

Inhibition of calcium silicate hydrate formation by lignosulfonate and lignin

*Kanao Toda¹, Tsubasa Otake¹, Tsutomu Sato¹

1. Laboratory of Environmental Geology, Faculty of Engineering, Hokkaido University

Dams and harbors have frequently dredged in order to secure the water storage capacity and shipping routes. Dredged soils are mostly treated as waste, though utilization of dredged soils for construction resources are economically and environmentally desired. Only a part of the dredged soils has been used for construction materials after mixing with steel slags due to their low physical strength. Mixture's strength development has been known to depend on utilized dredged soil. However, even under the same mixing conditions, some combinations may not be hardened. Soil composition is generally complex as it reflects the result of mineral-water-organic matter-microbe interactions occurred onto components from diverse origin. In solidification of the dredged soils to form construction materials, alkaline activators, steels slags in this case, are added, which triggers the formation of secondary phases such as calcium silicate hydrate (C-S-H). Factors affecting C-S-H formation have been reported previously (e.g., Tremblay et al., 2002; Zhu et al., 2007; Toda et al., 2018). However, inhibition mechanism of authentic organic matter in the soils and the quantitative effects of their functional groups on C-S-H formation are not fully understood.

In this context, the effects of 1) lignosulfonate and 2) lignin that contain carboxylic, sulfonic and thiol functional groups that have similar structures to soil organic matter and 3) simple organic molecule with one of carboxylic, sulfonic and thiol functional groups on C-S-H formation were investigated in this study. C-S-H was synthesized from $\text{Ca}(\text{OH})_2$ and amorphous silica in coexistence of multiple addition ratio of lignosulfonate and lignin to expecting amount of C-S-H formed, in 100 rpm shaker at 50°C for 10 days. After the syntheses, C-S-H were characterized by X-ray diffraction and FT-IR analysis, and chemical composition of the remaining solutions were analyzed by ICP-AES and TOC analyzer. After syntheses, solution pH were all above 12. The threshold quantity of lignosulfonate and lignin was evaluated to suppress the formation of C-S-H. Above the threshold, XRD peaks assigned to $\text{Ca}(\text{OH})_2$ and amorphous silica could still be obtained after synthesis, without C-S-H peaks. Furthermore, below the threshold, the broad diffraction peak assigned to (001) reflection of C-S-H decreased with increasing the added amount of lignosulfonate and lignin. This suggests that lignosulfonate and lignin may suppress the dissolution of initial phases but also C-S-H crystal growth. Both of the indicated inhibition factors could occur due to the surface coverage by negatively charged functional groups in the organic matter under alkaline condition, which may be interacting with positively charged sites such as $\text{Ca}(\text{OH})_2$ surface and CaO layer in C-S-H. C-S-H synthesis with simple organic molecule with various functional groups were also conducted to further discuss how the difference in soil organic matter structure in terms of functional group can inhibit C-S-H formation.

Keywords: dredged soils, soil organic matter, C-S-H, construction materials