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Co-Adsorption of Cd(II) and Phosphate on Hydroxyl-Aluminum (Al_{13}) Montmorillonites

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Introduction

Heavy metal cations and phosphate pollution

Heavy metal pollution

Lake Eutrophication

- **Inorganic ions**
- **Non-degradable**

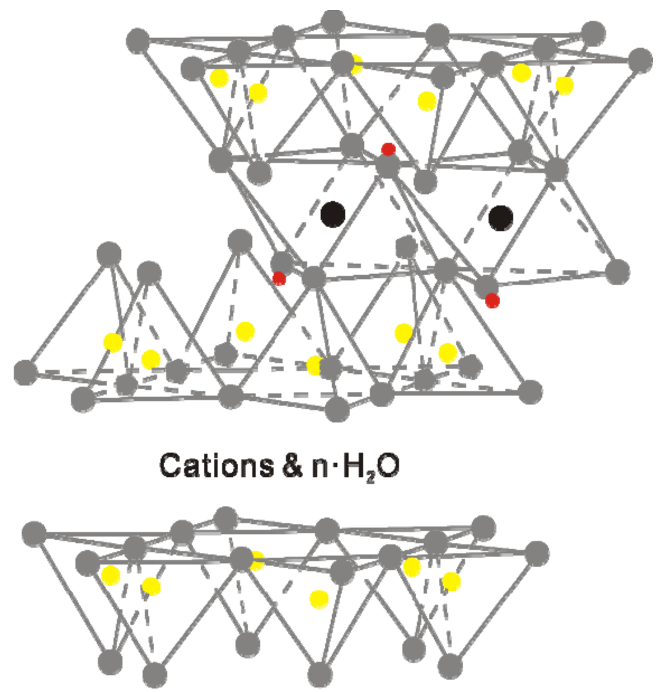
→ **Adsorption**

Clay mineral based adsorbent

- ✓ Cheap
- ✓ Environmental friendly

Montmorillonite

- **High cation exchange capacity**
- **High specific surface area**
- **Hydrophility and swelling**
- **Structure and properties can be modified**



Structure of Montmorillonite

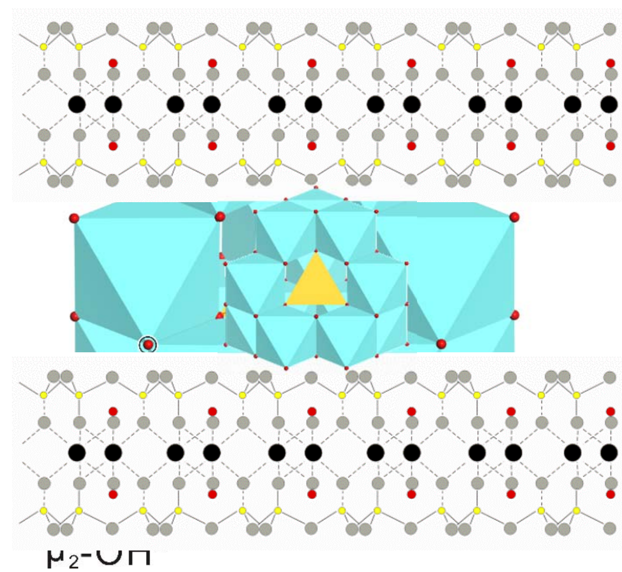
(Grim, 1968)

Hydroxyl-metal pillared montmorillonite

- **Hydrolysis of metal (Al, Fe, La, etc)**
- **Cation exchange with original cations of Mt**

Al_{13} cation

- **High reactive surface hydroxyl group**
- **High specific surface area**
- **Strong affinity for both heavy metal cation and oxyanion (Schlegel, 2007; Yan et al., 2010)**



Al_{13} cation (Keggin structure) (Casey, 2006)

the simultaneous adsorption of both contaminants

Simultaneous adsorption of heavy metal cations and oxyanions

- **Decrease**

  formation of non-adsorbing cation-anion complex (Benjamin and Leckle, 1982)

  competition for the same adsorption site (Li et al., 2013;)

- **Increase (synergistic adsorption)**

  formation of ternary surface complex (Li et al., 2013; Elzinga and Kretzschmar, 2013)

  surface precipitation (Talor et al., 2009)

Hydroxyiron-Montmorillonite complex

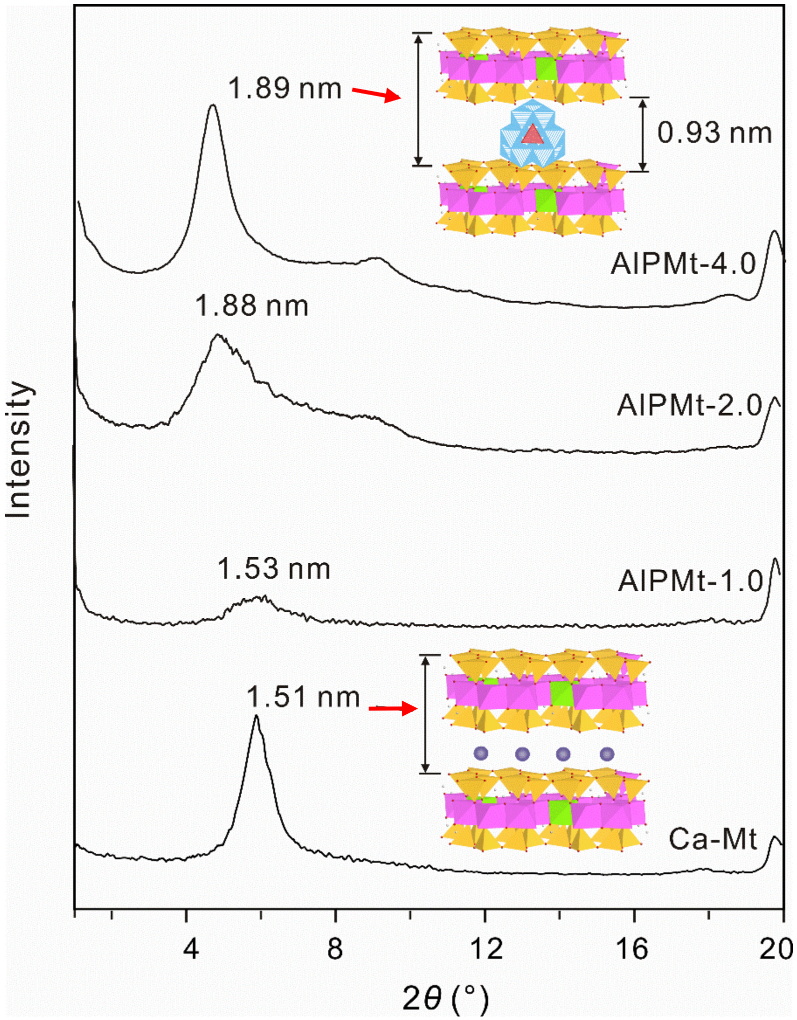
Phosphate and Cd formed P-bridged ternary complexes (Zhu et al., 2014)

Al_{13} pillared montmrillonite?

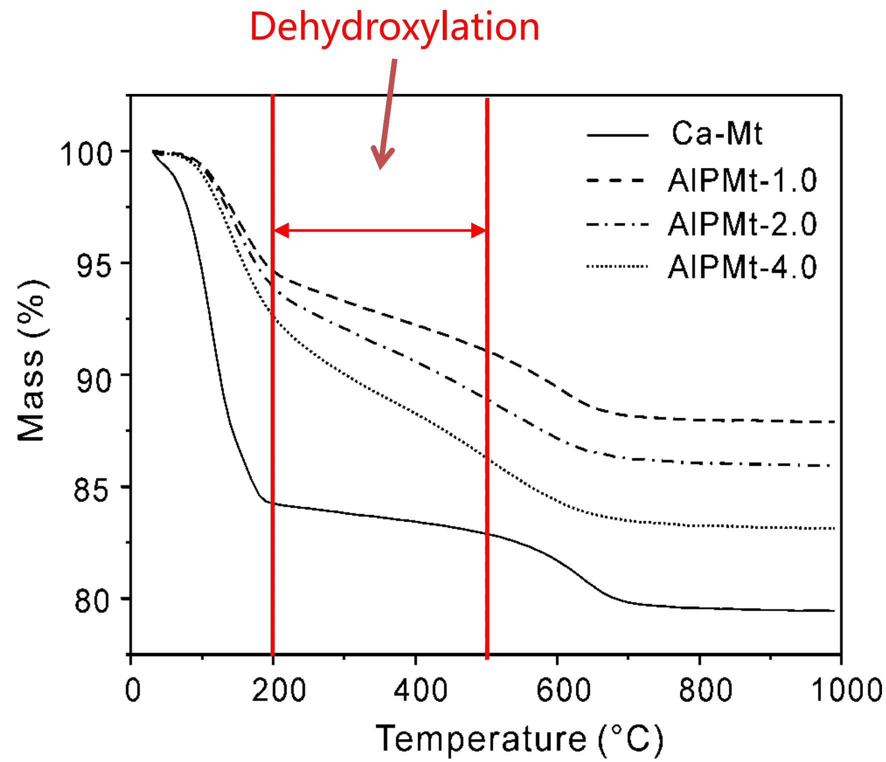
Simultaneous adsorption of phosphate and Cd^{2+} on AlPMT

- **Effect of the structure and property**
- **Effect of the co-exist contaminant**

Structure of Al_{13}-montmorillonite



XRD patterns



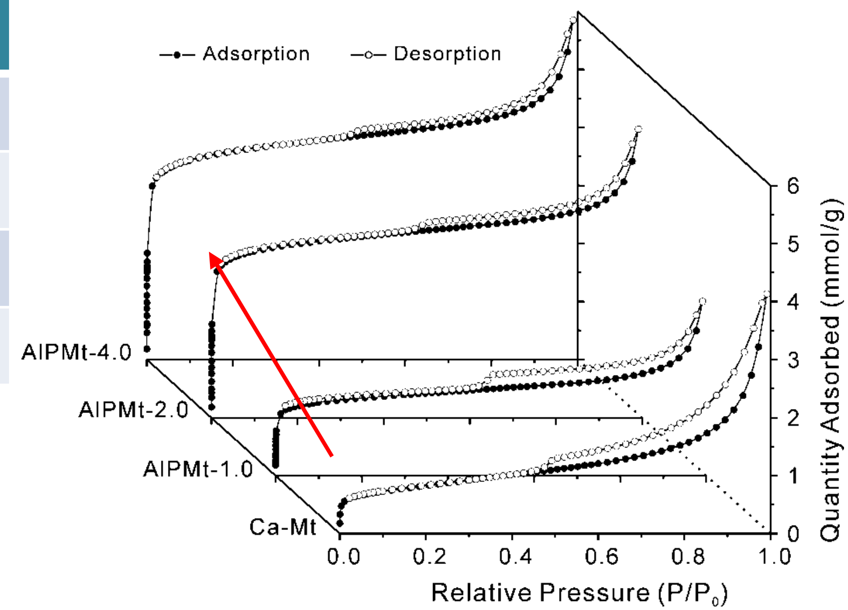
TG curve

- **Basal spacing**
- **Al_{13} loaded**

Specific Surface Area

Al_{13} contents and specific surface area

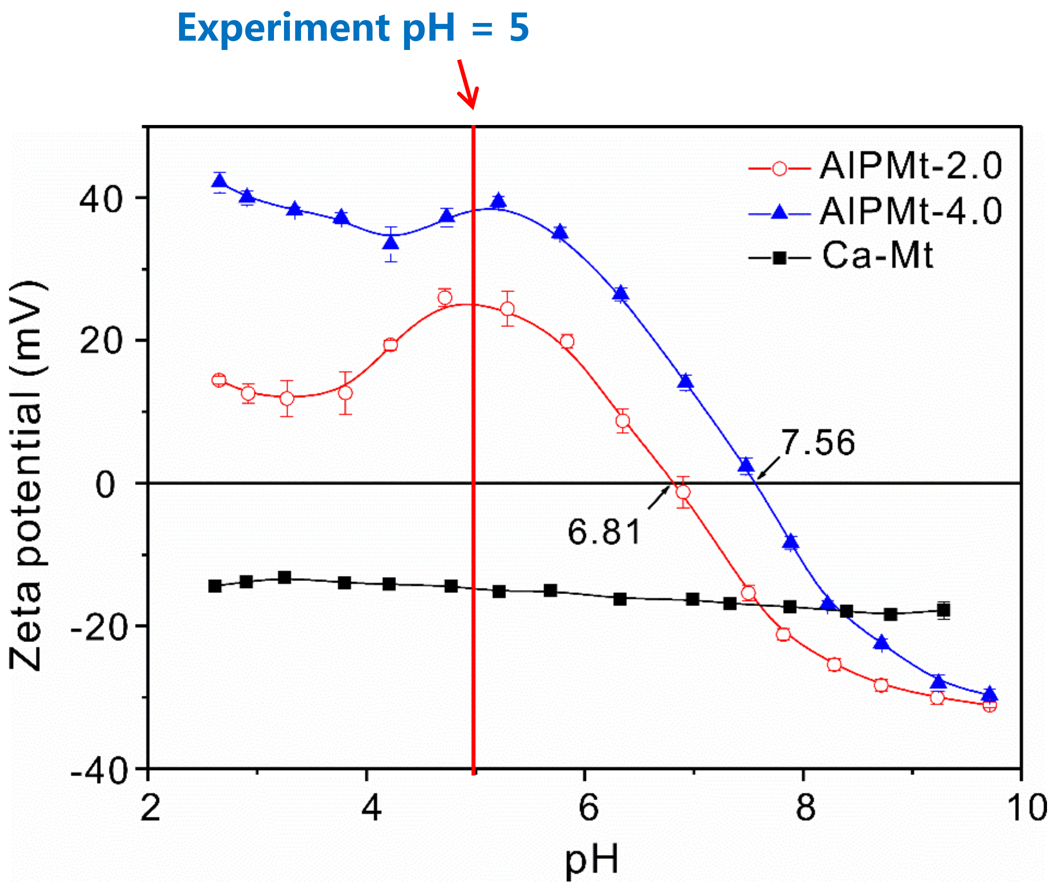
Samples	Mass Loss (200 – 500 °C, %)	BET (m^2/g)
Ca-Mt	1.93	65.64
AlPMt-1.0	3.54	111.86
AlPMt-2.0	5.01	254.72
AlPMt-4.0	6.33	304.94



N_2 adsorption-desorption isotherms

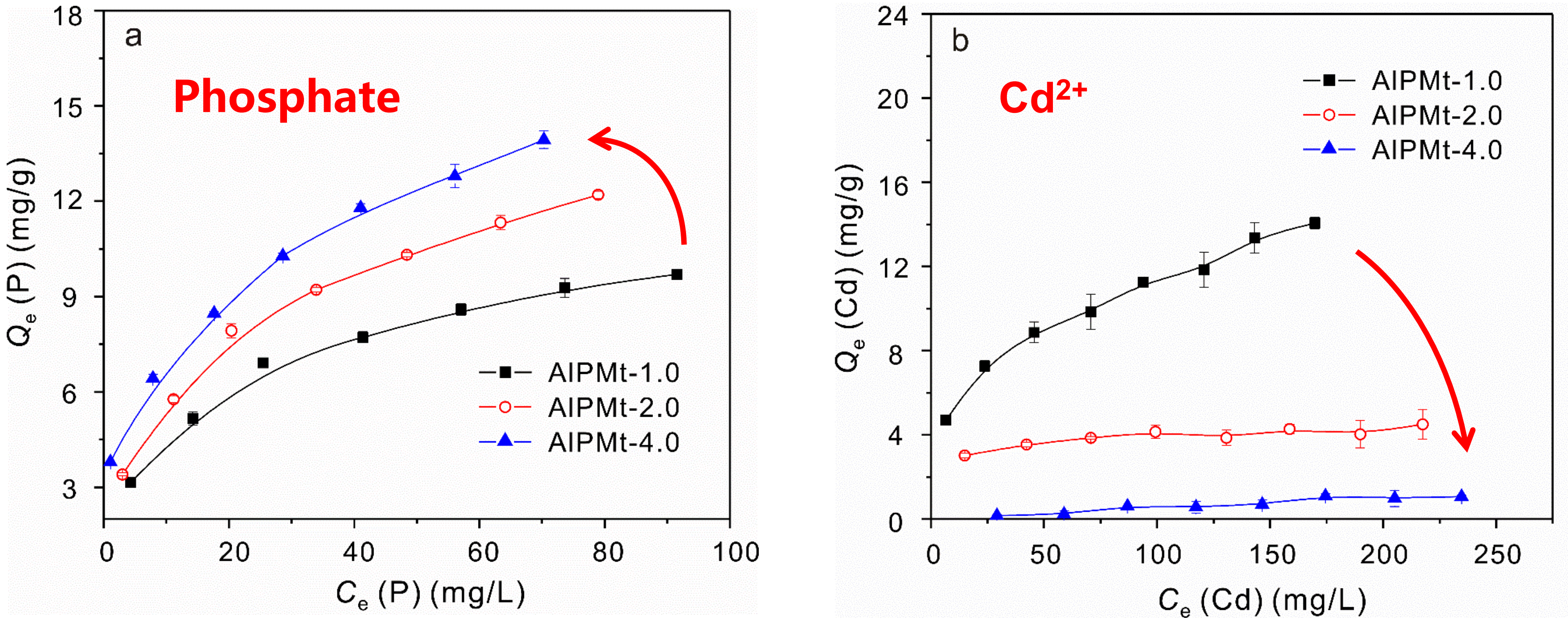
- **Specific surface area**
- **Micropores**

Zeta potentional



Zeta potential of Mt under different solution pH

Single adsorption system

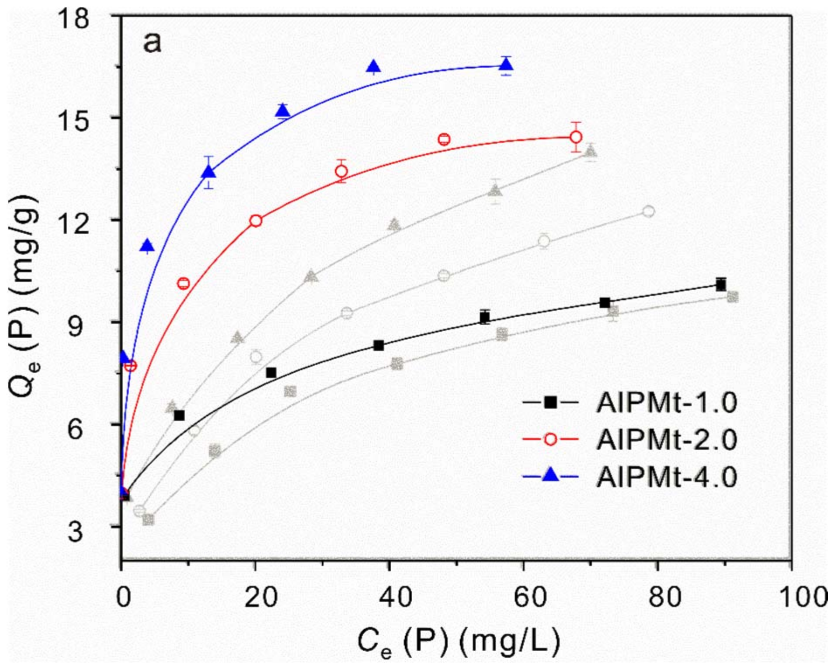


Adsorption isotherms of phospate and Cd^{2+} in single adsorption system

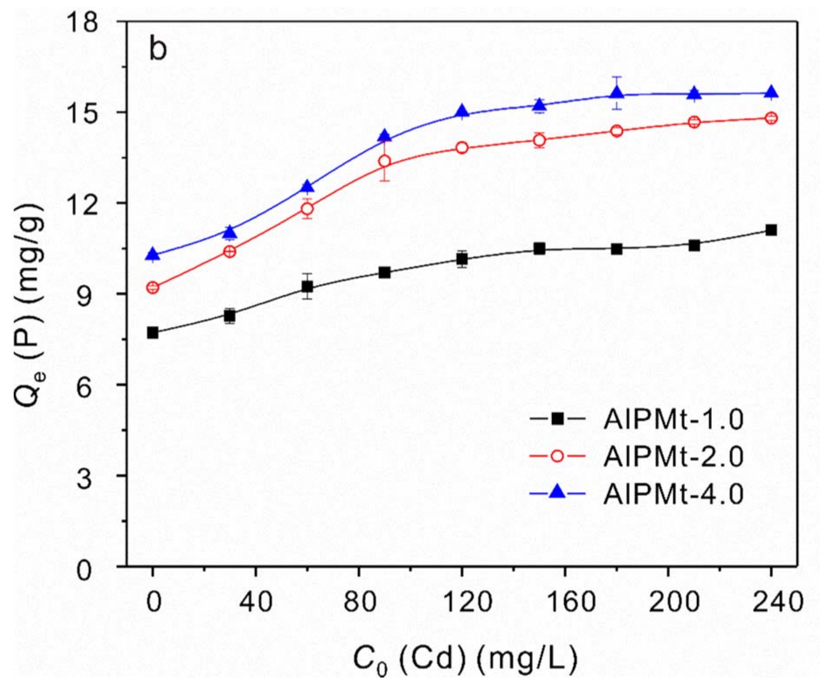
Al_{13} enhance the adsorption of phosphate, but not for Cd^{2+}

- **pH < pH_{zpc}, positive charged surface;**
- **Al_{13} cannot be changed by Cd^{2+}。**

Adsorption of phosphate in co-adsorption system



Adsorption isotherm of phosphate
(C_{Cd} = 90 mg/L)

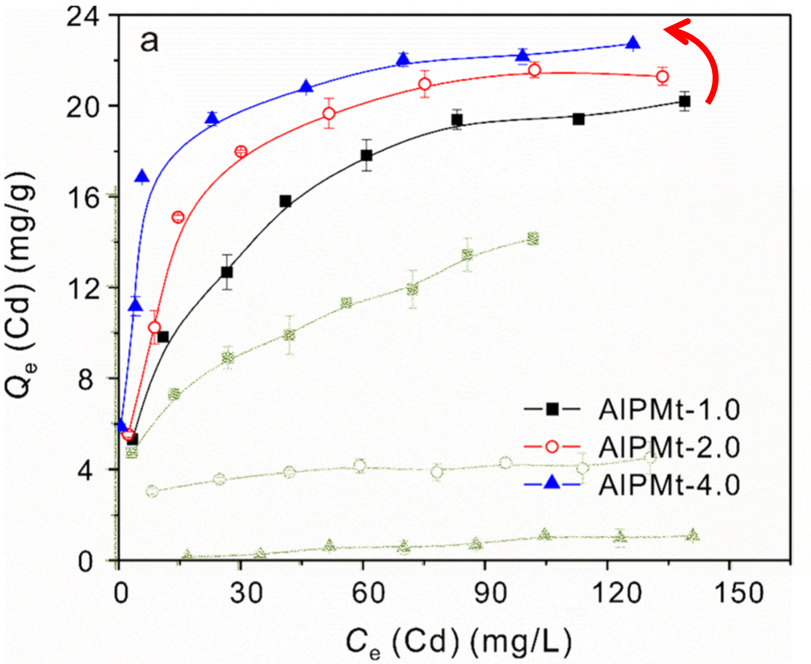


The effect of initial concentration of Cd^{2+}

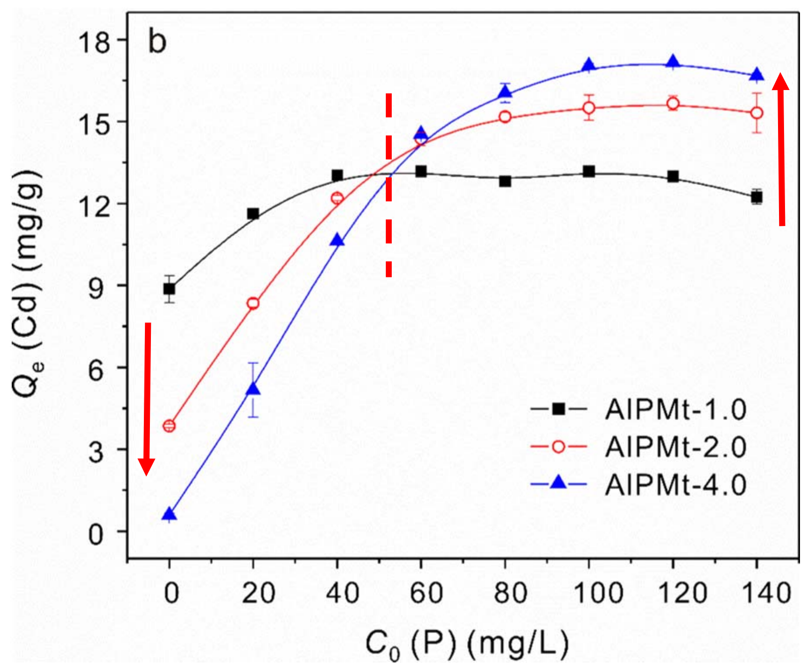
- Al_{13} content
- Initial concentration of Cd^{2+}

The enhancement of phosphate adsorption

Adsorption of Cd^{2+} in co-adsorption system



Adsorption isotherms of Cd^{2+}
($C_{phosphate}$ = 80 mg/L)

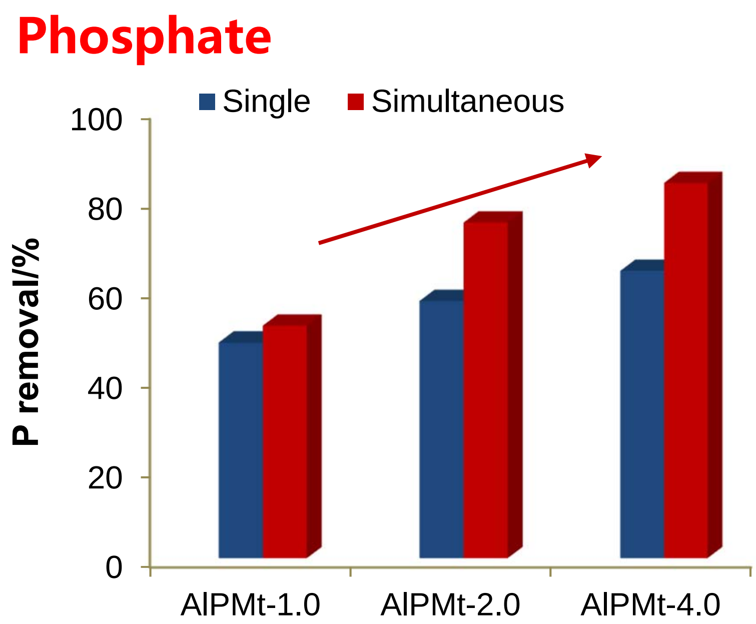


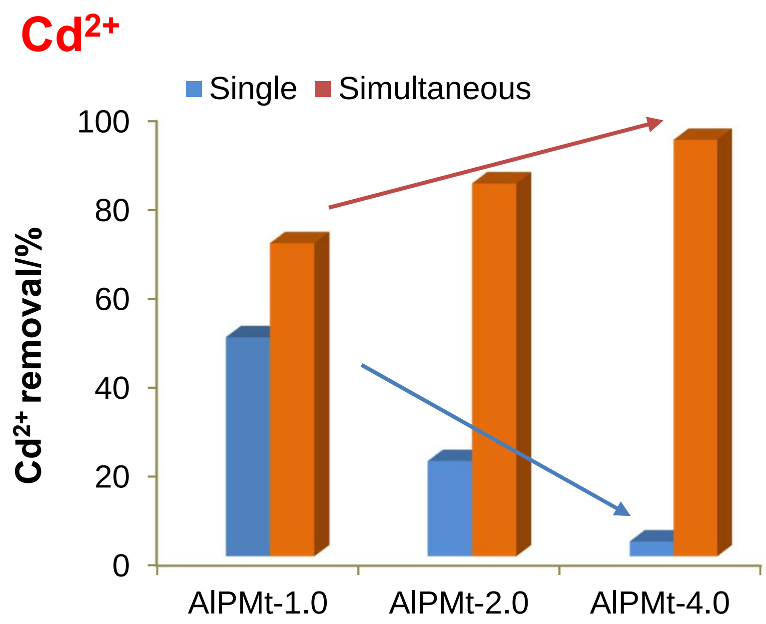
Effect of initial concentration of phosphate

- Al_{13} content
- initial concentration of phosphate

The adsorption of Cd^{2+} dramatically increase

The co-adsorption of phosphate and Cd^{2+}



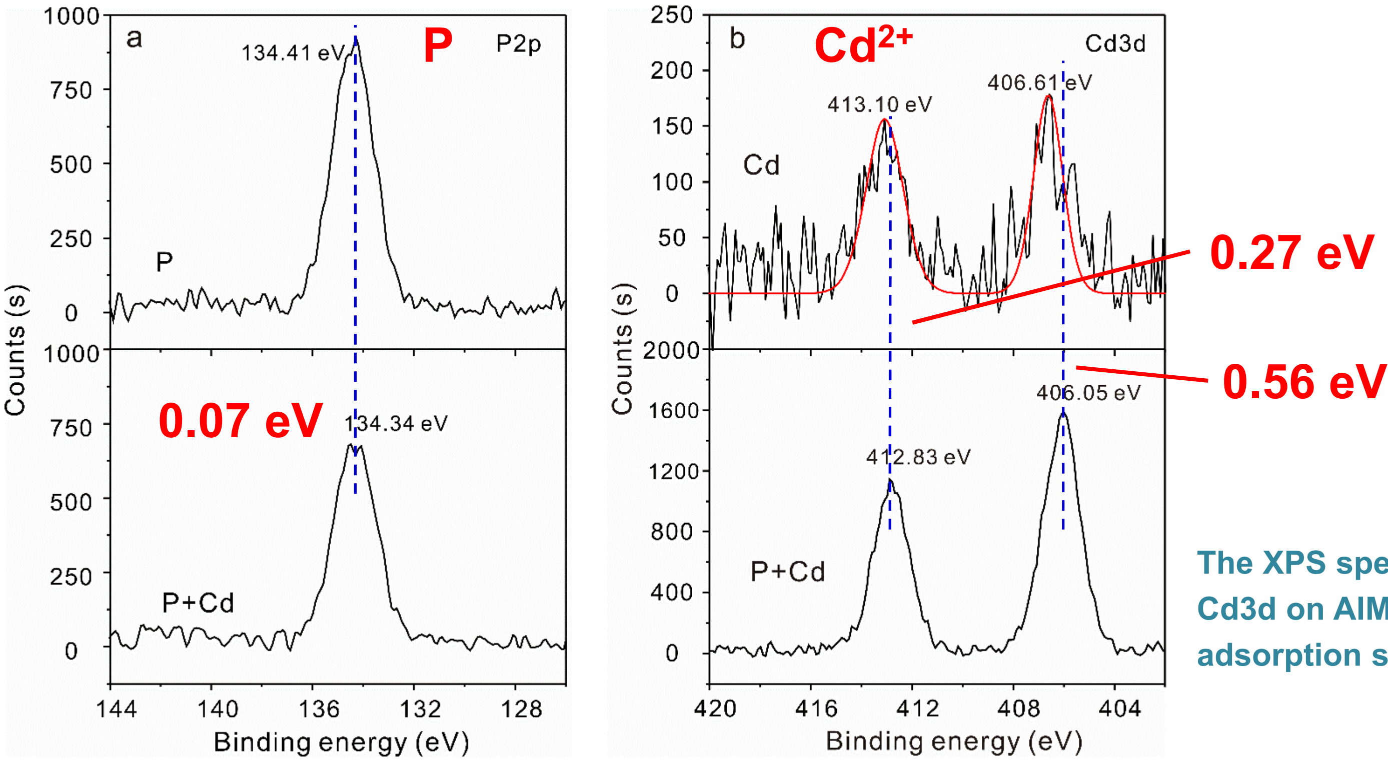


The removal of phosphate and Cd^{2+} in single and simultaneous systems

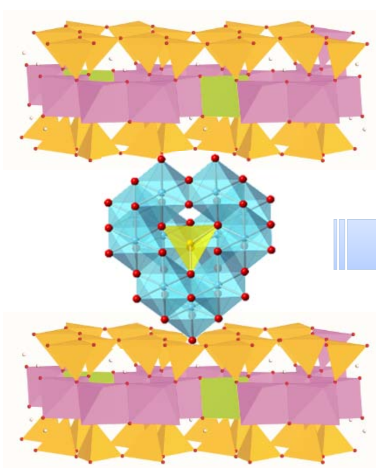
- **The enhancement of the adsorption of Cd^{2+} was higher than that of phosphate.**
- **The adsorption sites of Cd^{2+} were primarily provided by the adsorbed phosphate on AlPMt.**

The co-adsorption sites are mainly existed on the surface of Al_{13} cations

XPS analysis of AlPMt-4.0



The XPS spectrums of P2p and Cd3d on AlMt-4.0 in two adsorption system



≡Al –OH –P– Cd – P

P-bridge ternary surface complexes

Conclusion

- The adsorption of both phosphate and Cd^{2+} on AlPMts increased with the increase of loaded amount of Al_{13} cation, so did the enhancement of adsorption capacity of AlPMt toward both ions in co-adsorption system.

- The adsorption capacity of AlPMts with higher loaded amount of Al_{13} cations toward Cd^{2+} were significantly promoted in simutaneous adsorption system, indicating that the surface of intercalated Al_{13} cation were the co-adsorption sites.

- The formation of phosphate-bridge ternary surface complexs might be primarily reponsible for the co-adsorption of phophate and Cd^{2+} on AlPMt.

Further work

- The co-adsorption mechanism need to be further studied to clarify the binding model
- solution pH, ion strength, desorption, etc

SPONSORS

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Thanks for your attention!