Fugacity and fugacity coefficient for species in solution

it is known that the chemical potential, μ_i, is a function of fugacity of species in sol'n as

$$\mu_i = T_i(T) + RT \ln \hat{f}_i$$

However, the chemical potential between phases for each species, i, is in equilibrium, where,

$$\mu_i^{\alpha} = \mu_i^{\beta} = \cdots = \mu_i^{\pi} \quad \text{and} \quad \hat{f}_i^{\alpha} = \hat{f}_i^{\beta} = \cdots = \hat{f}_i^{\pi}$$

special case: For vap-liq equilibrium $\hat{f}_i^{V} = \hat{f}_i^{L}$

Let us go back to the residual properties for Gibbs free energy

$$G^R = G - G^{ig}$$

multiply by total # of moles in sol'n

$$nG^R = nG - nG^{ig}$$

differential w.r.t n_i ; $\left.\frac{\partial (nG^R)}{\partial n_i}\right|_{P,T,n_j} = \left.\frac{\partial (nG)}{\partial n_i}\right|_{P,T,n_j} - \left.\frac{\partial (nG^{ig})}{\partial n_i}\right|_{P,T,n_j}$

but $\left.\frac{\partial (nM)}{\partial n_i}\right|_{P,T,n_j} = \bar{M}_i$ (partial molar property $\bar{M}_i$)

$$\therefore \quad \bar{G}_i^R = \bar{G}_i - \bar{G}_i^{ig}$$