Supporting Information

Nucleation-dependant Chemical Bonding Paradigm: Effect of Rare Earth Ions on the Nucleation of Urea in Aqueous Solution

Xiaoyan Chen, a,b Congting Sun, a Sixin Wu, *,b and Dongfeng Xue*, a

a State Key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, China

b The Key Laboratory for Special Functional Materials of MOE, Henan University, Kaifeng, Henan 475004, China

*Corresponding author. E-mail: dongfeng@ciac.ac.cn
Figure S1. Time-dependent ATR-IR spectra of urea crystallization process at 20 °C. The time interval is 30 s, and the concentration of urea is 6.66 mol/L.
Figure S2. Time-dependent IR spectra of urea crystallization process in urea+LaCl₃ aqueous solution. The time interval is 30 s, and the concentration of LaCl₃ is 0.077 mol/L.
Figure S3. Time-dependent IR spectra of urea crystallization process in urea+GdCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of GdCl$_3$ is 0.077 mol/L.
**Figure S4.** Time-dependent IR spectra of urea crystallization process in urea+LuCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of LuCl$_3$ is 0.077 mol/L.
Figure S5. Time-dependent IR spectra of urea crystallization process in urea+LaCl₃ aqueous solution. The time interval is 30 s, and the concentration of LaCl₃ is 0.155 mol/L.
Figure S6. Time-dependent IR spectra of urea crystallization process in urea+GdCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of GdCl$_3$ is 0.155 mol/L.
Figure S7. Time-dependent IR spectra of urea crystallization process in urea+LuCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of LuCl$_3$ is 0.155 mol/L.
**Figure S8.** Time-dependent IR spectra of urea crystallization process in urea+LaCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of LaCl$_3$ is 0.310 mol/L.
Figure S9. Time-dependent IR spectra of urea crystallization process in urea+GdCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of GdCl$_3$ is 0.310 mol/L.
Figure S10. Time-dependent IR spectra of urea crystallization process in urea+LuCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of LuCl$_3$ is 0.310 mol/L.
Figure S11. Time-dependent IR spectra of urea crystallization process in urea+LaCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of LaCl$_3$ is 0.615 mol/L.
**Figure S12.** Time-dependent IR spectra of urea crystallization process in urea+GdCl$_3$ aqueous solution. The time interval is 30 s, and the concentration of GdCl$_3$ is 0.615 mol/L.
Figure S13. Time-dependent IR spectra of urea crystallization process in urea+LuCl₃ aqueous solution. The time interval is 30 s, and the concentration of LuCl₃ is 0.615 mol/L.
Figure S14. Raman spectra of NCN stretching vibrations in crystalline urea from urea/LnCl$_3$ aqueous solutions, and concentration of LnCl$_3$ are 0.077 mol/L (A) and 0.615 mol/L (B).