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Editorial

Metallurgical Slag

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The Special Issue on "Metallurgical Slag" is a collection of 23 original articles dedicated to theoretical and experimental research works providing new insights and practical findings in the field of metallurgical slag-related topics.

The metallurgical industry is the material basis and a key industry for the development of human society. The rapid development of human society comes with the leaping development of the metallurgical industry in recent years. Metallurgical slag is a byproduct generated during high-temperature metallurgical processes, and its large quantity and complex chemistry have been a burden and barrier for industrial development. There are very strict environmental rules placed by the government in many countries to deal with these wastes. Therefore, slag treatment and recycling are critical for sustainable development and have huge economic benefits, and they have attracted extensive attention and efforts from many researchers to explore ways to recycle waste slag in the metallurgical industry, as well as potential application in other fields. The complex chemistry and variant physical properties make it difficult to find a unified method to treat all slags at once, but it also provides opportunities to specify their application in different fields.

Thus, this Special Issue mainly focuses on the advances in the utilization of metallurgical slags. The purpose of the Special Issue is to explore the new treatment and recycling methods of slags waste from ferrous metallurgy and also nonferrous metallurgy.

All the papers can be virtually divided into three groups, namely (i) "pyrometallurgy"; (ii) "hydrometallurgy"; and (iii) "electrometallurgy".

The first group of papers is mainly devoted to the development of pyrometallurgy which is a metallurgical process carried out under high temperature conditions. Gabasiane et al. [1] created a short review of environmental and socio-economic impacts of copper slag, and recycling methods were considered. The characterization and composition of copper slag were also reviewed with the aim of reusing and recycling the slag. Furthermore, the crystallization behavior of TiO_2-CaO-SiO_2-Al_2O_3-MgO pentabasic slag, the main compositions of titanium-containing blast furnace slag, within the basicity range of 1.1–1.4 was investigated theoretically and experimentally by Lei et al. [2], and thermodynamic calculation showed that perovskite was the main titanium-containing phase and titanium could be enriched in perovskite. Xu et al. [3] investigated the phase change, morphology evolution, and the mechanical properties of modified steel slag. Tian et al. [4] studied the effects of decarburization annealing time on the primary recrystallization microstructure, and the texture and the magnetic properties of the final product of 0.047% Nb low temperature grain-oriented silicon steel were investigated by means of OM, EBSD, and XRD. The feasibility of calcination of calcium sulphoaluminate cement clinker using pyrite-rich cyanide tailings as Fe_2O_3 and SO_3 sources was investigated by Dong et al. [5] and the optimal conditions for the calcination of calcium sulphoaluminate cement using pyrite-rich cyanide tailings were confirmed. In another work [6], the dissolution behavior of Al_2O_3 into molten self-propagating high-temperature synthesis (SHS) metallurgical slags was investigated by employing a rotating cylinder and static dissolution methods; it was found that both temperature and rotating speed could increase the dissolution rate, and the rate limiting step was the diffusion of alumina in the boundary layer. The work in ref [7] determined the optimal roasting conditions for oxidized pellets used in vanadium-titanium magnetite (VTM) ores smelting were as follows: calcination temperature of 1523 K and a calcination time of 20 min. Lai et al. [8] proposed a series of Ti-bearing blast furnace slag-based glass ceramics with various amounts of TiO_2, and the crystallization process and mechanical properties were analyzed as well. Pei et al. [9] investigated the use of the gas quenching process for preparing porous bead slag abrasives. Zhang et al. studied the effects of Fe [10] and sintering temperature [11] on the microstructure and mechanical properties of $Fe/FeAl_2O_4$ cermet prepared by hot press sintering. Ren et al. [12] showed Mulliken populations, energy bands and density of states of Ti-bearing blast furnace (TBBF) slag using density functional theory (DFT).

The second group of papers focuses on hydrometallurgy, which is a metallurgical process carried out in a solution and includes leaching, purification, and metal preparation. In this field, Li et al. [13] described the feasibility and rationality of a cleaner zinc recovery process using secondary zinc oxide (SZO) coming from the zinc industry in a NH_3-NH_4HCO_3-H_2O system. The ultrasonically-enhanced leaching technology for multicomponent and complex nickel containing residue was studied via systematic ultrasonic-conventional comparative experiments by Guo et al. [14] and an ultrasonic leaching kinetics model was established, which provided reliable technological guidance and basic theory of the comprehensive utilization of nickel-containing residue. Further examples of hydrometallurgy are given by Li et al. [15] who designed an electrochemical method that could be used to remove impurities in zinc leaching night and enrich zinc ferrite in the ammonia leaching residue of the solution, and that of ammonia leaching slag after ammonia leaching of zinc hypoxide. Wang et al. [16] investigated the potential of argon oxygen decarburization slag (AODS) for use as a supplementary cementitious material, and explored the mechanisms of stabilization/solidification (S/S) of chromium in cement-based composite pastes.

Last but not the least, in the final group of papers, we mainly studied the application of electrometallurgy. Li et al. [17] prepared EAF stainless steel slag (EAF slag) samples with different carbonation degrees using the slurry-phase accelerated carbonation route, and Guo et al. [18] proposed a new method for oxygen-enriched microwave roasting to improve the dechlorination process. Molten salt electrolysis is a metallurgical process that uses electrical energy to extract and purify metals. Liu et al. [19] studied the electrochemical reduction process of $ZnFe_2O_4$ in NaCl-$CaCl_2$ melts and Fe_2O_3-Al_2O_3 was electro-deoxidized in an NaCl-KCl system by molten salt electrolysis to prepare FeO/Al_2O_3 [20]. Li et al. [21] proposed a new way of preparing W-Cu functional gradient materials (FGM) with molten salt electro-deposition. Fang et al. [22] attempted to add oxalic acid and phosphate to molten salt containing lithium ions to realize a two-part precipitation method to extract lithium, and a study of square wave voltammetry and open-circuit-chronopotentiometry showed that the reaction process of $LiMn_2O_4$ reduction to manganese in NaCl-$CaCl_2$ molten salt was: Mn (IV)$\rightarrow$Mn (III)$\rightarrow$Mn (II)$\rightarrow$Mn [23].

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