The Sorption of Denatonium Benzoate, n-Butylpyridinium Chloride, and 3-Methyl-n-butylpyridinium Chloride to Kaolinite and Montmorillonite Clay Minerals

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Abstract

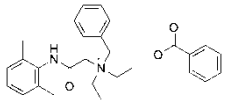
The constant temperature adsorption of organic salts, denatonium benzoate(DB) and two ionic liquids, n-butylpyridinium chloride (nb py cl) and 3-methyl-n-butylpyridinium chloride (3mnb py cl), to two clays were studied under varied solution conditions. Ultraviolet-Visible Spectroscopy was used to evaluate the extent salt absorption all clays. Kaolinite isotherms suggest that the clay's affinity for DB increases with concentration. Montmorillonite isotherms suggest the DB is being caught between the layers of the clay and not bonding to the clay surface. Initial experiments with ionic liquids suggest montmorillonite is able to sorb them.

Introduction

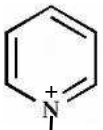
Contamination from chemical wastes is one of the major problems facing the environment today. DB is a common bittering agent that some law makers want to make a mandatory ingredient in antifreeze. The ionic liquids have low vapor pressures, which make them a possible "green" solvent that may replace more volatile organic solvents. Increased usage of these chemicals makes the likelihood of them contaminating the environment much greater. This study was under taken to see what would happen if these chemicals were leaked into the soil.

Materials and Methods

•Kaolinite clay (KGa-1b), 600ºC, 12 hours
•Montmorillonite clay (Swy-2), 105ºC, 12 hours
•Salt-clay suspensions in 50 mL centerfuge tubes were mixed end over end for up to 4 days at 25ºC
•Suspensions were centerfuged and supernate was collected for analysis
•The concentration of salt left in each supernate was quantified using UV-Vis spectroscopy
•Absorption isotherms were preformed for each salt for each set of conditions
•DB experiments were run at pH values 4-13

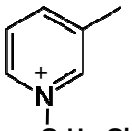


denatonium benzoate



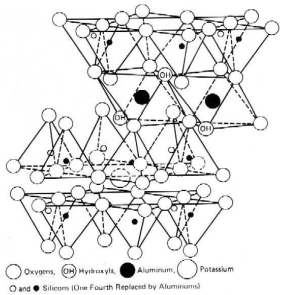
C_4H_9 Cl^-

n-butyl pyridinium chloride.

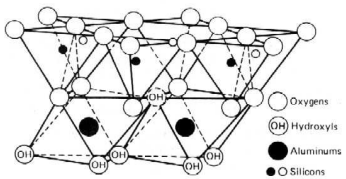


C_4H_9 Cl^-

3-methyl-n-butyl pyridinium chloride

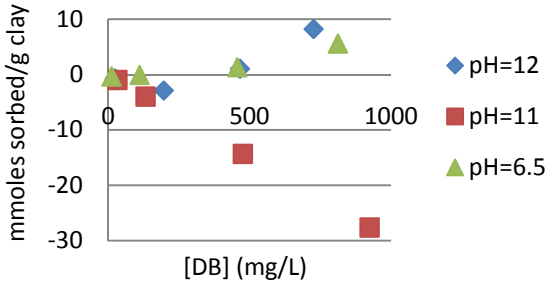


montmorillonite



kaolinite

Kaolinite Isotherm for DB



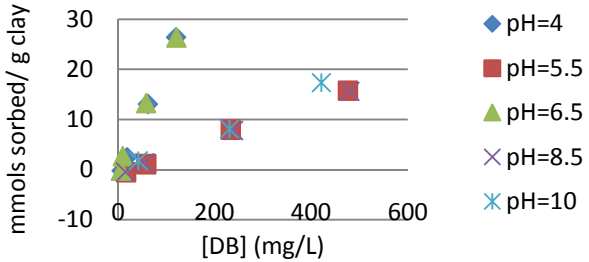
Results

Kaolinite Isotherm:
•elliptical and S shaped curves
- affinity for DB increases with concentration

•negative values
- interference from organic material and competition for sorption
- DB is desorbing or clay is dissolving at high pH's

•steepness of curve changes with pH
- pH dependent absorption

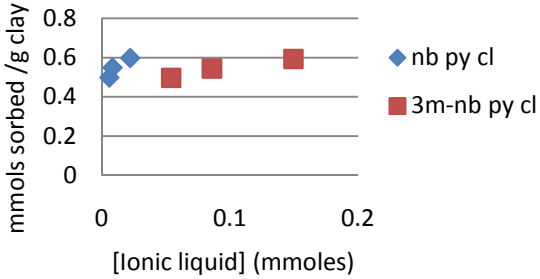
Montmorillonite Isotherm for DB



Montmorillonite Isotherm:
•C shaped curves
- DB caught between layers and no chemisorptions

•steepness of curve changes with pH
- pH dependent absorption

Montmorillonite Isotherm for Ionic Liquids



Ionic Liquid Isotherms:
•both ionic liquids are being sorbed to the clay
•suggests top of an S shaped curves
- sorption is concentration dependent

Conclusions

Kaolinite and montmorillonite both are able to sorb organic salts. Sorption of DB is pH dependent for both clays but is also dependent upon other environmental factors. Preliminary studies of ionic liquids suggest that montmorillonite has a large capacity to sorb them. These clays have the potential to help contain spills of these organic salts and help prevent them from entering reservoirs of drinking water. In areas with these clays, regulatory agencies would not have to worry about spills of these salts.

Future Work

•Variable pH studies of each ionic liquid
•Wider concentration range of DB
•Evaluate the adsorption properties of DB and the ionic liquids in other clays and sands
•Evaluate the adsorption kinetics of DB and the ionic liquids in kaolinite