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Recycling of Municipal Solid Waste Ash through an Innovative Technology to Produce Commercial Zeolite material of High Cation Exchange Capacity

Maysson Sallam,PhD[1]*, Robert P. Carnahan[2], Abla Zayed[3], and Sermin Sunol[4]
[1]Camp Dresser and McKee, CDM, West Palm Beach, FL, USA
[2,3]Department of Civil and Environmental Engineering, Faculty, University of South Florida, Tampa, Florida, USA
[4]Department of Chemical Engineering, Faculty, University of South Florida, Tampa, Florida, USA
*Corresponding author, e-mail sallamm@cdm.com, fax +561-689-9713.

ABSTRACT

Municipal solid waste ash (MSW ash) samples, obtained from a local incinerator in Florida, were converted via a chemical process into zeolite material. The conversion process was performed by applying a two step treatment. The ash samples were fused at 550°C under alkaline conditions and then the fused ash samples were treated hydro-thermally at 60 °C and 100°C for different periods. This innovative technology involves adjusting the $SiO_2/Al2O_3$ ratio of the ash from 13.9 to 2.5 by adding sodium aluminates and by using a solid to liquid ratio of 10. The fusion step formed sodium silicate and sodium aluminum silicate phases. These phases acted as precursors to the formation of zeolite A. Zeolite A was successfully formed within the ash matrix when samples were fused and $SiO_2/Al2O_3$ was adjusted. The maximum cation exchange capacity, CEC, was measured by using ammonium acetate solution. The CEC of the produced zeolitic ash material has increased significantly from 17 meq/100g for non-treated ash up to 212 meq/100g for the treated ash. The cation exchange capacity of the produced zeolite ash material is close to that available from commercial zeolite materials which have a CEC of 245meq/100g. Zeolite A formation within the ash matrix increased the potential of using the ash as an adsorbent for industrial and environmental applications including ammonia removal from waste water or any other similar application that involves cation exchange.

1. INTRODUCTION

In the United States, about 225 million tons of municipal solid waste are generated annually. One third of this waste is either recycled or composted. Landfilling or incineration manages about 150 million tons of municipal solid wastes. Incineration is becoming a favorable option for many reasons including problems associated with landfilling, excellent volume reduction, energy recovery and revenues gained. Landfilling is facing increasing opposition by both regulatory and public agencies due to their drastic effect on the environment; in consequence, landfills in the United States decreased from 8,000 in 1988 to 1,858 in 2001. In the United States, about 14% of generated waste, 86,000 tons, is incinerated yearly. Though incineration results in 70-90 % volume reduction of waste, a significant portion remains as ash. The remaining ash portion is usually divided into bottom ash fraction which accounts for 90% of the produce ash and fly ash fraction which accounts for only 10% of the total ash portion. Concerns still exist for landfilling of the remaining ash. This generated interest in treating and reusing the ash. To date, only 5% of the produced ash is being utilized in the United States. The majority of application has been in construction applications.

Only recently, an innovative technology proposed chemical conversion of the ash to produce zeolites material. The possibility of successfully producing zeolite from the ash is contributed to the fact that the ash has considerable fraction of silica and alumina, which are the primary elements required for building zeolite structure. This type of conversion is expected to increase the adsorption capacity of the ash due to the formation of zeolite minerals such as zeolite X, P and A within the ash matrix, which in consequence increases the potential of using the ash as an adsorbent in so many different applications. The investigation on zeolite synthesis process from municipal solid waste ash is still in its early stages and there is little work that has been done so far to address zeolite formation from municipal solid waste ash. None of the previous work addressed the formation process comprehensively to answer many questions regarding the types of zeolite that could be possibly produced, the optimization of the process, mechanism and theory of the formation, and the possibility of modeling the synthesis process. This paper addresses the formation process of zeolite A from MSW ash.

2. THEORY AND MECHANISM OF ZEOLITE SYNTHESIS

The mechanism of zeolite formation from MSW ash has not been investigated in the previous literatures. However, recent theory for Zeolite synthesis from coal ash has been provided by many authors and can be used for comparison purposes in this study since coal ash has a similar composition as MSW ash. Murayama et. al., 2002 and 2003, suggested a theory for zeolites formation from coal ash and was based on the formation of amorphous aluminosillicate gel on the solid particles under high alkaline conditions followed by crystallization of zeolite due to the reaction between the gel and the alkali or dissolved species in the mother liquor solution. This theory concluded for zeolite synthesis process using the hydrothermal method and it was based on type of zeolite produced as a function of time and by following the growth trend as observed in scanning electron microscopy images. Similarly, Molina and Poole, 2004,