

## Kinetic and Thermodynamics Studies of Cadmium Adsorption Behavior on Montmorillonite

XIAPING ZHU<sup>1\*</sup> HUI LIU<sup>2</sup> NIANNIAN XIANG<sup>3</sup> YINGFENG TIAN<sup>4</sup>

<sup>1,2,3,4</sup>Institute of Material and Chemistry & Chemical Engineering, Mineral Resources Chemistry Key Laboratory of Sichuan Higher Education Institutions, Chengdu University of Technology, Chengdu, China

<sup>1</sup>zhuxiaping@cdu.edu.cn (\* presenting author)

<sup>2</sup> 271212495@qq.com

<sup>3</sup> 841945777@qq.com

<sup>4</sup> 742911585 @qq.com

Montmorillonite is the most important clay minerals in soils. It has good cation exchange and adsorption capacity. Montmorillonite was a major factor for cadmium retention in soils due to electrostatic attraction, ion exchange, complexation, and precipitation<sup>[1]</sup>. The sample was collected from Sihui, Guangdong, China. Its physical and chemical properties had been measured, meanwhile, infrared spectroscopy, X-diffraction analysis, and simultaneous thermal analysis had been conducted, then cadmium adsorption behavior on montmorillonite had been studied. The cadmium adsorption on montmorillonite was fit to Langmuir model and Freundlich model, the latter was better. Adsorption of cadmium on montmorillonite was severely affected by ionic strength, the saturated adsorption capacity of cadmium calculated by the Langmuir model had a good negative correlation to ionic strength, the correlation coefficient was 0.9987. The adsorption index ( $1/n$ ) concluded by the Freundlich models were smaller, indicating that the montmorillonite was prone to adsorbing  $Cd^{2+}$ . The adsorption volume of cadmium on montmorillonite exhibited a process of rise-fall-rise-balance with the time delay at different temperature. The adsorption of cadmium on montmorillonite met the Lagergren second-order kinetic equation well, the correlation coefficients were 0.9999, 1, 0.9999 at 303, 313, 323 K, respectively. The false thermodynamic parameters were calculated through adsorption kinetics data of cadmium at the different temperature<sup>[2]</sup>, the adsorption enthalpy ( $\Delta H$ ) was 23.31 kJ/mol, it showed that the adsorption process was an endothermic process, and it was the physical adsorption, the free energy of adsorption ( $\Delta G$ ) at different temperature were less than zero, indicating that the adsorption was spontaneous. The absolute value of  $\Delta G$  increased and the driving force became larger with the temperature increase, the temperature was benefit to the adsorption. The entropy ( $\Delta S$ ) was greater than zero, the degree of disorder increased after Cd adsorbed to the montmorillonite. Cadmium replaced the more lively metal ions (Ca, Na, Mg, etc.) or the hydrogen ion in the interbedded area of montmorillonite, 1 mol of cadmium ion could exchange 2 mol of hydrogen or sodium ion, which induced the entropy increase more than the entropy decrease caused by ion adsorption<sup>[3]</sup>. The results reported in the present study will benefit environmental contamination applications concerning cadmium mobility, cadmium transformation, and other possible applications in various fields (e.g. soil decontamination, agriculture irrigation and water treatment).

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## Filamentous microorganisms interacting with sheet silicates

W. ZIDAN<sup>1\*</sup>, S. NIETZSCHE<sup>2</sup>, C. FISCHER<sup>3</sup>,  
E. KOTHE<sup>4</sup>, R. GAUPP<sup>1</sup>

<sup>1</sup>Institute of Geosciences, Jena, Germany, [wafaa.zidan@uni-jena.de](mailto:wafaa.zidan@uni-jena.de) (\* presenting author), [reinhard.gaupp@uni-jena.de](mailto:reinhard.gaupp@uni-jena.de)

<sup>2</sup>Center for Electron Microscopy, University Hospital Jena, Germany, [sandor.nietzsche@uni-jena.de](mailto:sandor.nietzsche@uni-jena.de)

<sup>3</sup>Georg-August-Universität Göttingen, Göttingen, Germany, [cornelius.fischer@geo.uni-goettingen.de](mailto:cornelius.fischer@geo.uni-goettingen.de)

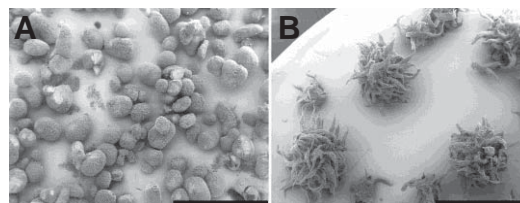
<sup>4</sup>Institute of Phytopathology, Jena, Germany, [erika.kothe@uni-jena.de](mailto:erika.kothe@uni-jena.de)

### Aim of the work

The goal of our work is to study the effect of two filamentous microorganisms (the fungus *Schizophyllum commune* and the actinobacterium *Streptomyces acidescabies E13*) on mineral dissolution and surface alteration when incubated with three different sheet silicates; the nontronites (Nau1, Nau2) and ripidolite (clinochlore). Incubation without iron added to the minimal media was performed in order to induce mineral dissolution by microorganisms for nutrient acquisition.

### Results and conclusion

While the actinobacterium *S. acidescabies E13* has formed microbial pellets with the three sheet silicates, the fungus *S. commune* hasn't formed any microbial pellets with any of the sheet silicates. The Streptomycete's pellets formed with nontronite were regular, round (Fig. 1A) and there were not too many mineral flakes left as they were dissolved to a large extent, but the hyphae were encrusted. Streptomycete's pellets formed with ripidolite, in contrast to nontronite were irregular (Fig. 1B), many mineral flakes were preserved and the hyphae were smooth. Our interpretation is that the higher Fe concentration of nontronite is responsible for this contrasting behavior in terms of pellet's shape and hyphae's encrustation.



**Figure 1:** SEM images of Streptomycete's pellets with nontronite (A) and with ripidolite (B). Scale bar: 2 mm.

Furthermore, the *S. acidescabies E13* had decreased the pH from 6 to 4, and once again increased to pH 7 in case of interacting with clinochlore, while with nontronite the pH decreased and stayed constant at pH 4. This suggests that acidification might be a mechanism for mineral dissolution by the actinobacterium. However, this is not the case for the fungus *S. commune*, where the pH stayed neutral. The fungus excreted more protein when interacting with Nau2 as compared to Nau1 and clinochlore. Incubation of *S. commune* with polished clinochlore samples caused an evolution of deep pits upon interaction as shown by vertical scanning interferometry (VSI). Data were used to analyze reaction kinetics as a function of crystallographic orientation. Our experiments showed different sheet silicate dissolution by filamentous bacterial and fungal microorganisms.