporous crystalline aluminosilicate.[2]

The synthesis of zeolites from low-cost silica-alumina sources has been the aim of many experiments. The sources of silica-alumina include fly ash, kaolinite, diatomite. In this experiment, perlite and rice husk ash were used.

Perlite or pearl stone is a natural glass generally of equivalent composition to granite, which has formed by rapid cooling of viscous lava or magma.[3] In Thailand, perlite is an abundant natural resource found in Lopburi Province. Rice husk is an agricultural waste, a by-product from rice milling. Because Thailand exports large amounts of rice, million tons of rice husk are produced. Some rice husk is used as fuel, brick making, animal feed, and fertilizer. When it is combusted under appropriate conditions, the ash having 70 to 97 percent by weight of amorphous silica is obtained. The amorphous silica can be utilized as a highly reactive reactant for many chemical processes.[4,5,6]

The objectives of this work were to identify the crystalline phases of zeolites synthesized from perlite and rice husk ash with varied $SiO_2/Al_2O_3$ molar ratio and NaOH concentrations, at 140 and 170 °C. Subsequently, the corresponding phase diagrams were constructed.

## MATERIALS AND METHODS

### Materials

Light color perlite with grain size less than 100 μm from Lopburi Province, Thailand was used as a starting material having the following chemical compositions: 80.44% $SiO_2$, 11.83% $Al_2O_3$, 5.68% $K_2O$, 1.60% $Fe_2O_3$, 0.39% $TiO_2$, and 0.06% $MnO_2$ by weigh. It should be noted that the original $SiO_2/Al_2O_3$ molar ratio of used perlite is 11.5. Its physical properties were as follows: