Key factors controlling the electrochemical response of Cu_2O thin film electrodes in Li-ion batteries.

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Oxides of 3d transition metals (Fe, Co, Ni and Cu) react reversibly with lithium in a lithium cell below 1.5 V [1]. As shown by a number of studies, such a singular property makes them potential candidates for use as negative electrodes in Li-ion batteries. In this sense, copper oxides are attractive as low-cost and non-toxic materials. Conversely, the increasing interest aroused by thin Li-ion batteries for potential applications such as smart cards, CMOS-based integrated circuits and microdevices has opened up promising prospects for these novel material-based electrodes.

Recently, we have reported about the reactivity of Cu_2O thin films towards lithium [2]. These films were prepared using the electrodeposition technique, which provides advantages such as the ability to use low synthesis temperature, low costs and a high purity in the products. In that paper, the role that morphology (including particle size), and thickness –as independent parameters- of the films, play on its behavior as Li-ion battery electrodes was not completely clear. With this communication, we pretend to elucidate the key factors that lead to obtain the best electrochemical performance for Cu_2O thin film electrodes. Thus, three main factors were re-examined, i) substrate pretreatment, ii) particle size and iii) thickness, which are interrelated. Characteristics of three studied films are in the next table:

Films	emery paper	concentration of HF solution	thickness
A	2000 + 800	24%	3.5 µm
B	2000	5%	3.5 µm
C	2000	5%	1.3 µm

Figure 1 shows two diffraction patterns corresponding to films with identical thickness but different substrate pretreatment. Film A has been deposited on an extremely clean substrate and the FWHM of the diffraction peaks has increased relative to film B. That points to a smaller particle size. In figure 2, two SEM micrographs of the same films are shown. The same morphology can be observed for both of them.

The electrochemical response of Li/Cu_2O cells was consistent with reaction:

$$Cu_2O + 2\ e^- + 2\ Li^+ \rightarrow 2\ Cu + Li_2O$$

All the electrodes were found to be highly reversible in the 3.0 – 0.0 V potential range vs. Li/Li^+. Nevertheless, the reversibility of that reaction decrease when electrode increases in thickness. In figure 3, it is possible to see that the better electrochemical behavior, film C, was found for the thinnest electrode. Thus, thickness plays a crucial role on the electrochemical behavior of these electrodes. Nevertheless, particle size should not be discarded as an important parameter affecting the yielding of the electrochemical reaction. After the determination of an optimal thickness for these electrodes, we will continue our studies in order to elucidate that point.

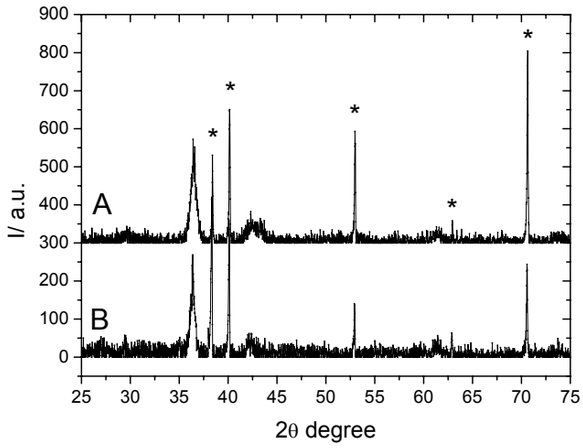

Fig 1: XRD difractograms of films A and B. Peaks with * correspond to Ti susbstrate.

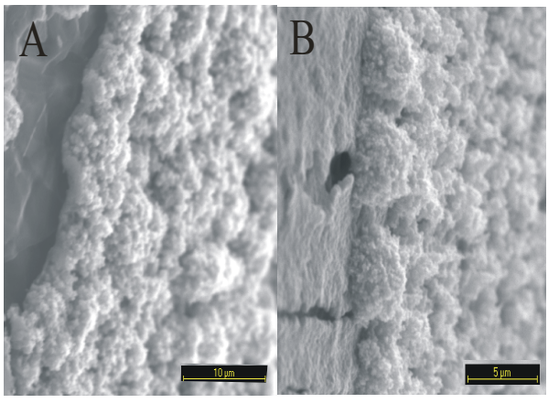

Fig 2: SEM micrographs of films A and B. Note the different magnification.

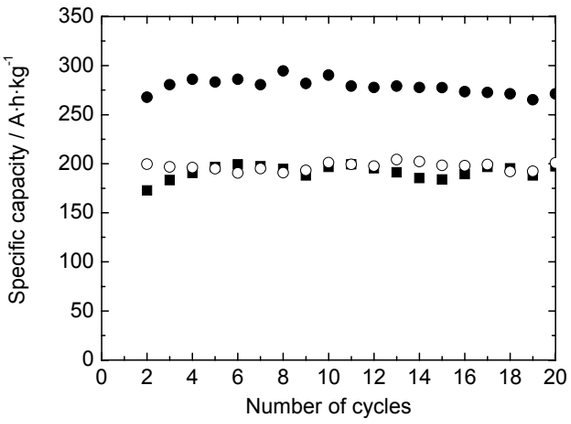

Fig 3: Cycling properties for Cu_2O deposits: (■) film A, (○) film B, (●) film C.

References

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