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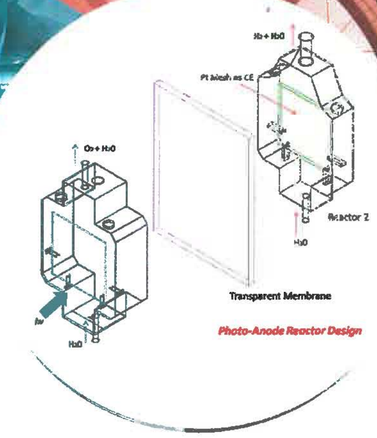

INVENTORS

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H_2-PEC-HEMATITE 'REACTORS FOR TOMORROW'S ENERGY': H_2 PRODUCTION VIA PHOTO-ELECTROCHEMICAL REACTOR

Patent No/ Patent Search No/Copyright no .: PT/4745/UniMAP/13

WHY HYDROGEN?

75% of global electrical energy production involves fossil fuel combustion, resulting in the detrimental effects of CO_2, SO_x and NO_x emissions (Fig. 1). Obviating such effects and fossil fuel depletion are the main drivers for development of energy carriers that are:

- CLEAN
- RENEWABLE
- AVAILABLE

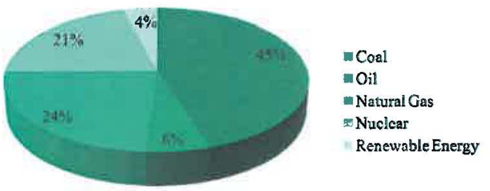

Fig. 1

MAJOR ADVANTAGES/NOVELTY

- Reactor systems for generation of carbon-free hydrogen using only SUNLIGHT and WATER.
- Reactor behaviour on scale-up for industrial uses, transportation etc.
- Can be used with other metal oxide: Fe_2O_3, TiO_2

MATERIAL CHALLENGES

Ideally, photo-anodes should:

- Be thermodynamically stable
- Have band gap energy matched the solar spectrum
- Require a potential bias of 1.23 eV
- Cheap and easily available

INVENTION DETAILS

- Solar radiation is the ultimate source of energy on earth. Semiconductors with band gap energies (E_{bg}) matched (ca. 2.5 eV) to the solar spectrum may be used to harvest solar energy.
- (Fig.3) Semiconducting photo-anode absorbs photons with energies, $hn > E_{bg}$, promoting electrons into semiconductor's conduction band (CB), leaving (electron) 'holes' in its valence band (VB).
- 'Holes' oxidise water: $2H_2O + 4h^+_{VB} \rightarrow O_2 + 4H^+$
- Electrons, conducted to metal cathode, reduce water to hydrogen: $2H_2O + 2e^-_{CB} \rightarrow H_2 + 2OH^-$

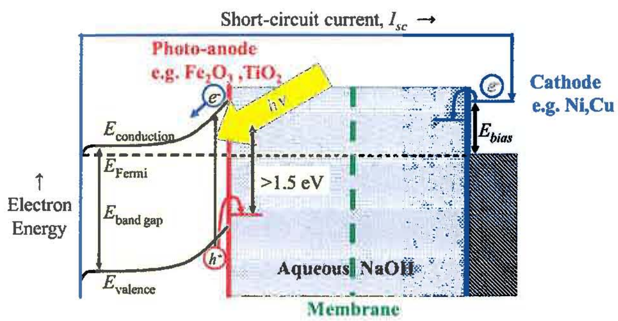

Fig. 2

ECONOMIC EVALUATION

Current work obtained current density is **6 A/m²**. According to the Shockley-Quiesser limit, best obtainable performance is 29% for a 1.1 eV bandgap semiconductor which correspond to a current density of 43 mA/cm². The ideal electrode potential to be used is the theoretical limit, 1.23 V vs RHE. 18.61 hectares of space is needed to produce 1000 kg H_2 a day.

A plant producing 1000kg H_2 a day will cost roughly RM 33560 per day.

As a fuel 1000kg H_2 can offset 4000 L gasoline which is equivalent to **RM 12960** and offset 9200 kg CO_2 which will cost **RM 29808** to remove.

SAVING (RM 42768 – RM 33560) = **RM 9208 per day using H_2 as fuel**

PUBLICATIONS

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- A.R. Muhd Hafiz, T.A. Tan, **M.A. Umi Fazara**, Fabrication and Characterization of Hematite (Fe2O3) as Photo-anode Thin Film for Photo-electrochemical Splitting of Water, International Postgraduate on Engineering & Management (IPCEM), UniMAP, 25-26 January 14.
- Muhd Hafiz Abd Rahim, Mohd Irfan Hatim Mohamed Dzahir, **Umi Fazara Md Ali**, Development of Hematite (α Fe2O3) Photo-Anoda Thin Film By Spray Pyrolysis ,9th World Congress of Chemical Engineering (WCCE9), Seoul Korea, 18-23 Aug 13.
- A.R. Muhd Hafiz, T.A. Tan, **M.A. Umi Fazara**, Characterization and Evaluation of Hematite (Fe2O3) as Photo-anode Thin Film for Photo-electrochemical Splitting of Water, International Conference of Chemical Engineering (ICCE 2013), San Francisco, USA, 23-25 October 13.