

With increasing global energy consumption and environmental pollution, traditional fossil energy sources cannot meet the sustainable development of human society. The utilisation of clean, renewable energy sources has become a prerequisite for the development of human society. Among a variety of new energy technologies, solar power is undoubtedly one of the most promising technologies. A solar cell is a device that converts light energy directly into electrical energy via photovoltaic effects or photochemical reactions. In 1839, the French physicist Becquerel discovered the photovoltaic effect for the first time. In 1876, British scientists Adams et al. found that a selenium semiconductor could produce electricity when it was radiated under sunlight [1]. In 1883, Fritts successfully prepared the first semiconductor/metal junction solar cell with a piece of germanium coated with a thin layer of gold although the efficiency was only ~1%. In 1954, Pearson et al. from US Bell Labs developed the first piece of crystalline silicon solar cell and achieved a conversion efficiency of 4.5%, thus beginning a new era for the utilisation of solar power [2]. The monocrystalline silicon/polycrystalline silicon solar cells currently employed in industrial applications have achieved a photovoltaic conversion efficiency of more than 20% [3, 4]. However, such silicon-based solar cells are characterised by a high cost, harsh preparation conditions, and serious environmental pollution. Cadmium telluride and copper indium gallium selenium thin-film solar cells have achieved a high efficiency of photovoltaic conversion in the laboratory, but the industrial applications are restricted by the high production cost, environmental pollution, and other problems [5]. In recent years, dye-sensitized solar cells, as the representative of the third-generation solar cells, have achieved a photoelectric conversion efficiency of more than 13% in the laboratory and have developed rapidly due to their significant advantages, including low cost, simple process, and high efficiency [4]. However, dye-sensitized cells still have two disadvantages. Firstly, in order to ensure the full absorption of sunlight's energy, the absorbing layer is thick ($>10\ \mu\text{m}$) because it is difficult to achieve complete light absorption using a thinner absorbing layer in the solid-state cells [6, 7]. Secondly, organic dyes cannot avoid the phenomenon of light bleaching. These two problems have prompted researchers to develop excellent all-solid dye materials. A perovskite is any material with the same type of crystal structure as calcium titanium oxide (CaTiO_3). Known as the perovskite structure ABX_3 . The term perovskite compounds of the generic formula $\text{A}_{1-x}\text{B}_x\text{MnO}_3$ where A and B can be a trivalent or divalent element, mostly rare earth (La, Pr, Nd, Sm) or alkaline earth (Sr, Ni, Ca, Pb, B).