The Role of Binders in Insertion Anodes

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A good binder for battery electrodes, but also for electrodes in fuel cells and capacitors, has to meet various requirements. Beyond being chemically inert towards the electrolyte and electrochemically stable at given electrode/electrolyte interface, it has to fulfill many other demands. For example, in insertion electrodes it has to be able to adjust to large dimensional changes during electrode operation. Furthermore, from the standpoint of energy density, it is desirable that sufficient binding properties are achieved at as low as possible a binder content. Today, as the size of active particles decreases, the role of binders becomes increasingly more important. In light of a huge number of investigations dealing with all kinds of active particle sizes (from micro- to nano-), it is surprising that very little attention has been devoted to studying the mechanisms of particle binding using various kinds of binders.

The effects of various binders (PVDF, teflon, gelatin, cellulose) on anode properties have been studied[1,2]. The self-arrangement of binders on flat surfaces was studied using AFM (Fig. 1). The same technique was also applied to study the forces between a binder and a surface of choice. The effects of binder type on intercalation process and on passivation was studied using X-ray diffraction and mass spectroscopy in combination with electrochemical methods. Impedance spectroscopy was also used for this purpose.

The main results are the following.
1. Most binders do not interact significantly with the active particles; the exception is gelatin which shows strong binding forces against most surfaces
2. Teflon and PVDF tend to form agglomerates (Fig.1a), cellulose forms thin wires (Fig.1b), while gelatin, at appropriate conditions, forms thin (thickness = few nm) homogeneous layers on surfaces of substrates (Fig.1b)
3. A consequence of point 2 is that only gelatin participates significantly in formation of passive films. On one hand, it helps create thin compact passive films while, on the other, it changes the passive film composition. Based on this finding, it is possible to claim that gelatin acts as surface modifier, while the other binders are more or less inert in this respect.
4. The critical content of binder at which the mechanical and electrochemical stability of the anode breaks down is different for different binders. Typically, the minimum content of gelatin (0.2 wt %) is an order of magnitude lower than for other binders. This fact, in correlation with AFM sudies, has lead us to a model which assumes two essentially different binding mechanism for gelatin and other binders[3].

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References
1. M. Gaberscek, M. Bele, J. Drofenik, R. Dominko, S. Pejovnik, Electrochem. Solid State Lett. 3 (2000) 171.
2. M. Bele, M. Gaberscek, R. Dominko, J. Drofenik, K. Zupan, P. Komac, K. Kocevar, I. Musevic, S. Pejovnik, Carbon 40 (2002) 1117.
3. M. Gaberscek, J. Drofenik, R. Dominko, M. Bele, and J. Jamnik, Binding and wiring in electrodes for Li ion batteries, presented at this symposium.

a)
b)
c)

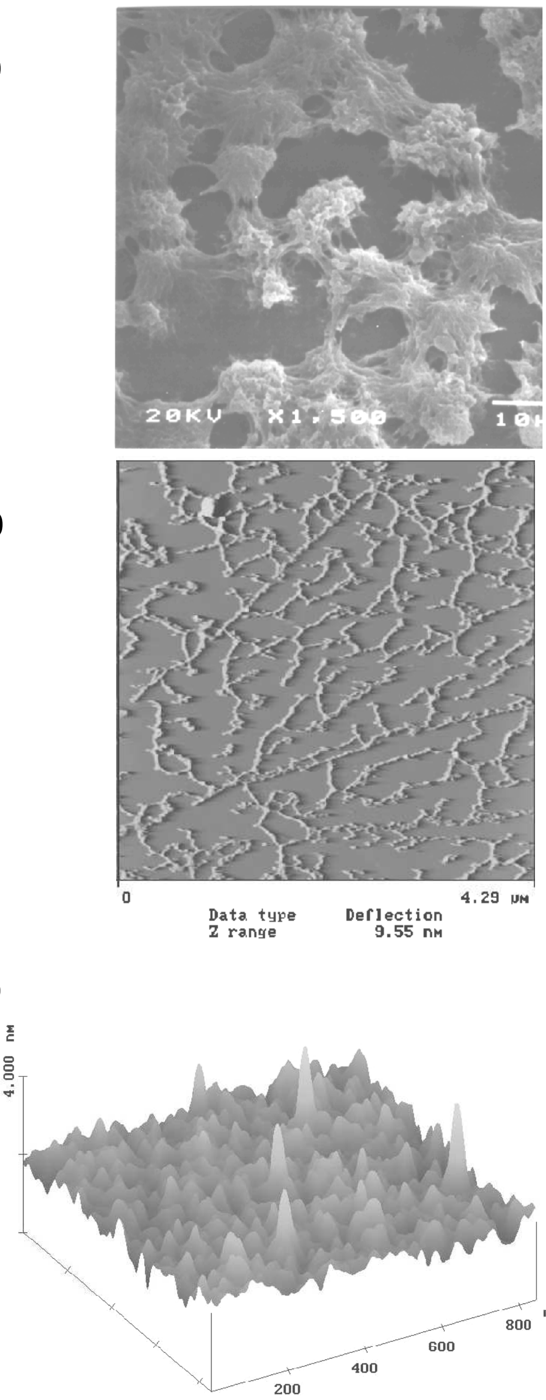

Figure 1. Morphology of different binder on a flat surface (HOPG or glass). a) PVDF, b) Carboxymethyl cellulose, c) gelatin.