Liquid Phase ionic transport measurement in a porous electrode: Effect of calendaring, size, amount of binder and particle shape

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For high power applications such as start-stop operations for the vehicles, it is extremely important to understand liquid phase transport of lithium ions in a lithium ion battery. The optical observation of non-uniform lithiation of the electrode particles made us rethink and re-understand the liquid phase transport in a porous electrode, since ionic transport through the electrolyte phase in a porous electrode determines the current distribution over the surface of the electrode. The conventional porous electrode transport model generally incorporates the 'Bruggeman relation' between tortuosity and porosity. Validity of Bruggeman relation has come under serious scrutiny since, the assumption of 'random distribution spherical particles' may not hold true in a real battery electrode.[1-3] Instead, real battery electrodes are made up of particles with random shapes and non-uniformly distributed in a polymeric binder. Also they are calendared with a unidirectional force. Factors such as particle shape, size, amount of binder, calendaring etc. inherently affect the diffusion path, and at the same time they may affect the diffusion rate. In this study we measure the diffusion rate of lithium ions through electrode laminates calendared to different thickness and porosity. We also study the effect of amount of binder and particle shape and size on the diffusion. We show that the liquid phase diffusion in a porous electrode is highly affected by these factors. Such a study is useful for designing the electrode structure for optimizing the power performance.

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