Abstract

Long-term illuminations on *cis*–Ru(2,2'–Bipyridyl–4,4'–Dicarboxylato acid)$_2$(NCS)$_2$ sensitized Dye Sensitization Solar Cells with TiO_2 semiconductor basis have been carried out, to gather information about the degradation behavior. Five different types of degradation have been observed.

The *photoinduced degradation* is the decrease of the efficiency as a result of the illumination and is linked to a chemical reaction of the dye molecule. There is a strong dependency to the terms of production. More than 30 % after only 9 days could be observed as well as 12.7 % after 175 days of continuous illumination with 100 $^{mW}/_{cm^2}$. Even within the same cell, differences of more than 30 % have been observed. This shows, that there are regional distinctions within the TiO_2 layer. Surface states may play a decisive role in this context. In the beginning of the illumination the degradation was very fast and slowed down with increasing time. However, it wasn't a first or second order reaction. This points out, that we are dealing with a complicated reaction mechanism. The *photoinduced degradation* occurred only with intact current flow. If the current flow is interrupted, the dye cannot inject the electron into the TiO_2 layer, and therefore it doesn't cycle the oxidized state. This shows, that the starting point of the degradation is the oxidized state of the dye. In situ FTIR studies of the electrolyte didn't show any degradation products of the dye. This means that they remain at the TiO_2 surface.

The *photoinduced degradation* was accompanied by a *secondary degradation*. In this case, a decline of photocurrent in illuminated as well as in not illuminated areas in equal measure can be observed. In some cases, the *secondary degradation* was very intense, whereas other cells didn't show any. It can be explained by a decrease of the injection rate and by an increase of recombination losses.

Cells stored in darkness for a longer period of time also showed a strong degradation. There was a decrease of the photocurrent up to 66 % within 2.5 month. This degradation phenomenon wasn't studied in detail, but a close connection to the processes of the *secondary degradation* can be assumed. As in this case, no illumination was necessary to initiate the degradation.

Beyond this a *degradation of the electrolyte* has been observed. After the preparation of the cells it showed a dark yellow color, which bleached more and more and was colorless at the end. The reason is a continuous loss of I_2.

The sealing of the cells with Surlyn turned out to be not stable, when illuminating the cells for a long time. Electrolyte disappeared from inside the cell and therefore gas bubbles became visible.

Altogether none of the cells showed a stability, which allows a working period of more than 20 years. The maximum lifetime was about 2 years and 5 month under real outdoor conditions. The *photoinduced degradation* within this period was 12.7 %.