Transformation mechanism of brucite to saponite in hydrothermal conditions

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Saponite, with a formula as $M_{x+}[Mg_3][Si_{4-x}Al_x]O_{10}(OH)_2 \cdot nH_2O$ (M=Na, Li *etc.*), is a trioctahedral phyllosilicate of the smectite group of clay minerals. Its layer contained a central brucite-like $[Mg_3(O,OH)_6]$ octahedral sheet, which is sandwiched by two reverse $[Si(O,OH)_4]$ tetrahedral sheets (2:1 type) on both sides. Four out of six octahedral OH- are replaced by O and shared with the tetrahedral sheets. Saponite holds much higher surface acidity and thermal stability than its dioctahedral smectite group counterpart, montmorillonite. Compared with homogeneous synthesis technology, heterogeneous synthesis can promote the nucleation and subsequently accelerate the growth of secondary minerals by providing a local environment with super-saturation of ion concentration and a relatively lower energy barrier.

Using brucite as a Mg source, series of samples with a fixed Mg/(Si+Al) ratio (3/4) were synthesized by altering Si/Al ratio, reaction temperature and time. Characteristic reflections of phyllosilicates were recorded in XRD patterns of the products with $d_{(001)}$ values of 1.30–1.41 nm and $d_{(060)} \geqslant 0.153$ nm, indicating a successful synthesis of saponite. The well-crystallized saponite was obtained in the initial Si/Al ratio range of 5.43–7.89, and their crystallinity was increased with the increase of reaction temperature. Samples with higher crystallinity are usually found with higher Al^{IV}/Al^{VI} ratio. For the sample synthesized at 160ºC, brucite and analcime existed as impurity phases, resulting from the low dissolution ability of brucite and the excess of Si^{4+} and Al^{3+} in the solution. Both of them disappeared with the extension of reaction time. For the sample synthesized at 300ºC, a small amount of chrysotile formed, corresponding to the rapid release and the excess of Mg^{2+}.