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Aluminium recovery from coal fly ash for sustainable alumina resource

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Coal fly ash (CFA) is a solid incombustible residue that is mainly produced during the combustion of pulverized coal in thermoelectric power stations. Eskom, the main power generator in South Africa, consumed 124.7 Mt of coal producing 36.2 Mt CFA in 2011 [1]. Only about 5% of CFA is currently recycled, mostly in the form of building materials such as bricks and as a cement extender, while the unused CFA is disposed of either in dry or slurry form in ash-handling dams which require maintenance and eventual rehabilitation. Sasol Synfuels generates an additional 4 million tons per annum.

Aluminium is typically the second most abundant element in CFA after silicon, which makes CFA a potential pre-mined substitute of bauxite for alumina production. This is of particular relevance to South Africa which has no mineable bauxite ore deposits, the raw material used to produce aluminium. The chemical extraction of aluminium from CFA has been well documented over the past 50 or so years, and the topic remains high on the R&D agenda globally [2]. It is generally performed using metallurgical methods, which can be categorized into three types of processes: (i) acid leaching; (ii) sintering; and (iii) HiChlor. All the processes have their own advantages and drawbacks. Although South Africa has been actively involved in research and development for CFA beneficiation and/or utilization, research on the recovery of aluminium from South African CFA is limited. It is also mostly restricted to acid leaching methods [3-5], which in our opinion are unlikely to be adopted at large scale. The focus of our group was to identify and test a promising aluminium extraction process that makes use of a widely available, low-cost, recyclable extracting agent. Ammonium sulphate salt (AS) meets all three criteria. An additional criterion for the selection of the extracting agent was its selectivity for the preferential extraction of aluminium over silicon, since the latter is undesirable for high-purity alumina synthesis.

The primary objective of this paper is to demonstrate the usefulness of thermochemical solid-solid treatment of a South African classified CFA with AS, coupled to aqueous dissolution, for aluminium extraction. This was achieved by investigating both the solution chemistry of the process and the physicochemical properties of formed solid products. The effects of parameters such as reaction temperature and the CFA to AS ratio were investigated.

A CFA:(NH₄)₂SO₄ of 2:6 at 500°C was the optimal condition for the extraction of aluminium from the amorphous phase of CFA when a 1h-long thermochemical treatment was used, where the selective recovery of *ca.* 95% aluminium from the amorphous phase was achieved. Significant extraction of aluminium from the mullite component appeared unlikely under the experimental conditions tested, although it could not be unambiguously demonstrated at this stage.

References:

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