

Abstract

Residues from the combustion of municipal solid waste with fluidized bed techniques are characterized with respect to mineralogy, total elemental contents and leaching behavior. The long and short term leaching behavior of these, residues so called ashes, is assessed by a two-stage batch leaching test. The ashes generated from the bottom of the combustion chamber, in the hopper and in the cyclone were mainly composed of aluminosilicate minerals, whereas the ash collected from a bag-house filter was composed of easily soluble salts and had high contents of heavy metals. The leaching test results generally followed the mineralogy of ashes i.e., high release of salts and heavy metals from the filter ash and a low release from the other three ashes. However, the released amounts of Cr(VI) from the bottom and Cl⁻ and Al from the hopper and cyclone ashes were high.

The leaching of Cr(VI) was reduced considerably when bottom ash was mixed with hopper ash. An oxidative dissolution of Al(0) to Al(III) is the possible reason for the reduction of Cr(VI). A simple multistage water extraction method was found to be appropriate for the removal of salts from the cyclone ash. However, this multistage extraction procedure was not useful for the filter ashes.

In the second part of this thesis attempts are being made to develop a model for surface complexation based on the statistical mechanics. First a corrected Debye-Hückel (CDH) theory for electrolyte solutions was developed. The ion size effects (which were neglected in the original Debye-Hückel theory) are taken into account in the form of hole correction to the electrostatic energy and by generalized van der Waals (GvdW) approach for hard sphere interactions. Internal energy, mean ionic activity and osmotic coefficients for 1:1 and 2:1 restricted primitive model electrolytes obtained by the CDH theory are in good accordance with the results of Monte Carlo simulations and Hypernetted chain integral equation theory. Thus the CDH theory can be applied a priori for these model electrolytes. The experimental data for a large number of salt solutions were also successfully fitted by adjusting the ionic diameter. The ionic diameters obtained from the fittings were in accordance with the current understanding of ionic hydration processes.

A statistical mechanical theory of surface charging (SC) phenomena was also developed. The proton binding with the surface sites are described by a binding energy and vibrational frequency. The experimentally determined surface charge data of goethite particles in NaClO₄ solution was modeled by the SC theory. At high ionic strengths i.e., at 1 M background electrolyte the theory was in good agreement with the experimental data. However, considerable deviations were found for low electrolyte concentrations. The SC theory is a linear theory and these deviations between the theory and experimental data are most probably due to the nonlinear effects.

Key Words: Combustion, FBC, MSW, waste, ashes, leaching, Cr(VI), electrolytes, corrected Debye-Hückel, CDH, surface charging, SC, surface complexation.