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Research Internship in the Group of Professor Nanba
Location: Okayama University, Japan
Term: April 29, 2022 – September 14, 2022

TAKENOKO Research

Innovative chemical waste processing for high recovery of Ti, P, Si as building elements for industry

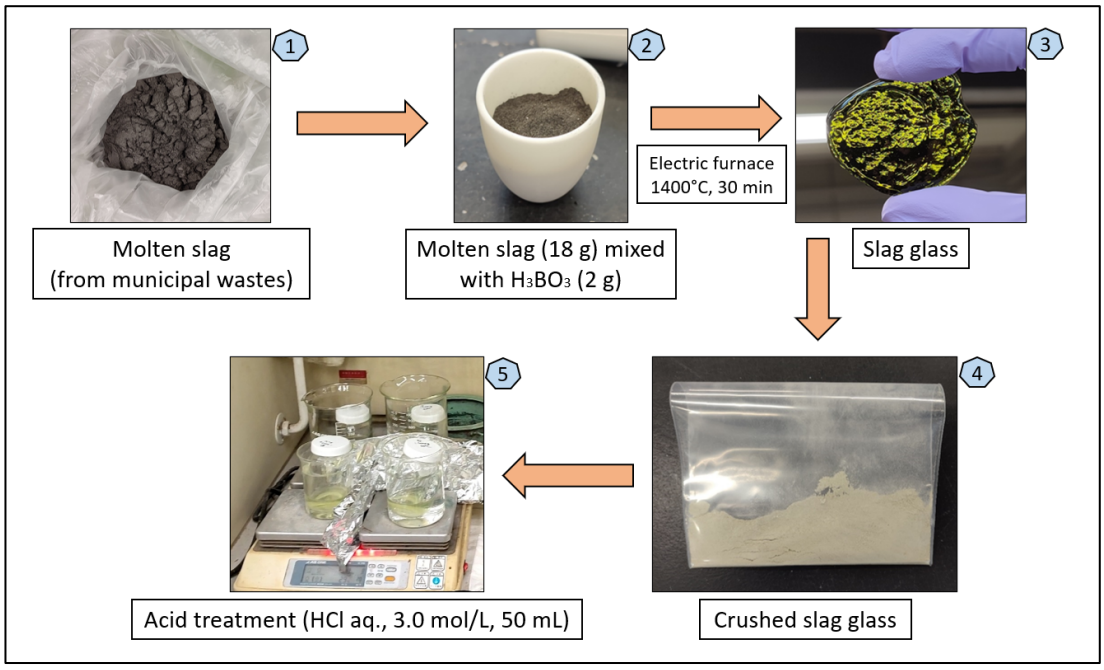
Research background

In Japan, municipal wastes are generally incinerated at temperatures higher than 1300°C. The residues are turned into molten slags. Previous studies [1] [2] showed that chemical composition of the slags is similar to commercial glasses, as for example, bottles and windows. The major constituents of slags are SiO_2, CaO, and Al_2O_3, and minor ones are P_2O_5 and TiO_2.

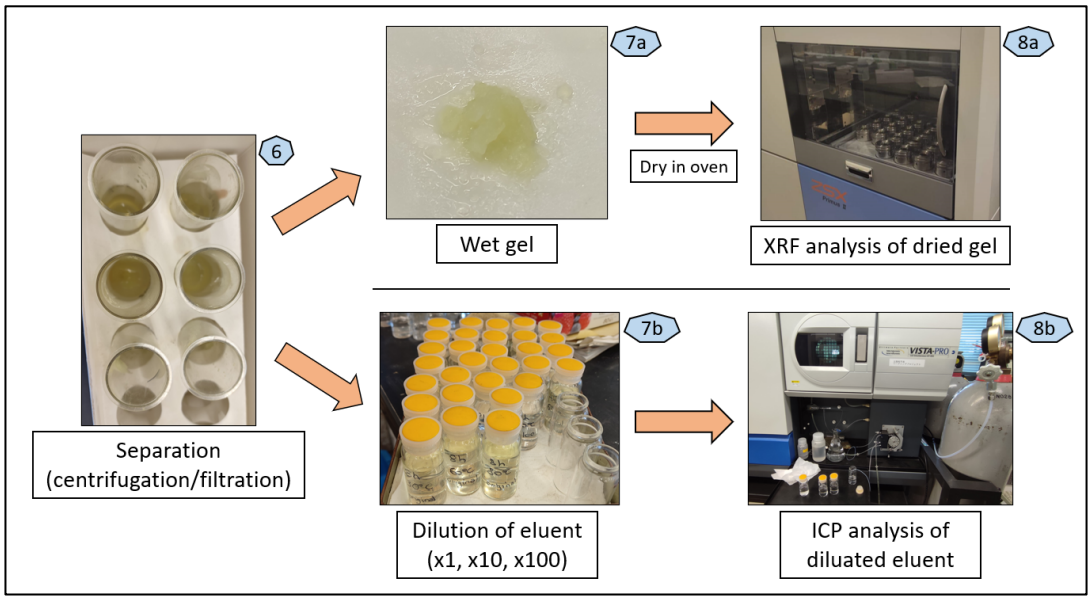
SiO_2 is used as a raw material of commercial glasses. As Japan is sharply dependent on phosphorus and titanium imports, it is crucial to considerably improve the waste processing of these highly valuable elements.

Recycling process

For the recovery, slags are first melted with H_3BO_3, to obtain homogeneous glass. The slag glass is crushed and treated with hydrochloric acid, obtaining silica-rich solids. At this time, B_2O_3, CaO, and Al_2O_3 as well as coloring components such as Fe_2O_3 and S are almost completely dissolved in the acid solution, and hence the recovered solids are colorless and transparent.



After acid treatment, the solid precipitates are separated from liquid with centrifugation or filtration. Chemical composition is determined by ICP (inductively coupled plasma) of eluent and by XRF (X-ray fluorescence) of dried precipitates. Finally, distribution rates of phases are determined.



My internship activities and main outcomes

My job in the project is to improve the reproducibility and the recovery efficiency by understanding the dissolution-reprecipitation mechanism, to confirm previous studies results and to improve them if possible. For that, it is needed to investigate the steps of the process.

In the slag glass preparation process (Steps 1 - 4), TG-DTA (thermal gravimetry and differential thermal analysis) are performed to evaluate the amount of adsorbed water and carbonates in the specimens.

In the acid treatment process (Step 5), conditions such as duration, temperature, and acid concentration are changed to understand the influence of these parameters on the recovery rates. In the separation process (Step 6), centrifugation and filtration methods are used to compare the separation efficiency.

Main outcomes:

a - water absorbed by slags is negligible and may have no influence on results.

b - temperature control at a low temperature (40°C) is needed to improve reproducibility, since ORP, pH and composition results seem stable.

c - Finally, high temperature and high duration results are hard to explain, and additional experiments are needed to fully understand the phenomena.

The waste recycling project is exciting because it is important in terms of resource recovery. In addition, it is quite innovative, and studying the distribution behavior of slag constituents by using many analysis techniques is very enriching on a practical training point de view.

Acknowledgement

I would like to thank the Nanba & Benino group for welcoming me and for their kind and very professional supervising of my research activities. Mr. Kazuaki Ueta's technical assistance was also specifically appreciated.

References

[1] Tokuro Nanba, Yutaro Kuroda, Shinichi Sakida and Yasuhiko Benino (2009), Chemical recycling of municipal waste slag by using phase separation, Journal of the Ceramic Society of Japan 117 [11] 1195-1198 2009

[2] Kohei Omura, Shinichi Sakida, Yasuhiko Benino & Tokuro Nanba (2013) Distribution behavior of inorganic constituents in chemical recycling processes of a municipal waste slag, Journal of Asian Ceramic Societies, 1:1, 108-113, DOI: 10.1016/j.jascer.2013.03.003

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