$$S = \frac{S_T}{1 + \sum_{i=1}^{n} \left([L]^i \prod_{j=1}^{i} K_{1j} \right)} \tag{8.38}$$

$$SL_n = S[L]^n \prod_{i=1}^{i} K_{1i} \tag{8.39}$$

$$Q_R = \Delta H_1^{\circ}(SL_1 + SL_2 \cdots + SL_n) + \Delta H_2^{\circ}(SL_2 \cdots + SL_n) + \cdots + \Delta H_n^{\circ}(SL_n) \tag{8.40}$$

ΔH° and K for the binding reaction can be simultaneously obtained by solving Equation 8.35 or 8.40 using a non-linear least squares curve fitting program. Once these values are known, other thermodynamic parameters can then be calculated from Equation 8.41.

$$\Delta G^{\circ} = -RT \ln K = \Delta H^{\circ} - T\Delta S^{\circ} \tag{8.41}$$

Since the thermal events observed calorimetrically contain both chemical and non-chemical components, all extraneous thermal effects must be subtracted from this composite of thermal events in order to obtain the relevant chemical reaction heat. Non-chemical thermal effects result from stirring, thermistor heating, heat transfer between the reaction vessel and the constant temperature bath, and titrant/titrate temperature mismatch. Chemical thermal effects result from evaporation, dilution of the reactants, and chemical reaction heat. Details of the data reduction and correction for extraneous heat effects are described by Winnike (1989).

Titration calorimetry has been successfully employed in the determination of thermodynamic parameters for complexation (Siimer et al. 1987; Tong et al. 1991). The technique has the advantage of employing direct calorimetric measurements and has been proposed as the most reliable method (Szejtli 1982). It should be noted that the information derived from multistep series reactions is macroscopic in nature. In contrast to spectrophotometric methods which provide information concerning only the equilibrium constant(s), titration calorimetry also provides information about the reaction enthalpy which is important in explaining the mechanism involved in the inclusion process.

Characterization of Complexes in Solid State

Several methods have been used to characterize complexes in solid state. Among the most commonly used methods are differential scanning calorimetry (DSC), X-ray powder diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), X-ray crystallography, and nuclear magnetic resonance (NMR) (Demirel et al. 2011; Sravya et al. 2013; Zenget al. 2013; Kim et al. 2014).

Differential Scanning Calorimetry

DSC has been utilized by many to investigate inclusion complexes in the solid state. The melting endotherm of the substrate typically is changed as a result of complexation. The complex formed may have a different melting point, or no melting endotherm because of its amorphous nature. The physical mixture in most cases will still exhibit the melting endotherms of the substrate and the CD (if it is crystalline).

X-ray Powder Diffraction

XRD is a useful tool to study complexes in the solid state (Simon et al. 1981; Kim et al. 2014). The complex should give a different X-ray powder diffraction pattern compared to the physical mixture of the host and guest molecules. If the complex formed is crystalline, it is possible to get the single crystal X-ray pattern to elucidate the structure of the complex.