Wetting Characteristics of Carbonate Melts

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The Molten Carbonate Fuel Cell (MCFC) is expected to offer the potential and promising energy source replacing the present fossil fuels. In its development, a lot of research effort has been directed to the wetting behavior of electrode materials and electrode performance in the molten carbonate fuel cell environment (1-4).

The typical Li-K electrolyte is now being replaced with Li-Na, attractive for its low ionic resistance, evaporation loss and NiO solubility. Therefore, comparative investigation on wetting properties of two different electrolyte compositions is indispensable to understand and estimate electrode performance. However, in spite of much experimental research about wetting phenomena, clear explanations about the effects of polarization, gas atmosphere, temperature, and electrolyte composition on meniscus was not given. Further optimization of electrolyte composition can be expected involving Li-Na-K ternary mixture and possibly Ba, Ca, and other alkaline earth carbonates. However, no predictive model is available. Therefore, a more physical molecular interpretation of wetting behavior should be pursued.

As a basis for this we initiated systematic measurements on inert metal (gold) to assess reproducibility as well as the above environmental influences. Meniscus heights on gold measured in our experiments were strongly dependent upon the applied potential and the gas environment.

Figure 1 shows the variations of meniscus height in Li-K melts as the function of applied potential under oxidizing and reducing environments. The arrows indicate the open circuit potential under each atmosphere. The meniscus height at open circuit potential is lower than when the surface has positive or negative charge (polarization). The larger the extent of polarization, the more the meniscus creeps up. However, meniscus height in reducing atmosphere first decreases and then increases in the positive charge region. This may be understood from the classical concept that the polarization brings about a change in interfacial tension between electrode and electrolyte (electrocapillary effect). Further changes in the meniscus height are caused by electrochemical reaction and mass transfer. Oxidant atmosphere shows more notable increase in meniscus height than reducing atmosphere.

Figure 2 compares two electrolyte systems, Li-K and Li-Na carbonates under oxidizing atmosphere, indicating that wetting by Li-K carbonate is better than by Li-Na at least at 650^{o}C. The reason for the difference in the wettability of these carbonate melts may be found in two aspects. First, the wetting is improved with increasing ionic radius of the alkali ions present. This is supported by the fact that surface tension decreases with increasing cationic radius (5). Second, the more basic carbonate melt, Li-Na exhibits poorer wettability. However, the basicity of the melt can also be influenced by the gas composition.

We are now attempting to explain this by the variation of surface tension at the three-phase boundaries under polarization and varying gas compositions. Also, a new type of wetting model needs to be pursued.

The wetting properties of molten carbonates are an important factor determining the electrolyte distribution in a porous electrode. The latter can be related to the utilization and performance of the electrode. Based on the wetting properties, an improved model for the performance of MCFC porous electrode may be developed.

Acknowledgement
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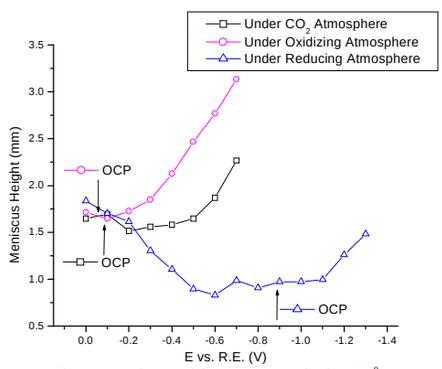

Figure 1. Meniscus Height Measurement in Li-K, 650^{o}C

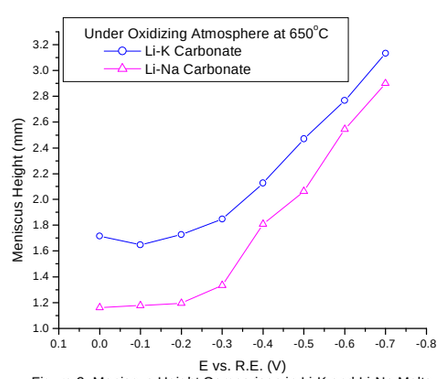

Figure 2. Meniscus Height Comparison in Li-K and Li-Na Melts