

15.4 APPROACH TO COMMERCIALIZATION

15.4.1 Stability of the DSSC

For commercialization of the DSSC to be successful, the cell and module must have long-term stability. In this section, studies of photochemical, chemical, and physical stability of the component materials of the DSSC and recent investigations concerning long-term stability of the cell will be discussed.

15.4.1.1 Photochemical and physical stability of materials

The photostability and thermal stability of Ru complexes have been investigated in detail [6, 159–162]. For example, it has been reported that the NCS ligand of the N3 dye, *cis*-Ru(II)(dcbpy)₂(NCS)₂ (dcbpy = 2,2'-bipyridyl-4,4'-dicarboxylic acid), is oxidized to a cyano group (–CN) under photo-irradiation in methanol solution, as measured by UV–Vis absorption spectroscopy and nuclear magnetic resonance (NMR) spectroscopy [6, 159]. In addition, the intensity of the IR absorption peak attributed to the NCS ligand starts to decrease at 135°C, and decarboxylation of N3 dyes occurs at temperatures above 180°C [161]. Desorption of the dye from the TiO₂ surface has been observed at temperatures above 200°C.

It has been considered that high stability of the dye can be obtained in a DSSC system by including I[–] ions as the electron donor to dye cations. Degradation of the NCS ligand to a CN ligand due to an intramolecular electron-transfer reaction producing Ru(II) from Ru(III) occurs within 0.1 to 1 s [159], while the rate of reduction of Ru(III) to Ru(II) due to electron transfer from I[–] ions into the dye cations is on the order of nanoseconds [28]. This indicates that one molecule of N3 dye can contribute to the photon-to-current conversion process with a turnover number of at least 10⁷ to 10⁸ without degradation [159]. Taking this into consideration, N3 dye is considered to be sufficiently stable in the redox electrolyte under irradiation.

We must also take into consideration the photoelectrochemical and chemical stability of the solvent in the electrolyte. Organic solvents employed in DSSCs are, for example, propylene carbonate, acetonitrile, propionitrile, methoxyacetonitrile, methoxypropionitrile, and their mixtures. It is known that carbonate solvents, such as propylene carbonate, decompose under illumination, resulting in the formation of a carbon dioxide bubble in the cell. Methoxyacetonitrile (CH₃O–CH₂CN) reacts with trace water in the electrolyte to produce the corresponding amide (CH₃O–CH₂CONH₂), which decreases the conductivity of the electrolyte [163]. Acetonitrile and propionitrile are considered to be relatively stable, giving 2000 h of stability under dark conditions at 60°C [163].

The stability of vapor-deposited Pt electrocatalyst on a TCO substrate used as a counter electrode has also been investigated. It was reported that the electrocatalytically active Pt layer did not seem to be chemically stable in an electrolyte consisting of LiI and I₂ dissolved in methoxypropionitrile [164].

15.4.1.2 Long-term stability of the cell

Professor Grätzel observed that a DSSC using an N3 dye and a nanocrystalline TiO₂ photoelectrode showed good long-term stability, which is due to effective photo-induced