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Editorial

Valuable Metal Recycling

Bong-Gyoo Cho [1], Jae-chun Lee [2] and Kyoungkeun Yoo [3,*]

1 R&D Center for Valuable Recycling, Daejeon 34132, Korea; bgcho@kigam.re.kr
2 Mineral Resources Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon 34132, Korea; jclee@kigam.re.kr
3 Department of Energy and Resources Engineering, Korea Maritime and Ocean University (KMOU), Busan 49112, Korea
* Correspondence: kyoo@kmou.ac.kr; Tel: +82-51-410-4686

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1. Introduction

As the global economy grows, demand for metal continues to increase. Unfortunately, metal resources are in limited supply. Waste-containing metals are a potential contaminant in the release of hazardous metal into the environment. Therefore, recycling processes have been developed to reclaim valuable resources from waste-containing metals as well as to reduce the amount of overall waste. Pyrometallurgical processes, such as smelter, have been applied to recover valuable metals from e-waste, but capital cost is relatively high in comparison with hydrometallurgical methods, which can be advantageous for small recycling companies. The governments of Korea and other countries have conducted research to promote the recycling industry; "Research and Development (R&D) Center for Valuable Recycling" is one of such projects, launched in Korea in 2011. These projects have focused on improving the economic efficiencies of recycling by providing solutions to technical and environmental issues intrinsic to the processes. The purpose of this Special Issue, "Valuable Metal Recycling", is to collect contributions which focus on current state-of-the-art research on metal recycling developed by the researchers who were involved in the "R&D Center for Valuable Recycling" project as well as external scholars.

2. Contributions

The reviews and research articles published in this special issue can further our understanding of the problems faced by recycling industry as well as offer ideas and solutions for such problems. The contributions we received can be classified according to two major categories: selective extraction of target metals and preparation of valuable materials from waste.

2.1. Selective Extraction of Valuable Metals from Wasts

The papers on the selective extraction of valuable metals from waste include the recycling of gold and improvements in recycling processes such as leaching, solvent extraction, physical separation, and thermal treatment.

Gold is a key precious metal for e-waste recycling because of its high price. Cyanide leaching has been commonly used for gold recovery as a result of its high selectivity; however, its use has been restricted because of its toxicity. Although thiosulfate leaching has been recognized as a viable alternative, this process also includes drawbacks, such as high consumption of thiosulfate and the difficult recovery of dissolved gold ion. Xu et al. [1] summarized four solutions to reduce thiosulfate consumption: the adjustment of reaction conditions, the utilization of additives, the in situ generation of thiosulfate, and substitution of conventional cupric-ammonia catalysis, the replacement of which is advantageous to recover gold thanks to the absence of interference from cuprous thiosulfate. They also suggested that ion-exchange resin adsorption may be beneficial for the recovery of aurothiosulphate because resins are often used in pulp or leach and can be easily regenerated. Liu et al. [2] investigated the behavior of thiosulfate consumption with pyrite and ammonium alcohol polyvinyl phosphate (AAPP). It has been found that pyrite has detrimental effects on the thiosulfate consumption but AAPP reduces this consumption. The separation and purification of gold from leach solution is also an important issue in terms of gold recovery. Aghaei et al. [3] summarized the potential use of magnetic adsorbents, such as magnetite, for selective adsorption of gold ion over other metal ions, such as Fe and Ni.

The following papers focused on the improvement of valuable metal recycling processes through enhanced process efficiency. Ilyas et al. [4] summarized methods of bio-recovery from secondary resources for strategic and energy critical metals, such as rare earth elements, precious metals, and a common nuclear fuel element; they also suggested that sustainable recycling could be achieved by means of bio-metallurgy. Reyes-Valderrama et al. [5] performed a voltammetry study for the recovery of Cu, Zn, and Ni from an e-waste leach solution to understand the behaviors of leaching and electrodeposition; they also reported selective electro-deposition with different pHs. Increasing attention has been paid to the leaching of refractory materials. Zhao et al. [6] investigated leaching kinetics of zinc from hemimorphite in an ammonium chloride solution and reported on how pregrinding may significantly enhance the leaching efficiency of Zn. Li et al. [7] developed an efficient method to recover Li and Al from coal fly ash by intensified acid leaching after predesilication. Zhou et al. [8] recovered iron and rare earth from tailings by means of water leaching following roasting processes. These studies [6–8] revealed that pretreatment is important for leaching of valuable metals from refractory materials. Kim et al. [9] reported on the preconcentration of copper from glass in automobile shredder residue by means of an electrostatic separation process. Baek et al. [10] introduced an efficient way to remove boron from photovoltaic silicon, which could be achieved by thermal plasma treatment coupled with steam and hydrogen gases.

2.2. Preparation of Valuable Materials from Waste

The preparation of valuable materials could significantly enhance the economic efficiency of recycling processes. This special issue introduced several contemporary challenges as follows.

The preparation of petroleum liquid catalyst [11], Sn-incorporated $LiNi_xCo_yMn_z$ (NCM) [12], Ni nanosized powder [13] was investigated using leach liquor of a lithium ion battery (LIB). Joo et al. [11] introduced a comprehensive recycling process, which included physical separation, leaching, solvent extraction and stripping, to prepare CMB (cobalt-manganese-bromide) and CMA (cobalt-manganese-acetate) liquid catalysts as petroleum liquid catalysts from the cathode materials of spent lithium ion batteries. Kang et al. [12] investigated the effect of Sn impurity on the LIB performance of Ni-rich NCM, resynthesized from leach liquor of spent LIB by conducting analyses such as scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) mapping, X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS). Shin et al. [13] investigated the fabrication of Ni nanosized powder from cathode active material, such as $LiNiO_2$ (LNO), as found in spent lithium ion batteries through a reduction with hydrazine monohydrate.

Li et al. [14] developed a recycling process for preparing highly pure vanadyl sulfate from iron and aluminum impurities. Vanadium and iron ions was selectively extracted by solvent extraction with 2-ethylhexyl phosphoric acid mono-2-ethylhexyl ester (EHEHPA) and tri-n-butyl phosphate (TBP) as the phase modifier; vanadium ion was selectively recovered by stripping with sulfuric acid solution. Ju et al. [15] prepared lightweight aggregates from tailings and reported that the mobility of heavy metals such as Pb and As could be reduced. The sequestration of carbon dioxide (CO_2) associated with climate change is currently a very important issue. Yoo et al. [16] proposed that the removal of Ca and the sequestration of CO_2 could be achieved simultaneously through the introduction of CO_2 gas into Ca-rich alkaline wastewater generated from concrete sludge. These processes of valuable material preparation could improve the economic efficiency of recycling processes, which would enable the practical use of developed recycling processes.

3. Closing Remarks

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Conflicts of Interest: The authors declare no conflict of interest.

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