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Short Communication

Prospects for the role of magnesium in solar-hydrogen energy-system

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ABSTRACT

It is most common to talk about energy systems that would utilize solar energy to split water to produce hydrogen. This way, solar energy has been stored in the form of hydrogen, being an ideal energy-carrier. However we are still facing the problem of how to store and transport hydrogen to end users? The overall scope of the proposed energy scheme involves using solar to vaporize a dynamic stream of pre-concentrated sea water (brine) flowing along an inclined Preferential Salt Separator (P.S.S.). This evaporation process takes place by direct solar radiation or by using a heating system powered by a photovoltaic source. Magnesium chloride salts soluble in sea water, will separate as end product. Fresh water will be produced as a byproduct as well. Anhydrous magnesium chloride is collected and then electrolyzed next to produce magnesium metal using energy generated by solar power. Once produced, magnesium represents a reliable source of stored energy that could be exported by air, sea or other means of transportation to remote locations for power-generation. Magnesium is used on site, to construct a galvanic cell that consists of magnesium/iron electrodes generating electricity. Water introduced to the cell is electrolyzed to produce hydrogen. Another option is to use magnesium as a storage-medium to store hydrogen in the form of magnesium hydride.

Introduction

The availability of magnesium metal from sea water plays a significant role as a key component in this proposed system. It is worth-mentioning that magnesium is ranked as the eighth element in order of occurrence in the world [1–3]. One cubic kilometer of sea water contains a minimum of one million tons magnesium, which makes the sea a "*storehouse*" of about 1.7×10^{24} tons. Magnesium (Mg) exists in sea water as ions of magnesium. It's typically extracted from sea water on an industrial scale in a process known as the **Dow Process** by precipitating it as magnesium hydroxide, then converting it to the chloride using hydrochloric acid. In the method proposed in this paper, known as Preferential Salt Separation (PSS), magnesium chloride is directly obtained from sea water and is used as a feed stock to manufacture magnesium. Magnesium

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is a commercially important metal with many uses [4–7]. It is only two thirds as dense as aluminum. It is easily machined, cast, forged, and welded. It is used extensively in alloys, chiefly with aluminum and zinc, and with manganese [8–10]. It is classified as a "strategic" metal. Our proposed energy scheme encompasses three main phases, as illustrated in Fig. 1.

Recovery of magnesium chloride from sea water

In this stage, solar energy is used to vaporize a *dynamic* stream of pre-concentrated sea water flowing along an inclined Preferential Salt Evaporator (P.S.S.). Magnesium chloride salts soluble in sea water, will separate as the very end product [4,5]. Distilled water will be produced as a byproduct in this phase. It represents an ideal feed of water for hydrogen production.

Production of magnesium metal from magnesium chloride

Anhydrous magnesium chloride is electrolyzed next, using energy generated by solar power in order to produce magnesium metal [11–14]. Once produced, magnesium represents a reliable source of stored energy that could be exported by air, sea or other means of transportation to remote locations for the production of hydrogen [15–17]. Another option is to use magnesium to store hydrogen in the form of magnesium hydride. Recent advances in system integration enable a sustainable and stable power supply from solar systems [1].

Hydrogen production using galvanic-electrolytic cell

Magnesium metal is used next to construct a galvanic cell made of magnesium/iron electrodes to generate electricity used to electrolyze water for hydrogen production. It is an electrochemical cell that derives electrical energy from spontaneous redox reaction taking place within the cell. It generally consists of two different metals connected by a salt bridge, or individual half-cells separated by a porous membrane. Simultaneously, electricity generated by the galvanic cell will electrolyze water into hydrogen and oxygen (electrolytic cell performance) [18–20]. This Galvanic-Electrolytic cell is a novel concept utilized to produce hydrogen, when needed in remote areas, as illustrated in Fig. 2.

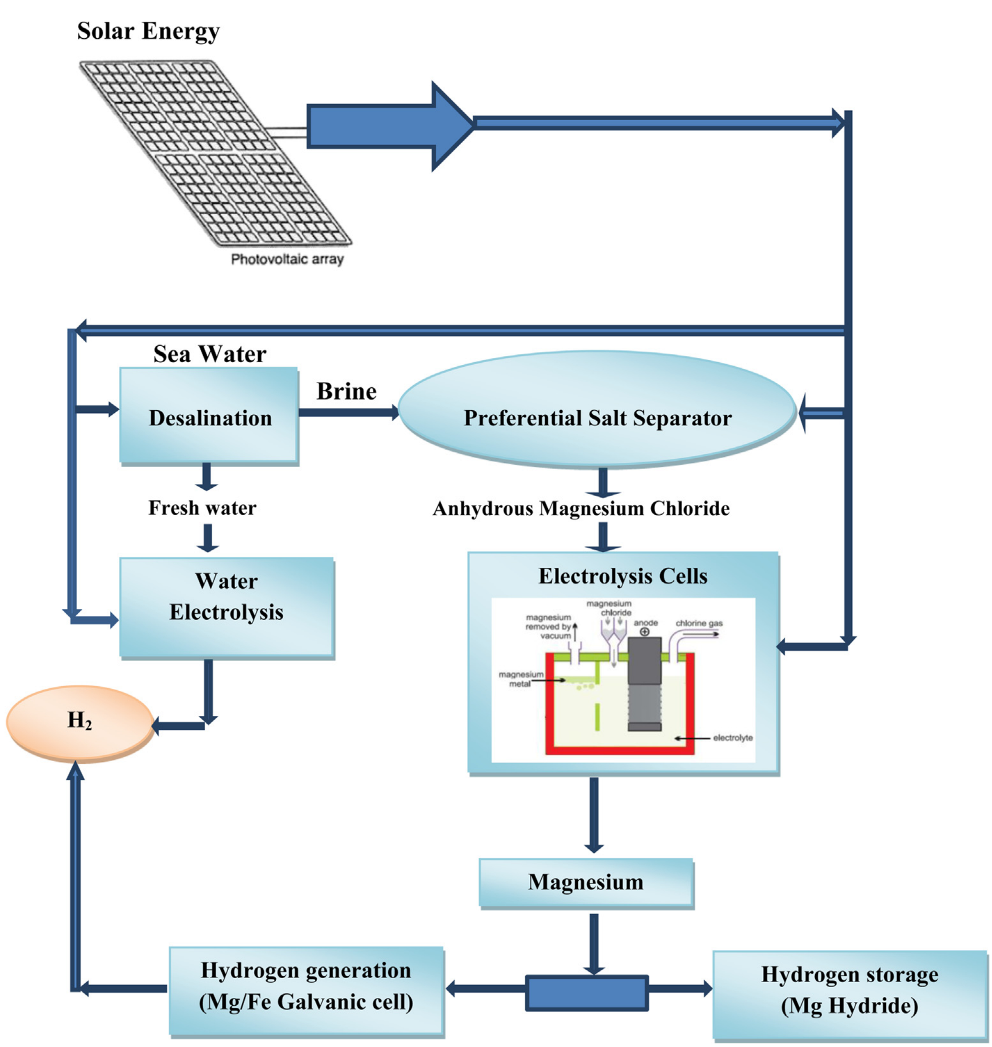

Fig. 1 – Overall proposed energy scheme.