INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Steel slag is an industrial byproduct of the steel-making process. It is created in enormous amounts during steel production using electric arc furnaces. LD-slag, also known as LD (Linz-Donawitz) converter slag, is a byproduct of steelmaking in a basic oxygen furnace. This kind of slag is typically created during the steelmaking process from iron ore. The LD-slag comprised several hazardous metallic oxides therefore, dumping such waste may cause several detrimental effects on the environment. The global output of LD-Slag is around 47 MT per year. As a result, there is a strong case to be made for making extensive use of LD-slag, either through conversion into useable material or recycling as process material. Taking all these above issues into consideration, the main objectives of this work are divided into four sections. The first section deals with wastewater treatment by different zeolites derived from LD-slag of the steel industry. The second section deals with the preparation of zeolites A and X and their physico-chemical study.

The third section deals with zeolite preparation and its utilization in nanolayered polymeric membrane fabrication for the decontamination of groundwater. And the last section deals with the CO_2 sequestration and preparation of value-added products from LD-slag.

Firstly, cubical-shaped zeolite A was produced via fusion-facilitated hydrothermal treatment using LD-slag as raw material. The Fe^{3+} adsorption studies were performed at 273, 298, 303, and 308 K, respectively, within the range of 10-40 mg/L Fe^{3+} ion concentration for kinetic and isotherm studies. A maximum adsorption capacity of 27.55 mg/g was obtained at a 1.4 g/L adsorbent dosage, with 99.99% Fe^{3+} ion removal. Isomorphic replacement of silicon by aluminum ion imparted a highly negative charge over the zeolite surface in the primary structure unit. For real- life sample drinking water, the Fe^{3+} ion removal efficiency was found to be 97.7%. The outcomes demonstrate that synthesized zeolite can be utilized as a potential adsorbent for wastewater treatment.

Secondly, zeolite A and X were prepared using the same preparation technique as discussed before. Here, the sodium-rich zeolite A and zeolite X (FAU-type) samples were synthesized from LD-slag via fusion-assisted hydrothermal treatment. The physicochemical and thermal stability of the prepared samples were examined with the help of various characterization techniques namely Fourier Transform Infrared (FTIR) Spectroscopy, X-ray diffraction (XRD), and thermogravimetric analysis (TGA) analysis at three different pH conditions and treatment time. In the methylene blue adsorption study zeolite A showed the highest removal efficiency of 98.13%, as compared to 94.47% for zeolite X, along with equilibrium sorption capacities of 25.30 and 23.57 mg/g, respectively.

Thirdly, zeolite type Y was synthesized via ultrasonic irradiation followed by a fusion-assisted hydrothermal technique. The prepared zeolite nanoparticles were coated on PSf substrate to fabricate a zeolite nanolayered membrane. An increased water flux of 28.83 L/m^{2}h and the highest fluoride rejection of 50.33% (1.47 mg/L, at permeate) was observed over the optimized synthetic membrane. Moreover, other contaminants namely chromium (Cr^{6+}) and manganese (Mn^{2+}) were removed very significantly over the modified membrane sample. The regeneration experiment was conducted by passing the HCl solution through the dead-end chamber. The flux recovery of membrane PSf/Zeolite-1wt.% was found to be 85.43%.

Fourthly, calcium oxide was converted to valuable calcium carbonate and subsequently contributes to the sequestration of carbon dioxide. Commercial-grade sugar was introduced as a promoter to enhance the conversion of CaO to $CaCO_3$. The valorization of the LD-slag process was conducted in a CO_2 atmosphere by varying the temperature over 25-55°C. The calcite phase is dominated in a temperature range of 25-55°C, whereas unstable vaterite was identified at 45°C. Further, at higher temperatures of ~55°C, the needle-like aragonite phase was found to dominate. The CO_2 sequestration efficiency in this study was found to be ~17%. It was estimated that 500 g of CO_2 could sequestrate by 1 kg of LD-slag.