

Chemical state analysis during a novel phosphorus recovery process

Hiroto Takatani¹, Shiho Fujimura², Kei Mitsuhashi¹, Masaru Takizawa¹,
and Eiji Yamasue²

1) Department of Physical Sciences, Faculty of Science and Engineering, Ritsumeikan University, 1-1-1 Noji-Higashi, Kusatsu, 525-8577, Japan

2) Department of Mechanical Engineering, Faculty of Science and Engineering, Ritsumeikan University, 1-1-1 Noji-Higashi, Kusatsu, 525-8577, Japan

Phosphorus (P) has many ways to use such as fertilizer and medicine. To obtain phosphorus, the process for phosphorus refinery from natural ores with carbon and silica at high temperature has been adopted. However, the depletion of phosphorus ore is a major worldwide concern. Moreover, CO₂ is emitted in this process [1]. To overcome these problems, a novel phosphorus recovery process using steelmaking slag and silicon (Si) sludge has been proposed [2]. This process does not generate CO or CO₂. In this study, we have analyzed the chemical states during this novel process by X-ray absorption fine structure (XAFS) measurements.

Calcium Phosphate (CAP) and Si powders, which are the main components of phosphorus ore and Si sludge, were utilized in the phosphorus recovery process. These powders were grinded by a ball milling, and the milled powders were heated at 1000 °C for 30 min in an electric furnace. Si and P *K*-edge XAFS spectra were measured at beamline 13 of SR center, Ritsumeikan University.

P *K*-edge XAFS spectra showed phosphate structure (P⁵⁺) during this process because only the remaining CAP contributes to the XAFS spectra. Si *K*-edge XAFS spectra changed significantly after the heating; metallic and oxide components were observed before the heating, while the prominent oxide components were observed after the heating [Fig. 1(a)]. Comparing with the reference spectra (CaSiO₃ and SiO₂), this oxide component is composed of CaSiO₃ and SiO₂. During the P recovery process, CAP and Si are considered to react to form CaSiO₃. In order to evaluate the amount of newly formed CaSiO₃, Si *K*-edge XAFS spectra are decomposed with three reference spectra (Si, CaSiO₃, and SiO₂), as shown in Fig. 1(b). Figure 2 shows thus obtained each component ratio of the samples. With increasing the milling time, the amount of the newly formed CaSiO₃ decreases. Although the milling process partially substitutes P in CAP with Si, a long-time milling process would make Si to be oxidized (SiO₂) and prevent the formation of CaSiO₃ after the heating.

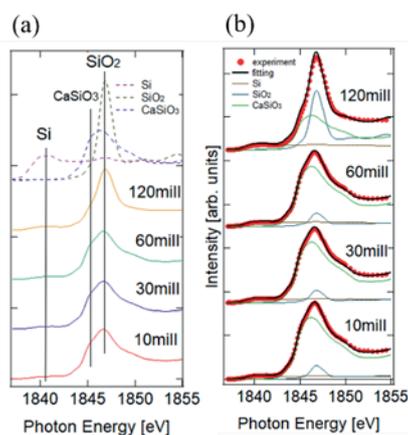


Fig. 1 Si *K*-edge XAFS spectra of the milled and heated samples with the references (a) and the decomposed Si *K*-edge spectra (b). The milling time was varied from 10 to 120 minutes (10mill, 30mill, 60mill, and 120mill).

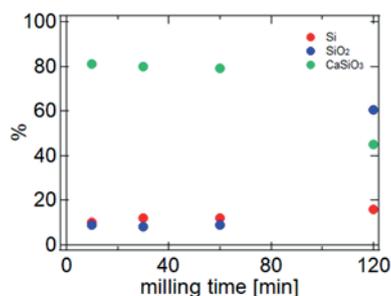


Fig. 2 Milling time dependence of each component ratio of the milled and heated samples.

References

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