separations

Editorial

Research on Hydrometallurgical Separation Technology

Keisuke Ohto

Department of Chemistry and Applied Chemistry, Faculty of Science and Engineering, Saga University, Saga 840-8502, Japan; ohtok@cc.saga-u.ac.jp

1. Introduction

The reservation of metallic resources has been an urgent global issue with increased demand in an advanced industry. Primary resources of metals are limited and are running dry, and secondary resources are becoming increasingly significant. However, the secondary resources consist of various elements, not only valuable metals but also hazardous elements. For the recycling of metal resources, effective separation of valuable metals and the removal of hazardous elements are required and are the focus of research for this purpose. Hydrometallurgical techniques are of importance, as well as physical sorting and pyrometallurgical techniques. Hydrometallurgical techniques, such as electrolytic refining, leaching, precipitation, solvent extraction, ion exchange, membrane separation, and floatation, have been extensively employed to recover critical metals and to remove hazardous elements.

Hydrometallurgical techniques are closely related to the Sustainable Development Goals (SDGs), which consist of 17 global goals. Some of these techniques can contribute to SDGs, such as Clean Water and Sanitation (#6), Affordable and Clean Energy (#7), Industry, Innovation and Infrastructure (#9), Sustainable Cities and Communities (#11), Life Below Water (#14), and Life on Land (#15) [1]. The topics of the Special Issue, in particular, would contribute to #9 and #11.

The Special Issue "Research on Hydrometallurgical Separation Technology" aimed to collect the latest research works with new challenges related to the design, preparation, and utilization of conventional or new separation reagents, such as precipitants, extractants, and adsorbents, and the establishment of new processes for the efficient separation of metal resources.

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Citation: Ohto, K. Research on Hydrometallurgical Separation Technology. *Separations* **2022**, *9*, 299. https://doi.org/10.3390/separations9100299

Received: 21 September 2022
Accepted: 3 October 2022
Published: 9 October 2022

2. Summary of Published Articles

This Special Issue included five research articles that cover new challenges for new use as a precipitant for Pt(IV) [2], as new extraction reagents for Pt(IV) [3] and aluminum group metals [4], as a new concept for the recovery of critical metals using a microreactor system [5], and the recovery of microalgae as a new separating reagent [6].

Platinum group metals (PGMs) are, without a doubt, one of the most critical metals. Despite that, there are difficulties in separating and recovering each PGM over other PGMs owing to similar chemical properties and inert properties for extraction and adsorption. Recently, precipitation-based selective PGM recovery methods have been developed by Matsumoto et al. using very simple primary amines as precipitants in metal-containing hydrochloric acid (HCl) solutions. They reported Rh(III) selective precipitation by using 4-alkylanilines [7]. They reported Pt(IV) selective precipitation over Pd(II) and Rh(III) as well as other base metals, Al(III), Cu(II), Fe(III), and Zn(II), by using simple 2-ethylhexylamine [2].

Another approach to selectively recover Pt(IV) using simple extraction reagents was reported by Ueda et al. [3]. Different from separating reagents for cationic species, those for anionic species are limited owing to only a few effective and positively charged groups, such as quaternary ammonium, protonated tertiary amino, protonated carbonyl, and phosphoryl groups. In this sense, a new proposal using ∂^+ nature of N-H hydrogen atoms as the new functional group for anionic species is of significance. They compared four compounds with or without N-H hydrogen atoms of secondary and tertiary amides and urea and found that tertiary amide did not work for the extraction of anionic Pt(IV) at lower HCl. This meant that ∂^+ nature of N-H hydrogen atoms of secondary amides and urea are effective for extraction of anionic species of metals. Other articles supporting this result also reported on the extraction of anionic species of metals, Ga(III) [8] and Pt(IV) [9] in HCl media.

The concept of molecular design and preparation as extraction reagents and adsorbents using macrocycles, calixarenes, and as tailor-made reagents were described [10]. This framework provides multidentate property for high coordinating ability, together with rigidity for high separation efficiency. When the structural effect caused by the framework is synergized with the effect of introduced functional groups to a target metal ion, improved coordinating and separation abilities can be observed. For such purpose, the same three acetic acid derivatives using three frameworks as macrocycles, trimethylols, and trihydroxytriphenylmethane with different sizes of coordination sites were introduced to compare amongst each other the extraction ability of trivalent aluminum group metals with different ionic sizes and to compare their monomeric and monopodal derivatives [4]. Allosteric extraction using trihydroxytriphenylmethane derivative was newly observed.

Biomaterials such as microalgae have been employed as biosorbents [11]. For a large recovery of microalgae by plankton net instead of by culture, effective separation of target microalga is required. A unique separation technique of various microalgae with different sizes and shapes was reported by Kawakita et al. [6]. Magnetite-containing gel was packed in a column for selective filtration and recovery of filtered microalgae by a magnetic field. This research itself includes a separation technique, but it is also useful as a preparation of biosorbents for metal separation and recovery.

3. Conclusions

Five articles published in this Special Issue presented new challenges to utilize, design, and prepare conventional or new separation reagents, such as precipitants and extraction reagents, to establish new processes for the efficient separation of metal resources and to recover biomaterial as biosorbents for critical metals by using a new separation technique. The Special Issue, including well-described and new concept-featured articles, would offer a significant contribution to the reservation of metallic resources.

Funding: This research received no external funding.

Acknowledgments: A.M.-E. Thanks to all the authors for their excellent contributions. The efforts of the reviewers are acknowledged as great contributions to the quality of this Special Issue.

Conflicts of Interest: The author declares no conflict of interest.

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