Multiphysics simulation and EIS verification of dynamic droplet corrosion under external atmospheric humidity

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Abstract Various factors affect atmospheric corrosion rate and uniformity, thus influencing material life-span and system reliability. In order to study the electrochemical characteristics of pure iron under the influence of dynamic saltwater droplets in different humidity environments, a two-dimensional axisymmetric model containing heat and moisture flow modules was developed. In contrast to previous models where the vertical flux of oxygen was solely determined by diffusion, the current model accounts for convection as a significant contributing factor, and the contribution of convection to oxygen transfer is shown in Fig.1(a). The findings suggest that under varied humidity conditions, the interior of the droplets manifests distinct convective structures and velocities so that the corrosion interface displays diverse electrochemical characteristics, Fig.1(b) shows the distribution characteristics of electrode potential at different humidity levels, indicating that the corrosion distribution characteristics commonly associated with the Evans ring are a special case occurring under high humidity conditions. The model also elucidates the role of humidity in local corrosion during the initial stages, its impact on the distribution characteristics of the cathode and anode (Fig.1(c)), and its effect on the distribution of oxygen within the droplets. Elevated conductivity in more porous corrosion products may lead to increased unevenness in corrosion, thus heightening the risk of localized corrosion (Fig.1(d). These conclusions are effectively corroborated through the measurement of local electrochemical impedance under different humidity conditions, employing a concentric electrode array. This study provides insights into the conditions under which localized corrosion is likely to occur; it facilitates the understanding and mitigation of corrosion risks in various applications.

Keywords dynamic saline droplet, electrochemical characteristics, atmospheric corrosion, convection

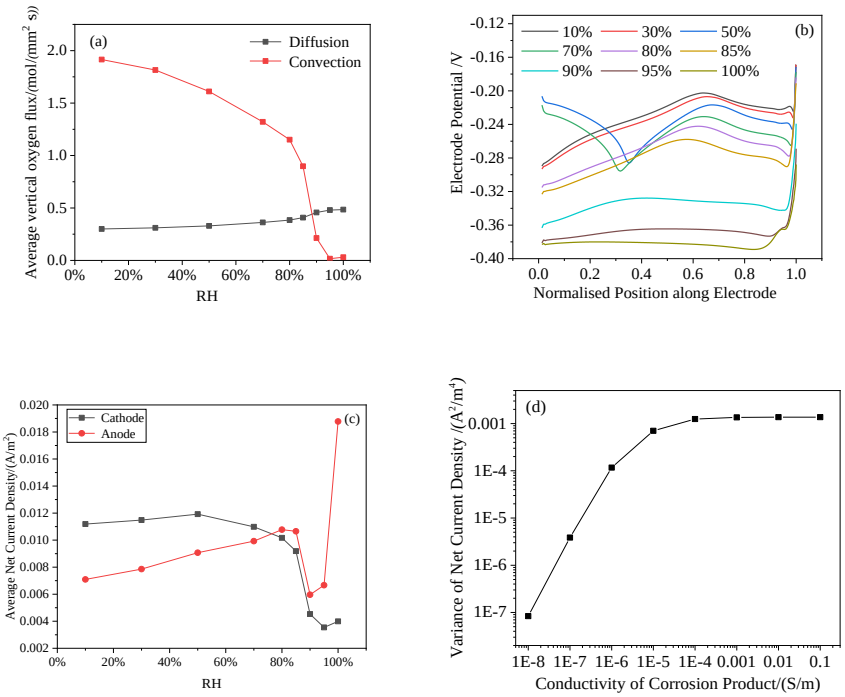

Fig 1. (a) Contribution of convection and diffusion to mass transfer in the vertical direction of oxygen, (b) Distribution of electrode potential under different humidity, (c) Average net current density of anode and cathode under different humidity, (d) Variance of net current density under corrosion products with different conductivity