Adsorption of quinoline on Berea sandstone

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Nitrogen containing heterocyclic compounds (NHCs) are pollutants in wastewater and in groundwaters from coal, oil shale, bitumen and asphalt production areas. The most representative example of NHCs is quinoline (Q), C_9H_7N (pK_a 4.9), which is highly soluble in water and potentially carcinogenic. Decontamination of quinoline is a challenging task because pollution extends across large areas and NHCs are highly mobile compounds. Natural materials such as quartz, clays and carbonate minerals, that naturally play a role in water treatment, can serve as adsorbents for quinoline. Also, mineral wettability is modified by adsorbed NHC compounds, making prediction of quinoline adsorption properties important for oil recovery. In particular, the presence of NHCs is often associated with the low salinity effect, which is known to increase oil production.

We studied the adsorption of quinoline on Berea sandstone at pH ranging from 3 to 9, with a range of concentrations of NaCl as background electrolyte. We observed maximum adsorption close to pH 6 and that the adsorbed amount of quinoline decreased from 2 equivalent monolayers at low salinity (0.05 M) to a single monolayer at high salinity (0.7 M). Based on our quantitative X-ray diffraction (XRD) analysis of the Berea sandstone (85% quartz and 5% kaolinite), we modelled the experimental data using a triple layer surface complexation model with the silanol surface sites from quartz and kaolinite and aluminol sites from kaolinite. Although the kaolinite content was low, its surface area was similar to that of quartz, so the amount of surface sites for quartz and kaolinite were nearly equal.

The best fit for the experimental data was obtained when both quartz and kaolinite were available for adsorption. Our results revealed that three types of quinoline complexes formed on the surface: 1) inner sphere >SiOHQ; 2) outer sphere >SiO^-QH^+ and 3) inner sphere >$AlOHQ_2$. We concluded that multilayer adsorption of quinoline (hemi-salt's analog) takes place in the Berea sandstone at kaolinite sites, whereas only monolayer formation is possible on quartz surface sites. Our results demonstrate the high efficiency and potential of clays for removing NHCs from waste and ground waters. They also show that quinoline adsorption is promoted at low ionic strengh, opposite to the low salinity effect.