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Production and evaluation of precipitated calcium carbonate from steelmaking slag

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ABSTRACT

This dissertation focus on the synergetic use of two of the essential wastes of modern steel manufacturing processes namely the steel slag (solid waste) and carbon dioxide (gaseous waste) in order to produce pure calcium carbonate which may be used for the neutralization of acidic mine waters. In this regards; calcium extraction from steel slag was first conducted using ammonium chloride and ammonium nitrate. Secondly precipitation of calcium carbonate from the calcium-rich leachate was assessed using carbon dioxide, and finally the calcium carbonate precipitated was evaluated for the neutralization of acidic mine waters from the Witwatersrand western basin. Both ammonium solutions selectively extract calcium from the steel slag, but the ammonium nitrate has better calcium extraction efficiency than ammonium chloride. The above was also confirmed by the number of extraction stages required to reach set extraction efficiency as determined using the Mc Cabe and Thiele Diagram method for the two different solvents. The carbonate (CO_3^{2-}) ions formation being stable in very basic solution, the use of ammonia was required in order to raise the pH of the solution after extraction above 10.3. The calcium carbonate precipitation yield at room temperature evolved as a function of volume and pressure of gaseous carbon dioxide (CO_2) injected and reached more than 80% at a pressure of 6.5 bar and a volume of 150 cm^3. The scanning electron microscopy analysis of the dry calcium carbonate precipitate obtained revealed that it is comprised mostly of fine particles of rhombohedral shapes. It is our view that the above approach may alleviate environmental management of industrial discharges from steel plants as it allows the reduction of both the solid steel slag and CO_2 emissions in the atmosphere via mineral sequestration and may eventually be a significant tool to help combat climate change. Finally, the recycle of the solvent after precipitation and associated losses were considered in order to reduce the cost implication of the overall project.