

## **Numerical modelling of electrochemical polarization around charged metallic particles**

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We extend an existing analytical model and carry out numerical simulations to study the polarization process around charged metallic particles immersed in an electrolyte solution. Electro-migration and diffusion processes in the electrolyte are described by the Poisson-Nernst-Planck system of partial differential equations. To model the surface charge density, we consider a time- and frequency-invariant electric potential at the particle surface, which leads to the build-up of a static electrical double layer (EDL). Upon excitation by an external electric field at low frequencies, we observe the superposition of two polarization processes. On the one hand, the induced dipole moment on the metallic particle leads to the accumulation of opposite charges in the electrolyte. This charge polarization corresponds to the long-known response of uncharged metallic particles. On the other hand, the unequal cation and anion concentrations in the EDL give rise to a salinity gradient between the two opposite sides of the metallic particle. The resulting concentration polarization enhances the magnitude of the overall polarization response. Furthermore, we use our numerical model to study the effect of relevant model parameters such as surface charge density and ionic strength of the electrolyte on the resulting spectra of the effective conductivity of the composite model system. Our results do not only give interesting new insight into the time-harmonic variation of electric potential and ion concentrations around charged metallic particle. They are also able to reduce incongruities between earlier model predictions and geophysical field and laboratory measurements. Our model thereby improves the general understanding of IP signatures of metallic particles and represents the next step towards a quantitative interpretation of IP imaging results.

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