High temperature metal hydrides for concentrated solar thermal energy storage

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Solar energy is the most abundant renewable energy resource that is available and therefore logically represents the most important renewable energy resource to focus our attention upon. The International Energy Agency roadmap for solar energy set a target of approximately 22% of global electricity production from solar energy by 2050, with 50% being produced from concentrating solar thermal power systems. Achieving this target will be possible only if the costs of producing electricity from solar energy are significantly reduced and cost effective energy storage technologies can be developed.

Energy storage is required to overcome the problems created by the fact that solar energy, like wind energy, is unevenly distributed geographically, seasonally variable, intermittent and unpredictable due to weather conditions. A major challenge is to achieve continuous, low-variability power generation from renewable energy sources, for stand-alone applications or for integration with domestic power grids. Solar mirror collection fields can collect thermal energy during the day and run a heat engine to convert it into electricity, but cannot provide power at night unless integrated with an energy storage system. At the present time Concentrated Solar Thermal (CST) systems with heat storage use the heat capacity (sensible heat) of binary liquid molten salt mixtures (40% $NaNO_3$; 60% KNO_3) to produce electricity during non-sun hours. A fundamental problem is the large quantity, volume and cost of the molten salts required to store sufficient heat to operate the plant for several hours during periods when the sun does not shine. The cost of solar thermal heat storage is a critical factor in its future deployment and there are two strategies for reducing its cost: 1) utilizing higher energy density storage materials to reduce the volume and mass of material required and; 2) utilizing higher energy storage temperatures to increase overall solar to electricity conversion efficiencies.

Reversible thermochemical reactions have the potential for substantially higher heat storage capacities than sensible heat or phase change materials. In a CST system paired with a reversible thermochemical reaction, heat energy is primarily used to operate the heat engine (i.e. steam turbine) to generate electricity. Excess heat energy can be stored chemically by allowing this heat to drive an endothermic chemical reaction. The beauty of the storage system lies in its reversibility, allowing heat to be generated on demand by allowing the chemical reaction to proceed in reverse, exothermically. Thus a CST system coupled with an optimised storage system allows for continuous electricity generation (day and night) from solar energy. By combining a high temperature metal hydride with a low temperature metal hydride a coupled pair reversible metal hydride thermochemical solar energy storage system is created [1].

I will discuss the use of CST worldwide and will present some results on the properties of metal hydrides that are suitable for CST applications, focussing on high temperature hydrides [2–9].

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