Preparation of Nano Hydroxy Sodalite Zeolite and its Characterizations

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Abstract— Nanoparticles, a unique subset of the broad field of nanotechnology, include any type of particle with at least one dimension of less than 100 nanometers. Nanoparticles play an important role in a wide variety of fields including advanced materials, pharmaceuticals, and environmental detection and monitoring. In this study, Nano Hydroxy Sodalite (NHS) zeolite was synthesized via hydrothermal method. The synthesized Nano Hydroxy Sodalite (NHS) was characterized by using X-ray powder diffraction (XRD) and Fourier Transform Infra-Red (FTIR) spectroscopy.

Key words: Nanoparticles, Nano Hydroxy Sodalite

I. INTRODUCTION

Nanotechnology literally means any technology on a nanoscale that has some applications in the real world. Nanotechnology deals with the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the integration of the resulting nanostructures into larger systems. The definition of a nanoparticle is an aggregate of atoms bonded together with a radius between 1 and 100 nm. These range of nanoparticles show enhanced physical, chemical, mechanical, biological, thermal properties. Due to change of its properties in nanoscale, it is used in several applications. Zeolite nanocrystals have excellent potential in adsorption, catalysis and separation processes to design thin films, membranes, and nanoscale devices largely used in industry and our everyday life.

Nano zeolites have crystal structures with uniform and molecular size channels [1]. They are used as catalysts, adsorbents and ion exchangers that are useful in refineries. Due to their uniform pore sizes, they have large internal surface area and active sites with high thermal resistance and high mechanical strength [2–9]. The framework and shape of the zeolite particles dictate the properties of zeolites crystals and hence play a crucial role in the mode and efficiency of their applications. More recently, many efforts have been focused on some factors to control the particulate properties and crystallization pathway of the final products. The results showed that chemical composition and reaction are the most important factors for influencing the zeolite particulate properties.

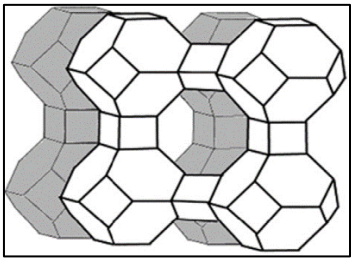


Fig. 1: Structure of Nano Hydroxy Sodalite Zeolite

The framework structure of Nano Hydroxy-sodalite is sodalite and consists of the cubic array of b-cages. Nano Hydroxy-sodalite has a six-membered ring aperture with a pore size of 2.8A ˚. The pore size of nano hydroxy sodalite is smaller than that of the zeolites with an eight membered ring aperture, e.g., NaA zeolite. Nano hydroxy sodalite zeolite incorporated in polymer for many separation applications. [10-14]

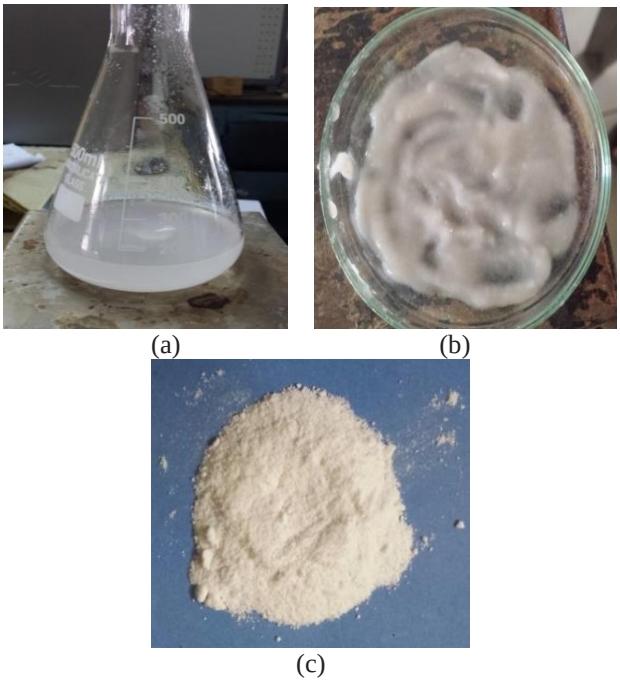
II. EXPERIMENTAL METHODS

A. Materials

Sodium Aluminate (Al-E Merck, 99%), Sodium Hydroxide Pellets (NaOH - BDH, 97.5%), Sodium Metasilicate (Na_2O_3Si - Loba, 99%) by Sigma Aldrich Pvt. Ltd, Bangalore, India. and double distilled water from the departmental laboratory.

B. Synthesis of Nano hydroxy sodalite zeolite

In order to prepare the Nano Hydroxy Sodalite (NHS), the synthesis solution was prepared by mixing aluminate solution and a silicate solution. The Aluminate solution was prepared by mixing the NaOH (4.12g), Sodium aluminate (0.22g) and double distilled water (23.53g) in a flask. The Silicate solution was prepared by mixing the NaOH (5.59g), double distilled water (23.53g) and Sodium Metasilicate (1.66g) in another flask. The aluminate solution was slowly added to the Silicate Solution under stirring at 90ºC for 4 hrs. In order to produce a clear homogeneous solution the molar ratio of this mixture solution was 5 SiO_2: Al_2O_3: 50 NaO_2: 1000H_2O. This solution was placed in an autoclave, maintained at 120^{0}C and 16 PSI for 20 minutes. After crystallization the powder was washed with double distilled water until the pH value of the wash was neutral. Then the powder was dried in air at room temperature 24 hrs. Finally, Nano hydroxy sodalite zeolite was obtained.



(a) (b)

(c)

Fig. 2: a) Mixed solution of sodium aluminate and sodium silicate. (b) nano hydroxy sodalite zeolite in wet condition. (c) Fine powder of nano hydroxy sodalite zeolite.

III. CHARACTERIZATIONS

A. Fourier Transform Infra-Red (FTIR)

This is one of the Infrared spectroscopy techniques, with the principle "molecular vibrational resonance". Using this technique, the unique molecular vibrations, based upon the bonding structure of the functional groups, can be understood. The functional group of nanoparticles was found using FTIR spectrometer (Bruker – ALPHA Eco-ATR).

B. X-Ray Powder Diffraction (XRD)

Crystal structure, average crystal size of nanoparticles was investigated using XRD (WRD PAN Analytical "XPERT^{3}PRO" Germany).

IV. RESULTS AND DISCUSSIONS

The FTIR spectra shows (Si, Al)-O bonds at 979 cm^{-1}. It indicates the nano hydroxy sodalite zeolite having tetrahedral stretching.

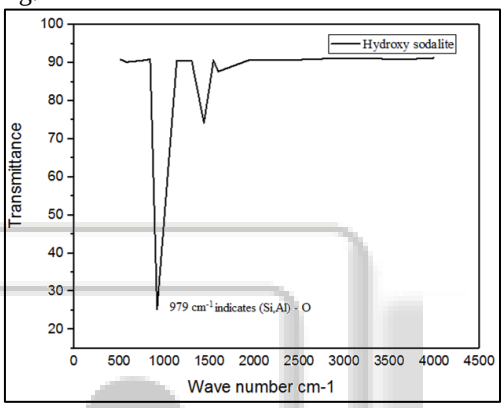


Fig. 3: FTIR spectra of Nano Hydroxy Sodalite zeolite

Using the XRD analysis, the lattice arrangement of the crystallites atoms and the size of crystals were obtained using Bragg's law and Debye-Scherrer Equation respectively. The structure of the nano hydroxy sodalite zeolite is cubic structure. The average crystallite size is 49.32nm. The two theta angles of nano hydroxy sodalite zeolite are 16.16º, 21.71º, 27.17º, 32.12º, 35.45º, 40.10º and 49.09º corresponding planes are (101), (020), (202), (302), (222) and (303) respectively.

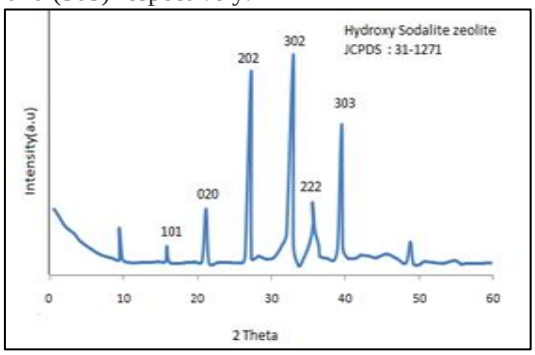


Fig. 4: XRD pattern of Nano Hydroxy Sodalite zeolite

V. CONCLUSIONS

Synthesis and characterizations of nano hydroxy sodalite zeolite was studied. The FTIR results indicated that the formation of nano hydroxy sodalite zeolite. The XRD results confirmed that the resultant nano hydroxy sodalite possessed cubic crystal structure and the average crystallite size is 49.32 nm.

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